Netgear 5G MHS Travel Router (FCC ID: PY321100529) RF Exposure Compliance Test Report

Part 0: SAR and Power Density Characterization

1-20-2022

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1 Introduction

The equipment under test (EUT) is Netgear 5G MHS Travel Router (FCC ID: PY321100529). It contains the Qualcomm SDX65 modem supporting 4G WWAN technologies and 5G NR technology. Modem is enabled with Qualcomm Smart Transmit feature to control and manage transmitting power in real time and to always ensure the time-averaged RF exposure is compliant to the FCC requirement.

For WWAN technology, this EUT supports LTE, Sub-6 and mmW 5G NR radios. In Part 0 report, the EUT SAR and power density (PD) are characterized for WWAN radios (Sub-6 and mmW NR) to determine the power limit that corresponds to the exposure design target 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 characterization are denoted as SAR Char and PD Char in this report.

SAR Char and PD Char will be used as input for Qualcomm Smart Transmit feature to operate. Both SAR Char and PD Char will be loaded and stored in the EUT via the Embedded File System (EFS) and cannot be accessed by end users.

The EUT supports WLAN radio as well, but WLAN modem is not enabled with time-averaging algorithm. Refer to Part 1 report for WLAN SAR test report and for simultaneous transmission analysis.

2. Product Description

The equipment under test (EUT) is 5G mmW NR enabled Travel Router. The EUT is data device only, it does not support any voice functionality. This report presents the SAR and PD Char, which is used as an input parameter for enabling Qualcomm's Smart Transmit Algorithm.

EUT	5G MHS Travel Router, data only device	
Brand name	Netgear	
Model No.	MR6500	
FCC ID.	PY321100529	
Integrated Module	WWAN	Brand name: QTI Model name: SDX65
Mode of Operation	• NR (mmWave & sub6) • LTE	
Tx frequency range (MHz)	mm NR Band 260 LTE Band 2 LTE Band 5 LTE Band 7 LTE Band 12 LTE Band 14 LTE Band 30 LTE Band 48 LTE Band 66 FR1 n2 FR1 n5 FR1 n12 FR1 n14 FR1 n30 FR1 n66 FR1 n77	37000 - 40000 1850 – 1910 824 - 849 2500 – 2570 699 – 716 788 - 789 2305 – 2315 3550 – 3700 1710 - 1780 1850 – 1910 824 – 849 699 – 716 788 – 798 2305 – 2315 1719 – 1780 3300 - 4200

3. SAR Characterization

SAR Char is generated to cover all LTE/5G Sub 6 bands and exposure scenarios that EUT supports.

3.1 Worst -case SAR determination

This EUT is a travel router. The body exposure condition is tested according to the hotspot SAR procedures specified in KDB 941225 D06. A test separation distance of 10 mm is used between the SAM flat phantom and all surfaces with a transmitting antenna within 25 mm from that surface. See Sporton SAR Report No. FA1O2008: FCC SAR Test Report for details.

The worst-case SAR for each band is determined by taking the maximum SAR value among all applicable surfaces tested. Fig.3-1 shows all device antennas 1, 2, 3, 4, 5 and 6 for LTE, Sub 6 NR, and WLAN. Only Ant 1 and 2 are transmit for LTE/Sub 6 NR, Ant 5 & 6 are only for Sound Referencing Signal (SRS) for n77 band and Ant 3 and 4 are for WLAN transmit, so ant 3 and 4 are not relevant for SAR testing.

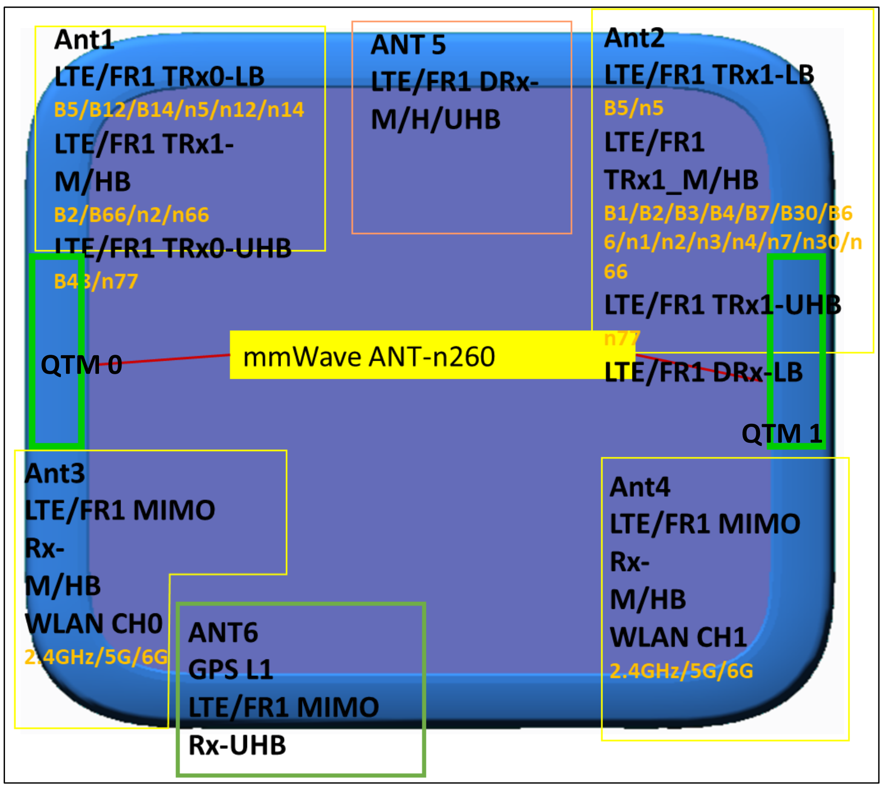


Figure 3 - 1:Netgear 5G MHS Travel Router (FCC ID: PY321100529) Antenna Block Diagram

3.2 SAR design target

The total device design related uncertainties of Netgear 5G MHS Travel Router (FCC ID: PY321100529) is 1dB (k=2), which includes TxAGC and device to device variation.

To account for total uncertainty, SAR_design_target should be determined as,

$$SAR\_design\_target < SAR_{regulatory_{limit}} * 10^{\frac{-total\ uncertainity}{10}}$$

For FCC SAR requirement of 1.6 W/kg for 1gSAR, the SAR_design_target for Netgear 5G MHS Travel Router (FCC ID: PY321100529) is determined as

$$SAR_{design_{target}} = 1.03\ \frac{W}{kg}\ for\ 1gSAR$$

As the EUT supports WLAN radio, which is not enabled by Smart Transmit, the above value has been chosen as to keep the simultaneous transmission in compliance with regulatory limit, more detail on simultaneous transmission in Part 1 report.

3.3 SAR Char of Netgear 5G MHS Travel Router (FCC ID: PY321100529)

Table 3 - 1: Worst-case reported SAR

Band	Antenna	Pmax Max time-average Power (dBm)	Reported SAR 1g (W/kg)
LTE 2	1	23.5	0.903
LTE 2	2	24	1.168
LTE 4	2	24.0	0.993
LTE 5	1	24.0	0.718
LTE 12	1	24.0	0.712
LTE 14	1	24.0	0.779
LTE 48	1	21	0.906
LTE 66	1	24.0	0.868
LTE 7	2	23.50	1.160
LTE 30	2	23.0	1.293
LTE 66	2	24.0	0.993
N2	1	23.5	0.928
N5	1	24.0	0.755
N12	1	24.0	0.675
N14	1	24.0	0.823
N66	1	24.0	0.922
N77	1	23.0	1.51
N2	2	24.0	1.127
N5	2	24.0	0.593
N30	2	23.0	1.183
N66	2	24.0	0.681
N77	2	23.0	1.537
N77	5	21.5	0.947
N77	6	20.5	1.292

Table 3 - 2: SAR Char of Netgear 5G MHS Travel Router (FCC ID: PY321100529)

Regulatory requirement	FCC
Reserve Power margin	3 dB
DSI	127
Tech/Band, Antenna	Plimit(dBm)
LTE_B2, 1	24
LTE_B2, 2	23.4
LTE_B4, 2	24.1
LTE_B5, 1	25.5
LTE_B7, 2	22.9
LTE_B12, 1	25.6
LTE_B14, 1	25.2
LTE_B30, 2	22
LTE_B66, 1	24.7
LTE_B66, 2	24.1
LTE_B48, 1	21.8
NR5G_N2, 1	23.9
NR5G_N2, 2	23.6
NR5G_N5, 1	25.3
NR5G_N5, 2	26.3
NR5G_N66, 1	24.4
NR5G_N66, 2	25.7
NR5G_N77, 1	21.3
NR5G_N77, 2	21.2
NR5G_N77, 5	21.8
NR5G_N77, 6	19.5
NR5G_N12, 1	25.8
NR5G_N14, 1	24.9
NR5G_N30, 2	22.3

4. Power Density Characterization

Netgear 5G MHS Travel Router (FCC ID: PY321100529) 5G mmW NR contains two Qualcomm QTM545 mmW antenna modules, denoted as QTM 0 & 1 which are installed at two different locations as shown in Figure 3-1. These are referred to as "Module" throughout this report. Total of 126 beams or antenna array configurations are supported. In this chapter, a hybrid approach using electromagnetic (EM) simulation in combination with measurement is taken to characterize power density profile efficiently and conservatively for Netgear 5G MHS Travel Router (FCC ID: PY321100529).

4.1 Exposure scenarios in PD evaluation

In general, for a device operating at frequencies > 6 GHz, the PD is required to be assessed for all antenna configurations (beams) from all mmW antenna modules that are installed inside the device. Furthermore, this PD evaluation should be performed at low, mid, and high channels for each supported mmW band.

For this EUT, the 4cm2 spatially averaged PD is evaluated along the surfaces (Left, Top, Bottom, Right, Front and Bottom as shown in Figure 4-2) of the EUT, and the worst-case PD is determined by taking the maximum PD among all PDs at the evaluated surfaces for each beam/band.

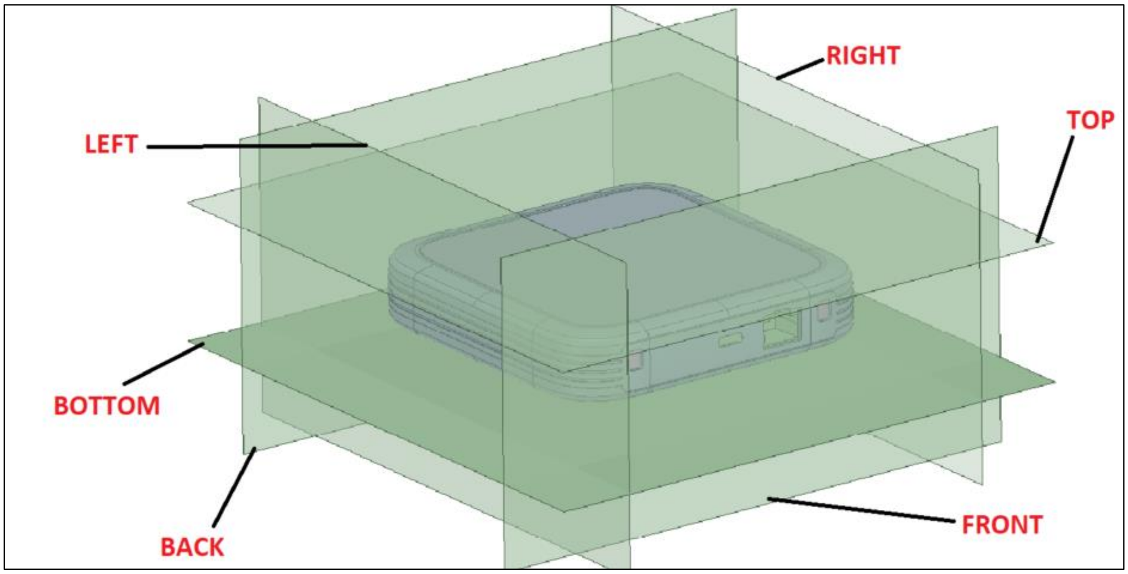


Figure 4 - 1 Device surface definition: Six surfaces of EUT

4.2 PD characterization Overview

Parameters used in PD characterization:

- The EUT supports total 126 beams in n260 band, where 84 beams are single beams (SISO) and 42 are beam pairs (MIMO) where two single beams are excited at the same time.
- PD_design_target: The design target for PD compliance. It should be less than FCC PD limit to account for all device design related uncertainties.
- input.power.limit: For a PD characterized wireless device, the input power level at antenna port(s) for each beam corresponding to PD_design_target.
- PD Char: the table that contains input.power.limit fed to antenna port(s) for all supported beams.

Figure 4-3 in the next page outlines the PD Char process.

