mmWave MPE (Averaged Power Density) Simulation

1 Introduction

This document provides an overview of the methodology used for Maximum Permissible Exposure (MPE) compliance of the 5G mmWave radios on next generation iPad BCGA2435. In the mmWave regime that this product will cover, the MPE is best represented by peak spatial-average power density (psPD).

Due to the presence of multiple antenna arrays and multiple antenna beams for each antenna array, we propose to use a combination of simulations and measurements to demonstrate MPE compliance. At a high level, the discussion is grouped into the following topics:

- Brief introduction to MPE simulation methodologies
- Explanation of the approach to demonstrate MPE (psPD) compliance in a device using measurements
- Brief review of the device configuration and operation, and detailed description of the simulation methodology and results

2 MPE Simulation Methodology

3D full-wave simulation is used to evaluate MPE for each antenna array module's beam. Each beam is created by invoking a pre-defined codebook that has the proper array elements' excitation (i.e., magnitude and phase) to create the beam.
The following steps are taken to verify the validity of the model used for MPE simulations and then the verified model is used for the MPE calculations:

1) **EM Simulation:**
    - Import a CAD model that represents the actual product in the simulation tool
    - Define material properties inside the product based on vendor's inputs
    - Perform mesh seeding and solve

2) **Compile Fields and Codebook:**
    - Extract field data from solved model and arrange in format required by Qualcomm Module Group (MG) Script [1]
    - Input PD char codebook generated by Qualcomm Webchar tool

3) **MPE Calculations:**
    - Set averaging area to 4cm^2 using MG Script configuration xml file
    - Run MG script to generate MPE and power limit tables for each beam ID in codebook

4) **Validate Simulation Model:**
    - Measure MPE
    - Compare measurement vs simulation
    - Once a correlation is established, and model's accuracy is verified, this model will be used for computational MPE assessments

5) **Run Additional Verifications:**
   - Use verification data generated by MG Script
   - Measure MPE for worst case beams given by MG Script
   - Use EM tools, MG Script to complete additional verifications

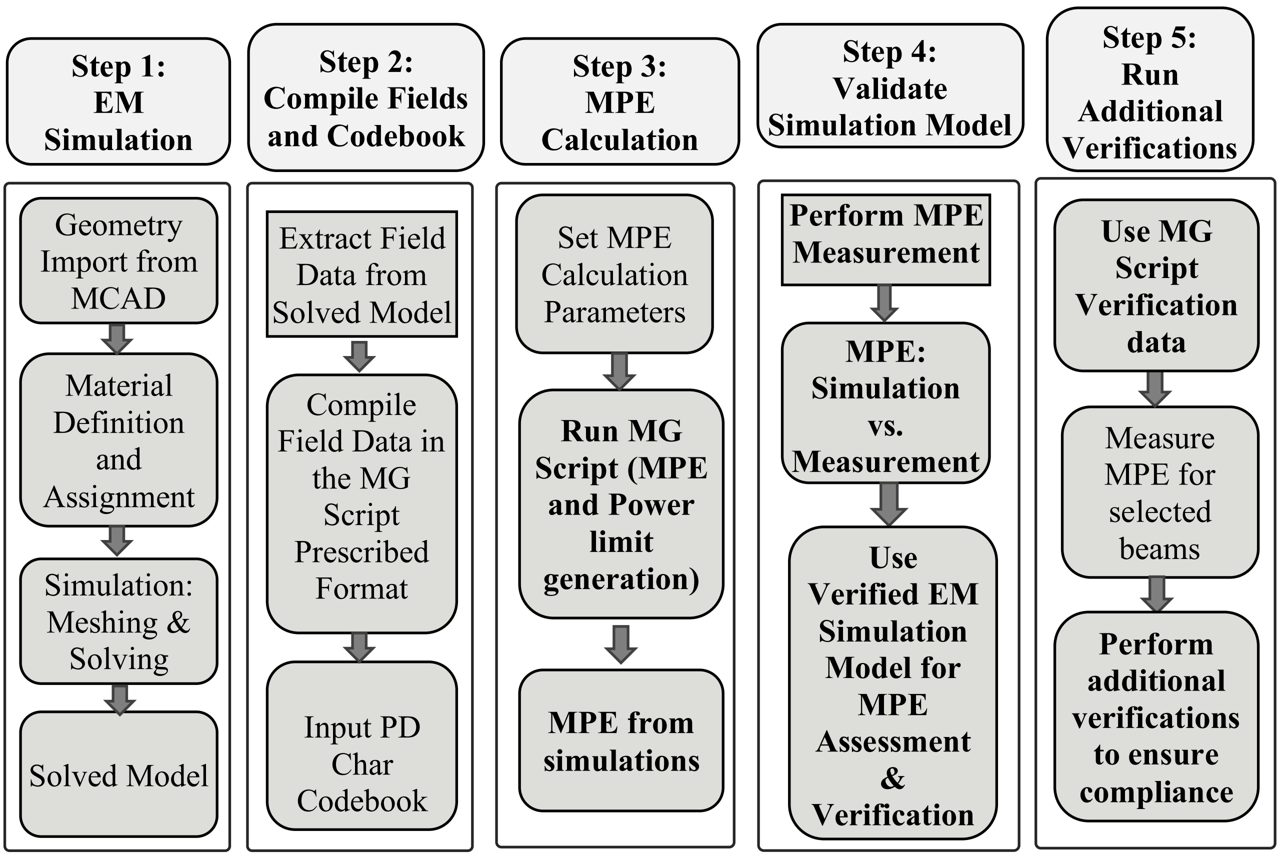


Figure 1. Model validation workflow for MPE simulation and evaluation

3 MPE Measurements

A mmWave DAE SN 1411 module from SPEAG is used to measure the MPE above the DUT. Figure 2 shows a typical measurement setup. The mmWave E-field probe is used to measure the electric field above DUT. The near-field magnetic field and MPE are further obtained using this setup. For more detail about the measurement algorithm, please refer to [2].

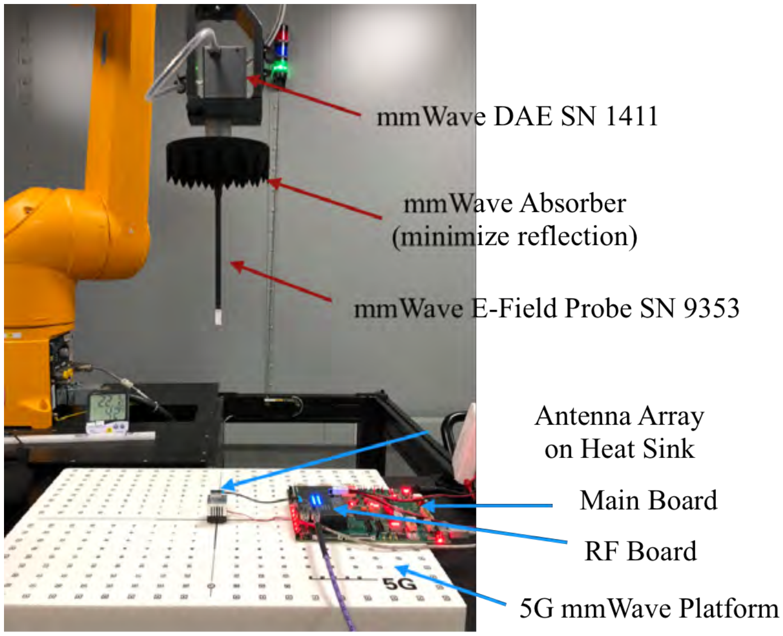


Figure 2. MPE measurement setup

The distance from the probe sensor tip to the edge of the housing is 1.5 mm, and there is 0.5 mm gap between the probe tip and the DUT surface to prevent any mechanical damages. Therefore, the closest distance that the setup can measure is 2 mm as shown below in Figure 3.

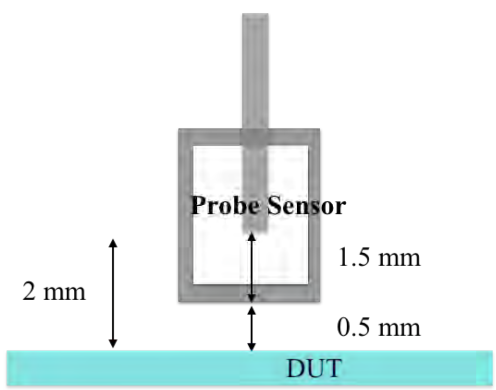


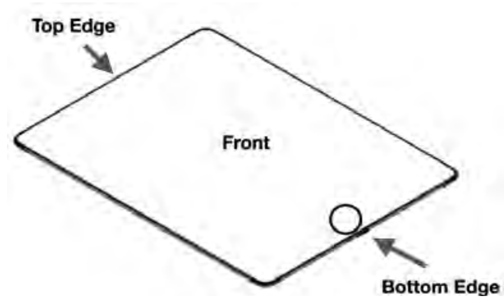
Figure 3. Schematic view of the probe showing that the minimum measurable distance is 2 mm

4 MPE Simulations

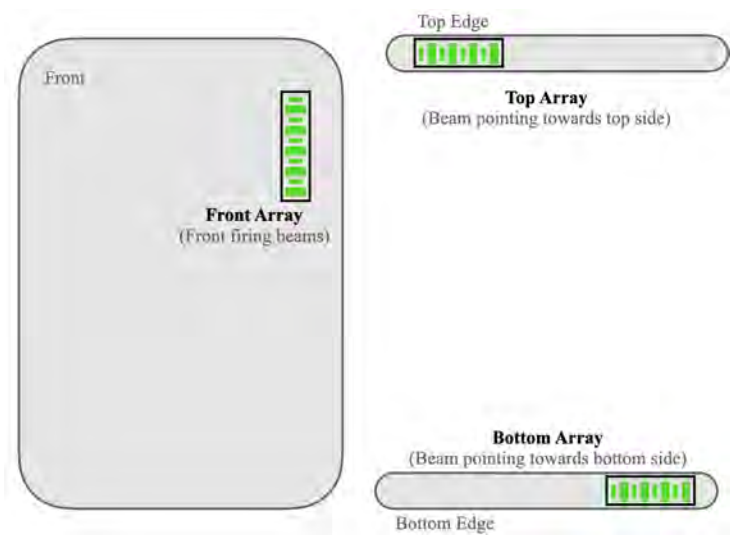
In 5G, array antennas are designed to direct the beam to specific directions to improve link budgets. Most arrays can be configured by using the codebook with each code resulting in a different exposure. The number of codes in the codebook can be very large and measurements of all possible configurations have been shown to be impractical. Therefore, simulation is used to determine the configurations that result in the highest MPE.

Simulation Models

Figure 4 shows a schematic view of the iPad. There are three antenna arrays located at the top left corner, bottom right corner, and front.



(a)



(b)

Figure 4. iPad schematic view (a) full view, (b) 5G arrays placement

The measurements and simulations are correlated across different evaluation surfaces 2 mm away from each DUT surface, as shown in Fig. 5 (drawing not to scale). Six surfaces will be evaluated, respectively: front (S1), back (S2), left (S3), right (S4), top (S5), and bottom (S6). As Table 1 shows, for the three antenna modules, only the 3 most significant PD evaluation planes within 2.5 cm from the edges of the antenna modules will be considered. This does not apply to the front-to-back condition since the fields from the front module will be blocked at the back plane by the metal parts (such as battery, MLB) in between.

The “left” and “right” edges in the report are defined relative to the front of the device.

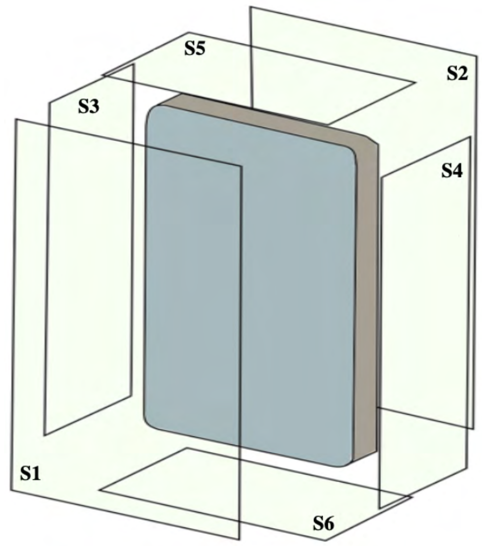


Figure 5. Evaluation surfaces for MPE (PD)

Table 1. PD evaluation planes (any distance less than 1 cm is reported as 0 cm)

	Front (S1)	Rear (S2)	Left from Front View (S3)	Right from Front View (S4)	Top (S5)	Bottom (S6)
Top Module	**Yes (0 cm)**	**Yes (0 cm)**	No (0 cm)	No (14 cm)	**Yes (0 cm)**	No (24 cm)
Bottom Module	**Yes (0 cm)**	**Yes (0 cm)**	No (14 cm)	No (0 cm)	No (24 cm)	**Yes (0 cm)**
Front Module	**Yes (0 cm)**	**Yes* (0 cm)**	No (17 cm)	**Yes (0 cm)**	No (7 cm)	No (18 cm)

**MPE is reported but its value is very small because of the internal metallic objects' blockage.*

Peak Spatial-Average Power Density Definition

After solving the 3D full-wave electromagnetic simulation, first, electric field $\vec{E}$ and magnetic field $\vec{H}$ are extracted. To evaluate peak spatial-average power density, Poynting vector can be defined as:

$$\vec{S} = \frac{1}{2}\vec{E} \times \vec{H}^*$$

The peak spatial-average power density (psPD) on an evaluation area (A) can be calculated by performing an averaging as described, below:

$$\text{psPD} = \frac{1}{A}\int_A ||Re(\vec{S}) \cdot d\vec{A}|| = \frac{1}{2A}\int_A ||\text{Re}(\vec{E} \times \vec{H}^*) \cdot d\vec{A}||$$

Where ||.|| is the norm operation. The evaluated area A is 4 cm^2. To capture the worst-case conditions (i.e., highest psPD), simulations and measurements were performed assuming a 100% duty cycle. The quantities described in this section are evaluated using Qualcomm MG Script. Please refer to Appendix A for worst case total power density derivation.

Simulation Methodology:
A time domain 3D Full-Wave Electromagnetic Simulation is performed using CST Studio Suite. The solver calculates electric and magnetic fields at discrete locations and time samples. To achieve high accuracy at all locations, the total electromagnetic energy inside the calculation domain is used as a convergence criterion. The solvers terminate when the normalized energy is decayed to -40 dB ensuring high accuracy of simulation output.

Boundary Conditions:
The boundary condition for simulating electromagnetic behavior in CST is to allow the electromagnetic waves to be electrically open at the boundary and radiated far away without reflection. CST can support the absorption boundary condition (ABC) for radiation boundary and normally requires a quarter-wavelength separation from the structure.

Source Excitation and Example Codebook:
Figure 6 shows an example of the codebook for the antenna modules. The third column of the codebook is the beam ID. The other notable columns are “Amplitude” and “Phase” columns which are the excitation amplitude and phase for each antenna element. Each beam has a “Paired_with” beam for concurrent MIMO streams. The last column is the index of the beam which is paired with the index shown in the second column. The “Amplitude” is in dBm, and “Phase” is in degrees.

Band	Shared_Bands	Beam_ID	Module	Ant_Group	Subarray	Ant_Type	Ant_Feed	Amplitude	Phase	Paired_With
257	261	0	0	0	7	PATCH	11	0	0	128
257	261	1	1	0	9	PATCH	11	0	0	129
257	261	2	2	0	11	PATCH	15	0	0	130
257	261	3	0	0	7	PATCH	12	0	0	131
257	261	4	1	0	9	PATCH	12	0	0	132
257	261	5	2	0	11	PATCH	14	0	0	133
257	261	6	0	0	7	PATCH	13	0	0	134
257	261	7	1	0	9	PATCH	13	0	0	135
257	261	8	2	0	11	PATCH	13	0	0	136
257	261	9	0	0	7	PATCH	14	0	0	137
257	261	10	1	0	9	PATCH	14	0	0	138
257	261	11	2	0	11	PATCH	12	0	0	139
257	261	12	2	0	11	PATCH	11	0	0	140
257	261	13	0	0	7	PATCH	11;12	0;0	348.75;146.2	141
257	261	14	0	0	7	PATCH	11;12	0;0	292.5;0	142
257	261	15	0	0	7	PATCH	11;12	0;0	11.25;348.75	143
257	261	16	0	0	7	PATCH	11;12	0;0	67.5;0	144

Figure 6. An example version of the antenna codebook

Averaging the Power Density for MPE:
Qualcomm MG script performs spatial averaging is needed to determine the MPE values from the power density simulation results over the 4 cm^2 area required by the FCC.

5 Uncertainty Budget for Simulation

Below is a table summarizing the budget of the uncertainty contributions of the numerical algorithm and of the rendering of the simulation setup. The table was filled using the IEC 62704-1 ED1 [3].

Table 2 – Preliminary budget of the uncertainty contributions of the numerical algorithm

Uncertainty component	**Probability distribution**	**Divisor f(d, h)[1]**	**Ci^2**	**Uncertainty %**
Mesh resolution	Normal	1	1	1.55
ABC	Normal	1	1	0.17
Power budget	Normal	1	1	1.35
Model Truncation				0.018
Convergence	Rectangular	1,73	1	0.01
DUT dielectrics	Normal	1	1	5.65
Lossy conductors	Rectangular	1,73	1	0.319
Combined standard uncertainty (k = 1)				9.067

Note 1: The divisor is a function of the probability distribution and degrees of freedom (v_i and v_{eff}).
Note 2: c_i is the sensitivity coefficient that is applied to convert the variability of the uncertainty component into a variability of psPD.

6 Simulation versus Measurement

To validate the accuracy of the model, measured MPE and simulated MPE values for n258 are summarized below in Table 3, with unit W/m^2. The difference between simulated and measured MPE values is in dB. Please be noted due to timeline, the simulation and measurement comparison is not obtained using the final version of codebook.

Table 3 - Simulated and measured n258 MPE (PD) at 2 mm away from DUT

a) Top Array, n258

Beam ID	Ant Pol	Simulation (W/m^2)	Measurement (W/m^2)	Delta = Sim – Meas. (dB)
		S5	S5	S5
34	V	21.11	10.5	3.03298934
37	V	21.91	15.2	1.5879879
49	V	21.59	13.2	2.13678711
162	H	14.91	14.6	0.09124788
177	H	14.8	12.7	0.66457994
180	H	15.24	14.1	0.33765854

b) Bottom Array, n258

Beam ID	Ant Pol	Simulation (W/m^2)	Measurement (W/m^2)	Delta = Sim – Meas. (dB)
		S6	S6	S6
39	V	21.68	14.8	1.65797562
42	V	22.21	15.8	1.47891472
53	V	20.94	16	1.16856695
167	H	14.65	15.4	-0.216831
170	H	12.98	12.1	0.30489322
184	H	14.43	13.8	0.19387245

c) Front Array 2, n258

Beam ID	Ant Pol	Simulation (W/m^2)	Measurement (W/m^2)	Delta = Sim – Meas. (dB)
		S1	S1	S1
45	V	25.29	20.6	0.89081609
47	V	23.3	25.4	-0.374778

59	V	24.32	26.7	-0.4054769
172	H	28.9	23.2	0.95409858
175	H	25.46	18.8	1.3170055
185	H	26.22	22.4	0.68384669

To validate the accuracy of the model, measured point PD patterns for the three arrays were compared to simulated point PD patterns for different beams for n258, as is shown in Figure 7. The plotted point PD pattern are normalized to its own maximum value, respectively. Please be noted due to timeline, the simulation and measurement comparison is not obtained using the final version of codebook.