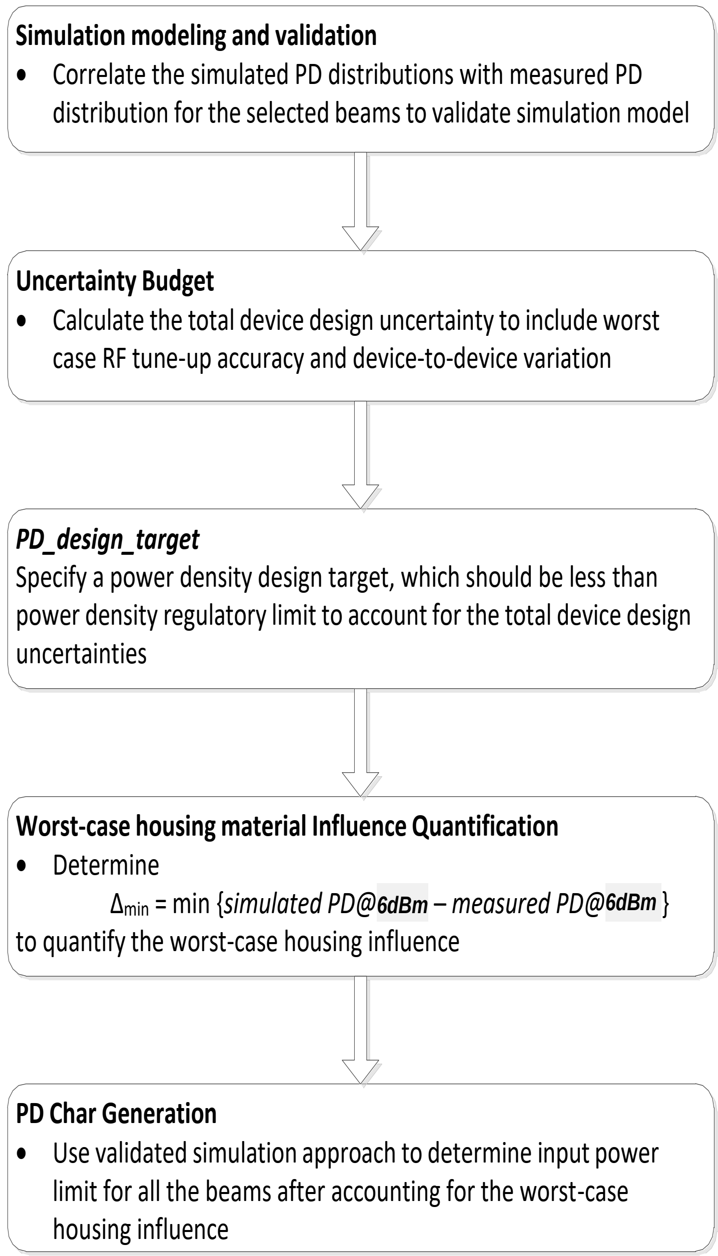


Figure 4 - 2: High level flow chart for power density characterization

For 2nd generation of Smart Transmit (Gen2), additional validation has been performed in Appendix D

4.3 Codebook for Netgear 5G MHS TRAVEL ROUTER (FCC ID: PY321100529)

In general, all the beams that the device supports are specified in the pre-defined codebook. The codebook contains a codeword for each beam in a defined set of beam pairs, which is a list of magnitude and phase weights applied to each active antenna element group's feeds to cause the desired beam to be formed. The codebook is device design specific and generated after evaluating radiation coverage from this specific device.

Table 4-1 shows all the beams and their relevant information in the codebook of Netgear 5G MHS Travel Router (FCC ID: PY321100529). There are two QTM mmW modules with module ID = 0 and 1, respectively, as shown in Figure 3-1. The PD evaluation needs to be performed for all the beams listed in Table 4-1.

Table 4 - 1: Codebook of Netgear 5G MHS Travel Router (FCC ID: PY321100529)

Beam_ID	Module_ID	Ant_Type	No_active_elements	Paired_With
0	1	PATCH	1	128
1	0	PATCH	1	129
2	1	PATCH	1	130
3	0	PATCH	1	131
4	1	PATCH	1	132
5	0	PATCH	1	133
6	1	PATCH	1	134
7	0	PATCH	1	135
8	1	PATCH	1	136
9	0	PATCH	1	137
10	1	PATCH	2	138
11	1	PATCH	2	139
12	1	PATCH	2	140
13	1	PATCH	2	141
14	0	PATCH	2	142
15	0	PATCH	2	143
16	0	PATCH	2	144
17	0	PATCH	2	145
18	1	PATCH	2	146
19	1	PATCH	2	147
20	1	PATCH	2	148
21	0	PATCH	2	149
22	0	PATCH	2	150
23	0	PATCH	2	151
24	1	PATCH	5	152
25	1	PATCH	5	153
26	1	PATCH	5	154
27	1	PATCH	5	155
28	1	PATCH	5	156
29	0	PATCH	5	157
30	0	PATCH	5	158
31	0	PATCH	5	159
32	0	PATCH	5	160
33	0	PATCH	5	161
34	1	PATCH	5	162
35	1	PATCH	5	163
36	1	PATCH	5	164
37	1	PATCH	5	165
38	0	PATCH	5	166
39	0	PATCH	5	167
40	0	PATCH	5	168
41	0	PATCH	5	169
128	1	PATCH	1	0
129	0	PATCH	1	1

130	1	PATCH	1	2
131	0	PATCH	1	3
132	1	PATCH	1	4
133	0	PATCH	1	5
134	1	PATCH	1	6
135	0	PATCH	1	7
136	1	PATCH	1	8
137	0	PATCH	1	9
138	1	PATCH	2	10
139	1	PATCH	2	11
140	1	PATCH	2	12
141	1	PATCH	2	13
142	0	PATCH	2	14
143	0	PATCH	2	15
144	0	PATCH	2	16
145	0	PATCH	2	17
146	1	PATCH	2	18
147	1	PATCH	2	19
148	1	PATCH	2	20
149	0	PATCH	2	21
150	0	PATCH	2	22
151	0	PATCH	2	23
152	1	PATCH	5	24
153	1	PATCH	5	25
154	1	PATCH	5	26
155	1	PATCH	5	27
156	1	PATCH	5	28
157	0	PATCH	5	29
158	0	PATCH	5	30
159	0	PATCH	5	31
160	0	PATCH	5	32
161	0	PATCH	5	33
162	1	PATCH	5	34
163	1	PATCH	5	35
164	1	PATCH	5	36
165	1	PATCH	5	37
166	0	PATCH	5	38
167	0	PATCH	5	39
168	0	PATCH	5	40
169	0	PATCH	5	41

(The single beams selected for modeling validation are highlighted in yellow)

4.4 PD Simulation and Modeling validation

4.4.1 Simulation Model

The EUT has two QTM545 mmW modules highlighted in Figure 4-4, which contains only patch antenna arrays. The QTM545 is designed by Qualcomm, who have provided the encrypted simulation model of this module for EM simulation. The entire Netgear MHS is first modeled along with housing, mmW modules, all LTE/Sub-6 antennas, PCB, shields, LCD, flex cables, and battery etc. as shown below.

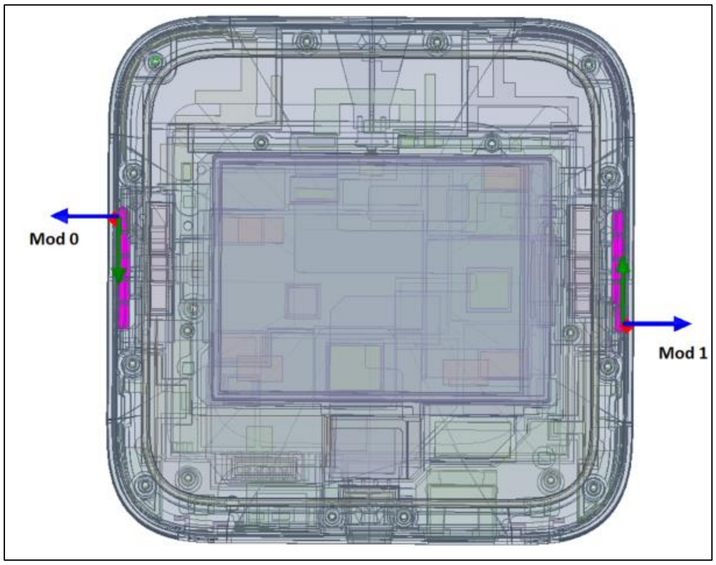


Figure 4 - 3:Netgear 5G travel router simulation model

As shown in Figure 4-4, the EM simulation is conducted for Module 0 and 1 in single model simultaneously with the relevant PD evaluation planes Left, Top, Bottom, Right, Front and Back at d=10mm where the PD is dominant.

This device level simulation model for PD assessment is constructed according to best engineering practices. However, to characterize the mm-wave PD behavior accurately all the important details within at least two wavelengths around each QTM module is considered.

4.4.2 Simulation Setup

FEM simulations were performed to assess the power density of the EUT with QTM545 modules using ANSYS Electromagnetics Suite 2021.R2. The auto initial mesh defined “lambda refinement” (i.e., ANSYS refines the initial mesh based on the material-dependent wavelength) and 30% maximum refinement per pass are selected as adaptive options in the simulation setup.

The system (ANSYS Electromagnetics suite 2021R2) computes the error, and the iterative process (solve –> error analysis –> adaptive refinement) repeats until the convergence criteria is met with maximum magnitude of delta S less than 2% which is defined by the user. If convergence is reached, the converged results are accurate. Figure 4-5 shows the adaptive mesh setup over a cross section.

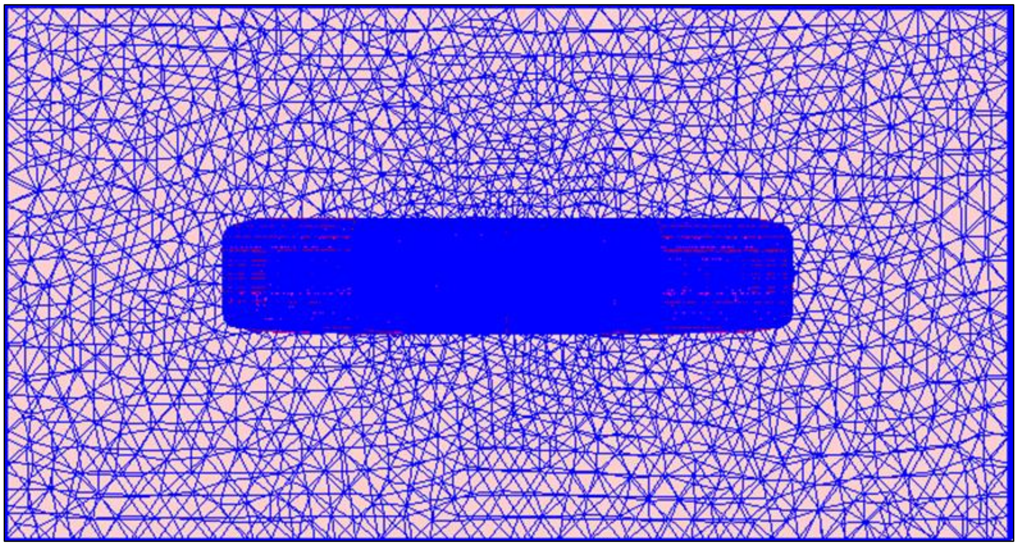


Figure 4 - 4: Simulation mesh setup

For radiation boundary, the 2nd order absorbing boundary condition (ABC) is used for all simulations in this report. This radiation boundary simulates an electrically open surface that allows waves to radiate infinitely far into space. The system absorbs the wave via the 2nd order radiation boundary condition, essentially ballooning the boundary infinitely far away from the structure and into space. The radiation boundaries may also be placed relatively close to a structure and can be of arbitrary shape.

Per ANSYS recommendations for their simulation tool, the radiation boundary plane must be located at least a quarter wavelength from strongly radiating structure, or at least a tenth of a wavelength from a weakly radiating structure. In this report, more than five wavelengths spacing (40mm) from the EUT in all directions are applied to ensure convergence (see Figure 4-6). This is enough to capture the PD hotspots at d=10mm which fall well within the simulation domain and have been verified later in Table 4-3.

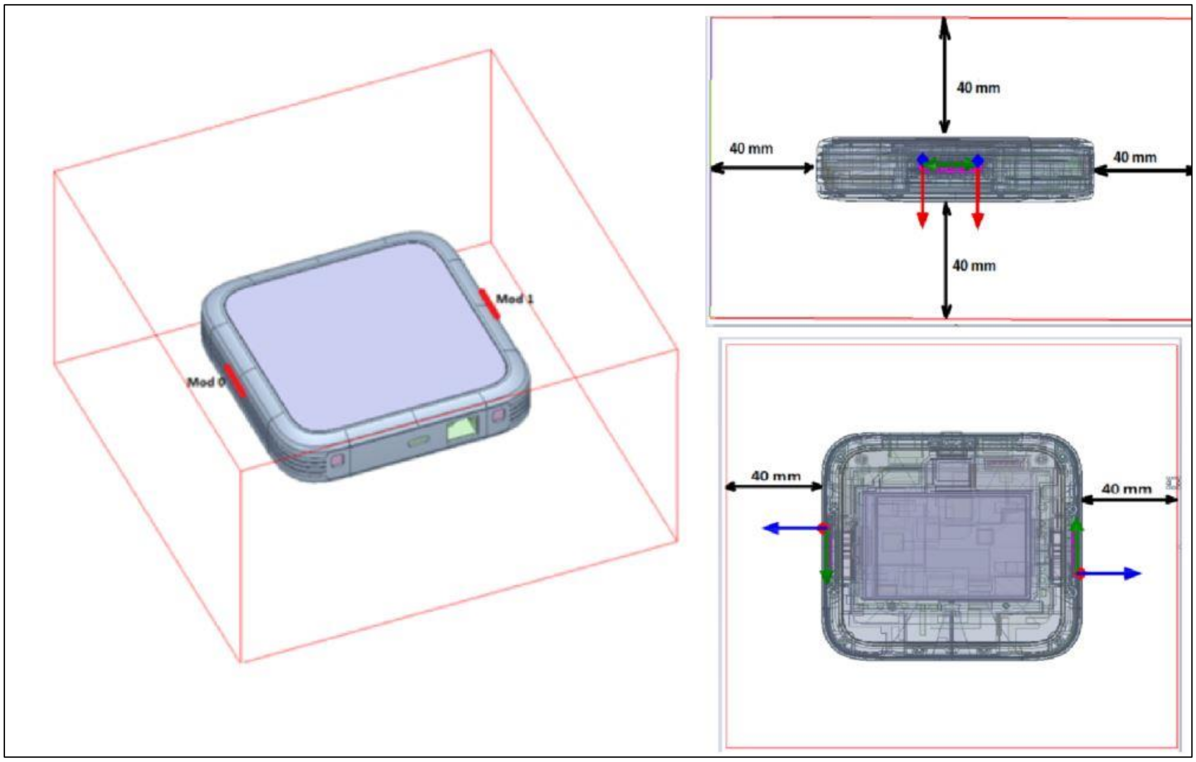


Figure 4 - 5:Radiation Boundary of Netgear 5G MHS Travel Router

Each antenna modules 0 & 1 are identical and has 20 ports. Out of these, 10 ports are for 1x5 patch array antennas for low band n258 (24.25-27.5 GHz) & n257/n261 (26.5-29.50 GHz) and 10 ports are for 1x5 patch array antennas for high band n260 (37-40 GHz) respectively. The device currently only supports n260 band and simulation analysis is for high band ports only. Out of 10 ports of the patch array, 5 are for horizontal (Pol 1) and 5 are for vertical (Pol 2) polarization feeding respectively. With the encrypted QTM simulation model, the magnitude and phase information can be loaded for each port by using "Edit Sources" in ANSYS Electromagnetics suite 2021R2. Fig.4-7 shows the antenna port excitations.

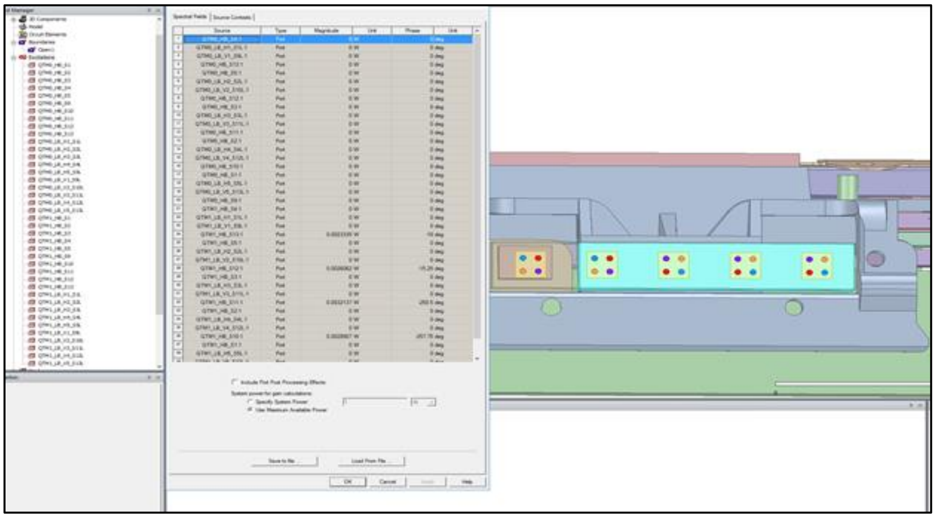


Figure 4 - 6: Antenna port excitation in ANSYS EM Suite 2021R2

After simulating the electric and magnetic (E & H) fields for a single beam formed by an array, the Poynting vector is calculated based on "peak" (i.e., non-RMS) field values in a grid with 0.95 mm step size, on the appropriate evaluation planes defined in Table 4-2. The Poynting vector at each spatial point is readily available in ANSYS Electromagnetics Suite 2021.R2 through the "Field Calculator" navigation option. The magnitude of the real part of the Poynting vector (all X, Y, Z components) at each spatial point i.e., the point power density is exported to do the averaging. The spatially averaged power density at each point on a given surface is then calculated by taking the average of the point power density over a 4 square cm area. Thus, the total power density (all X, Y, Z components) through any given surface is used to calculate the averaged power density

$$P_{avg} = \frac{1}{2A}\int_A \left|Re\left(\vec{E} * \overrightarrow{H^*}\right)\right|.dS$$

The PD calculation from the simulated E & H fields for a dual or beam pair is given in Appendix A.

4.4.3 Modeling validation with PD measurements

To validate modeling and simulation the process below is followed:

1. Select at-least one beam (i.e., antenna array configuration) per antenna type (dipole and/or patch), per antenna polarization (if applicable) and per antenna module.

This EUT contains two QTM545 mmW antenna modules (Mod 0 and Mod 1). Each module has only patch type antenna arrays. Therefore, the beam selection criteria for each mmW antenna are:

a) Two beams (Pol 1 & Pol 2) from Module 0
b) Two beams (Pol 1 & Pol 2) from Module 1

Note: Since the relative phase between two single beams in a beam pair is uncontrolled and could vary from run to run, for the validation purpose, the selection is limited to the single beam antenna array configuration. Additionally, single beam containing a higher number of active antenna elements is selected. For example, a single beam with five active patches should be selected over beam with a single active patch antenna beam.

The single beams for modeling validation are already highlighted in yellow in Table 4-1.

2. For a given reference power level(6dBm), perform both PD simulation and PD measurement to obtain the simulated PD distributions and measured PD distributions on the surface in front of the antenna array as well as the surfaces that are adjacent to the antenna array as they could potentially have strong radiating energy when considering the orientation of antenna array and type of antenna array (i.e., patch array).
3. Validate modeling and simulation by correlating the simulated PD distribution and measured PD distribution for all antenna array configurations selected in Step 1 and for all surfaces selected in Step 2. Additional validation for Gen2 is demonstrated in Appendix D.

The modeling validation is performed through correlating the simulated point PD distribution to measured point PD distribution.

The difference in 4cm2-avg PD is not used for the purpose of validity of the modeling because the housing material property (for non-metal material) used in the simulation is an approximation (note that accurate material properties are not available at mmW frequencies). This discrepancy in PD magnitude will be used to determine the worst-case housing influence (due to non-metal material property uncertainty) later in Section 4.7. The worst-case housing influence will be accounted for in PD Char generation for conservative RF exposure assessment, see Section 4.8 for details.

Based on the selection criteria described in Step 1 and Step 2, the beams and surfaces selected for modeling validation of the EUT are listed in Table 4-2.

Table 4 - 2: Beams and surfaces selection for PD correlation

Band	mmW Module	Polarization	Beam ID	Surface (see Fig.3-3)
n260	0	Pol 1(H)	31	Left, Top, Bottom
		Pol 2(V)	159	Left, Top, Bottom
	1	Pol 1(H)	36	Right, Top, Bottom
		Pol 2(V)	164	Right, Top, Bottom

With an input power of 6 dBm for n260 band, PD measurement and PD simulation are conducted for all beams and surfaces listed in Table 4-2:

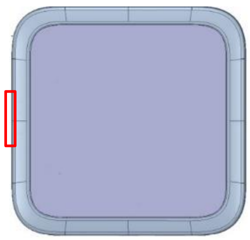
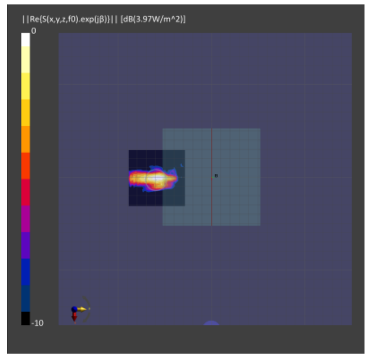
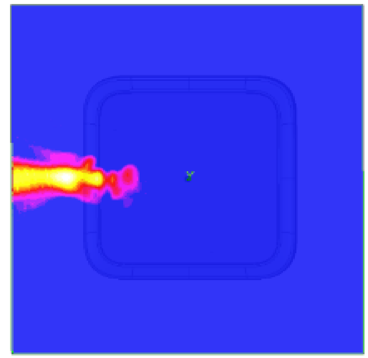
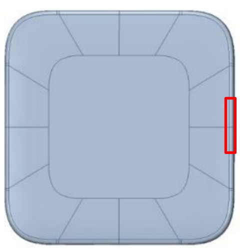
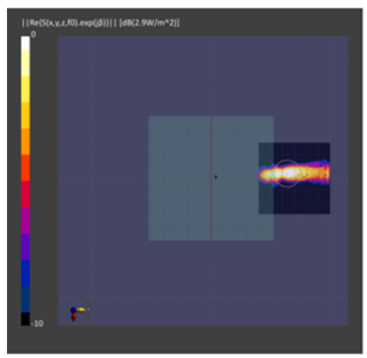
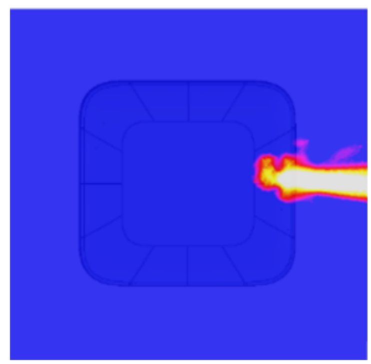
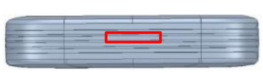
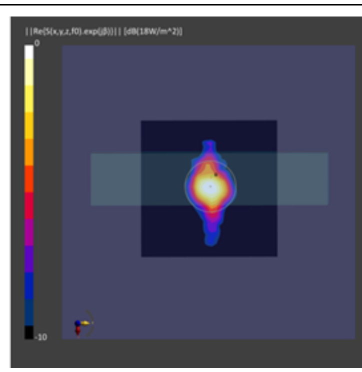
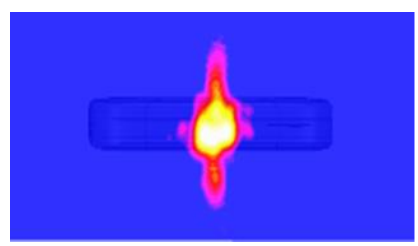
- PD distribution

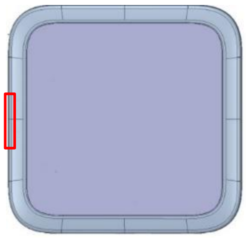
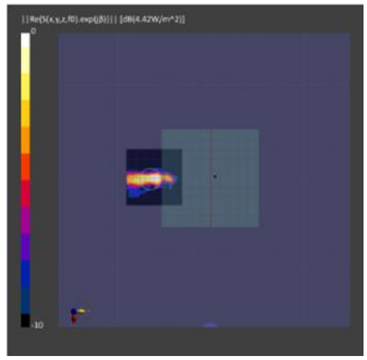
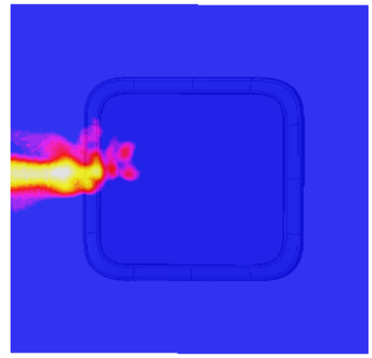
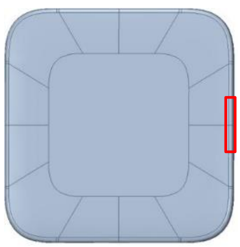
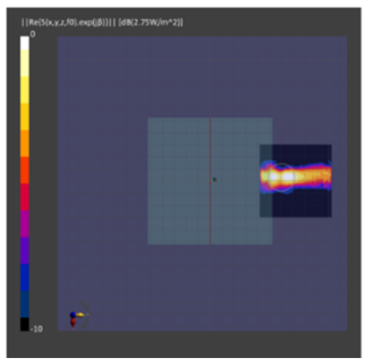
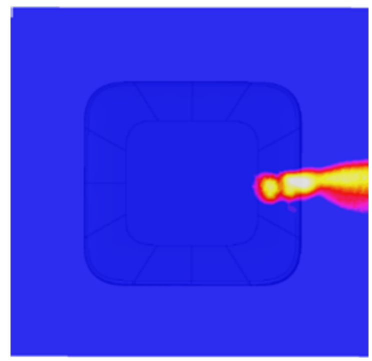
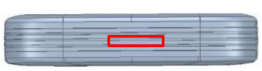
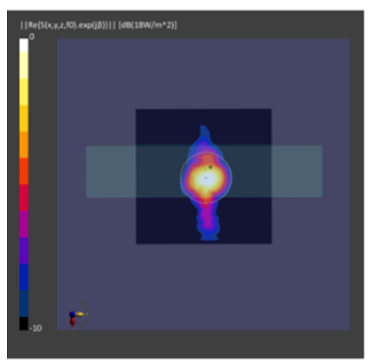
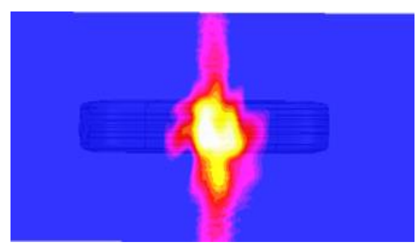
  Table 4-3 shows the measured and simulated point PD distributions for all selected beams and surfaces for n260 band. The “View” column depicts the orientation of the device, and the antenna module location is outlined in red. As can be seen, the simulated PD distributions correlate well with the measured PD distributions for all selected beams on all identified surfaces of the EUT. This confirms that the modeling is a good representation of the actual mmW QTM modules installed in the EUT. The location of the peak PD hotspots on various planes in Sporton Report No.: FA190614A: Power Density Measurement Report also match well with simulation. Therefore, the simulation model to be used for performing mmW NR RF exposure assessment is valid for this EUT.

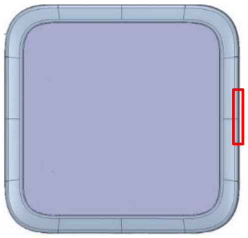
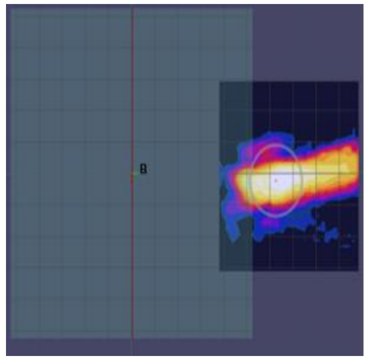
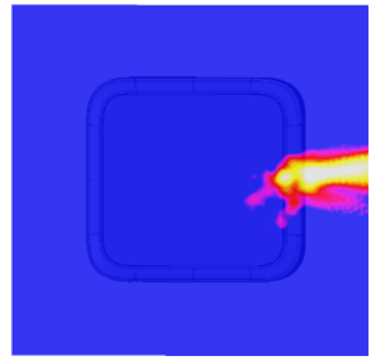
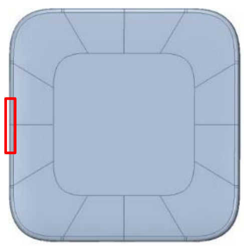
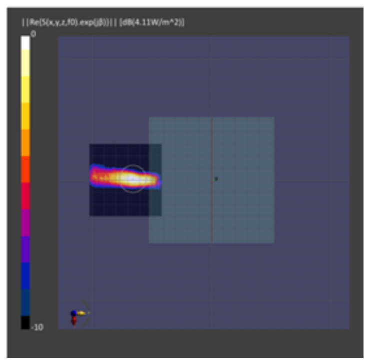
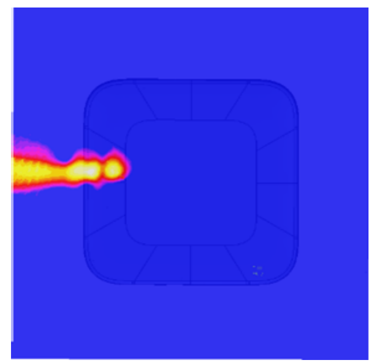
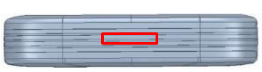
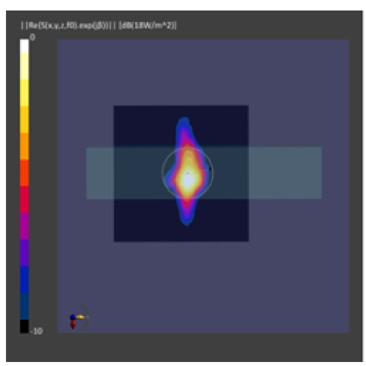
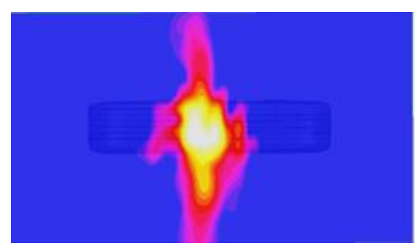
- 4cm2-averaged PD value

  Table 4-4 lists the measured 4cm2-averaged PD and simulated 4cm2-averaged PD for all selected beams and surfaces for n260 band. Refer to Sporton Report No.: FA190614A: Power Density Measurement Report (Sec 10) for measurement details. The discrepancy between simulated and measured PD value will be used to determine worst-case housing influence for conservative assessment (see Section 4.7).