a) Top Array, n258

<table>
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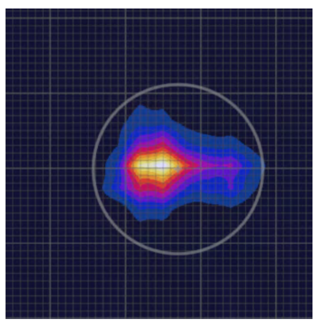
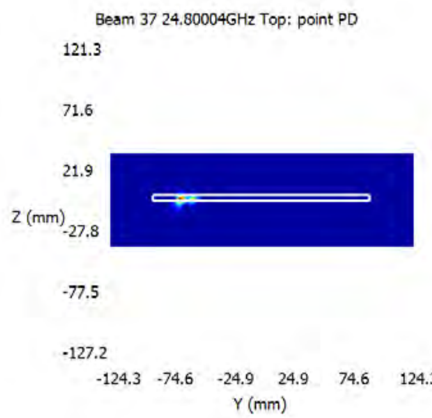
<tr><td rowspan="2">37</td><td>S5</td><td></td><td>
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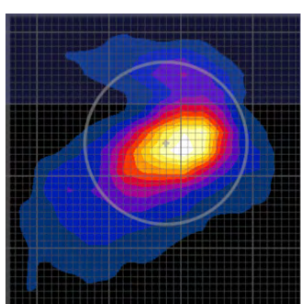
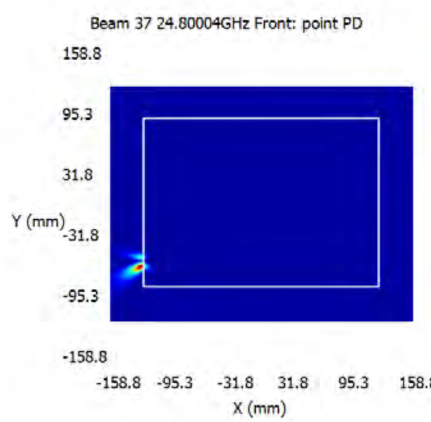
<tr><td>S1</td><td></td><td>
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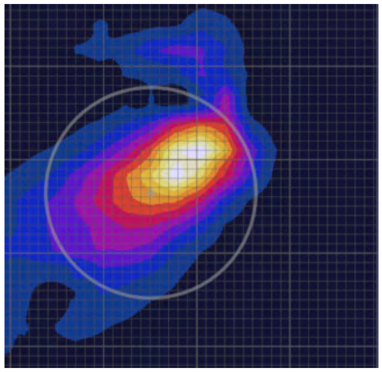
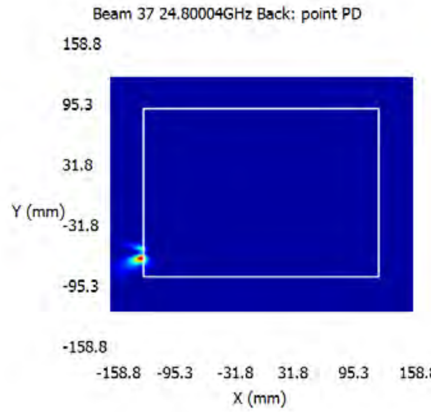
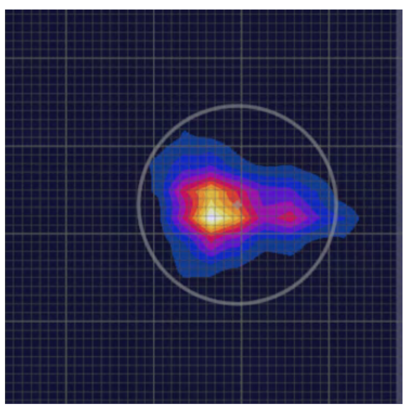
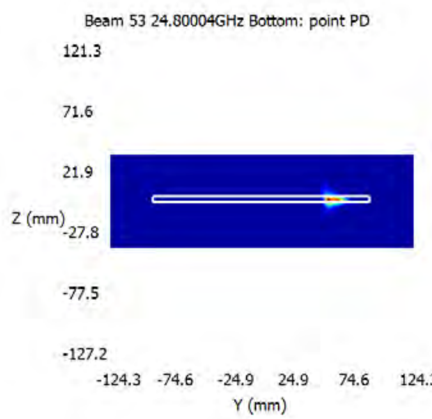
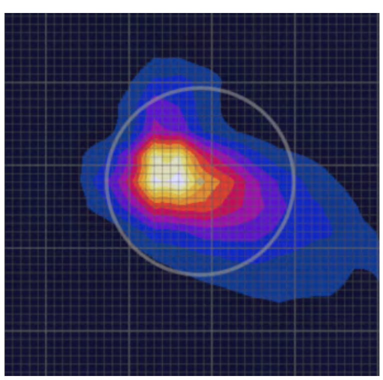
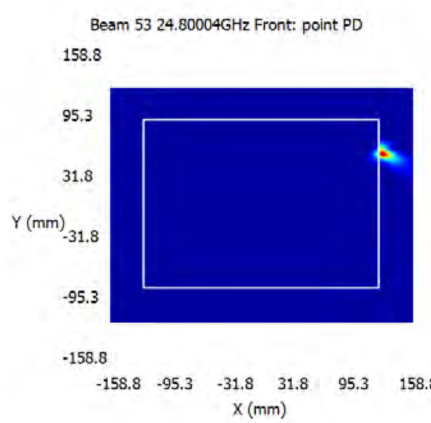
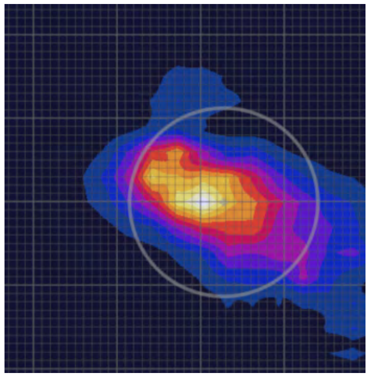
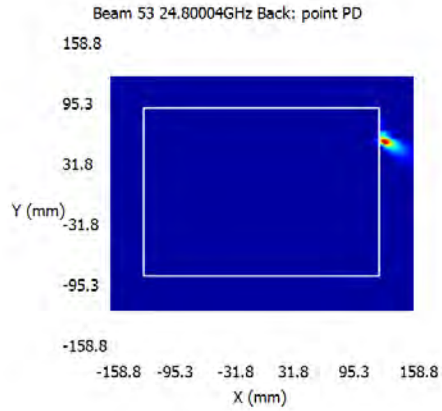
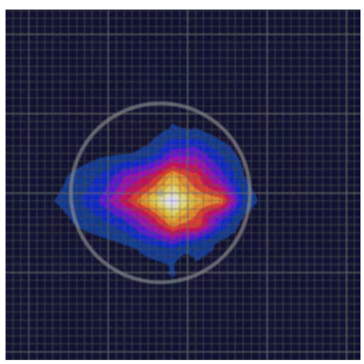
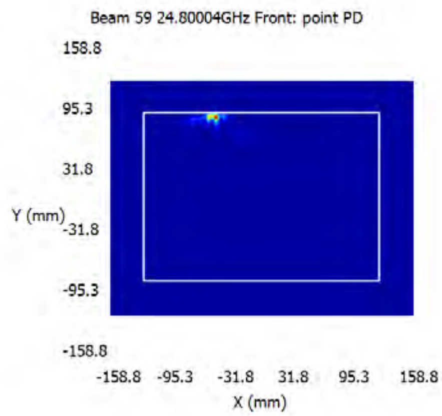
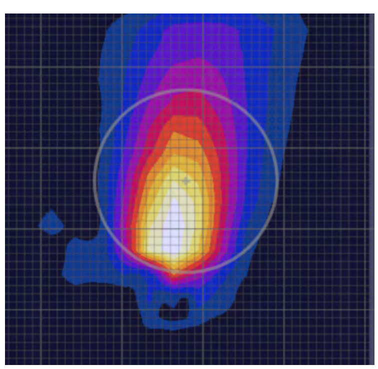
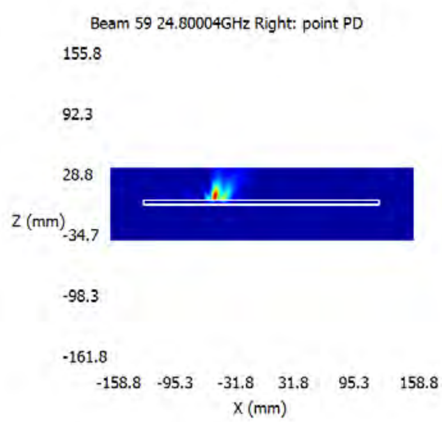
	S2		

b) Bottom Array, n258

Beam ID	**Surface**	**Measured Point PD**	**Simulated Point PD**
53	**S6**		
	S1		

	S2		

c) Front Array, n258

Beam ID	**Surface**	**Measured Point PD**	**Simulated Point PD**
59	**S1**		
	S4		

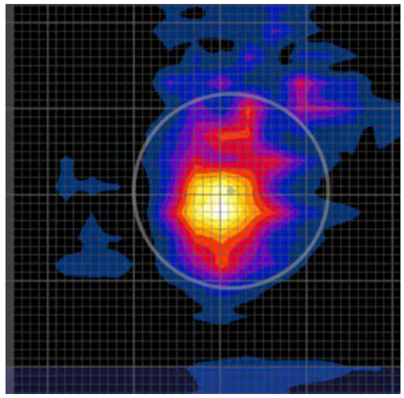
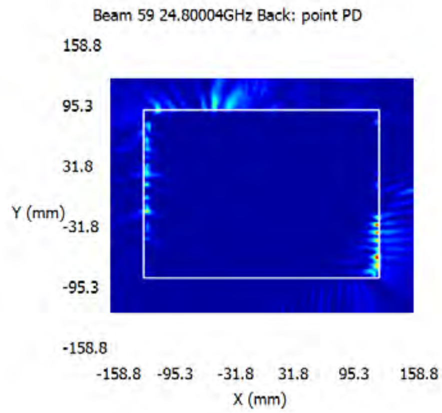
	S2		

Figure 7. Simulated and measured point PD for different beams for n258

To validate the accuracy of the model, measured MPE and simulated MPE values for n261 are summarized below in Table 4, with unit W/m^2. The difference between simulated and measured MPE values is in dB. Please be noted due to timeline, the simulation and measurement comparison is not obtained using the final version of codebook.

Table 4 - Simulated and measured n261 MPE (PD) at 2 mm away from DUT

a) Top Array, n261

Beam ID	Ant Pol	Simulation (W/m^2)	Measurement (W/m^2)	Delta = Sim – Meas. (dB)
		S5	S5	S5
34	V	19.19	10.5	2.61885676
37	V	18.89	15.2	0.9438837
49	V	20.83	13.2	1.98115339
162	H	16.87	14.6	0.62762227
177	H	19.81	12.7	1.93080755
180	H	18.96	14.1	1.2861922

b) Bottom Array, n261

Beam ID	Ant Pol	Simulation (W/m^2)	Measurement (W/m^2)	Delta = Sim – Meas. (dB)
		S6	S6	S6
39	V	17.19	14.8	0.65014161
42	V	19.59	15.8	0.93377349
53	V	18.66	16	0.66791657

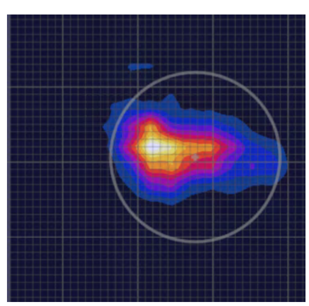
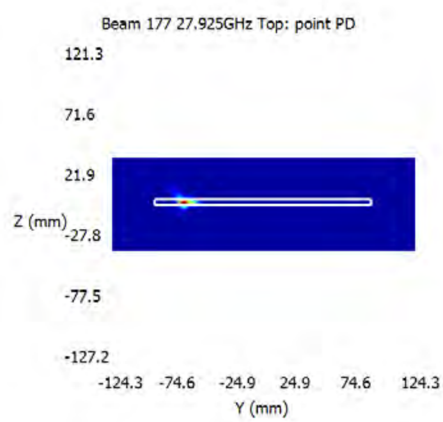
167	H	18.04	15.4	0.68715812
170	H	18.84	12.1	1.92295528
184	H	19.22	13.8	1.43874297

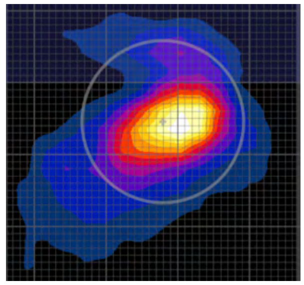
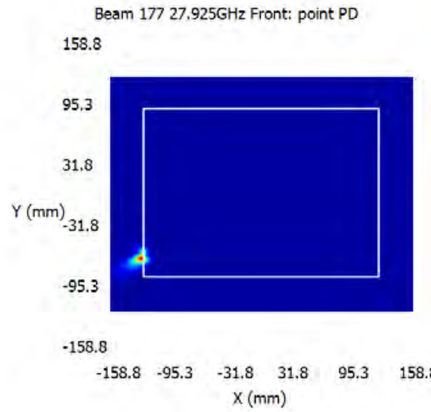
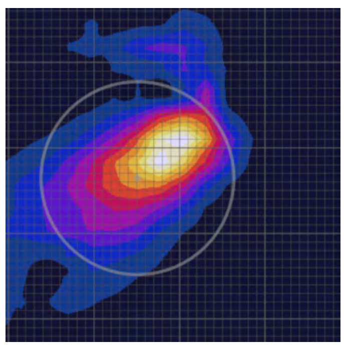
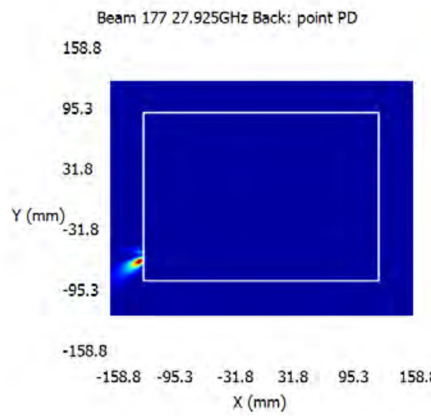
c) Front Array, n261

Beam ID	Ant Pol	Simulation (W/m^2)	Measurement (W/m^2)	Delta = Sim – Meas. (dB)
		S1	S1	S1
45	V	29.34	20.6	1.53592889
47	V	32.19	25.4	1.0288726
59	V	33.29	26.7	0.95802534
172	H	21.23	23.2	-0.3853799
175	H	37.52	18.8	3.0010498
185	H	19.68	22.4	-0.5622292

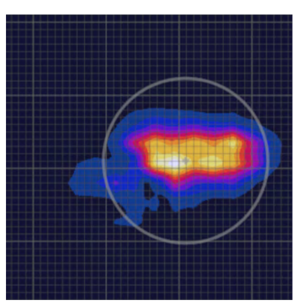
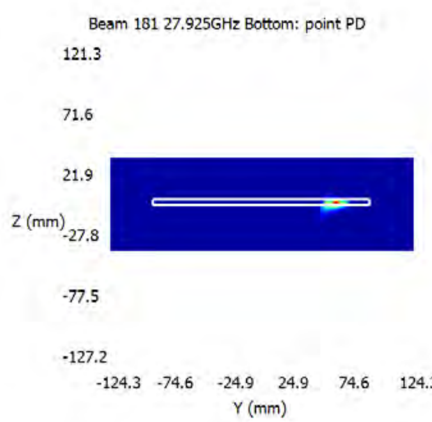
To validate the accuracy of the model, measured point PD patterns for the three arrays were compared to simulated point PD patterns for different beams for n261, as is shown in Figure 8. The plotted point PD pattern are normalized to its own maximum value, respectively. Please be noted due to timeline, the simulation and measurement comparison is not obtained using the final version of codebook.

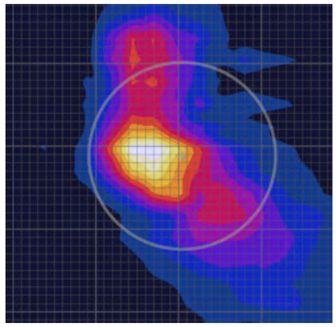
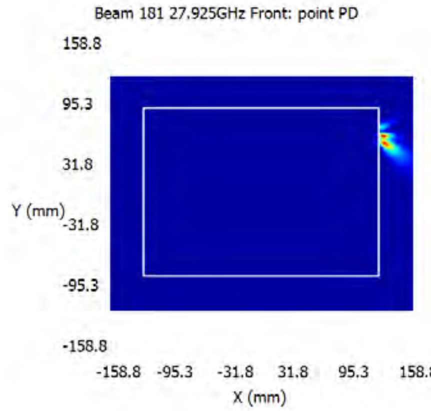
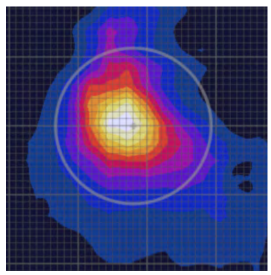
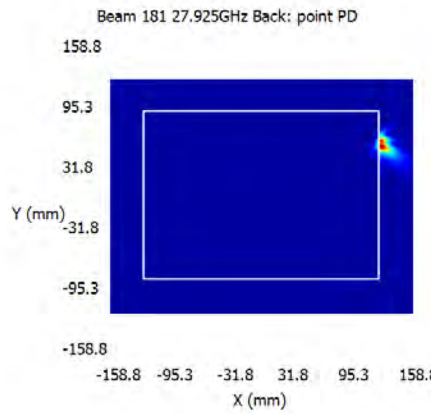
a) Top Array, n261

Beam ID	**Surface**	**Measured Point PD**	**Simulated Point PD**
177	**S5**		

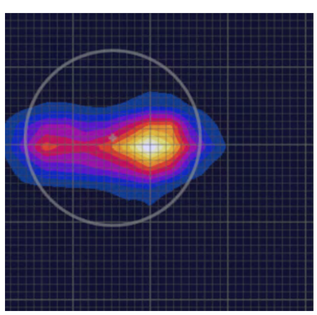
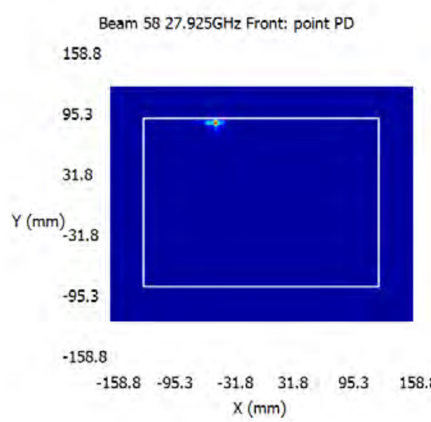
	S1		
	S2		

b) Bottom Array, n261

Beam ID	**Surface**	**Measured Point PD**	**Simulated Point PD**
181	**S6**		

	S1		
	S2		

c) Front Array, n261

Beam ID	Surface	Measured Point PD	Simulated Point PD
58	**S1**		

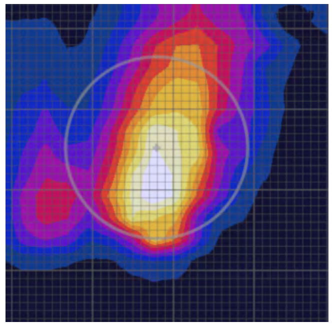
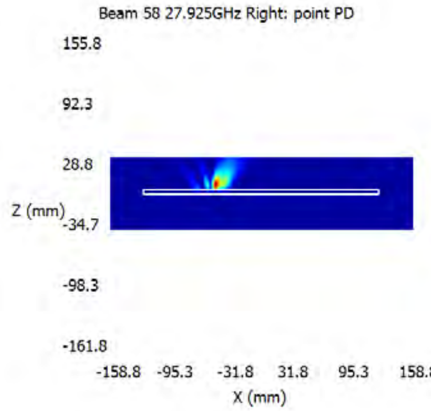
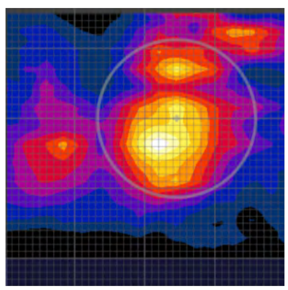
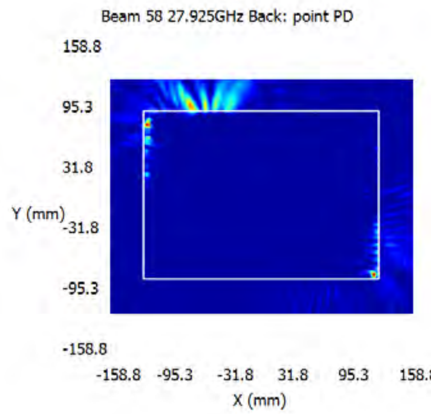
	S4		
	S2		

Figure 8. Simulated and measured point PD for different beams for n261

To validate the accuracy of the model, measured MPE and simulated MPE values for n260 are summarized below in Table 5, with unit W/m^2. The difference between simulated and measured MPE values is in dB. Please be noted due to timeline, the simulation and measurement comparison is not obtained using the final version of codebook.

Table 5 - Simulated and measured n260 MPE (PD) at 2 mm away from DUT

a) Top Array, n260

Beam ID	Ant Pol	Simulation (W/m^2)	Measurement (W/m^2)	Delta = Sim – Meas. (dB)
		S5	S5	S5
36	V	19.69	13	1.80302364
50	V	20.31	12.6	2.07339378
51	V	18.3	12.8	1.5524112
164	H	20.65	15	1.38828797

178	H	19.82	13.8	1.57224564
179	H	20.8	14.5	1.56695333

b) Bottom Array, n260

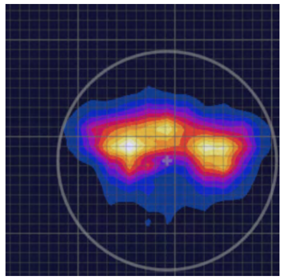
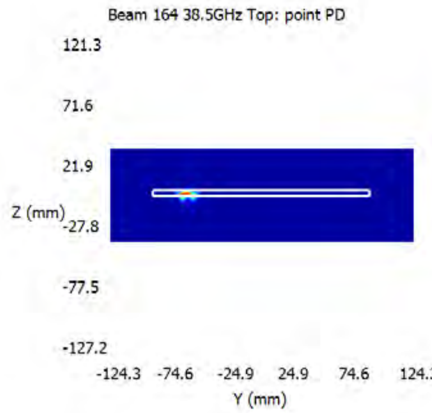
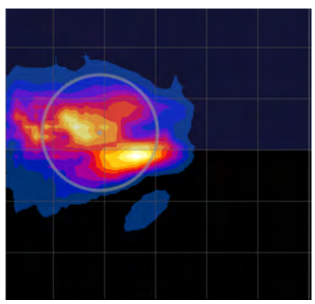
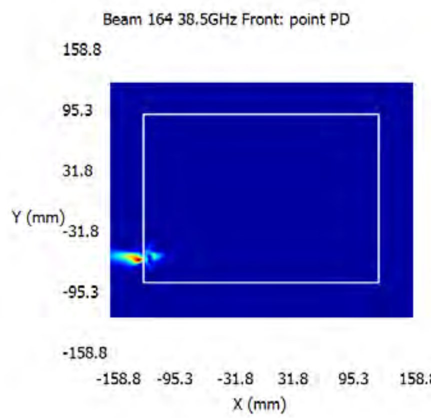
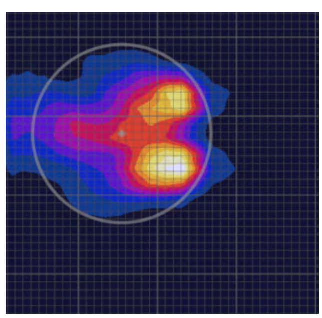
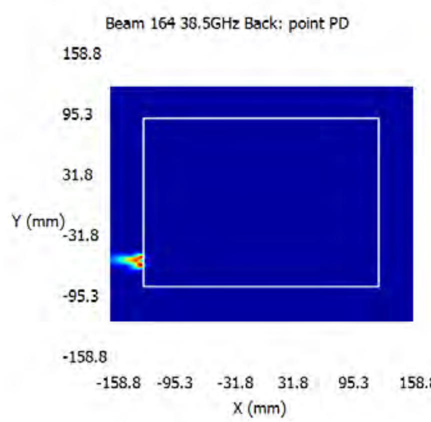
Beam ID	Ant Pol	Simulation (W/m^2)	Measurement (W/m^2)	Delta = Sim – Meas. (dB)
		S6	S6	S6
41	V	19.11	13.1	1.63989391
43	V	18.93	11.5	2.16452774
55	V	19.28	12.8	1.7789706
169	H	20.57	14.3	1.57898254
182	H	19.12	13.2	1.60913957
183	H	19.6	14.4	1.33893579

c) Front Array 2, n260

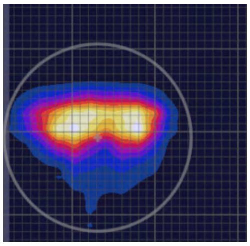
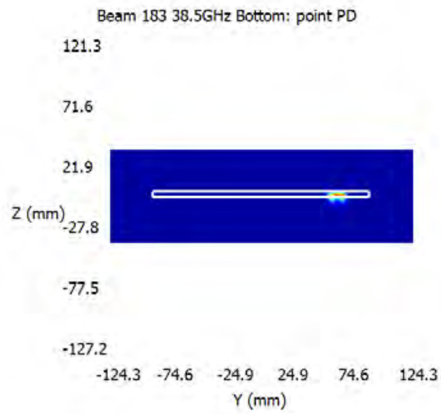
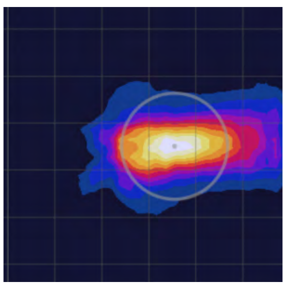
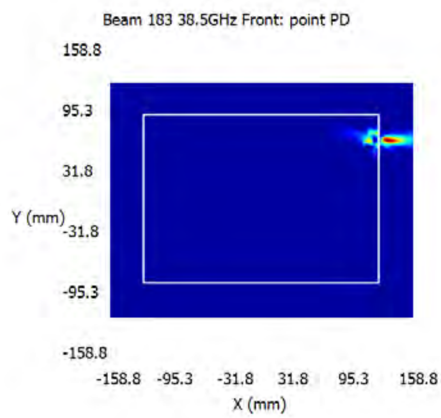
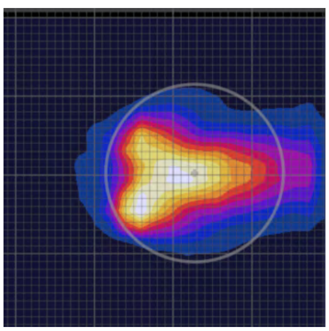
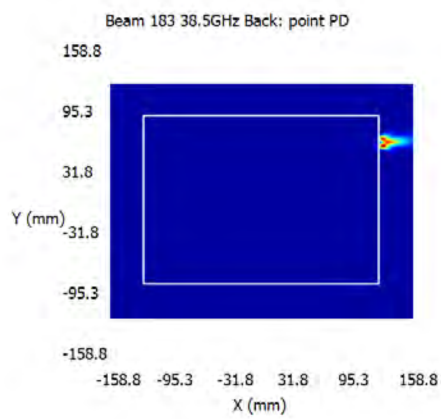
Beam ID	Ant Pol	Simulation (W/m^2)	Measurement (W/m^2)	Delta = Sim – Meas. (dB)
		S1	S1	S1
44	V	17.39	9.99	2.40734094
45	V	22.03	10	3.43014497
48	V	18.06	9.78	2.66378891
172	H	15.64	8.22	2.79364931
174	H	17.18	6.93	3.94289925
186	H	16.54	7.16	3.63622483