Table 4 - 3: Measured and Simulated PD distributions for selected beams in n260 band

Beam ID	Surface	View	Measured PD	Simulated PD
31	Top			
	Bottom			
	Left			

Beam ID	Surface	View	Measured PD	Simulated PD
159	Top			
	Bottom			
	Left			

Beam ID	Surface	View	Measured PD	Simulated PD
164	Top			
	Bottom			
	Right			

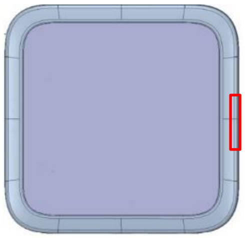
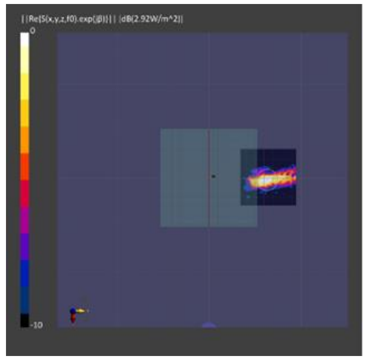
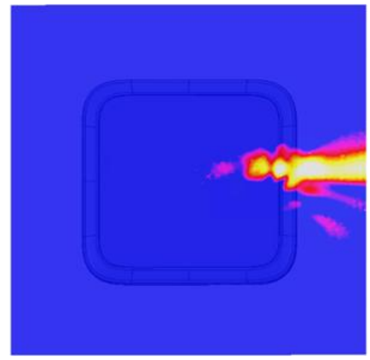
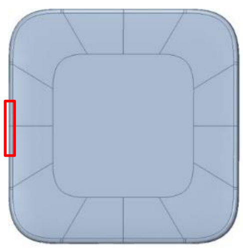
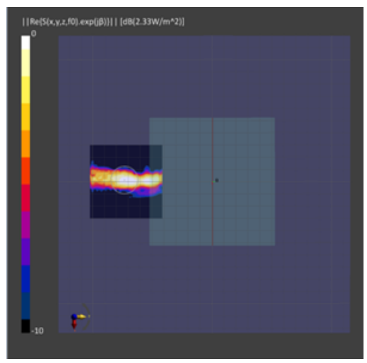
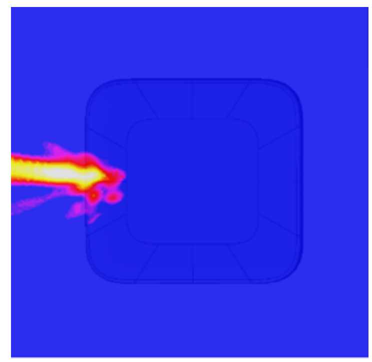
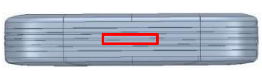
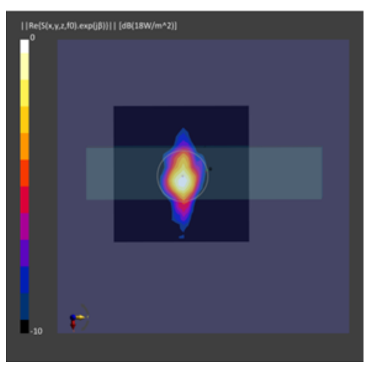
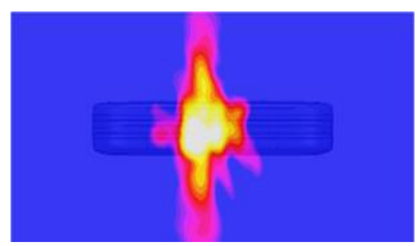
Beam ID	Surface	View	Measured PD	Simulated PD
36	Top			
	Bottom			
	Right			

Table 4 - 4: Measured and simulated 4cm² averaged PD for selected beams with 6dBm input power

4cm2 avg. PD (W/m2)						
Band	**Ant Pol**	**Beam ID**	**Surface**	**Meas.**	**Sim**	**Delta = Sim. - Meas. (dB)**
n260	Pol 1(H)	31	Top	2.08	2.63	1.02
			Bottom	1.59	2.48	1.93
			Left	7.27	9.65	1.23
	Pol 2(V)	159	Top	1.96	3.4	2.39
			Bottom	1.4	1.91	1.34
			Left	7.16	10.16	1.52
	Pol 1(H)	36	Top	1.42	2.47	2.4
			Bottom	1.25	2.33	2.7
			Right	6.58	9	1.36
	Pol 2(V)	164	Top	1.59	3.22	3.06
			Bottom	1.84	1.93	0.21
			Right	7.09	10.09	1.53

4.5 PD_design_target for Netgear 5G MHS Travel Router (FCC: PY321100529)

The 2dB of total uncertainty (k=2) provided by Qualcomm (please refer to document 80-W5693- 7: SDX65/QTM545 Uncertainty Budget for details) includes TxAGC (RF calibration) and IC/element level part to part variation.

To account for the total design related uncertainty, PD_design_target need to be:

$$PD\_design\_target < PD_{regulatory\ limit} * 10^{\frac{-total\ uncertainty}{10}}$$

For FCC 4cm2-averaged PD requirement of 10 W/m2, the PD_design_target for Netgear 5G MHS Travel Router (FCC ID: PY321100529) is determined as

$$PD\_design\_target = 4.75\ W/m^2$$

4.6 Power Density Simulation of NETGEAR 5G TRVEL ROUTER (FCC ID: PY321100529)

Using the simulation approach validated in Section 4.4, this section describes the procedure used to obtain simulated input power limit, $sim.power_{limit}$ that corresponds to PD_design_target.

4.6.1 Simulated input power limit for single beams

To determine $sim.input\ power_{limit}$, perform simulation at low, mid, and high channel for each mmW band supported, with a given *sim.input.power.per.active.port* (i.e., 6 dBm):

1. Obtain $PD_{surface}$ value (the worst PD among all identified surfaces of the EUT) at all three channels for all single beams specified in the codebook of Table 4-1.
2. Derive a scaling factor at low, mid, and high channel, $s(i)_{low\_or\_mid\_or\_high}$, by using:

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

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

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

4. Determine the simulated input power limit, sim.power$_{limit}$($\boldsymbol{i}$), among low, mid and high channels:

$$sim.power_{limit}(i)dBm = 10 * \log(s(i)) + sim.input.power.at.active.port, i \in single\ beams$$

For 2[nd] generation of Smart Transmit, the *sim.power$_{limit}$* is printed by "Qualcomm MG Script" for all three channels and is tabulated in Table B-1 and 4cm2-averaged PD values at a fixed reference level of 6dBm is tabulated in Table B-2.

4.6.2 Simulated input power limit For dual beams

The relative phase between beam pair is not controlled in QTM545 design and could vary from run to run. Therefore, for beam pair, based on the simulation results, the worst-case scaling factor needs to be determined mathematically to ensure the compliance.

For a beam pair, extract the E-fields and H-fields from the corresponding single beams at low, mid and high channel for each supported band and for all identified surfaces of the EUT.

For a given beam pair containing beam_a and beam_b, and for a given channel, let relative phase between beam_a and beam_b = ∅,

the total PD of the beam pair can be expressed as

$$total\ PD\ (\phi) = \frac{1}{2}\sqrt{Re\{PD_x(\phi)\}^2 + Re\{PD_y(\phi)\}^2 + Re\{PD_z(\phi)\}^2}$$

$$= \frac{1}{2}Re\{\left(\overrightarrow{E_a} + \overrightarrow{E_b e^{j\omega\phi}}\right) \times \left(\overrightarrow{H_a} + \overrightarrow{H_b e^{j\omega\phi}}\right)^*\}$$

where, $PD_x(\emptyset)$, $PD_y(\emptyset)$ and $PD_z(\emptyset)$ are the three components of the $total\ PD$ (∅); Ea and Ha are the extracted E-fields and H-fields of beam_a, while E_b and H_b are the extracted E-fields and H- fields of beam_b.

Sweep ∅ with a 5° step from 0° to 360° to determine the worst-case $\emptyset worstcase$ which results in the highest $total\ PD$ (∅) among all identified surfaces for this beam pair at this channel. For details on worst case $total\ PD$ (∅) derivation, see Appendix A.

Follow the above procedure to determine $\emptyset worstcase$ for all three channels, and obtain the scaling factor given by the below equation for low, mid and high channels

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

The $\emptyset_{worstcase}$ varies with channel and beam pair, the lowest scaling factor among all three channels, $s(i)$, is determined for the beam pair i:

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

The simulated input power limit, sim.power$_{limit}$, for beam pair I can be determined by

$$sim.power_{limit}(i)dBm = 10 * \log(s(i)) + sim.input.power.at.active.port, i \in\ beam\ pairs$$

For 2nd generation of Smart Transmit, the sim.powerlimit is printed by "Qualcomm MG Script" for all three channels and is tabulated in Table B-1 and 4cm2-averaged PD values at a fixed reference level of 6dBm is tabulated in Table B-2.

4.7 Worst-case housing influence determination

For non-metal material, the material property cannot be accurately characterized at mmW frequencies to date. The estimated material property for the device housing used in the simulation model 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.

For this EUT, simulated 4cm2-averaged PD and measured 4 cm2-averaged PD are compared in Table 4-4. Surfaces Left and Right are selected which always have the highest 4cm2 averaged PD for the selected beams/all beams from the patch elements of the respective modules. Also, the worst value out of both polarizations on these selected surfaces are considered. The worst error introduced when using the estimated material property in the simulation is 1.23dB for Mod 0 and 1.36dB for Mod 1 which are highlighted in Table 4-4.

It is also proved that all the other surface(s) near-by the mmW module, i.e., surface(s) not selected in previous paragraph (Front, Back, Top, Right and Bottom for module 0 and Front, Back, Top, Left and Bottom for module 1) are not required for housing material loss quantification by:

i. Scaling the simulated 4cm^2-averaged PD values for all single beams to correspond to their sim.power$_{limit}$, and identifying the worst-PD beam per each non-selected surface.(Refer to Table 4-5).
ii. 4cm^2-averaged PD at input. power.limit(determined in Section 4.8) is measured for the identified worst-PD beam at each non-selected surface in FTM mode at mid channel.
iii. It is demonstrated that 4cm^2-averaged PD values are below PD_design_target(4.75 W/m^2)

The measurements for non-selected surface(s) are tabulated in the Table 4-6

This worst-case housing influence, denoted as Δmin = Sim. PD − Meas. PD, represents the worst case where RF exposure is underestimated the most in simulation for each module when using the estimated material property for glass/plastics of the housing in the vicinity of the relevant module. For conservative assessment, Δmin is used as the worst-case factor and applied to all the beams of a given QTM module to determine input power limits in PD char for compliance (see Section 4.8 for details)

Table 4 - 5: mid channel, 4 cm^2-averaged PD at sim.power$_{limit}$

Module	Beam Id	Front	Back	Left	Right	Top	Bottom
0	1	0.10	0.24	4.62	0.03	0.93	0.76
0	3	0.13	0.20	4.64	0.03	1.05	0.82
0	5	0.12	0.18	4.62	0.03	1.04	1.16
0	7	0.16	0.12	4.66	0.03	1.06	0.99
0	9	0.20	0.13	4.65	0.03	1.19	0.96
0	14	0.22	0.26	4.64	0.02	1.22	0.89
0	15	0.11	0.11	4.64	0.01	1.10	0.92
0	16	0.06	0.19	4.65	0.03	1.33	0.98
0	17	0.36	0.31	4.64	0.05	1.67	1.36
0	21	0.27	0.06	4.64	0.01	1.37	1.36
0	22	0.08	0.07	4.64	0.02	1.19	1.26
0	23	0.15	0.27	4.64	0.03	1.30	0.85
0	29	0.54	0.43	4.63	0.04	2.49	1.46
0	30	0.27	0.05	4.64	0.02	1.19	1.25
0	31	0.03	0.03	4.64	0.02	1.26	1.19
0	32	0.04	0.30	4.64	0.04	1.25	1.00
0	33	0.24	0.38	4.64	0.04	1.33	1.08
0	38	0.40	0.10	4.64	0.03	1.72	1.40
0	39	0.10	0.03	4.64	0.01	1.13	1.22
0	40	0.03	0.11	4.64	0.03	1.35	1.17
0	41	0.11	0.42	4.64	0.05	1.19	1.03
0	129	0.07	0.22	4.64	0.04	1.09	0.47
0	131	0.13	0.23	4.66	0.03	1.20	0.74
0	133	0.16	0.13	4.64	0.03	1.17	0.80
0	135	0.20	0.14	4.63	0.03	1.15	0.92
0	137	0.23	0.09	4.65	0.00	1.21	0.80
0	142	0.51	0.29	4.65	0.02	1.60	0.91
0	143	0.12	0.05	4.64	0.03	1.26	0.59
0	144	0.08	0.17	4.64	0.01	0.94	1.02
0	145	0.15	0.50	4.64	0.07	1.42	0.96
0	149	0.17	0.16	4.64	0.02	1.29	0.75
0	150	0.07	0.05	4.64	0.01	1.37	0.95
0	151	0.20	0.25	4.64	0.01	0.99	1.00
0	157	0.49	0.30	4.64	0.02	1.05	1.19
0	158	0.25	0.07	4.64	0.03	1.68	0.98
0	159	0.04	0.03	4.64	0.01	1.55	0.87
0	160	0.02	0.31	4.64	0.03	1.25	1.00
0	161	0.49	0.79	4.64	0.04	2.24	1.21
0	166	0.49	0.14	4.64	0.02	1.30	1.19
0	167	0.09	0.04	4.63	0.02	1.64	0.81
0	168	0.04	0.09	4.64	0.02	1.27	0.92
0	169	0.15	0.50	4.65	0.03	1.77	1.26
1	0	0.10	0.24	0.03	4.65	1.19	1.05

1	2	0.13	0.22	0.03	4.65	1.08	1.04
1	4	0.12	0.21	0.03	4.64	1.02	1.11
1	6	0.20	0.13	0.00	4.63	1.05	0.89
1	8	0.24	0.14	0.00	4.63	0.94	0.84
1	10	0.17	0.24	0.02	4.65	1.42	0.94
1	11	0.02	0.16	0.02	4.63	1.29	1.20
1	12	0.11	0.05	0.04	4.63	1.27	1.03
1	13	0.34	0.60	0.05	4.64	1.74	1.45
1	18	0.14	0.49	0.04	4.65	1.62	1.68
1	19	0.13	0.12	0.03	4.64	1.05	1.08
1	20	0.18	0.15	0.03	4.64	1.38	0.74
1	24	0.61	0.88	0.02	4.64	2.79	1.45
1	25	0.09	0.56	0.04	4.64	1.63	1.40
1	26	0.04	0.09	0.02	4.65	1.23	1.37
1	27	0.23	0.05	0.04	4.64	1.28	1.05
1	28	0.42	0.35	0.02	4.64	1.43	1.09
1	34	0.28	0.58	0.03	4.64	2.28	1.42
1	35	0.07	0.29	0.03	4.64	1.25	1.33
1	36	0.04	0.06	0.03	4.64	1.27	1.20
1	37	0.31	0.14	0.02	4.64	1.41	1.07
1	128	0.09	0.26	0.03	4.64	1.20	0.77
1	130	0.09	0.21	0.03	4.64	1.20	0.88
1	132	0.13	0.16	0.03	4.65	1.18	0.83
1	134	0.16	0.13	0.03	4.63	1.13	0.72
1	136	0.18	0.11	0.04	4.64	1.04	0.50
1	138	0.37	0.27	0.02	4.65	1.23	1.08
1	139	0.02	0.15	0.02	4.64	1.47	0.84
1	140	0.09	0.03	0.01	4.64	1.18	0.98
1	141	0.23	0.59	0.04	4.64	1.63	0.96
1	146	0.15	0.24	0.02	4.64	1.19	0.77
1	147	0.03	0.13	0.01	4.65	1.46	0.98
1	148	0.28	0.09	0.02	4.65	1.32	0.83
1	152	0.43	0.68	0.05	4.65	1.92	1.44
1	153	0.05	0.40	0.05	4.65	1.27	1.11
1	154	0.03	0.06	0.01	4.64	1.67	0.83
1	155	0.12	0.03	0.01	4.64	1.26	0.97
1	156	0.64	0.47	0.03	4.64	2.26	1.13
1	162	0.12	0.36	0.04	4.64	1.10	1.25
1	163	0.05	0.25	0.03	4.65	1.64	0.88
1	164	0.04	0.05	0.01	4.64	1.48	0.89
1	165	0.29	0.07	0.02	4.64	1.59	1.13

Table 4 - 6: 4cm^2-averaged PD of the selected beams measured on the non-selected surfaces for Δ_{min} determination

Band	Beam Id	Module ID	Surface	input. power.limit (dBm)	Meas. 4cm^2 PD(W/m^2)
n260	29	0	Front	5.89	0.21
	161	0	Back	5.80	0.076
	145	0	Right	9.58	0.036
	29	0	Top	5.89	0.766
	29	0	Bottom	5.89	0.928
	156	1	Front	5.58	0.039
	24	1	Back	6.64	0.335
	152	1	Left	5.95	0.029
	24	1	Top	6.64	0.834
	18	1	Bottom	9.68	0.985

4.8 PD Char

The PD Char specifies the limit of input power at any given 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) determined in Section 4.7, given by:

$$input. power. limit(i) = sim. power_{limit}(i) + \Delta_{min},, i \in \ all\ beams$$

Equation 1

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.

The hardware design has uncertainty which must be properly considered. In Section 4.7, the TxAGC uncertainty is embedded in the process of Δmin determination. Since TxAGC uncertainty is already accounted for in PD_design_target (see Section 4.5), it needs to be removed to avoid double counting this uncertainty.

Thus equation 1 is modified to:

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

$$input. power. limit(i) = sim. power_{lmit}(i), i \in \ all\ beams$$

Equation 2

else If Δ_{min} < -TxAGC uncertainty,

$$input.power.limit(i) = sim.power_{lmit}(i) + (\Delta_{min} + TxAGC\ uncertainity), i \in\ all\ beams$$

Equation 3

else if Δ_{min} > TxAGC uncertainty,

$$input.power.limit(i) = sim.power_{lmit}(i) + (\Delta_{min} - TxAGC\ uncertainity), i \in\ all\ beams$$

Equation 4

Following above logic, the input.power.limit for this EUT can be calculated using Equations (2), (3) and (4), i.e.,

Table 4 - 7: input.power.limit calculation

Band	Module ID	*Input. Power. limit* calculation (dB)
n260	0	$sim.power_{limit}$ + 0.6
	1	$Sim.power_{limit}$ + 0.73

Following the above procedures, Table 4-8 also called PD char is generated.

Table 4 - 8: Netgear 5G MHS travel Router PD Char

Beam Id1	Paired with Beam Id	input. power. Limit (dBm)
0		12
1		11.83
2		11.73
3		11.34
4		11.01
5		10.92
6		11.51
7		11.52
8		12.01
9		11.71
10		8.56
11		7.64
12		7.5
13		10.4
14		8.94
15		7.51
16		7.7
17		10.17
18		9.68
19		7.86
20		8.35
21		8.2
22		7.19
23		8.39
24		6.64
25		5.17
26		3.76
27		4.46
28		5.77
29		5.89
30		4.41
31		3.31
32		4.32
33		5.24
34		5.86
35		4.85
36		3.5
37		5.43
38		5.17
39		3.5
40		3.86
41		5.04
128		11.3

129		11.99
130		11.41
131		11.32
132		10.7
133		10.59
134		11.53
135		11.19
136		12.07
137		11.18
138		10.29
139		7.42
140		7.11
141		9.58
142		9.63
143		7.67
144		6.92
145		9.58
146		8.8
147		7.1
148		9.26
149		8.52
150		6.87
151		7.74
152		5.95
153		4.59
154		3.46
155		3.71
156		5.58
157		5.06
158		4.68
159		3.18
160		4.21
161		5.8
162		5.17
163		4.82
164		3.33
165		4.61
166		4.76
167		3.54
168		3.33
169		4.91
0	128	8.09
1	129	8.43
2	130	7.96
3	131	7.78
4	132	7.43

5	133	7.33
6	134	7.89
7	135	7.76
8	136	8.56
9	137	8.03
10	138	5.38
11	139	3.86
12	140	3.34
13	141	4.73
14	142	6.26
15	143	3.93
16	144	2.82
17	145	7.23
18	146	6.25
19	147	3.85
20	148	6.14
21	149	5.95
22	150	3.41
23	151	3.16
24	152	2
25	153	0.98
26	154	0.24
27	155	0.15
28	156	1.48
29	157	1.19
30	158	0.91
31	159	-0.15
32	160	0.41
33	161	1.34
34	162	1.26
35	163	1.06
36	164	0.11
37	165	0.76
38	166	1
39	167	0.12
40	168	0.24
41	169	0.87

A Worst Phase Derivation for beam Pair

For beam pairs, beam ID M+1 ~ N, since the relative phase between two beams is unknown – finding the worst-case PD by sweeping the relative phase for all possible angles is required for conservative assessment.

Assuming E-field and H-field of beam_a are {Ex_a, Ey_a, Ez_a} and {Hx_a, Hy_a, Hz_a}, respectively; E-field and H-field of beam_b are {Ex_b, Ey_b, Ez_b} and {Hx_b, Hy_b, Hz_b}, respectively; and the relative phase is ∅, for beam pair consisting of beam_a and beam_b, the combined E and H, {Ex_pair_i, Ey_pair_i, Ez_pair_i} and {Hx_pair_i, Hy_pair_i, Hz_pair_i}, can be expressed as:

$$Ex(\emptyset)\_pair\_i = Ex\_a + Ex\_b \times e^{-j\omega\emptyset}$$

$$Ey(\emptyset)\_pair\_i = Ey\_a + Ey\_b \times e^{-j\omega\emptyset}$$

$$Ez(\emptyset)\_pair\_i = Ez\_a + Ez\_b \times e^{-j\omega\emptyset}$$

$$Hx(\emptyset)\_pair\_i = Hx\_a + Hx\_b \times e^{-j\omega\emptyset}$$

$$Hy(\emptyset)\_pair\_i = Hy\_a + Hy\_b \times e^{-j\omega\emptyset}$$

$$Hz(\emptyset)\_pair\_i = Hz\_a + Hz\_b \times e^{-j\omega\emptyset}$$

The combined PD can then be calculated:

$$PDx(\emptyset)pair\_i = Ey(\emptyset)\_pair\_i \times Hz(\emptyset)pair\_i^* - Ez(\emptyset)\_pair\_i \times Hy(\emptyset)\_pair\_i^*$$
$$PDy(\emptyset)\_pair\_i = Ez(\emptyset)\_pair\_i \times Hx(\emptyset)\_pair\_i^* - Ex(\emptyset)\_pair\_i \times Hz(\emptyset)\_pair\_i^*$$
$$PDz(\emptyset)\_pair\_i = Ex(\emptyset)\_pair\_i \times Hy(\emptyset)\_pair\_i^* - Ey(\emptyset)\_pair\_i \times Hx(\emptyset)\_pair\_i^*$$

$$PD\ (\emptyset) = \frac{1}{2}\sqrt{Re\{PDx(\emptyset)\}\_pair\_i^2 + Re\{PDy(\emptyset)\}\_pair\_i^2 + Re\{PDz(\emptyset)\}\_pair\_i^2}$$

Sweep ∅ from 0 degree to 360 degree to find the highest PD (out of low, mid, and high channel) and its corresponding ∅, $\emptyset_{worstcase}$, for all the beam pairs specified in the codebook_sim. The worst-case scaling factor s(i) for beam pair should be determined with $\emptyset(i)_{worstcase}$

B Scaling Factor S and 4cm^2-avg PD for Netgear M6

Table B-1 lists sim.power.limit for all the beams that Netgear 5G MHS Travel Router (FCC ID: PY321100529) supports.

NOTE: $sim.power_{limit}$ = min { $sim.power_{limit}\_L$, $sim.power_{limit}\_M$, $sim.power_{limit}\_H$ }, where $sim.power_{limit}\_L$, $sim.power_{limit}\_M$, $sim.power_{limit}\_H$ are the simulated power limits for low, mid, and high channels, respectively.

Table B - 1 Netgear MHS Travel Router Sim.power.limit

Pair with Beam Id	Beam_Id	Sim.power.limit_L	Sim.power.limit_M	Sim.power.limit_H	Sim.power.limit
	0	11.27	11.31	11.62	11.27
	1	11.23	11.38	11.76	11.23
	2	11.05	11	11.39	11
	3	11.51	11.17	10.74	10.74
	4	11.02	10.79	10.28	10.28
	5	10.97	10.86	10.32	10.32
	6	11.51	11.16	10.78	10.78
	7	11.13	10.92	11.56	10.92
	8	11.28	11.42	11.69	11.28
	9	11.11	11.18	11.51	11.11
	10	8.92	8.39	7.83	7.83
	11	6.91	6.94	7.65	6.91
	12	6.77	6.77	6.91	6.77
	13	10.31	10.14	9.67	9.67
	14	8.79	8.34	8.49	8.34
	15	6.91	7.02	7	6.91
	16	7.15	7.1	7.12	7.1
	17	10.07	10.09	9.57	9.57
	18	9.26	8.96	8.95	8.95
	19	7.13	7.24	7.2	7.13
	20	7.62	7.7	7.91	7.62
	21	7.87	7.6	8.28	7.6
	22	6.59	6.72	6.85	6.59
	23	7.99	7.79	7.86	7.79
	24	7.26	6.69	5.91	5.91
	25	5.39	4.83	4.44	4.44
	26	3.03	3.26	3.93	3.03
	27	4.26	3.99	3.73	3.73
	28	5.04	5.16	5.24	5.04
	29	6.5	5.83	5.29	5.29
	30	3.81	3.87	4.12	3.81
	31	2.71	2.82	3.64	2.71
	32	4.17	3.93	3.72	3.72
	33	4.64	5.12	5.04	4.64
	34	6.49	5.67	5.13	5.13
	35	4.12	4.23	4.4	4.12
	36	2.77	3.12	3.82	2.77
	37	4.7	4.8	4.75	4.7
	38	5.5	4.83	4.57	4.57
	39	2.9	3.09	3.79	2.9
	40	3.26	3.57	3.7	3.26
	41	4.48	4.44	4.46	4.44
	128	10.84	10.57	10.95	10.57