To validate the accuracy of the model, measured point PD patterns for the three arrays were compared to simulated point PD patterns for different beams for n260, as is shown in Figure 9. The plotted point PD pattern are normalized to its own maximum value, respectively. Please be noted due to timeline, the simulation and measurement comparison is not obtained using the final version of codebook.

a) Top Array, n260

Beam ID	Surface	Measured Point PD	Simulated Point PD
164	**S5**		
	S1		
	S2		

b) Bottom Array, n260

Beam ID	Surface	Measured Point PD	Simulated Point PD
183	**S6**		
	S1		
	S2		

c) Front Array, n260

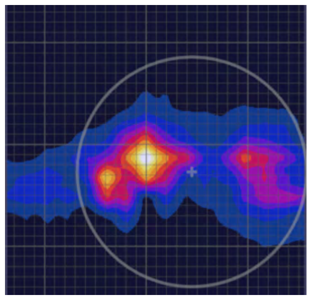
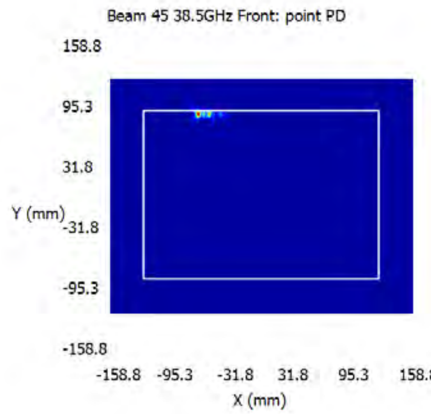
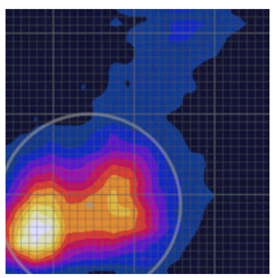
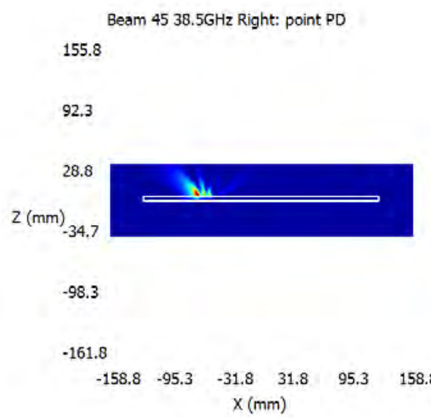
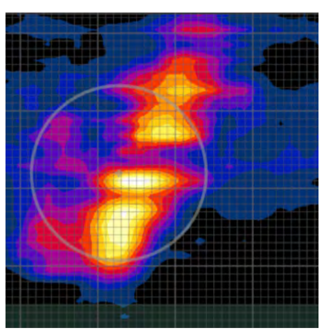
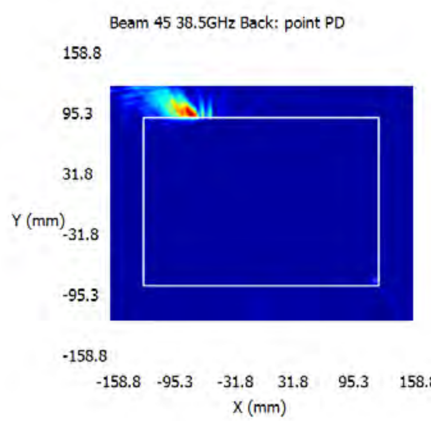
Beam ID	Surface	Measured Point PD	Simulated Point PD
45	**S1**		
	S4		
	S2		

Figure 9. Simulated and measured point PD for different beams for n260

Appendix A: Worst Phase Derivation for Beam Pair

For beam pairs, since the relative phase between two beams is unknown, so finding the worst-case power density by sweeping the relative phase for all possible angles is required for conservative assessments.

Assuming E-field and H-field for beam ID a are {Ex_a, Ey_a,Ez_a} and {Hx_a,Hy_a,Hz_a}, respectively; for beam pair which is ID b is {Ex_b,Ey_b,Ez_b} and {Hx_b,Hy_b,Hz_b}, respectively. The relative phase between beam a and b is θ, the combined E and H field after beam pairing is:

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

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

The beam pair Poynting vector can be calculated as:

$$Sx\_pair\_i(\theta) = 0.5\times Ey\_pair\_i(\theta)\times Hz\_pair\_i(\theta)^* - 0.5\times Ez\_pair\_i(\theta)\times Hy\_pair\_i(\theta)^*$$
$$Sy\_pair\_i(\theta) = 0.5\times Ez\_pair\_i(\theta)\times Hx\_pair\_i(\theta)^* - 0.5\times Ex\_pair\_i(\theta)\times Hz\_pair\_i(\theta)^*$$
$$Sz\_pair\_i(\theta) = 0.5\times Ex\_pair\_i(\theta)\times Hy\_pair\_i(\theta)^* - 0.5\times Ey\_pair\_i(\theta)\times Hx\_pair\_i(\theta)^*$$

The local power density per gird point (PD) for the beam pair can be calculated as:

$$PD(\theta) = [(Re(Sx\_pair\_i(\theta)))^2 + (Re(Sy\_pair\_i(\theta)))^2 + (Re(Sz\_pair\_i(\theta)))^2]^{1/2}$$

θ can be swept from 0 to 360 degrees to find the worst-case situation (highest PD). For more details, please refer to [4].

Appendix B: 4 cm^2 Averaged PD and Scaling Factor

4 cm^2 Averaging PD: The following tables show the simulated PD results for all three different arrays, at both band n258, n261 and band n260. Table a), b), and c) show the results for n258, for top array, bottom array and front array, respectively; table d), e), and f) show the results for n261, for top array, bottom array and front array, respectively and table g), h) and i) show the results for n260, for top array, bottom array and front array, respectively. Please be noted due to timeline, following results are not obtained using the final version of codebook.

a) *Simulated PD (W/m^2) at 4 cm^2 averaging for top array at n258*

			4 cm^2 PD (W/m^2) at 6 dBm per port, n258								
Module ID	Beam ID 1	Beam ID 2	LB			MB			HB		
0			S1	S2	S5	S1	S2	S5	S1	S2	S5
Top Array	0		3.11	2.7	7.22	2.77	2.43	6.68	2.29	2.03	5.64
	3		1.31	1.21	3.39	1.23	1.18	3.31	1.2	1.07	2.8
	6		1.09	1.1	2.85	1.36	1.43	3.7	1.78	1.78	4.79
	9		1.81	2.32	5.19	1.85	2.31	5.45	1.53	1.67	4.19
	13		3.03	1.99	5.94	3.27	2.27	6.56	3.47	2.44	7.19
	14		3.45	2.93	7.22	3.29	2.84	6.81	3.34	2.72	6.6
	15		4.83	5.5	11.12	4.14	5.09	9.96	3.64	4.46	8.53
	16		2.9	3.23	7.68	2.72	2.73	7.33	2.53	2.96	6.8
	25		5.54	3.22	11.05	5.2	3.3	10.81	4.2	2.22	8.38
	26		5.62	5.37	12.31	4.87	5.12	11.25	4.18	4.01	8.85
	27		1.3	1.93	4.39	1.9	2.81	6.4	2.6	3.52	8.23
	34		11.47	5.8	20.36	11.72	6	21.11	11.17	5.68	20.31
	35		10.72	8.95	21.18	9.93	8.82	20.11	9.03	7.24	17.52
	36		8.73	8.62	17.86	7.79	7.61	16.27	7.04	6.2	14.17
	37		7.13	11.07	20.62	8	11.36	21.91	7.28	10.07	19.51
	38		2.3	3.41	8.49	2.44	5.57	10.44	3.4	7.75	13.98
	49		11.8	6.92	21.28	11.77	7.16	21.59	11.16	6.51	20.39
	50		8.59	9.1	18.05	7.5	8.3	16.28	6.94	6.45	13.48
	51		8.63	9.35	19.93	8.46	8.94	19.54	7.33	7.69	17.1
	52		3.81	8.3	14.76	4.82	10.78	19	5.64	11.84	20.77
	128		0.8	0.99	2.38	0.89	1.05	2.56	1.27	1.14	3.03
	131		0.99	1.21	2.79	1.48	1.57	4.06	2.17	1.76	5.31
	134		0.94	0.88	2.44	1.04	1.01	2.87	1.38	1.38	3.83
	137		1.13	0.96	2.7	1.43	1.18	3.4	1.79	1.67	4.44
	141		1.2	2.22	4.4	1.82	3.28	6.76	2.6	4.44	9.49
	142		2	2.49	4.89	2.2	3.09	5.82	2.66	4.32	7.68
	143		2.88	2.05	5.71	3.41	2.31	6.76	4.1	3.08	8.37
	144		1.39	1.41	3.89	2.49	1.68	5.82	4.48	2.26	8.57
	153		2.1	3.21	6	2.31	3.68	6.92	2.53	3.98	7.71
	154		2.66	2.58	5.72	2.81	2.8	6.15	3.17	3.67	7.36

	155		2.53	1.38	4.76	3.38	1.7	6.36	4.45	2.38	8.61
	162		3.01	6.3	11.02	3.86	8.71	14.91	4.86	11.68	19.78
	163		3.68	5.55	10.65	4.51	7.23	13.52	5.64	9.86	17.78
	164		3.37	3.77	8.83	4.47	4.51	11.2	6.39	5.69	14.63
	165		5.72	4.41	10.76	6.82	5.34	12.67	8.47	6.57	15.55
	166		4.61	1.79	7.81	7.88	2.99	12.96	12.53	4.56	20.14
	177		3.09	6.26	11.04	3.92	8.63	14.8	4.94	11.61	19.68
	178		3.55	4.08	9.23	4.48	5.13	11.55	5.9	6.72	14.8
	179		3.79	3.99	8.4	4.49	4.68	9.92	6.39	5.95	13.18
	180		6.3	3.18	10.83	9.19	4.35	15.24	12.84	5.73	20.77
	0	128	5.2	5.1	12.59	4.48	4.75	11.47	4.56	4.18	11.03
	3	131	3.29	3.69	8.86	3.55	3.67	9.35	3.91	3.03	8.78
	6	134	2.99	2.74	7.34	3.13	3.04	8.25	3.54	3.53	9.4
	9	137	4.33	4.82	10.98	4.46	4.57	11.29	4.21	4.13	10.65
	13	141	6.08	6.08	12.96	7.25	7.75	15.65	8.35	8.98	17.98
	14	142	8.31	6.43	16.19	7.98	6.62	15.65	8.35	7.68	16.1
	15	143	8.79	7.01	17.03	8.42	7.16	17.5	8.45	7.44	17.94
	16	144	4.91	5.13	13.87	6.63	4.84	14.36	9.66	5.45	18.95
	25	153	10.29	9.71	21.96	10.42	10.46	22.81	9.57	8.56	18.98
	26	154	8.74	7.49	17.89	7.58	7.63	17.42	7.06	7.18	15.8
	27	155	5.74	3.74	11.49	7.8	5	15.75	9.93	6.72	19.88
	34	162	21.08	17.52	41.4	22.29	20.98	44.08	22.92	23.19	44
	35	163	21.88	22.28	45.72	21.26	24.42	45.98	21.05	24.26	43.77
	36	164	14.7	15.81	30.92	13.86	15.41	30.5	15.01	14.23	30.96
	37	165	18.76	22.54	42.17	22.24	23.87	45.53	23.2	22.75	43.46
	38	166	8.9	6.92	18.64	13.51	11.03	27.5	21.78	14.21	42.19
	49	177	21.71	19.26	43.38	22.39	22.86	45.75	22.88	24.61	45.41
	50	178	17.03	18.29	35.29	16.11	18.49	35.13	16.47	16.62	33.3
	51	179	16.13	18.52	36.17	16.25	18.46	35.56	16.68	17.12	33.61
	52	180	12.61	15.65	29.25	20.16	19.83	40.43	27.47	21.99	50.4

b) *Simulated PD (W/m²) at 4 cm² averaging for bottom array at n258.*

			4 cm² PD (W/m²) at 6 dBm per port, n258								
Module ID	Beam ID 1	Beam ID 2	LB			MB			HB		
1			S1	S2	S6	S1	S2	S6	S1	S2	S6
Bottom Array	1		2.39	2.07	5.8	2.62	2.34	6.64	2.42	2.14	6.29
	4		1.39	1.39	3.88	1.31	1.25	3.73	1.33	1.31	3.7
	7		1.06	1.08	2.97	1.19	1.29	3.51	1.49	1.58	4.35
	10		1.37	1.72	4.1	1.66	2.04	5.1	1.52	1.71	4.53
	17		3.32	2.76	6.66	3.56	2.74	7.11	3.93	2.61	7.8
	18		3.41	3.36	8.17	3.23	3.2	7.61	3.11	3.05	7.09
	19		1.72	2.81	5.58	1.99	3.19	6.57	2.5	4.01	8.41
	20		3.19	4.29	8.46	3.03	4.16	8.44	2.76	4.21	8.35
	28		5.06	3.3	10.28	5.41	3.82	11.74	5.12	3.56	11.05
	29		4.71	4.75	11.12	4.65	5	11.45	4.37	4.7	10.55
	30		3.83	4.9	9.81	3.59	4.78	9.56	3.23	4.73	9.17

	39		10.81	6.01	19.61	11.55	6.61	21.68	11.6	6.64	22.12
	40		7.93	8.02	17.16	7.93	8.41	17.84	7.55	7.56	16.23
	41		7.58	7.7	16.86	7.67	7.58	17.39	7.24	7.1	16.81
	42		5.59	10.42	19.02	6.79	11.59	22.21	7.17	11.46	22.28
	43		2.61	5.19	10.21	3.07	7.35	13.6	3.71	9.5	17.17
	53		10	7.52	19.47	10.26	8.23	20.94	9.82	7.77	20.1
	54		7.16	7.65	15.4	6.87	7.54	15.66	6.63	6.75	14.61
	55		7.25	8.66	18.73	8.03	9	20.23	7.75	8.64	19.56
	56		4.37	9	16.34	5.24	10.92	20.28	5.96	11.73	22
	129		1	1.25	3.14	1	1.2	3.11	1.21	1.24	3.34
	132		0.79	0.96	2.32	1.15	1.26	3.36	1.67	1.5	4.54
	135		1	0.98	2.79	1.04	0.98	2.99	1.26	1.24	3.69
	138		0.98	0.92	2.56	1.11	1.04	2.97	1.43	1.43	3.91
	145		2.25	3.23	6.61	2.25	3.46	6.99	2.31	3.78	7.6
	146		2.02	2.69	5.53	2.43	3.15	6.72	3.05	3.88	8.43
	147		2.4	2.25	5.52	2.87	2.53	6.37	3.67	2.82	7.64
	148		1.91	1.32	4.36	2.65	1.61	5.65	3.79	1.96	7.74
	156		1.61	2.27	4.58	1.77	2.65	5.4	2.05	3.6	7.12
	157		2.55	2.7	5.95	2.51	2.63	5.92	2.85	3.29	6.99
	158		2.61	1.69	5.3	3.05	1.83	6.15	3.85	2.31	7.86
	167		3.73	6.67	12.6	4.2	7.91	14.65	4.81	10.32	18.46
	168		3.7	4.27	9.52	4.07	4.7	10.67	5	5.72	12.81
	169		3.8	4.25	9.48	4.1	4.45	10.11	5.47	5.28	12.33
	170		5.68	4.49	11.57	6.52	5.11	12.98	7.88	5.94	15.22
	171		4.18	1.82	7.39	6.57	2.57	11.42	10.22	3.88	17.4
	181		3.74	5.22	10.6	4.11	5.93	12.03	4.94	7.66	15.15
	182		3.76	4.24	9.58	4.15	4.44	10.52	5.4	5.18	12.56
	183		4.23	4.33	9.92	4.55	4.65	10.44	5.82	5.5	12.43
	184		5.94	3.44	11.03	7.97	4.31	14.43	10.73	5.35	18.81
	1	129	4.82	4.71	12.21	4.54	4.74	11.99	4.24	4.28	11.26
	4	132	3	3.41	8.46	3.03	3.24	8.73	3.28	3.13	9.16
	7	135	3	2.87	7.88	2.9	2.79	8.02	3.04	3.04	8.68
	10	138	3.52	4	9.59	3.73	4.06	10.19	3.67	3.78	10.16
	17	145	5.22	7.07	14.88	5.38	7.53	15.95	5.9	7.94	17.13
	18	146	8.23	8.72	19.58	7.81	8.43	18.25	7.53	8.15	16.6
	19	147	6.4	6.54	14.02	7.18	6.91	14.77	8.73	7.96	17.2
	20	148	7.71	7.09	16.44	8.56	6.64	17.39	9.92	6.45	19.54
	28	156	9.27	6.4	19.08	9.7	6.88	20.39	9.15	7.03	19.26
	29	157	7.83	7.03	17.24	7.37	7.08	17.15	7.09	7.37	16.98
	30	158	8.33	6.91	17.4	8.48	6.54	17.97	8.93	6.78	19.28
	39	167	21.67	18.89	43.99	22.92	21.12	45.79	23.3	23.86	46.07
	40	168	17.3	18.45	37.49	16.91	18.68	37.09	16.82	17.68	34.3
	41	169	15.68	17.75	35.31	15.05	16.91	33.61	15.33	15.81	32.94
	42	170	15.88	21.36	40.26	19.35	23.67	44.11	22.05	23.6	43.94
	43	171	8.67	9.15	20.09	12.73	13.14	28.32	19.85	16.65	40.93
	53	181	20.71	19.79	43.24	21.13	21.4	44.15	21.32	22.18	42.8
	54	182	15.74	17.62	33.78	14.6	16.45	32.08	14.74	14.69	30.63
	55	183	16.02	19.25	38.74	16.89	19.31	38.38	17.63	18.63	37.05
	56	184	13.2	17.44	32.37	18.53	21.19	39.39	24.5	22.68	46.81

c) Simulated PD (W/m^2) at 4 cm^2 averaging for front array at n258.

			4 cm^2 PD (W/m^2) at 6 dBm per port, n258								
Module ID	Beam ID 1	Beam ID 2	LB			MB			HB		
2			S1	S2	S4	S1	S2	S4	S1	S2	S4
Front Array	2		3.41	0.06	0.83	4.76	0.05	1.12	4.66	0.07	1.11
	5		3.93	0.03	1	4.19	0.04	1.07	4.05	0.04	1.15
	8		3.67	0.03	0.98	4.35	0.03	1.09	4.32	0.03	1.08
	11		4.22	0.04	1.27	4.73	0.04	1.26	4.94	0.04	1.32
	12		3.89	0.04	1.04	4.91	0.06	1.33	5.15	0.07	1.48
	21		6.44	0.06	1.42	6.02	0.07	1.4	5.56	0.08	1.14
	22		9.23	0.07	2.51	9.07	0.07	2.49	8.24	0.08	2.21
	23		7.93	0.09	2.64	10.18	0.1	3.09	10.67	0.09	3.21
	24		5.93	0.09	1.57	6.61	0.08	1.3	6.12	0.09	1.02
	31		5.15	0.07	1.2	7.17	0.09	1.71	7.41	0.09	1.78
	32		6.92	0.1	2.7	8.95	0.11	2.89	9.7	0.08	2.96
	33		5.38	0.07	1.15	7.43	0.09	1.46	7	0.1	1.28
	44		18.41	0.23	5.26	21.92	0.22	6.17	23.14	0.27	6.9
	45		19.75	0.2	6.28	25.29	0.28	8.1	25.08	0.26	7.74
	46		14.58	0.16	4.48	18.04	0.17	5.08	20.21	0.16	5.73
	47		12.68	0.18	3.73	23.3	0.18	5.39	21.97	0.16	5.02
	48		11.68	0.24	3.52	12.54	0.18	3.13	12.11	0.17	2.51
	57		18.21	0.19	4.58	22.77	0.22	6.09	23.1	0.23	6.53
	58		14.3	0.15	4.61	17.67	0.2	5.43	18.78	0.19	5.19
	59		16.32	0.2	4.84	24.32	0.21	6.33	25.18	0.25	6.71
	60		11.2	0.21	3.31	16.51	0.16	3.84	15.03	0.18	3.21
	130		3.97	0.08	1.39	5.58	0.09	1.71	5.88	0.07	1.62
	133		4.7	0.09	1.79	4.82	0.12	1.87	5.18	0.14	2.03
	136		4.47	0.09	1.49	5.58	0.11	1.95	5.41	0.11	1.91
	139		4.51	0.1	1.5	5.8	0.09	1.79	5.78	0.1	1.93
	140		3.98	0.07	1.29	5.01	0.07	1.56	5.25	0.08	1.66
	149		7.85	0.16	2.39	9.74	0.24	3.64	8.41	0.21	3.22
	150		11.61	0.32	4.98	13.2	0.34	5.3	14.05	0.31	5.34
	151		7.98	0.2	2.83	8.75	0.18	3.02	8.2	0.17	2.49
	152		6.75	0.18	2.22	7.57	0.19	2.3	7.64	0.19	2.26
	159		11.61	0.32	4.98	13.2	0.34	5.3	14.05	0.31	5.34
	160		11.17	0.29	4.63	12.42	0.31	4.77	13.01	0.28	4.7
	161		10.63	0.33	4.65	11.82	0.34	5.05	12.99	0.36	5.31
	172		23.76	0.54	8.98	28.9	0.7	10.37	29.2	0.64	10.59
	173		22.06	0.55	8.21	23.95	0.62	9.05	24.87	0.6	9.45
	174		20.12	0.51	7.4	23.47	0.58	8.92	21.82	0.63	9.07
	175		23.89	0.84	9.68	25.46	0.73	9.95	23.74	0.63	8.6
	176		18.38	0.65	7.24	18.16	0.52	6.77	17.18	0.58	6.14
	185		23.93	0.61	9.39	26.22	0.7	10.59	28.88	0.72	11.59
	186		22.79	0.55	7.88	24.93	0.66	9.23	23.19	0.7	9.46
	187		19.39	0.61	7.67	22.76	0.61	8.68	22.26	0.59	8.4

	188		22.76	0.8	9.05	22.69	0.66	8.9	20.37	0.57	7.47
	2	130	10.2	0.22	3.13	12.23	0.2	3.8	13.15	0.23	3.94
	5	133	9.99	0.19	3.08	11.84	0.2	3.47	12.75	0.21	3.7
	8	136	9.63	0.21	3.09	12.77	0.23	3.98	12.91	0.2	3.67
	11	139	10.48	0.21	3.21	12.69	0.22	3.82	13.5	0.23	4.12
	12	140	8.56	0.19	2.89	10.32	0.23	3.47	11.73	0.25	3.9
	21	149	15.47	0.24	3.33	18.97	0.34	5.42	17.61	0.31	4.61
	22	150	23.2	0.51	8.03	26.3	0.55	8.99	26.33	0.5	9.24
	23	151	19.28	0.5	7.52	23.64	0.46	8.72	23.35	0.4	8.19
	24	152	12.23	0.3	3.87	13.74	0.3	4.38	15.2	0.25	4.34
	31	159	15.83	0.4	5.9	19.99	0.45	6.96	19.93	0.44	6.88
	32	160	17.84	0.45	6.49	19.66	0.44	7.14	20.63	0.41	6.87
	33	161	15.82	0.44	5.85	18.02	0.42	6.75	18.29	0.44	6.79
	44	172	41.76	1.01	15.9	52.58	1.2	18.05	53.66	1.14	17.99
	45	173	44.63	0.97	15.45	52.36	1.25	18.14	55.89	1.19	19.77
	46	174	37.88	1.07	15.02	48.62	1.22	18.89	52.23	1.22	20.27
	47	175	40.96	1.28	16.2	52.8	1.1	18.82	45.97	0.97	15.37
	48	176	34.54	1.14	12.87	36.16	0.93	12.5	35.24	0.94	11.53
	57	185	43.23	1.04	15.68	52.86	1.29	18.63	56.65	1.33	20.08
	58	186	39.23	0.95	13.49	46.6	1.18	15.82	46.93	1.2	17.59
	59	187	40.97	1.21	15.92	55.47	1.28	20	55.81	1.17	19.77
	60	188	37.23	1.29	15.35	40.03	1.04	16.08	38.41	0.89	13.05

d) Simulated PD (W/m^2) at 4 cm^2 averaging for top array at n261

			4 cm^2 PD (W/m^2) at 6 dBm per port, n261								
Module ID	Beam ID 1	Beam ID 2	LB			MB			HB		
0			S1	S2	S5	S1	S2	S5	S1	S2	S5
Top Array	0		2.29	2.36	5.57	2.16	2.1	5.21	2.61	2.65	6.26
	3		1.63	1.8	4.59	1.9	1.81	4.9	1.72	1.82	4.67
	6		1.81	1.64	4.25	1.89	1.52	4.23	1.83	1.37	4.09
	9		2.1	1.83	5.07	2.26	2.05	5.38	1.96	1.62	4.58
	13		3.47	3.78	9.34	3.57	3.8	9.67	3	2.96	7.98
	14		4.19	5.96	10.98	4.44	5.86	11.44	4.22	5.86	10.74
	15		4.43	3.45	8.83	5.67	3.65	10.38	4.04	3.13	8.17
	16		3.92	2.87	8.86	4.21	2.41	8.68	4.52	3.56	10.47
	25		3.5	6.15	10.71	3.76	5.78	11.16	3.65	6.11	10.77
	26		4.77	5.06	10.38	4.88	5.06	10.6	4.83	5.09	10.29
	27		4.99	3.11	9.15	4.98	2.85	8.74	5.67	3.89	10.73
	34		4.65	11.49	19.19	4.11	10.41	17.17	5.03	11.27	19.01
	35		8.58	9.56	18.47	8.89	10.2	19.88	7.7	8.29	16.22
	36		8.61	8.27	17.47	9.59	8.65	18.82	8.2	8	16.67
	37		10.15	7.03	18.89	10.77	6.7	19.11	10.57	7.23	19.44
	38		9.75	4.36	16.46	11.26	4.71	18.44	10.65	4.83	18.3
	49		7.03	11.95	20.83	6.63	11.89	21	6.95	10.64	18.96
	50		8.97	8.99	17.93	9.94	9.65	19.28	7.56	7.95	15.82

	51		8.87	7.71	17.83	9.37	7.39	18.26	9.07	7.78	17.85
	52		10.25	5.8	18.6	11.22	5.73	19.19	11.1	6.17	20.03
	128		2.15	1.85	4.95	2.37	2.21	5.6	1.97	1.75	4.74
	131		1.82	1.94	4.56	1.7	1.98	4.63	2.18	1.91	4.85
	134		1.8	1.43	4.24	1.49	1.3	3.66	1.71	1.43	3.85
	137		1.86	1.74	4.51	1.66	1.59	4.1	1.67	1.6	3.92
	141		4.68	2.6	9.18	4.01	2.29	8	4.08	1.95	7.5
	142		4.98	4.05	9.23	5.03	3.8	8.98	5.02	4.49	9.68
	143		3.57	5.13	10.16	3.98	5.78	11.39	3.13	4.47	8.89
	144		2.74	4.26	9.11	3	5.31	11.03	2.93	3.47	8.26
	153		5.1	2.99	9.19	4.51	2.64	8.17	4.36	2.14	7.05
	154		4.71	5.07	10.3	4.77	5.04	10.37	4.25	4.83	9.53
	155		2.74	4.26	9.11	3	5.31	11.03	2.93	3.47	8.26
	162		9.93	4.19	16.87	7.96	3.3	13.69	11.16	4.84	18.45
	163		9.78	7.15	17.37	10.09	6.97	17.57	8.41	6.44	15.05
	164		7.28	7.24	15.01	7.58	7.69	15.49	6.67	6.98	13.9
	165		6.33	9.83	18.61	6.16	10.4	18.77	6.48	10.25	18.55
	166		4.37	10.05	17.79	4.53	10.77	18.68	4.08	9.43	16.68
	177		11.61	6.46	19.81	10.88	5.68	18.5	10.39	6.19	17.56
	178		8.09	7.13	15.81	8.26	7.01	15.6	7.42	6.79	14.76
	179		6.83	8.19	15.89	6.91	8.83	16.37	6.78	8.43	15.84
	180		5.11	10.61	18.96	5.11	11.35	19.72	4.93	10.34	18.21
	0	128	5.71	5.55	14.48	5.34	5.01	12.99	6.18	6.18	15.86
	3	131	4.33	4.64	12.2	4.24	4.4	11.99	5.2	4.86	13.2
	6	134	4.83	3.63	10.12	4.96	3.88	11.08	3.95	3.57	9.12
	9	137	5.08	4.26	12.65	4.85	3.87	10.94	4.4	4	11.46
	13	141	11.84	7.87	22.53	10.29	8.18	20.81	10.2	6.1	20.86
	14	142	10.8	12.68	23.5	12	11.61	23.8	10.43	13.3	24.44
	15	143	7.64	11.92	22.26	9.52	12.68	24.19	7.08	11.04	20.71
	16	144	8.32	8.69	20.98	9.16	10.08	21.62	8.75	8.54	21.72
	25	153	9.96	8.16	20.22	10.31	7.3	20.39	8.48	7.69	18.09
	26	154	11.44	12.5	25.52	11.3	11.87	24.44	10.65	11.61	23.79
	27	155	9.57	10.19	21.25	10.16	10.55	21.92	10.19	9.98	21.35
	34	162	20.55	21.34	42.64	16.57	18.42	36.43	23.24	21.44	45.26
	35	163	25.98	20.06	43.8	27.85	21.98	47.46	22.76	16.65	38.23
	36	164	19.86	19.37	39.51	21.94	20.45	41.7	17.18	17.77	35.23
	37	165	22.52	24.18	47.21	22.88	23.35	47.41	22.91	24.4	42.83
	38	166	19.53	20.03	36.9	21.26	20.56	39.84	20.4	20.96	40.68
	49	177	26.98	23.22	45.74	25.62	22.54	45.9	25.61	19.64	43.48
	50	178	21.93	18.8	39.31	24.71	20.49	43.32	18.21	15.95	33.38
	51	179	20.13	22.22	43.79	21.13	21.78	44.08	19.16	21.83	40.69
	52	180	21.49	22.94	45.18	22.36	22.1	46.11	22.14	23.19	40.48

e) Simulated PD (W/m^2) at 4 cm^2 averaging for bottom array at n261

			4 cm^2 PD (W/m^2) at 6 dBm per port, n261								
Module ID	Beam ID 1	Beam ID 2	LB			MB			HB		
1			S1	S2	S6	S1	S2	S6	S1	S2	S6
Bottom Array	1		2.24	2.09	5.57	1.92	1.8	4.87	2.42	2.35	6.03
	4		1.62	1.68	4.65	1.75	1.64	4.59	1.55	1.71	4.55
	7		1.72	1.64	4.41	1.51	1.3	3.68	1.92	1.61	4.73
	10		1.84	1.69	4.77	1.91	1.73	4.7	1.67	1.56	4.31
	17		4.62	2.56	9	4.49	2.43	8.25	4.94	2.88	9.86
	18		4.11	3.14	8.26	4.14	2.98	7.74	4.56	3.07	8.9
	19		4.08	5.58	11.18	3.8	5.13	10.49	3.91	5.78	11
	20		3.12	5.25	10.42	2.79	4.41	9.25	2.98	5.71	10.46
	28		4.96	3.25	9.34	4.81	3.14	8.98	5.39	3.65	10.18
	29		4.64	4.97	10.75	4.51	4.9	10.58	4.58	5.03	10.66
	30		3.88	5.6	11.1	3.56	5.03	10.26	3.69	5.87	10.94
	39		9.79	4.65	17.19	9.63	4.31	16.32	9.72	4.44	17.37
	40		9.19	7.01	18.37	9.36	6.43	17.97	9.64	7.08	18.86
	41		8.36	7.91	18.04	8.5	7.71	17.76	7.97	7.61	17.38
	42		8.27	9.58	19.59	7.58	9.49	18.98	7.87	9.04	18.18
	43		5.28	11.24	20.63	4.41	9.43	16.93	5.55	12.02	21.47
	53		9.88	6.08	18.66	10.07	5.61	18.22	10.17	5.88	19.02
	54		8.52	7.26	17.8	8.59	6.79	17.44	8.88	7.41	18.12
	55		8.63	8.64	18.2	8.48	8.56	17.73	7.9	7.93	16.93
	56		7.11	11.13	21.58	6.18	10.28	19.65	7.04	11.12	20.86
	129		2.09	1.85	5.14	2.12	2.02	5.3	2.01	1.61	4.68
	132		1.81	1.82	4.8	1.57	1.68	4.4	1.76	1.63	4.2
	135		1.71	1.3	4.16	1.35	1.13	3.35	1.72	1.39	4.14
	138		1.56	1.6	4.2	1.42	1.43	3.74	1.43	1.59	3.87
	145		2.6	4.38	9.88	2.43	4.57	9.84	2.59	3.04	7.74
	146		4.05	4.9	10.23	4.03	4.88	10.19	3.75	4.44	9.32
	147		4.92	3.72	9.21	4.85	3.59	9.07	4.77	3.96	9.29
	148		4.36	2.48	8.71	3.62	1.96	7.16	3.85	2.24	7.81
	156		3.07	4.03	8.2	2.55	3.91	7.42	2.93	3.76	7.84
	157		4.5	4.51	9.78	4.46	4.4	9.68	4.35	4.47	9.57
	158		3.99	2.47	8.92	3.25	1.82	6.96	3.78	2.4	8.34
	167		4.32	9.8	18.04	3.57	9.08	16.04	3.59	7.71	14.49
	168		6.02	7.77	15.83	5.8	8.26	15.69	6.11	7.81	16.07
	169		7.14	6.78	15.6	7.05	6.88	15.2	6.89	6.68	14.94
	170		10.27	6.71	18.84	9.8	6.08	17.79	9.28	6.57	17.46
	171		9.32	3.58	16.84	7.06	2.7	12.73	9	3.77	15.75
	181		5.59	9.42	18.37	4.91	9.32	17.17	5.32	8.64	17.13
	182		6.41	6.92	14.42	6.53	7.68	14.89	6.35	6.9	14.37
	183		8.36	6.75	16.71	8.3	6.44	16.23	7.78	6.7	16.01
	184		10.62	4.89	19.22	8.91	3.86	16.07	9.89	5.06	17.8
	1	129	5.06	4.66	12.95	4.58	4.12	11.08	5.47	5.21	14.36

	4	132	4.16	4.12	12.19	3.96	3.59	10.93	4.12	4.02	11.47
	7	135	4.51	3.42	10.21	4.1	3.26	9.7	4.07	3.4	9.08
	10	138	4.11	3.7	11.04	4.05	3.49	9.38	3.68	3.58	10.4
	17	145	8.66	9.49	20.16	8.35	9.24	19.23	8.87	8.02	19.37
	18	146	7.3	8.82	19.12	7.58	8.55	18.63	7.21	7.97	18.06
	19	147	11.26	10.98	23.07	11.07	9.91	22.49	10.03	11.86	23.34
	20	148	9.29	6.78	20.07	8.39	5.99	18.03	7.82	7.25	18.24
	28	156	10.54	7.92	20.19	9.41	7.1	18.55	10.62	8.7	20.07
	29	157	11	11	24.3	10.62	10.17	22.87	10.51	10.97	23.89
	30	158	11.22	7.76	23.79	10.04	6.65	21.3	10.08	8.36	21.69
	39	167	19.05	19.79	38.06	17.16	17.52	35.46	18.71	16.89	34.15
	40	168	19.73	20.64	43.65	19.52	19.5	41.83	20.28	20.23	41.79
	41	169	19.37	17.02	38.2	19.82	17.26	38.43	17.22	15.5	34.7
	42	170	26.32	20.13	45.61	25.21	19.71	45.4	22.84	18.72	39.42
	43	171	20.89	19.91	43.96	16.4	15.91	34.9	20.18	21.58	45.47
	53	181	20.78	21.83	45.1	19.83	20.02	43.08	21.62	20.2	40.95
	54	182	19.01	18.57	39.94	19.03	18.16	38.83	18.54	18.37	38.58
	55	183	22.43	17.83	40.32	22.79	18.17	41.21	19.13	15.75	34.94
	56	184	25.5	20.78	46.06	22.19	17.7	42.02	23.13	21.53	41.27

f) Simulated PD (W/m^2) at 4 cm^2 averaging for front array at n261

			4 cm^2 PD (W/m^2) at 6 dBm per port, n261								
Module ID	Beam ID 1	Beam ID 2	LB			MB			HB		
2			S1	S2	S4	S1	S2	S4	S1	S2	S4
Front Array	2		7.98	0.1	2.01	7.83	0.09	1.88	7.88	0.09	2.06
	5		7.52	0.1	1.91	7.46	0.11	1.86	7.48	0.1	1.94
	8		7.59	0.1	1.83	7.5	0.11	1.79	7.53	0.1	1.86
	11		7.6	0.07	2.04	7.19	0.07	1.94	7.6	0.07	2.05
	12		6.14	0.11	2.09	6.75	0.12	2.24	5.5	0.1	1.9
	21		13.21	0.28	3.69	12.63	0.29	3.47	13.36	0.27	3.75
	22		14.76	0.07	3.88	14.78	0.08	3.82	14.55	0.08	3.9
	23		16.69	0.22	5.17	16.59	0.24	4.98	16.3	0.23	5.28
	24		16.87	0.28	5.77	16.81	0.3	5.52	16.52	0.27	5.87
	31		12.79	0.24	2.83	12.27	0.24	2.66	12.96	0.23	2.89
	32		12.31	0.25	2.96	12.37	0.27	2.98	12.18	0.25	2.91
	33		15.97	0.33	5.65	15.63	0.36	5.39	15.83	0.32	5.77
	44		20.39	0.4	5.28	20.03	0.38	5.16	21.19	0.45	5.03
	45		29.34	0.23	8.01	29.13	0.25	7.91	29.28	0.25	7.97
	46		36.05	0.27	11.42	37.41	0.29	11.72	34.47	0.27	10.9
	47		32.19	0.45	11.34	32.16	0.47	11.17	31.43	0.43	11.32
	48		31.47	0.69	11.24	30.45	0.75	10.51	31.43	0.7	11.48
	57		24.02	0.27	6.24	23.78	0.24	5.99	24.31	0.27	6.09
	58		34.49	0.25	10.29	35.23	0.29	10.67	33.56	0.25	9.89
	59		33.29	0.34	11.13	33.62	0.35	11.03	32.24	0.33	10.86
	60		32.3	0.66	11.17	31.77	0.74	10.69	32.02	0.66	11.46
	130		7.86	0.16	2.7	7.72	0.16	2.75	7.87	0.14	2.68