	129	11.39	11.59	11.73	11.39
	130	10.98	10.68	10.81	10.68
	131	11.38	11.1	10.72	10.72
	132	10.36	10.27	9.97	9.97
	133	10.4	10.26	9.99	9.99
	134	11.46	10.98	10.8	10.8
	135	10.99	10.59	10.78	10.59
	136	11.34	11.56	11.7	11.34
	137	10.65	10.58	10.84	10.58
	138	9.9	9.91	9.56	9.56
	139	6.95	6.69	7.26	6.69
	140	6.55	6.38	6.92	6.38
	141	9.5	9.2	8.85	8.85
	142	10.42	9.47	9.03	9.03
	143	7.07	7.26	7.3	7.07
	144	6.59	6.32	6.41	6.32
	145	9.98	9.38	8.98	8.98
	146	8.29	8.26	8.07	8.07
	147	6.37	6.47	6.53	6.37
	148	9.08	8.68	8.53	8.53
	149	7.93	8.01	7.92	7.92
	150	6.27	6.29	6.36	6.27
	151	7.59	7.14	7.17	7.14
	152	5.22	5.38	5.4	5.22
	153	4.89	4.34	3.86	3.86
	154	2.73	2.9	3.66	2.73
	155	3.09	2.98	3.23	2.98
	156	5.68	5.31	4.85	4.85
	157	5.03	4.71	4.46	4.46
	158	4.23	4.35	4.08	4.08
	159	2.58	2.6	3.33	2.58
	160	3.92	3.61	3.65	3.61
	161	6.2	5.82	5.2	5.2
	162	4.98	4.57	4.44	4.44
	163	4.1	4.22	4.09	4.09
	164	2.6	2.63	3.2	2.6
	165	4.6	4.2	3.88	3.88
	166	5.14	4.52	4.16	4.16
	167	2.94	3.26	3.68	2.94
	168	2.73	2.85	3.22	2.73
	169	5.09	4.76	4.31	4.31
128	0	7.65	7.36	7.59	7.36
129	1	8.05	8.07	7.83	7.83
130	2	7.3	7.23	7.56	7.23
131	3	7.86	7.43	7.18	7.18
132	4	6.91	6.79	6.7	6.7
133	5	6.89	6.91	6.73	6.73
134	6	7.95	7.31	7.16	7.16
135	7	7.39	7.16	7.49	7.16
136	8	8.02	8.09	7.83	7.83

137	9	7.46	7.43	7.54	7.43
138	10	5.98	5.13	4.65	4.65
139	11	3.6	3.13	3.22	3.13
140	12	3.07	2.61	2.74	2.61
141	13	4.94	4.36	4	4
142	14	6.21	5.66	5.7	5.66
143	15	3.72	3.52	3.33	3.33
144	16	2.67	2.22	2.26	2.22
145	17	7.7	6.97	6.63	6.63
146	18	6.57	6.03	5.52	5.52
147	19	3.13	3.22	3.12	3.12
148	20	5.99	5.68	5.41	5.41
149	21	5.93	5.55	5.35	5.35
150	22	2.81	3.1	3.34	2.81
151	23	3.27	2.56	2.57	2.56
152	24	2.44	1.92	1.27	1.27
153	25	1.55	1.1	0.25	0.25
154	26	-0.44	-0.36	-0.49	-0.49
155	27	0.13	-0.29	-0.58	-0.58
156	28	0.88	0.75	0.78	0.75
157	29	2.7	1.3	0.59	0.59
158	30	0.49	0.33	0.31	0.31
159	31	-0.61	-0.67	-0.75	-0.75
160	32	0.47	-0.14	-0.19	-0.19
161	33	0.79	0.9	0.74	0.74
162	34	2.25	1.14	0.53	0.53
163	35	0.63	0.37	0.33	0.33
164	36	-0.62	-0.39	-0.14	-0.62
165	37	0.49	0.06	0.03	0.03
166	38	1.79	1.19	0.4	0.4
167	39	-0.22	-0.48	-0.33	-0.48
168	40	-0.36	-0.06	-0.04	-0.36
169	41	0.6	0.32	0.27	0.27

Table B - 2:PD at input power of 6dBm

Mod Id	Beam 1	Beam 2	4cm^{2}PD(W/m^2) at 6dBm																	
			Low Channel						Mid Channel						High Channel					
			Front	Back	Left	Right	Top	Bott-om	Front	Back	Left	Right	Top	Bott-om	Front	Back	Left	Right	Top	Botto-m
1	0		0.03	0.09	0.01	1.38	0.3	0.36	0.04	0.07	0.01	1.37	0.36	0.31	0.03	0.01	0.01	0.81	0.32	0.27
0	1		0.04	0.06	1.39	0.01	0.31	0.21	0.03	0.07	1.34	0.01	0.27	0.22	0.02	0.06	1.23	0.01	0.28	0.24
1	2		0.03	0.08	0.01	1.45	0.33	0.35	0.04	0.06	0.01	1.47	0.34	0.33	0.04	0.01	0.01	1.01	0.29	0.33
0	3		0.04	0.07	1.3	0.01	0.34	0.2	0.04	0.06	1.41	0.01	0.32	0.25	0.03	0.05	1.56	0.01	0.31	0.26
1	4		0.04	0.08	0.01	1.46	0.36	0.39	0.04	0.07	0.01	1.52	0.35	0.36	0.04	0.01	0.01	1.58	0.35	0.4
0	5		0.05	0.05	1.48	0.01	0.37	0.38	0.05	0.07	1.52	0.01	0.35	0.38	0.05	0.05	1.72	0.01	0.36	0.37
1	6		0.06	0.05	0	1.3	0.34	0.19	0.06	0.04	0	1.43	0.32	0.27	0.04	0.01	0	1.54	0.3	0.26
0	7		0.05	0.04	1.43	0.01	0.33	0.34	0.05	0.04	1.51	0.01	0.34	0.32	0.06	0.05	1.29	0.01	0.31	0.35
1	8		0.05	0.04	0	1.38	0.3	0.21	0.07	0.04	0	1.33	0.27	0.23	0.06	0	0	1.25	0.28	0.24
0	9		0.06	0.04	1.43	0.01	0.33	0.34	0.06	0.04	1.4	0.01	0.35	0.28	0.06	0.05	1.3	0.01	0.34	0.31
1	10		0.14	0.23	0.01	2.37	0.74	0.49	0.1	0.15	0.01	2.68	0.82	0.54	0.07	0.02	0.01	3.05	0.85	0.49
1	11		0.01	0.13	0.02	3.77	1.05	1.05	0.02	0.13	0.02	3.73	1.05	0.99	0.02	0.02	0.03	2.49	1.03	0.84
1	12		0.08	0.07	0.02	3.89	1.03	1.07	0.09	0.04	0.02	3.87	1.07	0.86	0.07	0.01	0.03	2.95	0.97	0.7
1	13		0.1	0.24	0.02	1.72	0.54	0.51	0.13	0.23	0.02	1.8	0.66	0.55	0.11	0.02	0.02	1.4	0.6	0.56
0	14		0.13	0.17	2.44	0.01	0.71	0.44	0.13	0.15	2.71	0.01	0.72	0.53	0.08	0.15	2.62	0.01	0.73	0.55
0	15		0.08	0.06	3.77	0.01	1.01	0.83	0.1	0.09	3.67	0.01	0.89	0.73	0.1	0.1	3.69	0.01	0.8	0.57
0	16		0.09	0.13	3.56	0.02	0.9	0.9	0.05	0.15	3.66	0.02	1.05	0.77	0.03	0.14	3.59	0.02	0.99	0.77
0	17		0.16	0.12	1.82	0.01	0.58	0.51	0.14	0.11	1.83	0.02	0.65	0.51	0.18	0.14	2.04	0.02	0.6	0.56
1	18		0.05	0.29	0.03	2.19	0.78	0.81	0.08	0.25	0.02	2.33	0.83	0.85	0.07	0.03	0.03	2.29	0.75	0.86
1	19		0.08	0.04	0.01	3.57	1.04	0.9	0.1	0.09	0.02	3.5	0.79	0.81	0.11	0.02	0.02	3.38	0.61	0.8
1	20		0.1	0.09	0.01	3.2	0.79	0.83	0.12	0.1	0.02	3.15	0.93	0.53	0.12	0.01	0.02	1.07	0.44	0.29
0	21		0.18	0.03	3.02	0.02	1	0.95	0.19	0.04	3.23	0.01	0.94	0.91	0.2	0.05	2.75	0.02	0.86	1.02
0	22		0.06	0.05	4.05	0.01	1.1	1.16	0.07	0.06	3.97	0.02	1.03	1.07	0.08	0.05	3.82	0.02	1.06	1.05
0	23		0.13	0.17	2.93	0.01	0.72	0.69	0.1	0.19	3.12	0.02	0.87	0.57	0.09	0.17	3.02	0.02	0.83	0.62
1	24		0.68	0.75	0.03	3.47	2.47	1.2	0.51	0.74	0.02	3.97	2.4	1.26	0.41	0.04	0.03	4.74	2.1	1.24
1	25		0.16	0.84	0.07	5.34	2.07	1.79	0.12	0.73	0.05	6.08	2.13	1.84	0.14	0.09	0.05	6.61	1.97	1.88
1	26		0.05	0.09	0.03	9.2	2.97	2.7	0.07	0.16	0.04	8.76	2.32	2.58	0.07	0.05	0.04	7.24	2.19	2.24
1	27		0.29	0.07	0.05	6.92	2	2.07	0.36	0.08	0.07	7.36	2.05	1.69	0.28	0.04	0.05	6.27	1.6	1.49
1	28		0.42	0.72	0.03	5.79	1.43	1.56	0.51	0.43	0.02	5.58	1.77	1.34	0.45	0.05	0.02	3.41	1.9	0.81
0	29		0.44	0.61	4.14	0.04	2.69	1.56	0.55	0.45	4.85	0.04	2.62	1.52	0.55	0.28	5.46	0.03	2.16	1.57
0	30		0.3	0.07	7.69	0.04	2.34	2	0.45	0.08	7.59	0.03	1.94	2.01	0.44	0.08	7.16	0.02	1.88	1.88
0	31		0.11	0.04	9.91	0.03	3.07	2.75	0.06	0.06	9.6	0.04	2.64	2.48	0.12	0.13	7.99	0.04	2.36	2.28
0	32		0.07	0.42	7.07	0.05	2.24	1.81	0.07	0.48	7.55	0.06	2.04	1.6	0.07	0.43	7.85	0.06	2.41	1.59
0	33		0.51	0.59	6.35	0.04	1.35	1.75	0.29	0.47	5.77	0.05	1.61	1.35	0.2	0.54	5.79	0.04	1.81	1.4
1	34		0.54	0.84	0.06	4.15	2.58	1.58	0.29	0.62	0.03	5.02	2.46	1.53	0.22	0.05	0.04	5.68	2.17	1.51
1	35		0.1	0.3	0.04	7.16	2.26	1.97	0.11	0.43	0.05	6.97	1.88	2.03	0.14	0.08	0.05	6.72	1.74	1.88
1	36		0.03	0.11	0.04	9.76	2.82	2.72	0.07	0.11	0.06	9.09	2.47	2.33	0.1	0.02	0.06	6.77	2.24	2.09
1	37		0.49	0.37	0.03	6.26	1.56	1.83	0.42	0.2	0.03	6.05	1.87	1.43	0.39	0.05	0.02	3.38	1.25	0.63
0	38		0.72	0.14	5.2	0.04	2.07	1.81	0.53	0.13	6.06	0.04	2.28	1.8	0.43	0.15	6.46	0.03	2.1	1.99
0	39		0.08	0.04	9.49	0.03	2.93	2.42	0.18	0.05	9.05	0.02	2.21	2.37	0.25	0.08	7.72	0.03	1.99	2.07
0	40		0.05	0.12	8.73	0.05	2.54	2.38	0.05	0.2	8.2	0.06	2.38	2.04	0.06	0.25	7.88	0.05	2.49	2.13
0	41		0.19	0.72	6.58	0.06	1.86	1.82	0.16	0.6	6.72	0.07	1.7	1.51	0.14	0.53	6.62	0.04	1.79	1.5

1	128		0.04	0.08	0.01	1.52	0.5	0.24	0.03	0.09	0.01	1.6	0.42	0.26	0.03	0.01	0.01	0.9	0.32	0.23
0	129		0.03	0.06	1.34	0.01	0.25	0.18	0.02	0.06	1.29	0.01	0.3	0.13	0.02	0.08	1.24	0.01	0.28	0.21
1	130		0.04	0.07	0.01	1.47	0.41	0.3	0.04	0.07	0.01	1.59	0.41	0.31	0.04	0.01	0.01	1.04	0.35	0.24
0	131		0.03	0.09	1.34	0.01	0.31	0.32	0.04	0.07	1.43	0.01	0.37	0.23	0.03	0.06	1.57	0	0.36	0.25
1	132		0.05	0.06	0.01	1.7	0.48	0.28	0.05	0.05	0.01	1.74	0.43	0.31	0.04	0.01	0	1.66	0.48	0.27
0	133		0.06	0.07	1.69	0.01	0.47	0.28	0.06	0.05	1.75	0.01	0.44	0.31	0.05	0.05	1.85	0	0.49	0.32
1	134		0.07	0.04	0.01	1.32	0.3	0.35	0.05	0.04	0.01	1.47	0.36	0.23	0.05	0.01	0.01	1.54	0.38	0.24
0	135		0.07	0.05	1.47	0.01	0.42	0.31	0.07	0.06	1.62	0.01	0.4	0.32	0.07	0.04	1.55	0	0.35	0.31
1	136		0.04	0.03	0	1.36	0.25	0.18	0.05	0.03	0.01	1.29	0.29	0.14	0.06	0.01	0	1.25	0.28	0.23
0	137		0.08	0.04	1.59	0	0.49	0.26	0.08	0.03	1.62	0	0.42	0.27	0.07	0.03	1.52	0	0.43	0.28
1	138		0.19	0.11	0.01	1.89	0.4	0.55	0.15	0.11	0.01	1.89	0.49	0.44	0.15	0.03	0.01	2.05	0.52	0.36
1	139		0.02	0.14	0.02	3.73	1.15	0.74	0.01	0.13	0.02	3.93	1.24	0.71	0.02	0.03	0.03	2.65	1.07	0.74
1	140		0.09	0.04	0.01	4.09	1.34	0.83	0.08	0.03	0.01	4.24	1.07	0.89	0.08	0.01	0.01	1.36	0.71	0.72
1	141		0.13	0.29	0.02	2.07	0.89	0.44	0.1	0.28	0.02	2.22	0.76	0.46	0.08	0.02	0.02	1.79	0.56	0.39
0	142		0.23	0.17	1.68	0.01	0.67	0.47	0.23	0.14	2.11	0.01	0.72	0.42	0.24	0.15	2.31	0.01	0.77	0.4
0	143		0.08	0.04	3.63	0.01	0.79	0.67	0.09	0.04	3.49	0.02	0.95	0.44	0.07	0.04	3.44	0.01	0.98	0.52
0	144		0.12	0.17	4.06	0.01	1.11	0.77	0.07	0.16	4.35	0.01	0.89	0.98	0.07	0.13	4.22	0.01	0.76	1.03
0	145		0.05	0.26	1.85	0.03	0.58	0.45	0.07	0.23	2.13	0.03	0.65	0.45	0.07	0.25	2.34	0.02	0.71	0.43
1	146		0.12	0.13	0.01	2.74	0.54	0.63	0.08	0.14	0.01	2.75	0.7	0.45	0.1	0.03	0.01	2.88	0.75	0.43
1	147		0.02	0.09	0.01	4.26	1.42	0.89	0.03	0.12	0.01	4.19	1.31	0.88	0.03	0.02	0.01	3.53	1.25	0.84
1	148		0.17	0.04	0.01	2.28	0.7	0.53	0.16	0.05	0.01	2.5	0.71	0.46	0.15	0.02	0.01	2.5	0.71	0.44
0	149		0.1	0.12	2.98	0.01	0.62	0.62	0.11	0.1	2.93	0.01	0.81	0.47	0.09	0.1	2.98	0.01	0.75	0.46
0	150		0.05	0.04	4.37	0.01	1.41	0.92	0.07	0.05	4.35	0.01	1.3	0.9	0.07	0.05	4.28	0.01	1.22	0.94
0	151		0.19	0.22	3.22	0.01	0.97	0.6	0.16	0.19	3.62	0.01	0.78	0.8	0.16	0.14	3.54	0.01	0.7	0.81
1	152		0.8	0.72	0.08	5.56	1.86	1.48	0.53	0.76	0.05	5.4	2.14	1.64	0.39	0.06	0.03	5.33	1.66	1.18
1	153		0.08	0.75	0.06	5.99	1.64	1.94	0.07	0.59	0.06	6.77	1.87	1.62	0.08	0.09	0.06	7.58	2.22	1.62
1	154		0.06	0.06	0.03	9.86	3.27	2.36	0.07	0.12	0.03	9.46	3.39	1.7	0.12	0.03	0.03	7.59	2.81	1.68
1	155		0.2	0.05	0.03	9.07	2.96	1.93	0.24	0.06	0.02	9.27	2.49	1.93	0.23	0.02	0.02	6.3	2.22	1.91
1	156		0.71	0.59	0.06	5	2.7	1.29	0.76	0.54	0.03	5.4	2.57	1.35	0.64	0.06	0.02	3.23	1.39	0.82
0	157		0.62	0.55	5.81	0.04	1.17	1.93	0.65	0.42	6.28	0.04	1.42	1.61	0.7	0.25	6.61	0.02	1.93	1.34
0	158		0.25	0.11	6.97	0.04	2.21	1.86	0.37	0.1	6.79	0.04	2.47	1.44	0.35	0.09	7.23	0.02	2.22	1.73
0	159		0.06	0.07	10.19	0.02	3.53	2.36	0.09	0.07	10.2	0.02	3.41	1.92	0.14	0.11	8.58	0.01	2.95	1.87
0	160		0.07	0.48	7.49	0.05	2.53	1.71	0.04	0.55	8.09	0.05	2.18	1.78	0.05	0.45	7.97	0.03	2.09	1.86
0	161		0.64	0.86	4.43	0.04	2.68	1.21	0.52	0.83	4.88	0.04	2.35	1.33	0.37	0.74	5.58	0.02	2.48	1.1
1	162		0.23	0.63	0.05	5.87	1.28	2.05	0.17	0.5	0.04	6.43	1.51	1.72	0.22	0.08	0.04	6.65	1.61	1.45
1	163		0.08	0.28	0.03	7.2	2.2	1.87	0.08	0.36	0.03	6.98	2.47	1.29	0.12	0.05	0.05	7.19	2.21	1.52
1	164		0.07	0.07	0.02	10.16	3.63	2.16	0.08	0.11	0.02	10.08	3.21	1.94	0.12	0.02	0.02	7.45	2.81	2.1
1	165		0.62	0.15	0.03	6.4	2.65	1.56	0.44	0.11	0.02	6.96	2.35	1.71	0.42	0.06	0.02	4.01	1.44	1.09
0	166		0.63	0.14	5.66	0.04	1.61	1.91	0.69	0.2	6.58	0.03	1.84	1.69	0.59	0.1	7.08	0.02	2.03	1.57
0	167		0.1	0.09	9.39	0.03	2.98	2.33	0.18	0.08	8.76	0.04	3.11	1.5	0.24	0.09	7.92	0.02	2.55	1.65
0	168		0.06	0.1	9.85	0.02	3.24	1.9	0.09	0.19	9.6	0.04	2.63	1.91	0.05	0.2	8.8	0.02	2.48	2.04
0	169		0.35	0.92	5.73	0.06	2.74	1.47	0.2	0.67	6.21	0.04	2.39	1.74	0.14	0.54	6.85	0.03	2.18	1.52
1	0	128	0.1	0.23	0.03	3.17	0.98	0.94	0.1	0.31	0.03	3.36	1.16	0.95	0.1	0.03	0.04	2.51	1.04	0.82
0	1	129	0.08	0.17	2.89	0.03	0.75	0.56	0.09	0.23	2.9	0.03	0.83	0.54	0.06	0.25	3.04	0.02	0.83	0.56
1	2	130	0.12	0.21	0.02	3.44	0.99	1.03	0.12	0.21	0.02	3.49	1.08	1.01	0.11	0.04	0.03	2.87	0.89	0.83
0	3	131	0.12	0.23	3.02	0.03	0.89	0.71	0.13	0.22	3.34	0.03	0.99	0.75	0.09	0.19	3.54	0.01	0.92	0.68

1	4	132	0.12	0.22	0.02	3.76	1.1	1.06	0.13	0.21	0.02	3.82	1.2	1	0.1	0.03	0.02	3.69	1.15	0.91
0	5	133	0.15	0.21	3.79	0.02	1.11	1.06	0.16	0.21	3.82	0.02	1.23	1.05	0.19	0.15	3.92	0.01	1.18	0.81
1	6	134	0.19	0.15	0.01	2.96	0.91	0.75	0.18	0.15	0.02	3.44	0.98	0.74	0.14	0.02	0.01	3.56	0.9	0.65
0	7	135	0.18	0.15	3.37	0.02	1.01	1.04	0.2	0.16	3.59	0.02	1.08	0.98	0.2	0.14	3.29	0.01	0.91	0.83
1	8	136	0.17	0.1	0.01	2.92	0.7	0.53	0.2	0.09	0.01	2.86	0.83	0.55	0.21	0.02	0.01	3.04	0.79	0.6
0	9	137	0.25	0.11	3.31	0.02	1.03	0.92	0.22	0.11	3.35	0.01	1.1	0.91	0.25	0.13	3.26	0.02	1.05	0.84
1	10	138	0.43	0.51	0.03	4.66	1.73	1.16	0.4	0.41	0.02	5.67	2.03	1.07	0.34	0.05	0.02	6.33	1.78	1.06
1	11	139	0.04	0.47	0.06	8.06	2.99	2.91	0.04	0.46	0.07	9	3.41	2.97	0.07	0.08	0.11	7.45	2.86	2.4
1	12	140	0.29	0.12	0.03	9.12	2.62	2.63	0.3	0.1	0.05	10.7	2.55	2.41	0.24	0.03	0.05	5.44	2.15	1.46
1	13	141	0.35	0.79	0.08	5.92	2.25	1.51	0.35	0.95	0.06	6.78	2.3	1.61	0.32	0.07	0.05	5.11	2.08	1.54
0	14	142	0.46	0.39	4.42	0.03	1.45	0.97	0.45	0.41	5.04	0.03	1.64	1.05	0.35	0.32	4.97	0.02	1.82	0.98
0	15	143	0.23	0.14	7.85	0.03	2.11	2	0.3	0.16	8.24	0.03	2.18	1.55	0.28	0.15	8.58	0.02	1.77	1.5
0	16	144	0.24	0.52	9.99	0.03	2.34	2.22	0.23	0.58	11.25	0.05	2.35	2.07	0.17	0.46	10.99	0.03	2.44	2.17
0	17	145	0.27	0.45	3.14	0.04	1.12	1	0.26	0.42	3.73	0.05	1.33	0.86	0.27	0.42	4.02	0.04	1.24	0.86
1	18	146	0.22	0.49	0.05	4.07	1.4	1.36	0.15	0.49	0.04	4.57	1.65	1.18	0.16	0.07	0.04	5.18	1.49	1.26
1	19	147	0.12	0.24	0.04	8.98	3.29	2.65	0.16	0.38	0.04	8.81	3.03	2.49	0.17	0.05	0.04	8.1	2.82	1.87
1	20	148	0.29	0.14	0.03	4.65	1.51	1.24	0.28	0.16	0.03	5.02	1.64	1.03	0.36	0.04	0.03	4.07	1.27	0.75
0	21	149	0.32	0.19	4.71	0.03	1.37	1.44	0.33	0.15	5.19	0.03	1.6	1.21	0.32	0.17	5.39	0.03	1.37	1.39
0	22	150	0.18	0.15	9.67	0.03	3.42	3.19	0.25	0.2	9.14	0.03	3.47	3.04	0.28	0.16	8.56	0.04	2.94	2.29
0	23	151	0.39	0.66	8.7	0.03	2.3	1.52	0.48	0.7	10.42	0.05	2.32	1.6	0.44	0.55	10.24	0.03	2.37	1.86
1	24	152	1.3	2.04	0.12	10.53	5.42	3.81	1	2.1	0.11	11.78	6.15	4.11	0.79	0.12	0.08	13.78	6.26	3.47
1	25	153	0.25	2.18	0.2	12.94	4.48	5.51	0.23	1.7	0.18	14.42	5.31	5.09	0.31	0.23	0.17	17.29	6.22	5.31
1	26	154	0.15	0.19	0.09	20.45	8.38	8.09	0.24	0.33	0.12	20.1	8.5	6.95	0.24	0.1	0.12	19.73	7.26	5.91
1	27	155	0.63	0.19	0.08	17.95	5.33	5.27	0.69	0.18	0.1	19.6	4.85	4.23	0.59	0.06	0.11	14.79	5.18	4.23
1	28	156	1.46	1.5	0.08	15.09	5.39	2.78	1.5	1.33	0.06	15.41	5.26	3.1	1.11	0.15	0.05	9.17	5.5	2.21
0	29	157	1.51	1.03	9.92	0.09	4.48	4.95	1.65	0.95	13.74	0.09	5.24	4.4	2.08	0.88	16.13	0.06	5.71	4.08
0	30	158	0.89	0.21	16.5	0.08	6.07	6.12	1.22	0.23	17.17	0.09	6.36	5.71	1.1	0.24	17.21	0.08	6.41	5.21
0	31	159	0.24	0.11	21.25	0.1	8.64	8.1	0.16	0.19	21.48	0.1	8.97	6.91	0.37	0.4	21.95	0.06	7.4	5.94
0	32	160	0.21	1.07	16.59	0.13	4.94	4.09	0.16	1.29	19.23	0.15	5	3.28	0.16	1.12	19.3	0.11	5.34	4.33
0	33	161	1.38	1.84	15.42	0.11	4.64	3.21	1.33	1.83	15.24	0.14	5.1	3.37	0.91	1.6	15.6	0.07	5.6	3.56
1	34	162	1.08	1.65	0.14	11.01	4.25	5.14	0.64	2.04	0.11	14.19	4.96	4.67	0.54	0.18	0.11	16.37	5.7	4.26
1	35	163	0.27	0.89	0.1	15.98	6.1	6.12	0.27	1.24	0.14	16.94	6.35	5.44	0.3	0.18	0.19	16.39	6.37	5.21
1	36	164	0.15	0.27	0.09	21.32	8.29	7.42	0.24	0.25	0.11	20.37	8.22	6.58	0.35	0.05	0.11	17.67	6.61	5.64
1	37	165	1.6	0.68	0.07	16.52	5.11	3.42	1.31	0.44	0.06	18.02	5.88	3.2	1.22	0.12	0.06	10.08	4.62	2.21
0	38	166	1.6	0.37	12.23	0.11	4.43	5.29	1.47	0.39	14.13	0.11	5.33	5.33	1.54	0.4	16.85	0.06	6.16	5.35
0	39	167	0.23	0.15	19.46	0.08	7.84	7.65	0.6	0.18	20.61	0.09	7.94	6.44	0.86	0.27	19.94	0.07	7.03	5.54
0	40	168	0.17	0.32	20.08	0.09	7.2	6.25	0.15	0.55	18.85	0.1	6.49	5.35	0.19	0.6	18.64	0.09	5.9	4.51
0	41	169	0.68	2.21	16.08	0.12	5.5	3.09	0.45	1.91	17.38	0.11	5.43	3.52	0.26	1.54	17.36	0.08	5.69	3.97

C. Simulated PD Distribution Plots

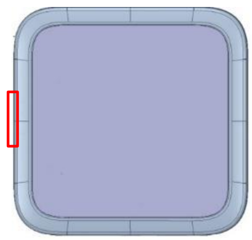
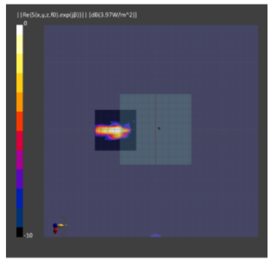
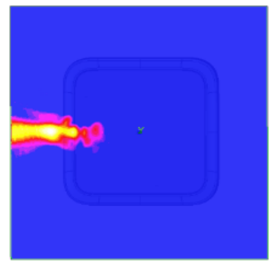
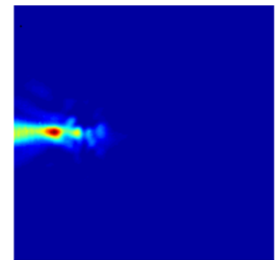
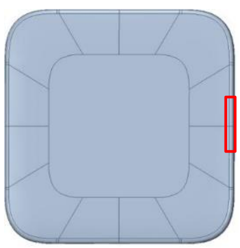
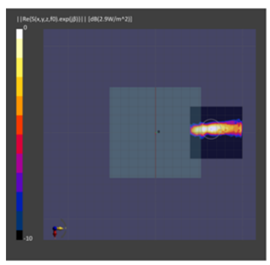
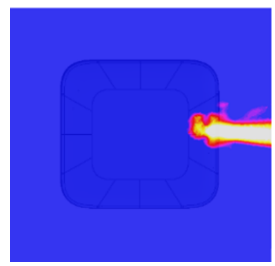
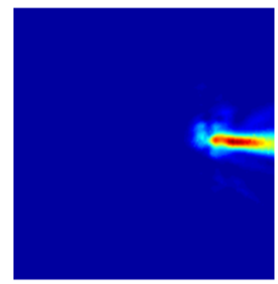
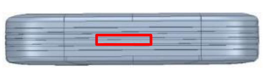
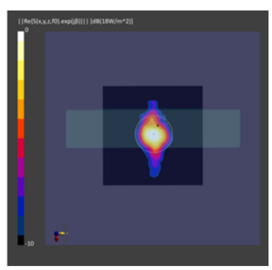
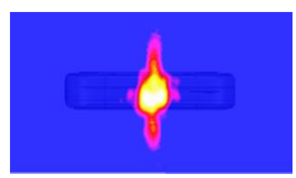
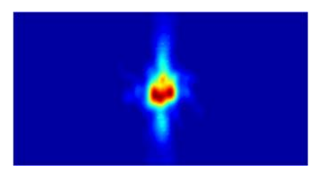
To comply with 2nd generation of Smart Transmit, entire EUT is simulated, therefore as suggested in Qualcomm document number 80-W2112-2 there is no need to print the PD distributions as the hotspot for all the beams is captured in simulation domain.