	133		7.5	0.13	2.24	7.46	0.14	2.31	7.49	0.13	2.17
	136		6.83	0.13	2.11	6.77	0.14	2.17	6.91	0.12	2.09
	139		7	0.14	2.34	6.94	0.13	2.35	7.02	0.13	2.3
	140		5.8	0.08	1.47	5.98	0.08	1.52	5.67	0.08	1.44
	149		14.17	0.19	4.51	14.12	0.18	4.69	14.31	0.18	4.41
	150		13.17	0.44	4.96	12.74	0.44	4.88	13.43	0.42	4.93
	151		16.08	0.45	6.88	16.03	0.48	6.98	15.88	0.42	6.78
	152		16.71	0.31	6.74	16.85	0.33	6.87	16.4	0.29	6.6
	159		13.07	0.31	3.09	12.82	0.31	3.01	13.35	0.31	3.13
	160		15.19	0.48	6.53	14.97	0.51	6.59	15.15	0.44	6.44
	161		16.39	0.22	5.67	16.8	0.26	5.96	16.12	0.21	5.47
	172		21.23	0.69	7.96	20.55	0.69	7.78	22.19	0.67	8.07
	173		23.29	0.86	9.04	21.69	0.85	8.53	24.81	0.81	9.33
	174		28.27	0.88	12.16	28.51	0.89	12.35	27.88	0.86	12.04
	175		37.52	0.69	14.47	38.78	0.74	15.04	35.76	0.66	13.68
	176		31.72	0.43	10.72	32.6	0.48	11	31.68	0.44	10.74
	185		19.68	0.65	7.36	18.78	0.65	7.09	20.71	0.63	7.68
	186		25.1	0.84	10.67	24.32	0.82	10.5	25.75	0.79	10.61
	187		36.2	0.86	14.84	37.05	0.91	15.26	35	0.87	14.41
	188		32.96	0.61	11.34	34.04	0.63	11.8	31.95	0.56	11.18
	2	130	17.11	0.34	5.07	16.35	0.34	5.13	17.25	0.32	5.09
	5	133	15.82	0.31	4.68	15.2	0.36	4.74	16.19	0.31	4.65
	8	136	14.87	0.31	4.65	14.67	0.34	4.72	15.15	0.31	4.67
	11	139	14.95	0.31	4.63	14.79	0.3	4.47	15.26	0.3	4.73
	12	140	14.6	0.34	4.93	14.69	0.34	4.78	14.33	0.33	4.92
	21	149	29.2	0.64	10.52	27.85	0.76	10.72	30.02	0.55	10.34
	22	150	28.49	0.68	10.34	27.17	0.74	10.15	29.39	0.68	10.48
	23	151	33.16	1	14.06	33.06	1.13	14.18	32.51	0.97	14.07
	24	152	35.6	1	13.56	35.9	1.07	13.61	34.85	0.96	13.53
	31	159	28.41	0.5	7.71	26.31	0.61	7.87	29.57	0.49	7.67
	32	160	22.13	0.69	9.35	21.62	0.73	9.2	22.55	0.67	9.23
	33	161	34.32	0.94	13.38	34.5	1.05	13.56	34.08	0.89	13.17
	44	172	43.88	1.3	16.18	43.91	1.21	15.57	44.68	1.24	16.13
	45	173	54.94	1.39	20.11	52.72	1.4	19.47	56.49	1.33	20.36
	46	174	70.46	1.77	28.05	70.14	1.82	28.09	69.66	1.76	27.68
	47	175	72.74	1.89	28.35	72.83	2.06	28.99	71	1.79	27.36
	48	176	66.33	1.77	26.25	65.37	2.01	25.75	67.14	1.82	26.74
	57	185	49.15	1.27	16.28	47.77	1.19	15.53	50.15	1.22	16.56
	58	186	67.02	1.54	25.93	65.31	1.67	25.53	67.9	1.44	25.64
	59	187	72.25	1.97	28.27	73.17	2.05	28.21	69.72	1.93	27.75
	60	188	71.18	1.85	26.76	71.14	2.05	27.35	70.51	1.78	26.88

g) Simulated PD (W/m^2) at 4 cm^2 averaging for top array at n260

			4 cm^2 PD (W/m^2) at 6 dBm per port, n260								
Module ID	Beam ID 1	Beam ID 2	LB			MB			HB		
0			S1	S2	S5	S1	S2	S5	S1	S2	S5
Top Array	0		2.38	2.48	6.09	2.72	2.4	6.15	2.15	1.54	4.8
	3		2.56	2.53	6.69	2.29	2.45	5.61	1.35	1.34	3.12
	6		2.08	2.49	5.69	1.49	1.54	3.67	1.15	1.45	3.19
	9		2.15	2.07	5.18	1.97	1.93	4.81	1.59	1.58	3.93
	13		3.85	4.07	12.36	4.52	3.72	11.59	3.3	3.1	9.64
	14		5.11	5.6	11.56	4.93	4.94	10.47	3.48	2.84	6.86
	15		5.45	5.23	12.03	5.35	5.59	12.06	3.4	2.54	6.74
	16		4.72	4.78	12.57	5.19	4.87	12.47	3.37	2.83	8.99
	25		4.38	4.8	12.01	4.46	3.84	10.67	3.32	3.04	8.54
	26		5.43	5.4	11.48	5.36	5.69	11.23	3.46	2.58	5.78
	27		5.23	5.09	12.41	5.33	5.35	12.48	3.37	2.65	7.88
	34		8.53	8.57	20.74	7.56	7.26	17.41	5.39	5.15	13.4
	35		9.22	9.89	19.5	9.14	8.93	18.15	5.47	5.65	13.16
	36		10.18	10.41	20.18	9.39	10.43	19.69	4.64	5.94	11.4
	37		10.29	10.29	21.87	7.68	7.02	15.76	5.03	3.69	11.01
	38		8.03	8.07	20.99	6.7	6.01	16.63	5.41	5.93	14.69
	49		9.1	9.57	19.06	7.59	7.59	16.63	5.36	5.73	14.1
	50		9.57	10	19.81	10.38	10.47	20.31	4.99	6.25	12.18
	51		10.41	10.64	20.88	8.42	9.14	18.3	5.04	4.35	9.24
	52		9.57	9.49	21.92	6.86	6.01	15.49	5.09	5.11	13.3
	128		1.37	3.17	5.23	1.79	3.45	5.77	1.49	3.34	5.29
	131		1.6	3.36	5.63	1.36	3.07	5.17	0.86	2.25	3.73
	134		1.28	3.13	5.15	1.13	3.15	5.08	0.73	2.35	3.43
	137		1.39	3.04	5.02	1.39	2.81	4.61	0.91	2.04	3.18
	141		2.02	5.73	10.63	2.04	5.11	9.77	1.6	3.39	6.14
	142		3.41	6.55	9.98	3.86	7.59	10.55	2.57	5.82	8.11
	143		2.44	5.32	8.66	2.56	4.72	8.32	1.72	4.11	6.45
	144		1.98	6.17	11.47	2.58	4.43	9.34	2.32	5	9.21
	153		2.51	5.75	10.64	2.71	5.42	9.33	2.48	5.35	8.59
	154		2.99	6.91	9.23	2.42	5.52	7.9	1.77	4.1	6
	155		2.22	5.34	10.12	1.73	5.74	10.42	1.82	3	6.09
	162		4.78	11.32	18.73	3.91	9.94	19.03	3.29	8.9	13.6
	163		7.22	14.73	21.66	4.61	13.02	17.17	3.92	10.96	15.46
	164		7.22	13.63	19.64	8.72	13.62	20.65	4.75	10.42	14.73
	165		5.36	12.13	17.81	5.15	13.29	17.7	3.07	9.06	13.65
	166		3.78	8.57	17.32	4.6	9.02	18.22	3.83	5.67	12.34
	177		5.99	13.15	20.2	4.4	10.41	15.8	3.11	9.87	13.96
	178		7.07	14.93	20.44	6.95	14.33	19.82	4.69	10.62	14.94
	179		6.49	12.81	18.59	7.44	14.91	20.8	4.33	10.12	14.76
	180		4.64	11.01	17.41	5.07	8.27	16.54	3.78	6.06	13.05
	0	128	4.89	6.97	13.43	5.5	7.25	12.93	5.03	5.38	11.87

	3	131	5.7	7.35	14.57	4.31	6.35	11.17	2.86	4.32	8.03
	6	134	3.75	6.34	11.54	3.4	5.7	9.27	2.02	4.57	7.63
	9	137	4.04	6.1	11.34	4.09	5.57	10.22	3.43	4.45	7.71
	13	141	6.24	13.4	26.69	7.14	12.52	24.81	6.14	7.77	17.02
	14	142	9.21	16.17	24.91	9.79	15.4	23.83	7.64	10.63	18.23
	15	143	8.31	11.93	21.42	8.26	11.12	20.37	4.89	7.88	12.44
	16	144	8.49	15.29	26.07	8.42	12.71	25.81	8.01	10.02	21.21
	25	153	8.16	14.74	26.05	7.77	12.73	23.21	9.08	12.07	21.8
	26	154	8.98	12.21	21.68	7.62	11.59	19.99	5.51	8.7	13.09
	27	155	8.6	13.18	24.09	7.8	14.16	26.11	6.76	7.79	14.84
	34	162	15.42	30.84	48.99	12.23	21.58	41.46	10.91	17.64	32
	35	163	17.53	30.57	47.31	15.76	27.01	41.32	12.82	24.35	35.45
	36	164	19.41	26.26	43.76	20.26	27.03	44.69	11.47	22.66	32.07
	37	165	17.27	29.44	45.57	13.85	26.21	39.88	9.48	16.19	27.31
	38	166	15.92	27.23	45.3	15.54	24.03	42.03	12.9	15.1	32.76
	49	177	17.23	31.32	47.23	12.83	23.51	38.66	10.91	21.96	34.11
	50	178	18.4	26.79	41.89	18.14	26.69	42.57	10.4	20.65	31.67
	51	179	19.05	27.04	42.61	19.21	30.32	45.81	11.26	21.64	31.31
	52	180	15.47	30.5	48.16	13.77	19.71	38.25	11.68	15.49	31.81

h) Simulated PD (W/m^2) at 4 cm^2 averaging for bottom array at n260

			4 cm^2 PD (W/m^2) at 6 dBm per port, n260								
Module ID	Beam ID 1	Beam ID 2	LB			MB			HB		
1			S1	S2	S6	S1	S2	S6	S1	S2	S6
Bottom Array	1		2.54	2.62	6.38	2.62	2.38	6	2.05	1.65	5.02
	4		2.55	2.6	6.76	2.25	2.43	5.47	1.22	1.37	2.99
	7		2.05	2.42	5.67	1.53	1.58	3.72	1.02	1.4	2.95
	10		2.15	2.13	5.22	1.95	2	4.98	1.44	1.53	3.75
	17		4.97	4.95	13.19	4.99	4.81	12.31	3.13	2.82	8.89
	18		5.8	5.53	12.6	5.21	5.49	11.73	3.09	2.58	6.62
	19		5.01	5.7	12.03	4.55	4.43	10.09	3.31	3.06	7.98
	20		4.37	4.5	13.1	4.74	4.39	12.07	3.13	2.95	9.44
	28		5.59	5.35	13.05	5.18	5.26	12.25	3.1	2.67	7.75
	29		5.47	5.76	11.66	5.1	5.37	10.34	3.31	2.8	6.25
	30		4	4.47	12.61	4.22	3.66	10.93	3.17	3.16	9.56
	39		7.52	7.19	21.71	6.87	6.62	17.78	4.77	5.78	13.73
	40		10.42	10.47	22.52	7.36	6.6	15.32	4.58	3.66	10.48
	41		10.12	10.63	20.38	9.33	10.27	19.11	4.81	6.18	12.28
	42		9.18	9.71	19.02	7.63	8.1	16.81	4.76	5.89	13.42
	43		7.92	8.15	21.69	7.23	7.29	18.93	5.01	4.94	12.37
	53		9.29	9.14	22.17	6.61	6.09	15.88	4.57	5.31	12.45
	54		10.35	10.83	21.17	8.35	8.81	17.9	4.69	4.14	8.97
	55		9.22	9.71	19.28	10.03	9.89	19.28	5.39	5.85	12.68
	56		8.93	9.19	20.92	7.37	7.24	17.28	4.69	4.68	12.34
	129		1.46	3.31	5.4	1.61	3.58	5.77	1.64	3.27	5.35
	132		1.54	3.4	5.77	1.61	3.09	5.29	0.87	2.12	3.61

	135		1.5	3.19	5.41	1.07	3.13	4.75	1.01	2.37	3.57
	138		1.49	2.49	4.36	1.28	2.04	3.2	0.9	1.58	2.57
	145		2.55	4.06	9.24	2.21	4.34	7.81	1.97	3.7	5.75
	146		3.12	5.32	8.9	1.98	4.4	6.91	1.63	4.01	6.24
	147		3.05	6.57	10.49	3.35	7.32	10.3	2.93	5.44	8.16
	148		1.93	5.98	11.39	2.56	4.51	9.31	2.45	4.73	8.84
	156		2.41	5.36	10.24	1.71	5.74	9.93	1.67	3.36	6.16
	157		3.61	7.21	10.15	4.4	8.57	11.49	3.03	5.88	8.61
	158		2.58	6.37	11.39	2.34	4.83	9.11	1.67	4.25	6.66
	167		3.71	7.63	16.96	4.15	7.77	15.93	4.52	5.42	11.47
	168		5.35	12.03	18.1	4.09	11.1	15.85	2.81	8.54	13.65
	169		7.65	13.87	20.24	8.24	13.89	20.57	6.15	9.57	15
	170		6.65	14.48	20.74	5.22	13.66	17.44	5.19	9.78	14.4
	171		3.51	8.97	17.57	4.16	7.66	16.85	3.7	6.17	11.65
	181		4.43	8.87	16.69	4.78	7.21	15.55	5.14	5.06	11.82
	182		6.43	12.98	19.09	6.03	14.16	19.12	3.52	9.73	14.44
	183		7.22	14.57	20.31	7.14	14.02	19.6	7.11	9.44	15.37
	184		6.03	13.45	20.54	5.07	10.64	15.27	3.18	9.6	13.36
	1	129	4.8	7.17	13.6	5.22	7.31	12.69	5.23	5.34	12.02
	4	132	5.63	7.59	15.07	4.53	6.32	11.17	2.78	4.31	7.89
	7	135	4.28	6.39	11.69	3.2	5.94	9.27	2.31	4.46	7.21
	10	138	4.21	5.24	10.29	3.79	4.55	9.01	3.37	3.53	7.26
	17	145	8.22	10.16	20.05	8.03	11.98	21.17	5.43	6.84	13.28
	18	146	10.03	12.07	21.71	7.6	10.72	19.16	4.97	8.09	12.72
	19	147	8.82	17.32	26.58	8.92	15.34	23.95	7.98	10.93	19.65
	20	148	8.32	14.48	27.5	8.09	10.88	24.2	8.39	10.92	22.27
	28	156	9.6	13.24	24.45	7.43	13.6	25.15	6.06	8.55	15.2
	29	157	9.38	15.57	24.32	10.22	14.77	22.87	7.35	10.79	16.71
	30	158	7.2	15.74	27.37	8.02	12.66	24.2	6.13	9.66	18.15
	39	167	15.33	24.69	46.34	15.09	23.86	42.44	10.84	15.53	30.19
	40	168	18.1	31.51	48.79	12.11	23.68	38.24	9.3	16.9	27.96
	41	169	18.89	26.84	45.01	18.98	27.62	43.57	14.6	22.15	31.45
	42	170	19.06	32.83	46.28	14.91	26.88	40.62	11.47	22.45	36.92
	43	171	14.17	29.12	48.95	14.2	23.24	43.94	10.42	14.52	27.96
	53	181	15.62	27.51	45.65	12.85	19.28	37.15	11.5	15.82	29.51
	54	182	19.38	28.99	45.76	17.04	29.94	43.86	9.61	20.88	29.67
	55	183	17.82	27.74	43.02	19.77	25.57	41.07	15.18	17.98	32.29
	56	184	18.22	33.11	48.71	11.79	21.49	38	10.8	18.54	32.93

i) Simulated PD (W/m^2) at 4 cm^2 averaging for front array at n260

			4 cm^2 PD (W/m^2) at 6 dBm per port, n260								
Module ID	Beam ID 1	Beam ID 2	LB			MB			HB		
2			S1	S2	S4	S1	S2	S4	S1	S2	S4
Front Array	2		3.41	0.05	1.4	4.2	0.12	1.67	3.93	0.08	1.38
	5		3.17	0.07	1.4	3.5	0.12	1.59	3.79	0.1	1.69

	8		3.11	0.07	1.34	3.7	0.1	1.61	3.68	0.09	1.63
	11		2.82	0.03	0.94	3.67	0.1	1.61	3.78	0.09	1.63
	12		5.05	0.09	1.99	5.11	0.13	2.03	5.42	0.13	2.28
	21		7.1	0.15	3.23	8.63	0.32	3.95	8.32	0.25	3.82
	22		6.17	0.11	2.06	7.08	0.21	3.09	7.46	0.23	3.3
	23		4.86	0.11	2.52	5.33	0.22	2.28	5.33	0.22	3.08
	24		6.28	0.14	3.3	5.9	0.25	2.56	5.85	0.25	3.32
	31		7.35	0.13	2.7	9.54	0.24	4.4	9.8	0.22	4.16
	32		7.88	0.13	3.02	7.53	0.18	3.01	8.22	0.22	3.6
	33		5.26	0.11	2.62	4.82	0.14	1.52	5.08	0.18	2.61
	44		16.76	0.36	8.97	17.39	1.03	10.88	15	0.6	7.01
	45		14.8	0.36	6.18	22.03	0.82	11.31	21.52	0.81	11.09
	46		9.91	0.23	3.4	12.42	0.53	5.35	11.04	0.34	4.56
	47		15.41	0.44	8.52	11.94	0.4	4.26	12.53	0.52	7.63
	48		16.08	0.34	8.58	18.06	0.95	10.65	15.8	0.64	7.28
	57		16.71	0.46	8.53	16.88	0.73	9.3	17.02	0.72	9.01
	58		13.47	0.26	6.16	17.01	0.75	8.42	18.4	0.69	8.58
	59		13.04	0.15	5.85	11.57	0.51	4.63	13.26	0.56	7.07
	60		13.99	0.3	7.11	15.27	0.46	6.47	13.12	0.5	7.36
	130		4.56	0.13	2.23	4.35	0.15	1.97	4.19	0.14	1.63
	133		3.98	0.13	1.98	4.05	0.14	1.48	3.93	0.08	1.15
	136		3.59	0.12	1.89	3.84	0.12	1.46	3.83	0.08	1.14
	139		4.14	0.13	2.17	3.69	0.12	1.39	3.78	0.06	1
	140		4.29	0.12	2.26	3.8	0.1	1.46	3.39	0.07	1.4
	149		7.67	0.14	3.32	7.12	0.14	1.95	7.09	0.16	2
	150		8.37	0.25	4.77	6.38	0.21	2.67	6.01	0.12	1.96
	151		7.71	0.15	3.4	6.61	0.14	2.2	6.4	0.14	2.06
	152		8.07	0.32	5.41	6.91	0.35	3.82	7.15	0.22	2.61
	159		9.06	0.24	4.4	8.67	0.28	3.22	7.44	0.18	2.31
	160		8.38	0.23	2.56	8.85	0.28	2.98	8.88	0.28	3.16
	161		7.7	0.26	4.28	7.27	0.26	3.37	8.28	0.24	2.93
	172		17.81	0.77	12.41	15.64	0.79	7.89	13.7	0.33	4.8
	173		19.53	0.81	12.43	14.41	0.78	7.75	12.95	0.25	3.86
	174		16.59	0.48	9.07	17.18	0.59	5.64	15.89	0.6	5.91
	175		14.64	0.32	5.35	12.44	0.5	5.36	15.46	0.58	6.39
	176		17.98	0.69	11.18	14.6	0.66	6.93	13.63	0.39	4.74
	185		16.78	0.75	11.52	13.95	0.78	7.79	13.66	0.43	4.61
	186		16.87	0.61	10.81	16.54	0.6	7.6	13.76	0.45	4.54
	187		18.17	0.59	8.24	14.01	0.44	5.04	13.74	0.43	3.98
	188		14.84	0.56	7.87	13.53	0.65	6.51	15.5	0.63	6.75
	2	130	9.53	0.21	5.39	10.46	0.38	4.09	9.9	0.32	3.3
	5	133	8.91	0.25	5.19	8.41	0.33	3.51	9.62	0.26	3.47
	8	136	8.44	0.24	4.9	8.57	0.29	3.73	9.42	0.22	3.21
	11	139	7.85	0.27	4.76	8.6	0.31	3.4	9	0.22	3.1
	12	140	11.84	0.33	6.23	9.82	0.32	4.48	10.25	0.26	5.33
	21	149	15.91	0.43	8.84	18.68	0.64	8.8	17.18	0.37	5.86
	22	150	13.86	0.48	8.25	11.32	0.48	6.33	11.5	0.38	4.94
	23	151	14.7	0.42	8.96	14.06	0.58	5.78	15.05	0.47	6.68
	24	152	16.19	0.6	10.7	14.94	0.62	6.19	15.59	0.43	6.76
	31	159	13.04	0.32	5.95	12.46	0.34	5.23	11.8	0.35	5.27

	32	160	14	0.41	5.25	11.95	0.31	4.61	11.92	0.33	4.59
	33	161	14.49	0.46	8.53	12.67	0.5	5.86	15.86	0.44	6.58
	44	172	37.1	1.2	22.7	39.62	1.91	19.26	34.08	0.89	12.53
	45	173	36.57	1.39	20.82	39.06	1.23	18.05	39.36	1.21	16.86
	46	174	28.1	0.88	14.99	35.22	1.61	15.83	33.68	0.9	12.16
	47	175	33.37	0.84	15.17	28.06	0.95	10.44	31.78	0.99	14.06
	48	176	37.78	1.2	22.11	36.7	1.62	16.56	33.57	1.11	13.91
	57	185	37.92	1.26	21.62	34.39	1.51	15.81	31.12	1.15	14.85
	58	186	33.18	0.9	19.8	33.03	0.99	14.92	35.71	0.97	13.98
	59	187	31.55	0.93	17.31	31.14	1.42	13.97	32.41	1.22	15.08
	60	188	30.21	0.8	14.11	30.48	0.97	11.91	31.27	1.08	14.12

Scaling factor calculation: The following tables show the scaling factor results for all three different modules, at n258, n261 and n260 bands. The scaling factor is defined as the MPE internal design limit (4.5 W/m^2) divided by the simulated peak spatial average power density. The data is provided for both single polarization beams and paired beams. Please be noted due to timeline, following results are not obtained using the final version of codebook.