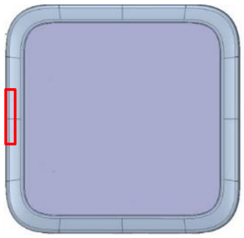
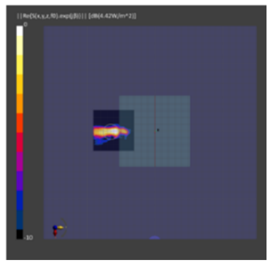
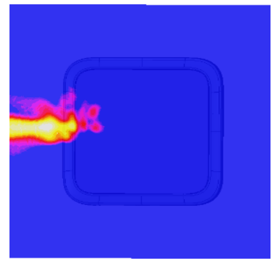
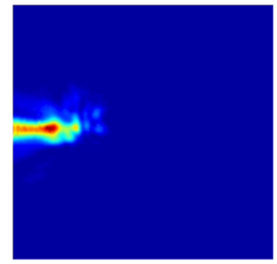
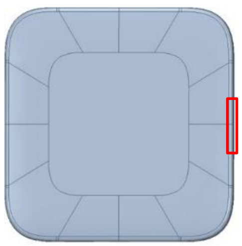
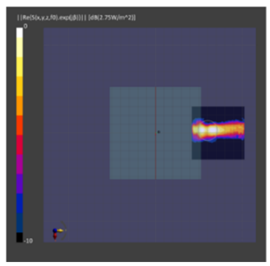
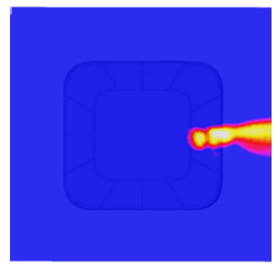
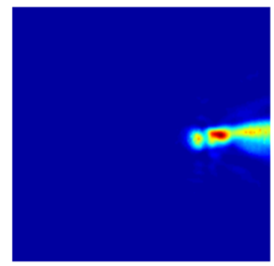
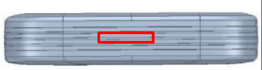
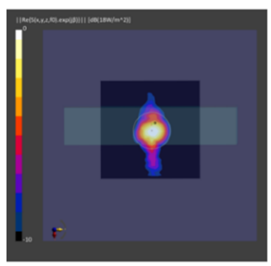
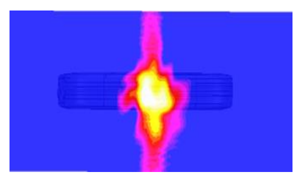
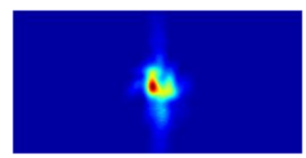
D PD Char Requirements for 2nd Generation of Smart transmit (GEN 2)

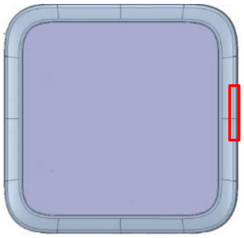
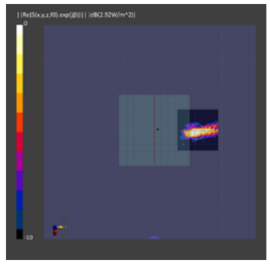
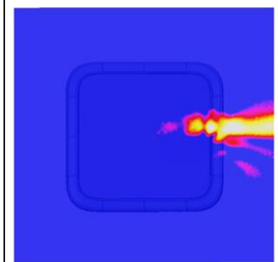
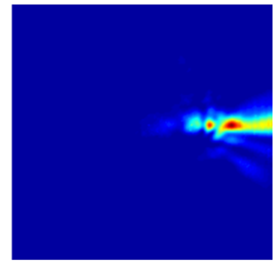
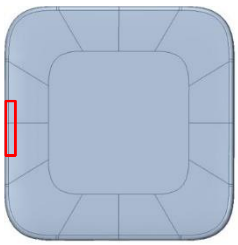
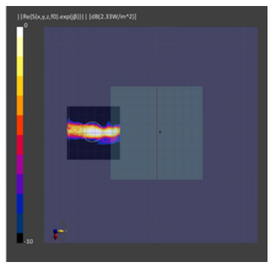
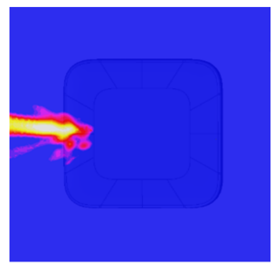
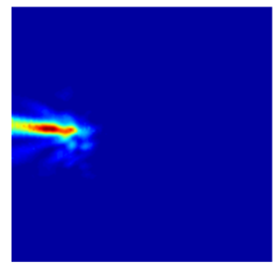
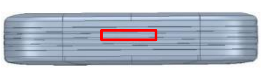
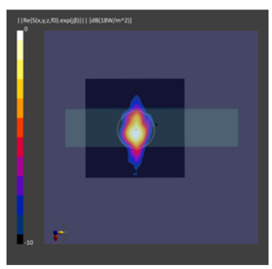
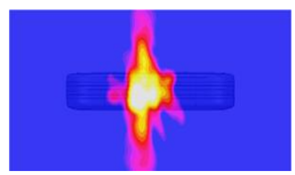
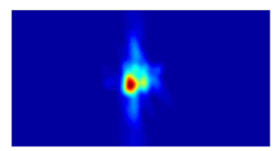
D.1 Verification 1

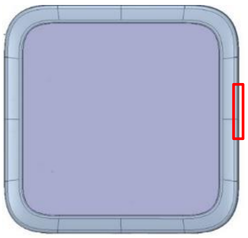
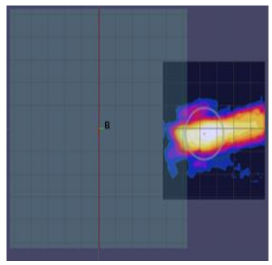
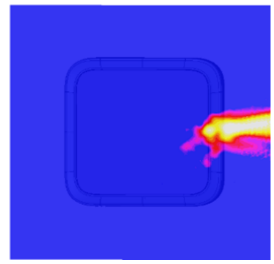
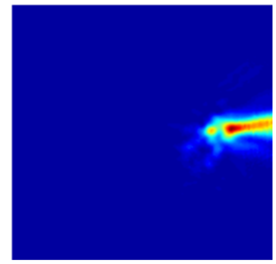
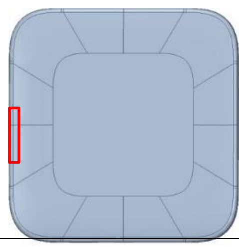
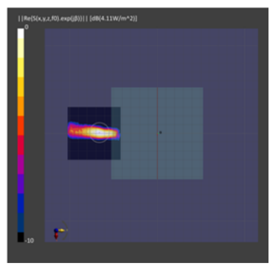
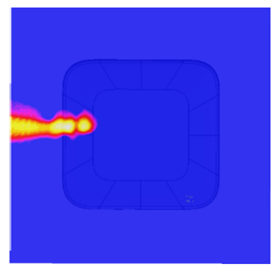
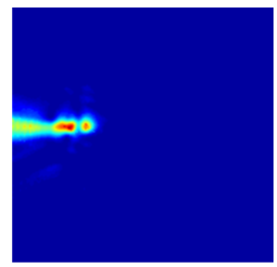
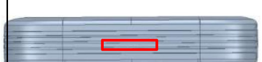
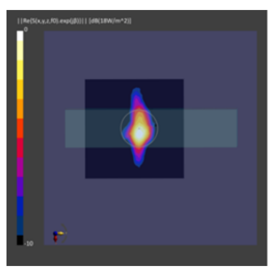
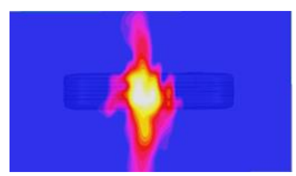
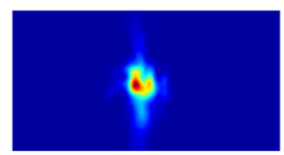
"Qualcomm MG script" is used to print the PD plots for all the beams selected and evaluated in Section 4-4 for model validation. PD distribution plots illustrated in Table 4-3 are compared to plots printed by MG script and are compared in Table D -1. It is noted that the values match well, hence validating the MG script.

Table D - 1:Measured and simulated PD distribution for selected beams

Beam ID	Surface	View	Measured PD	Simulated PD	MG Script
31	Top				
	Bottom				
	Left				

Beam ID	Surface	View	Measured PD	Simulated PD	MG Script
159	Top				
	Bottom				
	Left				

Beam ID	Surface	View	Measured PD	Simulated PD	MG Script
36	Top				
	Bottom				
	Right				

Beam ID	Surface	View	Measured PD	Simulated PD	MG Script
164	Top				
	Bottom				
	Right				

D-2 Verification 2:

"Qualcomm MG script" identifies the worst-case 4cm2PD and its location (*x,y,z*). This worst-case 4cm2PD is maximum 4cm2PD value out of all exposure surfaces when assuming the worst beam from each of the QTMs are active. The script then identifies the worst beam from each module that contributes the most to the worst 4cm2PD and it prints their contribution factor, as well as the worst surface corresponding to the worst-case $4cm^2$PD, backoff value for each QTM and *verification.sim.powerlimit* (before backoff) value for each identified beams.

HFSS is used to calculate the simulated contribution factor for the identified beams. The simulated contribution factor, $C_{simulated}(i,j)$, for beam *i* from QTM *j* can be computed by

$$C_{simulated}(i,j) = \frac{4\ cm^2\ PD\ at\ (x,y,z) at\ verification.sim.power_{limit}}{PD\_design\_target}$$

Following two conditions must be verified:

1. the printed contribution factor, c(i,j), matches the simulated contribution factor, $C_{simulated}(i,j)$, obtained from within 2% of numerical tolerance.
2. the normalized combined PD at worst-case location of (x,y,z) does not exceed 1.0, i.e.,

   $$normalized\ combined\ PD = \sum (b_j * c(i,j)) \leq 1.0$$

   where *combined PD* = PD from current QTM + PD contributions from other QTMs; *bj* = backoff value for QTM*j*, *j* = QTM #; *c(i,j)* = contribution factor of beam*i* from QTM*j* to the worst 4cm2PD. Both *bj* and *c(i,j)* are printed from "Qualcomm MG script".

The above two verification are tabulated below in Table D-2.

Table D - 2: Contribution factors from Qualcomm MG script and from HFSS for selected beams, and normalized combined PD verification, for EUT with 2 QTM's

				Worst-Case Surface:	Right	
				Worst-Case Location(x,y,z):	(0.06250m, 0.01190m, -0.02150m)	
				PD_Design_Target	4.75 W/m^2	
Values printed from Qualcomm MG script					Values obtained from HFSS	
QTM #	Beam ID	$C_{MGScript}$	Backoff Factor b_j	*verification.sim.power*$_{limit}$(before backoff) [dBm]	Simulated 4cm^2 at worst location at *verification.sim.power*$_{limit}$ on Right	$C_{Simulated}$(I,j) = 4cm^2 PD(I,j)/ PD_design_target
0	145	0.0092	0.9772	9.48	.020*10^ ((9.48-6)/10)	0.044/4.75 = 0.0093
1	13	1.0000	0.9772	10.24	1.78*10^ ((10.24-6)/10)	4.72/4.75 = 0.994
Verify 1:		*c (i,j)=C*$_{simulated}$ *(i,j), i = 145, 13; j = 0, 1* *i. c (0,145) [0.0092] = C*$_{Simulated}$ *(0,145) [0.0093]* *ii. c (1,13) [1.0] = C*$_{Simulated}$ *(0,13) [0.994]*				
Verify 2:		b_0* *c (0,145) +* b_1* *c (1,13) = 0.9772*(0.0092) +0.9772*(1) = 0.986 < 1*				

D-3 verification 3:

Measure power density for the beams identified by “Qualcomm MG script” on their corresponding worst surfaces printed from the script. Set the device in FTM mode, the PD measurement should be performed at the reference power level with CW modulation. Scale the measured PD to obtain 4cm2PD(i,j) for beam *i* from QTM *j* at their *input.power.limit*. Demonstrate that the *combined PD* (i.e., □[*c(i,j)***PD(i,j)*]) at the printed worst surface of QTM *j* is less than or equal to *PD_design_target* within the uncertainty at reference power level, i.e.,

$$combined\ PD = \sum[c(i,j) * measured\ 4cm^2 PD(i,j)] \\ \leq PD_{design_{target}} + uncertainityat\ reference\ power\ level(6\ dBm)$$

The verification is tabulated in Table D-3 below.

Table D - 3:Measured 4cm2 PD on worst surface and combined PD at worst-case location for EUT with 2 QTM's

QTM #	**Beam ID**	**Dominant Surface**	**Measure 4cm^2 PD at *input power.limit* on dominant Surface**
0	145	Left	2.40
1	13	Right	3.20
Combined PD at Worst-case location (x, y, z)	*0.0092* meas.4cm^{2}PD (145,0) + 1* meas.4cm^{2}PD (13,1)* = 3.22 W/m^2		
PD_design_target + Uncertainty at ref power(6dBm)	= 4.75*10$^{0.2}$ = 7.528 W/m^2		
Verify	Combined PD [3.22 W/m^2] < PD_design_target + Uncertainty [7.53 W/m^2]		