In the tables below, the values reported represent the scaled factors for low-band, mid-band and high-band results (S_LB, S_MB, and S_HB, respectively) and the scaling factor SF is the most restrictive of the three band-specific values.

a) *Scaling factor for top array n258*

Beam ID 1	Beam ID 2	S_LB	S_MB	S_HB	S
0		0.623268698	0.673652695	0.79787234	0.623268698
3		1.327433628	1.359516616	1.607142857	1.327433628
6		1.578947368	1.216216216	0.939457203	0.939457203
9		0.867052023	0.825688073	1.07398568	0.825688073
13		0.757575758	0.68597561	0.625869263	0.625869263
14		0.623268698	0.660792952	0.681818182	0.623268698
15		0.404676259	0.451807229	0.527549824	0.404676259
16		0.5859375	0.613915416	0.661764706	0.5859375
25		0.407239819	0.416281221	0.53699284	0.407239819
26		0.365556458	0.4	0.508474576	0.365556458
27		1.025056948	0.703125	0.546780073	0.546780073
34		0.221021611	0.213169114	0.221565731	0.213169114
35		0.212464589	0.223769269	0.256849315	0.212464589
36		0.251959686	0.276582667	0.317572336	0.251959686
37		0.218234724	0.205385669	0.230650948	0.205385669
38		0.530035336	0.431034483	0.321888412	0.321888412
49		0.211466165	0.208429829	0.22069642	0.208429829
50		0.249307479	0.276412776	0.333827893	0.249307479
51		0.225790266	0.230296827	0.263157895	0.225790266
52		0.304878049	0.236842105	0.216658642	0.216658642
128		1.890756303	1.7578125	1.485148515	1.485148515
131		1.612903226	1.108374384	0.847457627	0.847457627
134		1.844262295	1.567944251	1.174934726	1.174934726

137		1.666666667	1.323529412	1.013513514	1.013513514
141		1.022727273	0.665680473	0.474183351	0.474183351
142		0.920245399	0.773195876	0.5859375	0.5859375
143		0.788091068	0.665680473	0.537634409	0.537634409
144		1.156812339	0.773195876	0.525087515	0.525087515
153		0.75	0.650289017	0.583657588	0.583657588
154		0.786713287	0.731707317	0.611413043	0.611413043
155		0.945378151	0.70754717	0.522648084	0.522648084
162		0.408348457	0.301810865	0.227502528	0.227502528
163		0.422535211	0.332840237	0.253093363	0.253093363
164		0.509626274	0.401785714	0.30758715	0.30758715
165		0.418215613	0.355169692	0.289389068	0.289389068
166		0.576184379	0.347222222	0.223435948	0.223435948
177		0.407608696	0.304054054	0.228658537	0.228658537
178		0.487540628	0.38961039	0.304054054	0.304054054
179		0.535714286	0.453629032	0.341426404	0.341426404
180		0.415512465	0.295275591	0.216658642	0.216658642
0	128	0.357426529	0.392327812	0.407978241	0.357426529
3	131	0.507900677	0.481283422	0.512528474	0.481283422
6	134	0.613079019	0.545454545	0.478723404	0.478723404
9	137	0.409836066	0.398582817	0.422535211	0.398582817
13	141	0.347222222	0.287539936	0.250278087	0.250278087
14	142	0.277949351	0.287539936	0.279503106	0.277949351
15	143	0.264239577	0.257142857	0.25083612	0.25083612
16	144	0.32444124	0.313370474	0.237467018	0.237467018
25	153	0.204918033	0.197281894	0.237091675	0.197281894
26	154	0.251537172	0.258323766	0.284810127	0.251537172
27	155	0.391644909	0.285714286	0.226358149	0.226358149
34	162	0.108695652	0.102087114	0.102272727	0.102087114
35	163	0.098425197	0.097868639	0.102810144	0.097868639
36	164	0.145536869	0.147540984	0.145348837	0.145348837
37	165	0.106710932	0.098835932	0.103543488	0.098835932
38	166	0.241416309	0.163636364	0.106660346	0.106660346
49	177	0.10373444	0.098360656	0.099097115	0.098360656
50	178	0.127514877	0.128095645	0.135135135	0.127514877
51	179	0.124412497	0.126546682	0.133888724	0.124412497
52	180	0.153846154	0.111303488	0.089285714	0.089285714

b) Scaling factor for bottom array n258

Beam ID 1	Beam ID 2	S_LB	S_MB	S_HB	S
1		0.775862069	0.677710843	0.715421304	0.677710843
4		1.159793814	1.206434316	1.216216216	1.159793814
7		1.515151515	1.282051282	1.034482759	1.034482759
10		1.097560976	0.882352941	0.993377483	0.882352941
17		0.675675676	0.632911392	0.576923077	0.576923077
18		0.550795594	0.591327201	0.634696756	0.550795594
19		0.806451613	0.684931507	0.535077289	0.535077289
20		0.531914894	0.533175355	0.538922156	0.531914894

28		0.437743191	0.38330494	0.407239819	0.38330494
29		0.404676259	0.3930131	0.426540284	0.3930131
30		0.458715596	0.470711297	0.490730643	0.458715596
39		0.229474758	0.207564576	0.203435805	0.203435805
40		0.262237762	0.252242152	0.277264325	0.252242152
41		0.266903915	0.258769408	0.267697799	0.258769408
42		0.23659306	0.202611436	0.201974865	0.201974865
43		0.440744368	0.330882353	0.262085032	0.262085032
53		0.231124807	0.214899713	0.223880597	0.214899713
54		0.292207792	0.287356322	0.308008214	0.287356322
55		0.240256273	0.222441918	0.23006135	0.222441918
56		0.275397797	0.221893491	0.204545455	0.204545455
129		1.433121019	1.446945338	1.347305389	1.347305389
132		1.939655172	1.339285714	0.991189427	0.991189427
135		1.612903226	1.505016722	1.219512195	1.219512195
138		1.7578125	1.515151515	1.150895141	1.150895141
145		0.680786687	0.643776824	0.592105263	0.592105263
146		0.813743219	0.669642857	0.533807829	0.533807829
147		0.815217391	0.706436421	0.589005236	0.589005236
148		1.032110092	0.796460177	0.581395349	0.581395349
156		0.982532751	0.833333333	0.632022472	0.632022472
157		0.756302521	0.760135135	0.643776824	0.643776824
158		0.849056604	0.731707317	0.572519084	0.572519084
167		0.357142857	0.307167235	0.243770314	0.243770314
168		0.472689076	0.421743205	0.351288056	0.351288056
169		0.474683544	0.445103858	0.364963504	0.364963504
170		0.388936906	0.346687211	0.295663601	0.295663601
171		0.608930988	0.394045534	0.25862069	0.25862069
181		0.424528302	0.374064838	0.297029703	0.297029703
182		0.469728601	0.427756654	0.358280255	0.358280255
183		0.453629032	0.431034483	0.362027353	0.362027353
184		0.407978241	0.311850312	0.23923445	0.23923445
1	129	0.368550369	0.375312761	0.39964476	0.368550369
4	132	0.531914894	0.515463918	0.491266376	0.491266376
7	135	0.57106599	0.561097257	0.51843318	0.51843318
10	138	0.46923879	0.441609421	0.442913386	0.441609421
17	145	0.302419355	0.282131661	0.262697023	0.262697023
18	146	0.229826353	0.246575342	0.271084337	0.229826353
19	147	0.320970043	0.304671632	0.261627907	0.261627907
20	148	0.273722628	0.258769408	0.230296827	0.230296827
28	156	0.235849057	0.22069642	0.23364486	0.22069642
29	157	0.261020882	0.262390671	0.265017668	0.261020882
30	158	0.25862069	0.250417362	0.23340249	0.23340249
39	167	0.102295976	0.098274732	0.097677447	0.097677447
40	168	0.120032009	0.121326503	0.131195335	0.120032009
41	169	0.127442651	0.133888724	0.136612022	0.127442651
42	170	0.111773472	0.102017683	0.102412381	0.102017683
43	171	0.223992036	0.158898305	0.109943806	0.109943806
53	181	0.104070305	0.101925255	0.105140187	0.101925255

54	182	0.13321492	0.140274314	0.146914789	0.13321492
55	183	0.116159009	0.117248567	0.12145749	0.116159009
56	184	0.139017609	0.114242193	0.096133305	0.096133305

c) Scaling factor for front array n258

Beam ID 1	Beam ID 2	S_LB	S_MB	S_HB	S
2		1.319648094	0.945378151	0.965665236	0.945378151
5		1.145038168	1.07398568	1.111111111	1.07398568
8		1.226158038	1.034482759	1.041666667	1.034482759
11		1.066350711	0.951374207	0.910931174	0.910931174
12		1.156812339	0.916496945	0.873786408	0.873786408
21		0.698757764	0.747508306	0.809352518	0.698757764
22		0.487540628	0.496141125	0.546116505	0.487540628
23		0.567465322	0.442043222	0.421743205	0.421743205
24		0.758853288	0.680786687	0.735294118	0.680786687
31		0.873786408	0.627615063	0.607287449	0.607287449
32		0.650289017	0.502793296	0.463917526	0.463917526
33		0.836431227	0.605652759	0.642857143	0.605652759
44		0.244432374	0.205291971	0.194468453	0.194468453
45		0.227848101	0.177935943	0.179425837	0.177935943
46		0.308641975	0.249445676	0.222662048	0.222662048
47		0.35488959	0.193133047	0.204824761	0.193133047
48		0.385273973	0.358851675	0.371593724	0.358851675
57		0.247116969	0.197628458	0.194805195	0.194805195
58		0.314685315	0.25466893	0.239616613	0.239616613
59		0.275735294	0.185032895	0.178713264	0.178713264
60		0.401785714	0.272562084	0.299401198	0.272562084
130		1.133501259	0.806451613	0.765306122	0.765306122
133		0.957446809	0.933609959	0.868725869	0.868725869
136		1.006711409	0.806451613	0.831792976	0.806451613
139		0.997782705	0.775862069	0.778546713	0.775862069
140		1.130653266	0.898203593	0.857142857	0.857142857
149		0.573248408	0.46201232	0.535077289	0.46201232
150		0.387596899	0.340909091	0.320284698	0.320284698
151		0.563909774	0.514285714	0.548780488	0.514285714
152		0.666666667	0.594451783	0.589005236	0.589005236
159		0.387596899	0.340909091	0.320284698	0.320284698
160		0.402864816	0.362318841	0.345887779	0.345887779
161		0.423330198	0.38071066	0.346420323	0.346420323
172		0.189393939	0.155709343	0.154109589	0.154109589
173		0.203989121	0.187891441	0.180940893	0.180940893
174		0.223658052	0.191734129	0.206232814	0.191734129
175		0.188363332	0.17674784	0.189553496	0.17674784
176		0.244831338	0.247797357	0.26193248	0.244831338
185		0.188048475	0.171624714	0.155817175	0.155817175
186		0.197455024	0.180505415	0.194049159	0.180505415
187		0.232078391	0.19771529	0.202156334	0.19771529

188		0.19771529	0.198325253	0.220913108	0.19771529
2	130	0.441176471	0.36794767	0.342205323	0.342205323
5	133	0.45045045	0.380067568	0.352941176	0.352941176
8	136	0.46728972	0.35238841	0.348567002	0.348567002
11	139	0.429389313	0.354609929	0.333333333	0.333333333
12	140	0.525700935	0.436046512	0.383631714	0.383631714
21	149	0.290885585	0.237216658	0.255536627	0.237216658
22	150	0.193965517	0.171102662	0.17090771	0.17090771
23	151	0.23340249	0.19035533	0.192719486	0.19035533
24	152	0.36794767	0.327510917	0.296052632	0.296052632
31	159	0.284270373	0.225112556	0.225790266	0.225112556
32	160	0.252242152	0.22889115	0.218128938	0.218128938
33	161	0.284450063	0.249722531	0.246036085	0.246036085
44	172	0.107758621	0.085583872	0.083861349	0.083861349
45	173	0.100829039	0.085943468	0.080515298	0.080515298
46	174	0.118796199	0.092554504	0.086157381	0.086157381
47	175	0.109863281	0.085227273	0.097889928	0.085227273
48	176	0.130283729	0.124446903	0.1276958	0.124446903
57	185	0.104094379	0.085130533	0.079435128	0.079435128
58	186	0.114708132	0.096566524	0.095887492	0.095887492
59	187	0.109836466	0.081124932	0.080630711	0.080630711
60	188	0.120870266	0.112415688	0.11715699	0.112415688

d) Scaling factor for top array n261

Beam ID 1	Beam ID 2	S_LB	S_MB	S_HB	S
0		0.807899461	0.863723608	0.71884984	0.71884984
3		0.980392157	0.918367347	0.96359743	0.918367347
6		1.058823529	1.063829787	1.100244499	1.058823529
9		0.887573964	0.836431227	0.982532751	0.836431227
13		0.481798715	0.465356774	0.563909774	0.465356774
14		0.409836066	0.393356643	0.418994413	0.393356643
15		0.509626274	0.433526012	0.550795594	0.433526012
16		0.507900677	0.51843318	0.429799427	0.429799427
25		0.420168067	0.403225806	0.417827298	0.403225806
26		0.433526012	0.424528302	0.437317784	0.424528302
27		0.491803279	0.514874142	0.419384902	0.419384902
34		0.234497134	0.262085032	0.236717517	0.234497134
35		0.243638332	0.226358149	0.277435265	0.226358149
36		0.25758443	0.239107333	0.269946011	0.239107333
37		0.238221281	0.235478807	0.231481481	0.231481481
38		0.273390036	0.244034707	0.245901639	0.244034707
49		0.216034566	0.214285714	0.237341772	0.214285714
50		0.250976018	0.23340249	0.284450063	0.23340249
51		0.252383623	0.246440307	0.25210084	0.246440307
52		0.241935484	0.234497134	0.224663005	0.224663005
128		0.909090909	0.803571429	0.949367089	0.803571429
131		0.986842105	0.971922246	0.927835052	0.927835052

134		1.061320755	1.229508197	1.168831169	1.061320755
137		0.997782705	1.097560976	1.147959184	0.997782705
141		0.490196078	0.5625	0.6	0.490196078
142		0.487540628	0.501113586	0.464876033	0.464876033
143		0.442913386	0.395083406	0.506186727	0.395083406
144		0.493962678	0.407978241	0.544794189	0.407978241
153		0.489662677	0.550795594	0.638297872	0.489662677
154		0.436893204	0.433944069	0.472193075	0.433944069
155		0.493962678	0.407978241	0.544794189	0.407978241
162		0.266745702	0.328707085	0.243902439	0.243902439
163		0.259067358	0.256118384	0.299003322	0.256118384
164		0.299800133	0.290510006	0.323741007	0.290510006
165		0.241805481	0.239744273	0.242587601	0.239744273
166		0.252951096	0.240899358	0.269784173	0.240899358
177		0.227158001	0.243243243	0.256264237	0.227158001
178		0.284629981	0.288461538	0.304878049	0.284629981
179		0.283196979	0.274893097	0.284090909	0.274893097
180		0.237341772	0.228194726	0.247116969	0.228194726
0	128	0.310773481	0.346420323	0.283732661	0.283732661
3	131	0.368852459	0.375312761	0.340909091	0.340909091
6	134	0.444664032	0.406137184	0.493421053	0.406137184
9	137	0.355731225	0.411334552	0.392670157	0.355731225
13	141	0.199733688	0.216242191	0.215723873	0.199733688
14	142	0.191489362	0.18907563	0.184124386	0.184124386
15	143	0.202156334	0.186027284	0.217286335	0.186027284
16	144	0.21448999	0.208140611	0.20718232	0.20718232
25	153	0.222551929	0.22069642	0.248756219	0.22069642
26	154	0.176332288	0.184124386	0.189155107	0.176332288
27	155	0.211764706	0.205291971	0.210772834	0.205291971
34	162	0.105534709	0.123524568	0.099425541	0.099425541
35	163	0.102739726	0.094816688	0.117708606	0.094816688
36	164	0.113895216	0.107913669	0.127732047	0.107913669
37	165	0.095318788	0.094916684	0.105066542	0.094916684
38	166	0.12195122	0.112951807	0.110619469	0.110619469
49	177	0.09838216	0.098039216	0.10349586	0.098039216
50	178	0.114474688	0.103878116	0.134811264	0.103878116
51	179	0.102763188	0.102087114	0.110592283	0.102087114
52	180	0.099601594	0.097592713	0.111166008	0.097592713

e) Scaling factor for bottom array n261

Beam ID 1	Beam ID 2	S_LB	S_MB	S_HB	S
1		0.807899461	0.924024641	0.746268657	0.746268657
4		0.967741935	0.980392157	0.989010989	0.967741935
7		1.020408163	1.222826087	0.951374207	0.951374207
10		0.943396226	0.957446809	1.044083527	0.943396226
17		0.5	0.545454545	0.456389452	0.456389452
18		0.544794189	0.581395349	0.505617978	0.505617978
19		0.402504472	0.428979981	0.409090909	0.402504472

20		0.431861804	0.486486486	0.430210325	0.430210325
28		0.481798715	0.501113586	0.442043222	0.442043222
29		0.418604651	0.425330813	0.422138837	0.418604651
30		0.405405405	0.438596491	0.411334552	0.405405405
39		0.261780105	0.275735294	0.259067358	0.259067358
40		0.244964616	0.250417362	0.238600212	0.238600212
41		0.249445676	0.253378378	0.258918297	0.249445676
42		0.229709035	0.237091675	0.247524752	0.229709035
43		0.218128938	0.265800354	0.209594783	0.209594783
53		0.241157556	0.246981339	0.23659306	0.23659306
54		0.252808989	0.258027523	0.248344371	0.248344371
55		0.247252747	0.253807107	0.265800354	0.247252747
56		0.208526413	0.229007634	0.215723873	0.208526413
129		0.875486381	0.849056604	0.961538462	0.849056604
132		0.9375	1.022727273	1.071428571	0.9375
135		1.081730769	1.343283582	1.086956522	1.081730769
138		1.071428571	1.203208556	1.162790698	1.071428571
145		0.455465587	0.457317073	0.581395349	0.455465587
146		0.439882698	0.441609421	0.482832618	0.439882698
147		0.488599349	0.496141125	0.484391819	0.484391819
148		0.516647532	0.62849162	0.576184379	0.516647532
156		0.548780488	0.606469003	0.573979592	0.548780488
157		0.460122699	0.464876033	0.470219436	0.460122699
158		0.504484305	0.646551724	0.539568345	0.504484305
167		0.249445676	0.280548628	0.310559006	0.249445676
168		0.284270373	0.286806883	0.280024891	0.280024891
169		0.288461538	0.296052632	0.301204819	0.288461538
170		0.238853503	0.252951096	0.257731959	0.238853503
171		0.267220903	0.353495679	0.285714286	0.267220903
181		0.244964616	0.262085032	0.262697023	0.244964616
182		0.312066574	0.302216253	0.313152401	0.302216253
183		0.26929982	0.277264325	0.281074329	0.26929982
184		0.234131113	0.280024891	0.252808989	0.234131113
1	129	0.347490347	0.406137184	0.313370474	0.313370474
4	132	0.369155045	0.411710887	0.392327812	0.369155045
7	135	0.440744368	0.463917526	0.495594714	0.440744368
10	138	0.407608696	0.479744136	0.432692308	0.407608696
17	145	0.223214286	0.23400936	0.232318018	0.223214286
18	146	0.235355649	0.241545894	0.249169435	0.235355649
19	147	0.195058518	0.200088928	0.192802057	0.192802057
20	148	0.224215247	0.249584027	0.246710526	0.224215247
28	156	0.222882615	0.242587601	0.224215247	0.222882615
29	157	0.185185185	0.19676432	0.188363332	0.185185185
30	158	0.189155107	0.211267606	0.20746888	0.189155107
39	167	0.118234367	0.126903553	0.131771596	0.118234367
40	168	0.103092784	0.107578293	0.107681263	0.103092784
41	169	0.117801047	0.117096019	0.129682997	0.117096019
42	170	0.098662574	0.099118943	0.114155251	0.098662574
43	171	0.102365787	0.128939828	0.098966351	0.098966351

53	181	0.099778271	0.104456825	0.10989011	0.099778271
54	182	0.112669004	0.115889776	0.116640747	0.112669004
55	183	0.111607143	0.109196797	0.128792215	0.109196797
56	184	0.097698654	0.107091861	0.109038042	0.097698654

f) Scaling factor for front array n261

Beam ID 1	Beam ID 2	S_LB	S_MB	S_HB	S
2		0.563909774	0.574712644	0.57106599	0.563909774
5		0.598404255	0.603217158	0.601604278	0.598404255
8		0.592885375	0.6	0.597609562	0.592885375
11		0.592105263	0.625869263	0.592105263	0.592105263
12		0.732899023	0.666666667	0.818181818	0.666666667
21		0.340651022	0.356294537	0.336826347	0.336826347
22		0.304878049	0.304465494	0.309278351	0.304465494
23		0.269622528	0.27124774	0.27607362	0.269622528
24		0.266745702	0.267697799	0.272397094	0.266745702
31		0.351837373	0.366748166	0.347222222	0.347222222
32		0.365556458	0.363783347	0.369458128	0.363783347
33		0.281778334	0.287907869	0.284270373	0.281778334
44		0.22069642	0.224663005	0.212364323	0.212364323
45		0.153374233	0.154479918	0.153688525	0.153374233
46		0.12482663	0.120288693	0.130548303	0.120288693
47		0.139794967	0.139925373	0.14317531	0.139794967
48		0.142993327	0.147783251	0.14317531	0.142993327
57		0.18734388	0.189234651	0.185109009	0.185109009
58		0.130472601	0.127732047	0.1340882	0.127732047
59		0.135175728	0.133848899	0.139578164	0.133848899
60		0.139318885	0.141643059	0.140537164	0.139318885
130		0.572519084	0.582901554	0.571791614	0.571791614
133		0.6	0.603217158	0.600801068	0.6
136		0.65885798	0.664697194	0.651230101	0.651230101
139		0.642857143	0.648414986	0.641025641	0.641025641
140		0.775862069	0.752508361	0.793650794	0.752508361
149		0.317572336	0.318696884	0.314465409	0.314465409
150		0.341685649	0.35321821	0.335070737	0.335070737
151		0.279850746	0.280723643	0.283375315	0.279850746
152		0.26929982	0.267062315	0.274390244	0.267062315
159		0.344299923	0.351014041	0.337078652	0.337078652
160		0.296247531	0.300601202	0.297029703	0.296247531
161		0.274557657	0.267857143	0.279156328	0.267857143
172		0.211964202	0.218978102	0.202794051	0.202794051
173		0.193215973	0.20746888	0.181378476	0.181378476
174		0.159179342	0.157839355	0.161406026	0.157839355
175		0.119936034	0.116039195	0.125838926	0.116039195
176		0.14186633	0.13803681	0.142045455	0.13803681
185		0.228658537	0.239616613	0.217286335	0.217286335
186		0.179282869	0.185032895	0.174757282	0.174757282

187		0.124309392	0.12145749	0.128571429	0.12145749
188		0.136529126	0.132197415	0.14084507	0.132197415
2	130	0.263004091	0.275229358	0.260869565	0.260869565
5	133	0.284450063	0.296052632	0.277949351	0.277949351
8	136	0.30262273	0.306748466	0.297029703	0.297029703
11	139	0.301003344	0.304259635	0.294888598	0.294888598
12	140	0.308219178	0.306330837	0.314026518	0.306330837
21	149	0.154109589	0.161579892	0.149900067	0.149900067
22	150	0.157950158	0.16562385	0.153113304	0.153113304
23	151	0.135705669	0.136116152	0.138418948	0.135705669
24	152	0.126404494	0.125348189	0.129124821	0.125348189
31	159	0.158394931	0.171037628	0.152181265	0.152181265
32	160	0.203343877	0.208140611	0.199556541	0.199556541
33	161	0.131118881	0.130434783	0.132042254	0.130434783
44	172	0.102552416	0.10248235	0.100716204	0.100716204
45	173	0.081907535	0.085356601	0.079660117	0.079660117
46	174	0.063866023	0.064157399	0.064599483	0.063866023
47	175	0.061864174	0.061787725	0.063380282	0.061787725
48	176	0.067842605	0.068838917	0.067024129	0.067024129
57	185	0.09155646	0.094201382	0.089730808	0.089730808
58	186	0.067144136	0.068902159	0.066273932	0.066273932
59	187	0.062283737	0.061500615	0.06454389	0.061500615
60	188	0.063220006	0.063255552	0.063820735	0.063220006

g) *Scaling factor for top array n260*

Beam ID 1	Beam ID 2	S_LB	S_MB	S_HB	S
0		0.738916256	0.731707317	0.9375	0.731707317
3		0.67264574	0.802139037	1.442307692	0.67264574
6		0.79086116	1.226158038	1.410658307	0.79086116
9		0.868725869	0.935550936	1.145038168	0.868725869
13		0.36407767	0.388265746	0.466804979	0.36407767
14		0.389273356	0.429799427	0.655976676	0.389273356
15		0.374064838	0.373134328	0.667655786	0.373134328
16		0.357995227	0.360866079	0.500556174	0.357995227
25		0.37468776	0.421743205	0.526932084	0.37468776
26		0.391986063	0.400712378	0.778546713	0.391986063
27		0.362610798	0.360576923	0.57106599	0.360576923
34		0.216972035	0.258472142	0.335820896	0.216972035
35		0.230769231	0.247933884	0.341945289	0.230769231
36		0.222993062	0.228542407	0.394736842	0.222993062
37		0.205761317	0.285532995	0.408719346	0.205761317
38		0.214387804	0.27059531	0.306330837	0.214387804
49		0.236096537	0.27059531	0.319148936	0.236096537
50		0.227158001	0.221565731	0.369458128	0.221565731
51		0.215517241	0.245901639	0.487012987	0.215517241
52		0.205291971	0.290510006	0.338345865	0.205291971
128		0.86042065	0.779896014	0.850661626	0.779896014

131		0.79928952	0.87040619	1.206434316	0.79928952
134		0.873786408	0.885826772	1.311953353	0.873786408
137		0.896414343	0.976138829	1.41509434	0.896414343
141		0.423330198	0.460593654	0.732899023	0.423330198
142		0.450901804	0.426540284	0.55487053	0.426540284
143		0.519630485	0.540865385	0.697674419	0.519630485
144		0.392327812	0.481798715	0.488599349	0.392327812
153		0.422932331	0.482315113	0.523864959	0.422932331
154		0.487540628	0.569620253	0.75	0.487540628
155		0.444664032	0.431861804	0.738916256	0.431861804
162		0.240256273	0.236468734	0.330882353	0.236468734
163		0.207756233	0.262085032	0.291073739	0.207756233
164		0.229124236	0.217917676	0.305498982	0.217917676
165		0.252667041	0.254237288	0.32967033	0.252667041
166		0.259815242	0.246981339	0.364667747	0.246981339
177		0.222772277	0.284810127	0.32234957	0.222772277
178		0.220156556	0.227043391	0.301204819	0.220156556
179		0.242065627	0.216346154	0.304878049	0.216346154
180		0.258472142	0.272067715	0.344827586	0.258472142
0	128	0.335070737	0.348027842	0.379106992	0.335070737
3	131	0.308853809	0.402864816	0.560398506	0.308853809
6	134	0.389948007	0.485436893	0.589777195	0.389948007
9	137	0.396825397	0.440313112	0.583657588	0.396825397
13	141	0.168602473	0.181378476	0.26439483	0.168602473
14	142	0.180650341	0.1888376	0.246845858	0.180650341
15	143	0.210084034	0.220913108	0.361736334	0.210084034
16	144	0.172612198	0.174351027	0.212164074	0.172612198
25	153	0.172744722	0.193881947	0.206422018	0.172744722
26	154	0.207564576	0.225112556	0.343773873	0.207564576
27	155	0.186799502	0.172347759	0.303234501	0.172347759
34	162	0.091855481	0.10853835	0.140625	0.091855481
35	163	0.095117311	0.108906099	0.126939351	0.095117311
36	164	0.102833638	0.100693667	0.140318054	0.100693667
37	165	0.098749177	0.112838516	0.164774808	0.098749177
38	166	0.099337748	0.107066381	0.137362637	0.099337748
49	177	0.095278425	0.116399379	0.131926121	0.095278425
50	178	0.107424206	0.105708245	0.142090306	0.105708245
51	179	0.105609012	0.098231827	0.14372405	0.098231827
52	180	0.093438538	0.117647059	0.141464948	0.093438538

h) Scaling factor for bottom array n260

Beam ID 1	Beam ID 2	S_LB	S_MB	S_HB	S
1		0.705329154	0.75	0.896414343	0.705329154
4		0.665680473	0.822669104	1.505016722	0.665680473
7		0.793650794	1.209677419	1.525423729	0.793650794
10		0.862068966	0.903614458	1.2	0.862068966
17		0.341167551	0.365556458	0.506186727	0.341167551
18		0.357142857	0.383631714	0.679758308	0.357142857

19		0.374064838	0.445986125	0.563909774	0.374064838
20		0.34351145	0.372825186	0.476694915	0.34351145
28		0.344827586	0.367346939	0.580645161	0.344827586
29		0.38593482	0.435203095	0.72	0.38593482
30		0.356859635	0.411710887	0.470711297	0.356859635
39		0.207277752	0.253093363	0.327749454	0.207277752
40		0.19982238	0.293733681	0.429389313	0.19982238
41		0.220804711	0.235478807	0.366449511	0.220804711
42		0.23659306	0.267697799	0.335320417	0.23659306
43		0.20746888	0.237717908	0.363783347	0.20746888
53		0.202976996	0.283375315	0.361445783	0.202976996
54		0.21256495	0.251396648	0.501672241	0.21256495
55		0.23340249	0.23340249	0.35488959	0.23340249
56		0.215105163	0.260416667	0.364667747	0.215105163
129		0.833333333	0.779896014	0.841121495	0.779896014
132		0.779896014	0.850661626	1.246537396	0.779896014
135		0.831792976	0.947368421	1.260504202	0.831792976
138		1.032110092	1.40625	1.750972763	1.032110092
145		0.487012987	0.576184379	0.782608696	0.487012987
146		0.505617978	0.651230101	0.721153846	0.505617978
147		0.428979981	0.436893204	0.551470588	0.428979981
148		0.395083406	0.483351235	0.509049774	0.395083406
156		0.439453125	0.453172205	0.730519481	0.439453125
157		0.443349754	0.391644909	0.522648084	0.391644909
158		0.395083406	0.493962678	0.675675676	0.395083406
167		0.265330189	0.282485876	0.392327812	0.265330189
168		0.248618785	0.283911672	0.32967033	0.248618785
169		0.222332016	0.218765192	0.3	0.218765192
170		0.216972035	0.258027523	0.3125	0.216972035
171		0.256118384	0.267062315	0.386266094	0.256118384
181		0.269622528	0.289389068	0.38071066	0.269622528
182		0.235725511	0.235355649	0.311634349	0.235355649
183		0.221565731	0.229591837	0.292778139	0.221565731
184		0.219084713	0.294695481	0.336826347	0.219084713
1	129	0.330882353	0.354609929	0.37437604	0.330882353
4	132	0.298606503	0.402864816	0.570342205	0.298606503
7	135	0.384944397	0.485436893	0.624133148	0.384944397
10	138	0.437317784	0.499445061	0.619834711	0.437317784
17	145	0.224438903	0.21256495	0.338855422	0.21256495
18	146	0.207277752	0.234864301	0.353773585	0.207277752
19	147	0.169300226	0.187891441	0.229007634	0.169300226
20	148	0.163636364	0.185950413	0.202065559	0.163636364
28	156	0.18404908	0.178926441	0.296052632	0.178926441
29	157	0.185032895	0.19676432	0.26929982	0.185032895
30	158	0.164413592	0.185950413	0.247933884	0.164413592
39	167	0.09710833	0.106032045	0.149055979	0.09710833
40	168	0.092232015	0.117677824	0.160944206	0.092232015
41	169	0.099977783	0.103282075	0.143084261	0.099977783
42	170	0.097234226	0.110782866	0.121885157	0.097234226

43	171	0.091930541	0.102412381	0.160944206	0.091930541
53	181	0.098576123	0.121130552	0.152490681	0.098576123
54	182	0.098339161	0.102599179	0.151668352	0.098339161
55	183	0.10460251	0.109569028	0.139362032	0.10460251
56	184	0.092383494	0.118421053	0.136653507	0.092383494

i) Scaling factor for front array n260

Beam ID 1	Beam ID 2	S_LB	S_MB	S_HB	S
2		1.319648094	1.071428571	1.145038168	1.071428571
5		1.41955836	1.285714286	1.187335092	1.187335092
8		1.446945338	1.216216216	1.222826087	1.216216216
11		1.595744681	1.226158038	1.19047619	1.19047619
12		0.891089109	0.880626223	0.830258303	0.830258303
21		0.633802817	0.521436848	0.540865385	0.521436848
22		0.729335494	0.63559322	0.603217158	0.603217158
23		0.925925926	0.844277674	0.844277674	0.844277674
24		0.71656051	0.762711864	0.769230769	0.71656051
31		0.612244898	0.471698113	0.459183673	0.459183673
32		0.57106599	0.597609562	0.547445255	0.547445255
33		0.855513308	0.933609959	0.885826772	0.855513308
44		0.26849642	0.258769408	0.3	0.258769408
45		0.304054054	0.204266909	0.209107807	0.204266909
46		0.454086781	0.362318841	0.407608696	0.362318841
47		0.29201817	0.376884422	0.359138069	0.29201817
48		0.279850746	0.249169435	0.284810127	0.249169435
57		0.26929982	0.266587678	0.26439483	0.26439483
58		0.334075724	0.264550265	0.244565217	0.244565217
59		0.345092025	0.388936906	0.339366516	0.339366516
60		0.321658327	0.294695481	0.342987805	0.294695481
130		0.986842105	1.034482759	1.07398568	0.986842105
133		1.130653266	1.111111111	1.145038168	1.111111111
136		1.253481894	1.171875	1.174934726	1.171875
139		1.086956522	1.219512195	1.19047619	1.086956522
140		1.048951049	1.184210526	1.327433628	1.048951049
149		0.586701434	0.632022472	0.634696756	0.586701434
150		0.537634409	0.705329154	0.74875208	0.537634409
151		0.583657588	0.680786687	0.703125	0.583657588
152		0.557620818	0.651230101	0.629370629	0.557620818
159		0.496688742	0.519031142	0.60483871	0.496688742
160		0.53699284	0.508474576	0.506756757	0.506756757
161		0.584415584	0.618982118	0.543478261	0.543478261
172		0.252667041	0.287723785	0.328467153	0.252667041
173		0.230414747	0.312283137	0.347490347	0.230414747
174		0.27124774	0.26193248	0.283196979	0.26193248
175		0.307377049	0.361736334	0.291073739	0.291073739
176		0.250278087	0.308219178	0.330154072	0.250278087
185		0.2681764	0.322580645	0.32942899	0.2681764

186		0.266745702	0.272067715	0.327034884	0.266745702
187		0.24766098	0.321199143	0.327510917	0.24766098
188		0.303234501	0.332594235	0.290322581	0.290322581
2	130	0.472193075	0.430210325	0.454545455	0.430210325
5	133	0.505050505	0.535077289	0.467775468	0.467775468
8	136	0.533175355	0.525087515	0.477707006	0.477707006
11	139	0.573248408	0.523255814	0.5	0.5
12	140	0.380067568	0.458248473	0.43902439	0.380067568
21	149	0.282840981	0.240899358	0.26193248	0.240899358
22	150	0.324675325	0.397526502	0.391304348	0.324675325
23	151	0.306122449	0.320056899	0.299003322	0.299003322
24	152	0.277949351	0.301204819	0.288646568	0.277949351
31	159	0.345092025	0.361155698	0.381355932	0.345092025
32	160	0.321428571	0.376569038	0.377516779	0.321428571
33	161	0.310559006	0.355169692	0.283732661	0.283732661
44	172	0.121293801	0.113579001	0.132042254	0.113579001
45	173	0.123051682	0.115207373	0.114329268	0.114329268
46	174	0.160142349	0.127768313	0.133610451	0.127768313
47	175	0.134851663	0.160370634	0.14159849	0.134851663
48	176	0.119110641	0.122615804	0.134048257	0.119110641
57	185	0.118670886	0.130851992	0.144601542	0.118670886
58	186	0.13562387	0.136239782	0.126015122	0.126015122
59	187	0.142630745	0.144508671	0.138846035	0.138846035
60	188	0.148957299	0.147637795	0.143907899	0.143907899

Appendix C: Additional Verifications for GEN 2

The PD for GEN2 cannot be finalized until the additional verifications described in this section are performed and passed. The below steps are followed for verifications in the mid channel [4]. Please be noted due to timeline, the verifications are not performed using the final version of codebook.

VERIFICATION 1: Use "Qualcomm MG script" to print the PD plots for all the beams selected and evaluated for model validation. Compare the printed PD plot to the corresponding simulated/measured PD, the printed PD distributions should match the simulated PD distributions as shown in Table C.1, C.4 and C.7 verify that "Qualcomm MG script" is properly used.

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

Use HFSS (or other EM simulation tool) 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

$$csimulated\ (i, j) = 4cm^2\ PD\ at\ (x, y, z)\ at\ verification.\ sim.\ power\ limit\ /\ PD\_design\_target$$

Verify:

1. the printed contribution factor, $c(i,j)$, matches the simulated contribution factor, $c_{simulated}(i,j)$, obtained from HFSS (or other EM simulation tool) within 2% of numerical tolerance.
2. the normalized *combined PD* 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 antenna module + PD contributions from other antenna modules; b_j = backoff value for antenna module j, j = antenna module #; $c(i,j)$ = contribution factor of beam i from antenna module j to the worst 4cm^2 PD. Both bj and $c(i,j)$ are printed from "Qualcomm MG script".

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 4cm^2 PD(i,j) for beam i from antenna module j at their *input.power.limit*. Demonstrate that the *combined PD* (i.e., $\sum[c(i,j)*PD(i,j)]$) is less than or equal to *PD_design_target* within the uncertainty at reference power level, i.e., *combined PD* = $\sum[c(i,j)*measured\ 4cm^2\ PD(i,j)] \leq PD\_design\_target$ + uncertainty **at reference power level.**

As an example of one of the iPad programs, which contains 3 antenna modules (top, bottom and front), the following verifications are for n258, n261 and n260 respectively.

1) Band n258

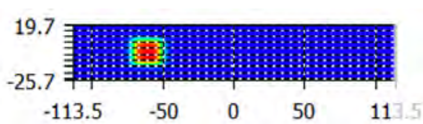
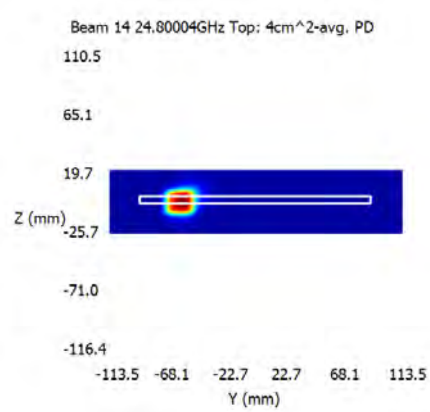
"Qualcomm MG script" identifies worst beam for module 0 is 14, worst beam for module 1 is 168 and for module 2 is 24. The script prints below information corresponding to the identified worst-case 4cm^2 PD:

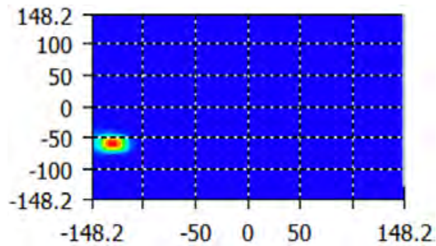
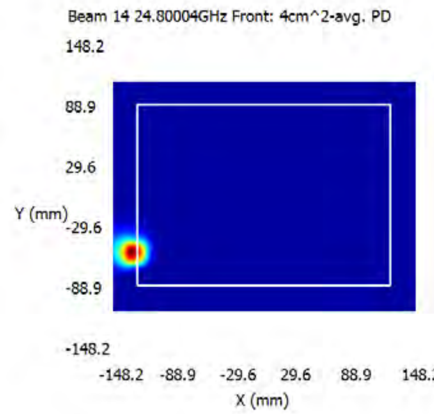
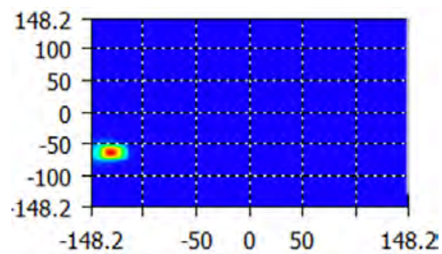
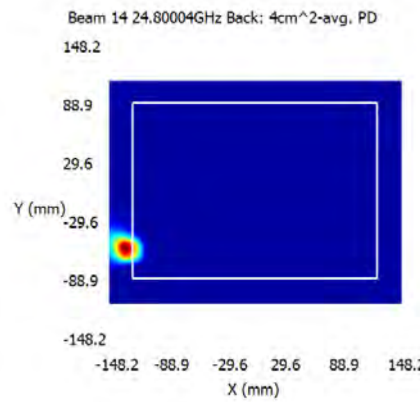
- the backoff values (in linear) for Module 0, Module 1 and Module 2: b_0 = 0.9772; b_1 = 0.9772; b_2 = 0.9772
- the worst location coordinates (*x, y, z*) in meter = (-0.12582, -0.05626, -0.00195) the worst-surface = S5 (top surface, see Table C.1)
- the verification.sim.power limit (before backoff) for the beams for module 0, beam 14 is 4.20 dBm, for module 1, beam 168 is 2.25 dBm and for module 2, beam 24 is 4.33 dBm
- worst surface for Module 0 is S5 (top); worst surface for Module 1 is S6 (bottom); worst surface for Module 2 is S1 (front); the contribution factors *c*(14*, 0*) = 1.000, *c*(*168, 1*) = 0.0002 and *c*(*24, 2*) = 0.0117 at the worst-case 4cm^2 PD location (-0.12582, -0.05626, -0.00195)

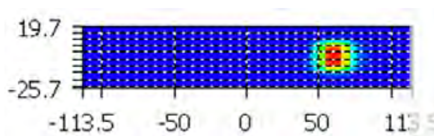
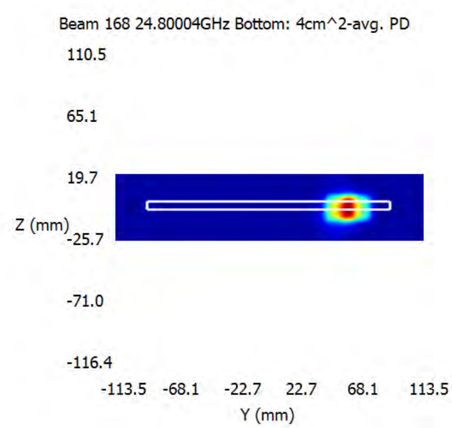
As shown in Table C.2, the printed contribution factor matches the simulated contribution factor ~ 2%, and the *normalized combined PD* is less than 1.0. Thus, the verification 2 is completed for this program.

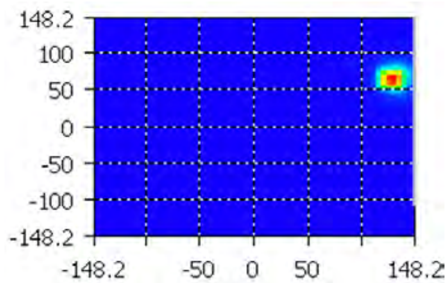
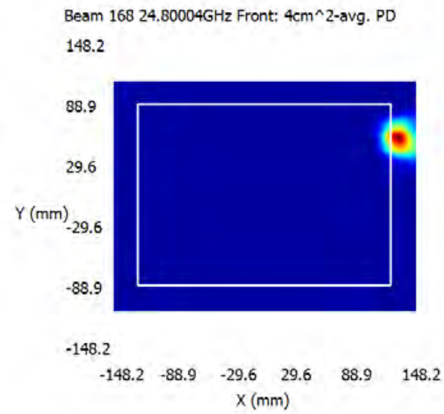
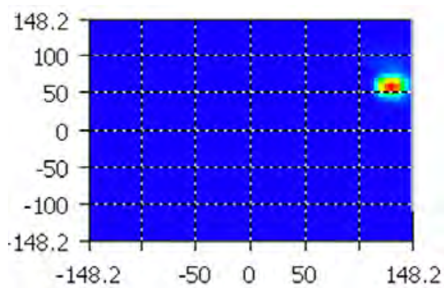
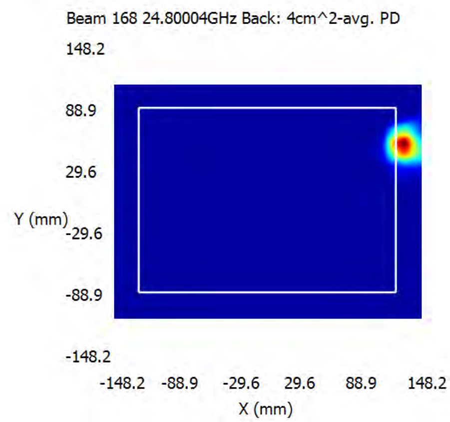
As shown in Table C.3, the *combined* measured *PD* at the worst location ≤ *PD_design_target* uncertainty at reference power level. Thus, the verification 3 is competed for this program.

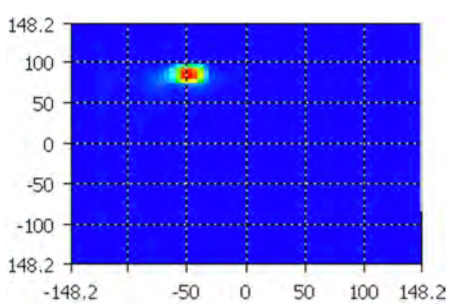
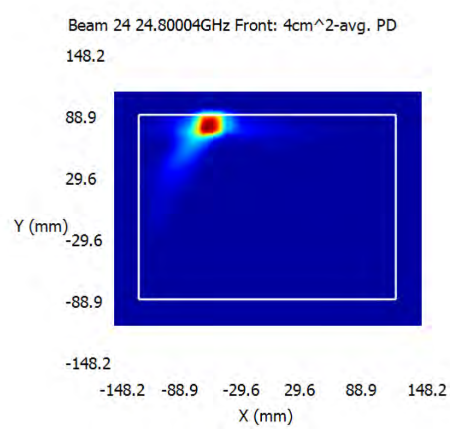
Table C.1 - Simulated PD distributions for selected beams

Beam ID	Surface	Simulated Point PD (from CST Studio Suite)	Simulated Point PD (from MG Script)
14	**S5**		

	S1		
	S2		

Beam ID	**Surface**	**Simulated Point PD (from CST Studio Suite)**	**Simulated Point PD (from MG Script)**
168	**S6**		

	S1		
	S2		

Beam ID	Surface	Simulated Point PD (from CST Studio Suite)	Simulated Point PD (from MG Script)
24	**S1**		

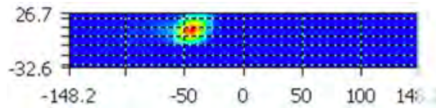
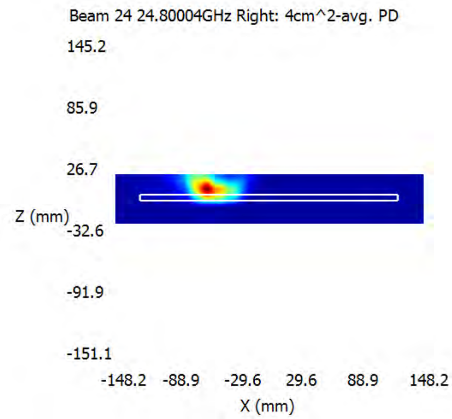
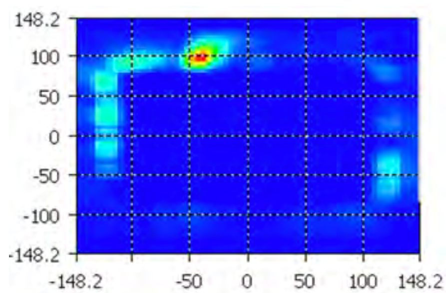
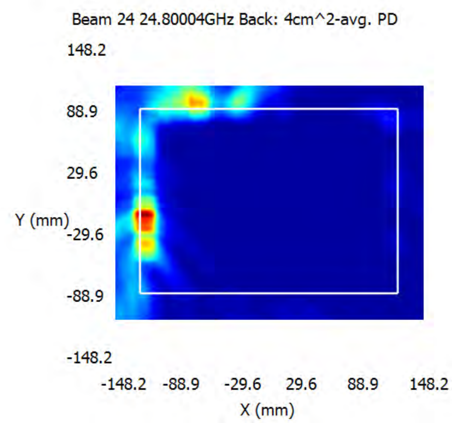
	S4		
	S2		

Table C.2 - Contribution factors from Qualcomm MG script and from CST Studio Suite for selected beams, and normalized combined PD verification, for device with 3 antenna modules

Worse-case surface					S5 (top surface)	
Worst-case location *(x,y,z)* in meters					(-0.12582, -0.05626, -0.00195)	
PD_design_target (W/m^2)					4.5	
Value printed by MG Script					Value by EM tool	
Module #	Beam ID	*c(i ,j)*, *i*=beam ID, *j*=module #	Backoff factor b_j	$verification.sim.power_{limit}$ (before backoffs) [dBm]	Simulated 4cm^2 PD at (-0.12582, -0.05626, -0.00195) with $verification.sim.power_{limit}$ on S5 (W/m^2)	$c_{simulated}(i ,j)$
0	14	1.0000	0.9772	4.20	4.8647	4.8647/4.5 = 1.08

1	168	0.0002	0.9772	2.25	0.000765	0.000765/4.5= 0.00017
2	24	0.0117	0.9772	4.33	0.0552	0.0552/4.5= 0.0122
Verify 1	$c(i,j) = c_{simulated}(i,j)$, i = 14, 168, 24 ; j = 0, 1, 2					
Verify 2	b_0 x $c(14,0)$ + b_1 x $c(168,1)$ + b_2 x $c(24,2)$ = 0.9772 x 1.0000 + 0.9772 x 0.0002+0.9772 x 0.0117 = 0.9888 ≤ 1					

Table C.3: Measured 4cm^2 PD on worst surface and combined PD at worst-case location for device with 3 antenna modules.

Module#	Beam ID	Dominant Surface	Measured 4cm^2 PD at input.power.limit on dominant surface (W/m^2)
0	14	S5	4.16
1	168	S6	5.06
2	24	S1	6.20
combined PD at the worst-case location (*x,y,z*)			*c(14,0)* x meas.4cm^{2}PD*(14,0)* + *c(168,1)* x meas.4cm^{2}PD (168,*1)* + + *c(24,,2)* x meas.4cm^{2}PD*(24,2)* = 1.0000 x 4.16+ 0.0002 x 5.06+ 0.0117x 6.20 =4.23 W/m^2
PD_design_target + uncertainty at reference power level of 1 dB			= 4.5*10$^{(+1/10)}$ = 5.66 W/m^2
Verify			combined PD < PD_design_target + uncertainty at reference power level

Note *c(i,j)* is obtained from Table C.2.

2) *Band n261*

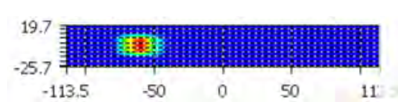
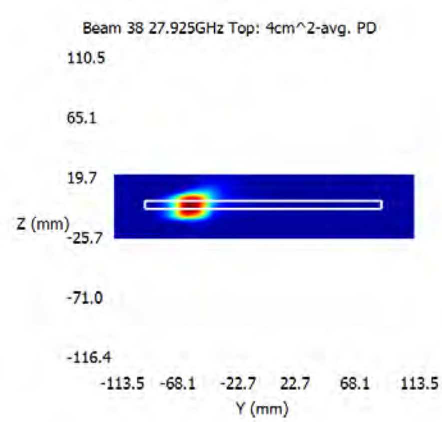
"Qualcomm MG script" identifies worst beam for module 0 is 38, worst beam for module 1 is 55 and for module 2 is 24. The script prints below information corresponding to the identified worst-case 4cm^2 PD:

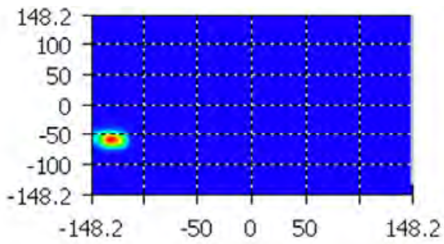
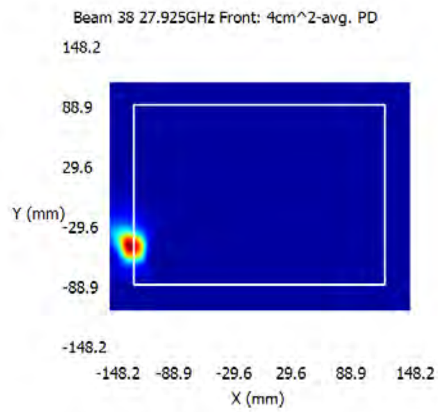
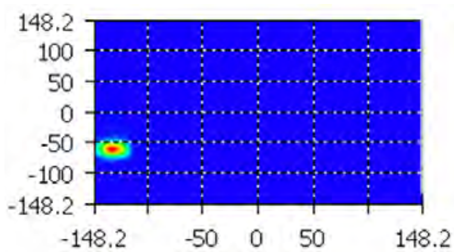
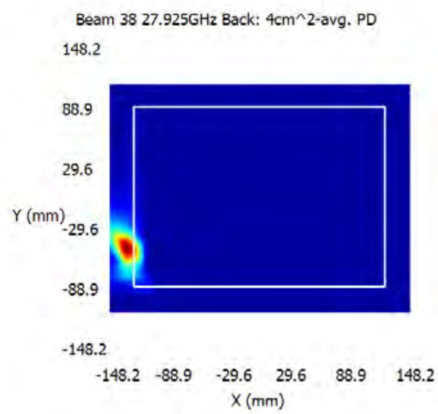
- the backoff values (in linear) for Module 0, Module 1 and Module 2: b_0 = 0.9772; b_1 = 0.9772; b_2 = 0.9772
- the worst location coordinates (*x, y, z*) in meter are (-0.05882, 0.08174, 0.00200)
- the worst-surface = S1 (Front surface, see Table C.4)
- the verification.sim.power limit (before backoff) for the beams for module 0, beam 38 is 0.37 dBm, for module 1, beam 55 is -0.07 dBm and for module 2, beam 24 is 0.26 dBm
- worst surface for Module 0 is S5 (top); worst surface for Module 1 is S6 (bottom); worst surface for Module 2 is S1 (front); the contribution factors *c*(38*, 0*) = 0.0062, *c*(*55, 1*) = 0.0005 and *c*(*24, 2*) = 1.000 at the worst-case 4cm^2 PD location (-0.05882, 0.08174, 0.00200)

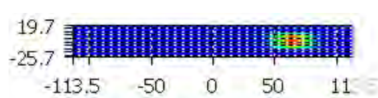
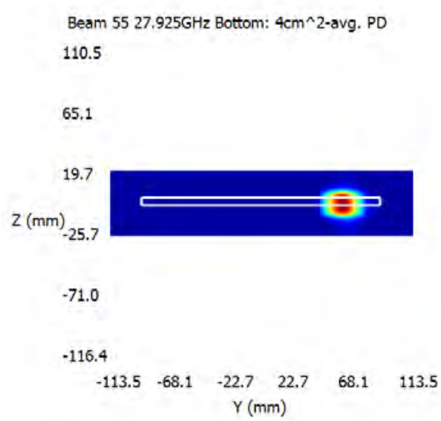
As shown in Table C.5, the printed contribution factor matches the simulated contribution factor ~ 2%, and the *normalized combined PD* is less than 1.0. Thus, the verification 2 is completed for this program.

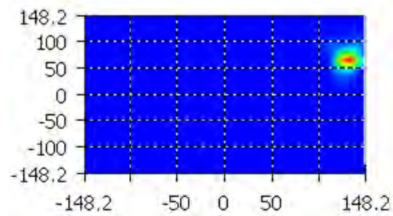
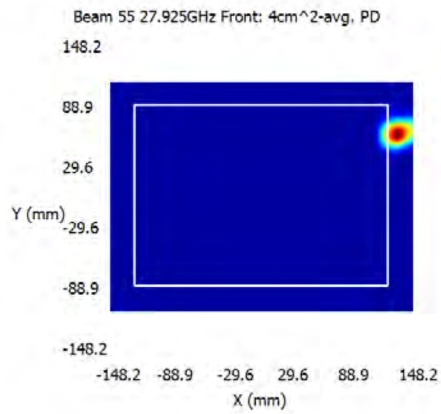
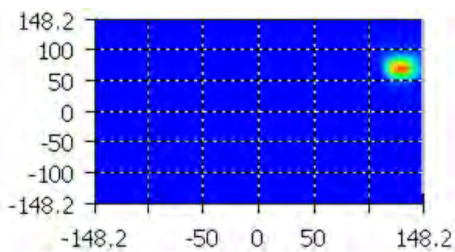
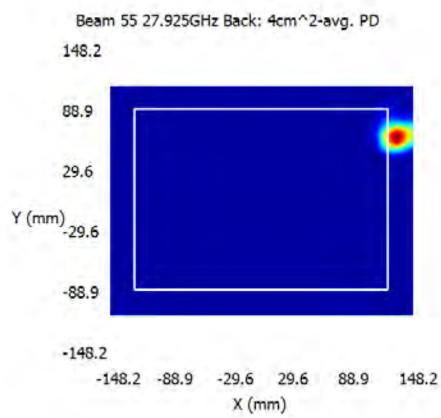
As shown in Table C.6, the *combined* measured *PD* at the worst location ≤ *PD_design_target* uncertainty at reference power level. Thus, the verification 3 is competed for this program.

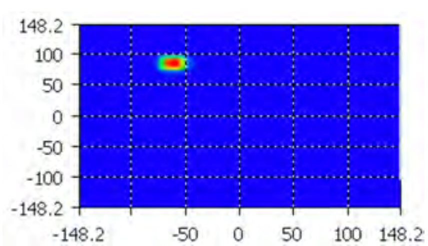
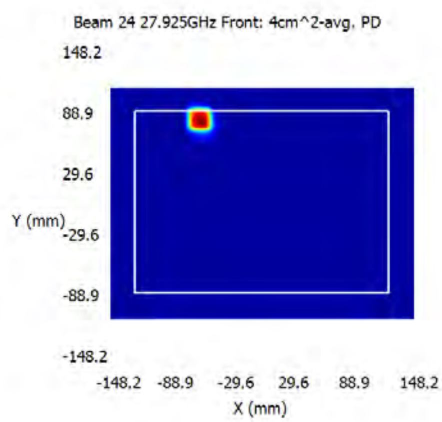
Table C.4 - Simulated PD distributions for selected beams

Beam ID	Surface	Simulated Point PD (from CST Studio Suite)	Simulated Point PD (from MG Script)
38	S5		

	S1		
	S2		

Beam ID	Surface	Simulated Point PD (from CST Studio Suite)	Simulated Point PD (from MG Script)
55	S6		

	S1		
	S2		

Beam ID	Surface	Simulated Point PD (from CST Studio Suite)	Simulated Point PD (from MG Script)
24	**S1**		

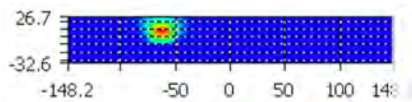
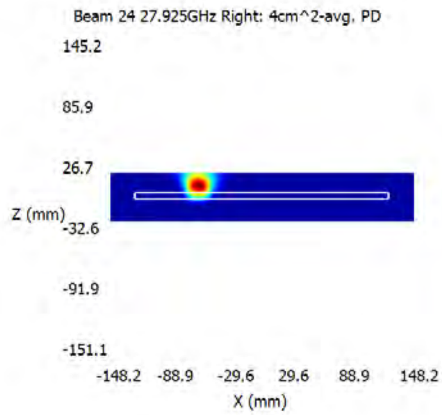
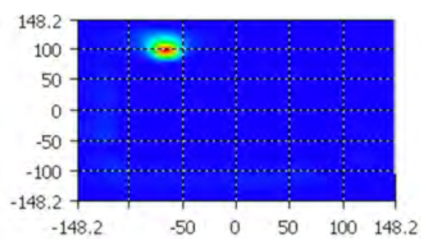
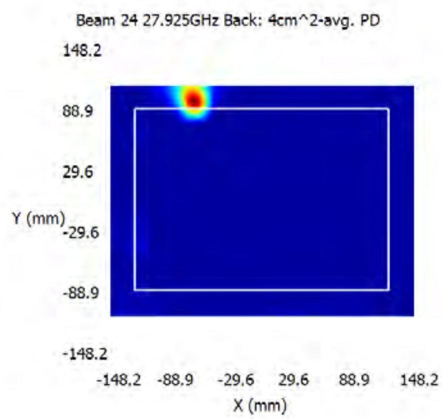
	S4		
	S2		

Table C.5 - Contribution factors from Qualcomm MG script and from HFSS for selected beams, and normalized combined PD verification, for device with 3 antenna modules

Worse-case surface					S1 (front surface)	
Worst-case location *(x,y,z)* in meters					(-0.05882, 0.08174, 0.00200)	
PD_design_target (W/m^2)					4.5	
Value printed by MG Script					Value by EM tool	
Module #	Beam ID	*c(i ,j)*, *i*=beam ID, *j*=module #	Backoff factor b_j	$verification.sim.power_{limit}$ (before backoffs) [dBm]	Simulated 4cm^2 PD at (-0.05882, 0.08174, 0.00200) with $verification.sim.power_{limit}$ on S1 (W/m^2)	$c_{simulated}(i\ ,j)$
0	38	0.0062	0.9772	0.37	0.0284	0.0284/4.5 = 0.0063

1	55	0.0005	0.9772	-0.07	0.0021	0.0021/4.5 = 0.00047
2	24	1.000	0.9772	0.26	4.8556	4.8556/4.5= 1.079
Verify 1	$c(i,j)=c_{simulated}(i,j)$, i = 38, 55, 24; j = 0, 1, 2					
Verify 2	b_0 x $c(38,0)$ + b_1 x $c(55,1)$ + b_2 x $c(24,2)$ = 0.9772 x 0.0062+ 0.9772 x 0.0005+ 0.9772 x 1.0000 = 0.9837 ≤ 1					

Table C.6: Measured 4cm² PD on worst surface and combined PD at worst-case location for device with 3 antenna modules

Module#	Beam ID	Dominant Surface	Measured 4cm² PD at input.power.limit on dominant surface (W/m²)
0	38	S5	3.77
1	55	S6	3.11
2	24	S1	1.64
combined PD at the worst-case location (*x,y,z*)			$c(38,0)$ x meas.4cm²PD$(38,0)$ + $c(55,1)$ x meas.4cm²PD$(55,1)$ + $c(24,2)$ x meas.4cm²PD$(24,2)$ = 0.0062 x 3.77 + 0.0005 x 3.11+ 1.0000 x 1.64 =1.66 W/m²
PD_design_target + uncertainty at reference power level of 1 dB			= $4.5*10^{(+1/10)}$ = 5.66 W/m²
Verify			combined PD < PD_design_target + uncertainty at reference power level

Note $c(i,j)$ is obtained from Table C.5.

3) Band n260

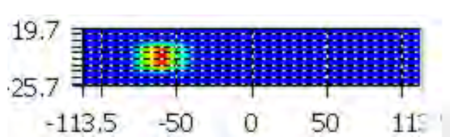
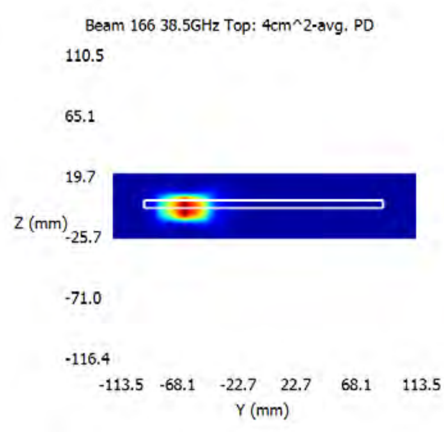
"Qualcomm MG script" identifies worst beam for module 0 is 166, worst beam for module 1 is 146 and for module 2 is 133. The script prints below information corresponding to the identified worst-case 4cm^2 PD:

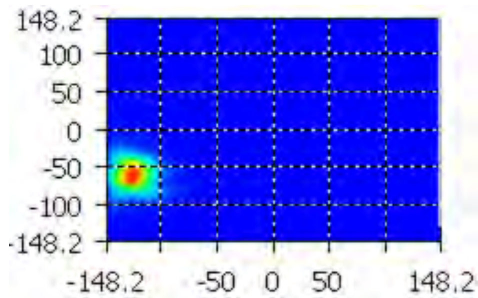
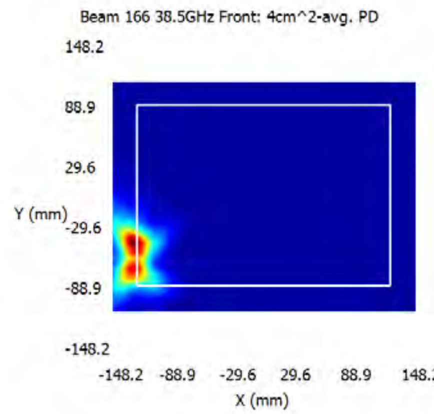
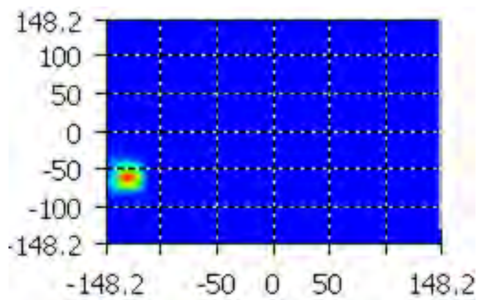
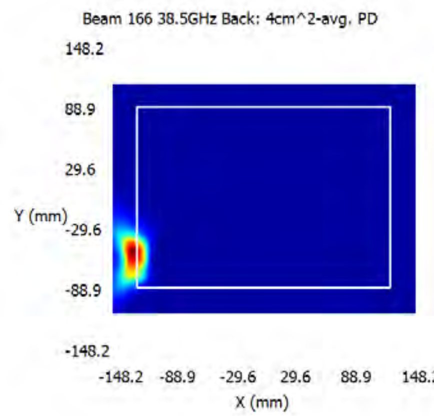
- the backoff values (in linear) for Module 0, Module 1 and Module 2: b_0 = 0.9772; b_1 = 0.9772; b_2 = 0.9772
- the worst location coordinates (*x,* y, z) in meter are (-0.04982, 0.08074, 0.00200)
- the worst-surface = S1 (Front surface, see Table C.7)
- the verification.sim.power limit (before backoff) for the beams for module 0, beam 180 is -0.07 dBm, for module 1, beam 146 is 4.14 dBm and for module 2, beam 133 is 6.46 dBm
- worst surface for Module 0 is S5 (top); worst surface for Module 1 is S6 (bottom); worst surface for Module 2 is S1 (front); the contribution factors *c(180, 0)* = 0.0051, *c*(*146, 1*) = 0.0161 and *c*(*133, 2*) = 1.0000 at the worst-case 4cm^2 PD location (-0.04982, 0.08074, 0.00200)

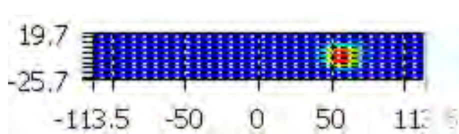
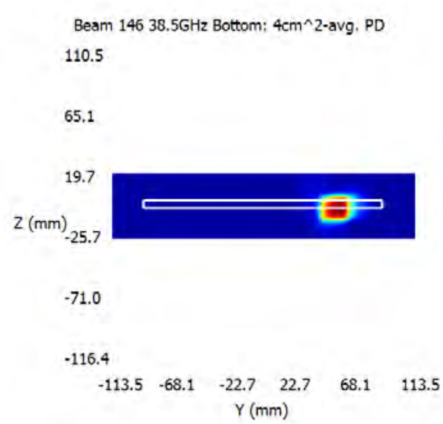
As shown in Table C.8, the printed contribution factor matches the simulated contribution factor within ~2%, and the *normalized combined PD* is less than 1.0. Thus, the verification 2 is completed for this program.

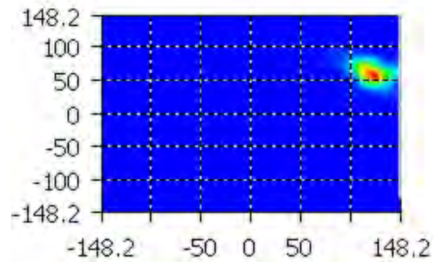
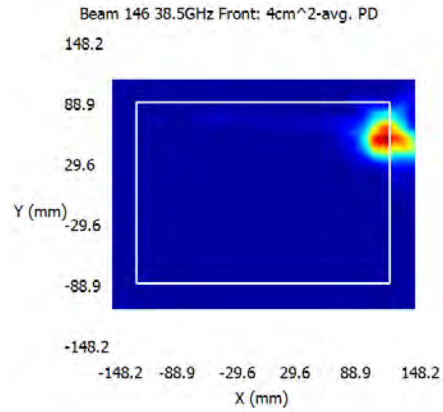
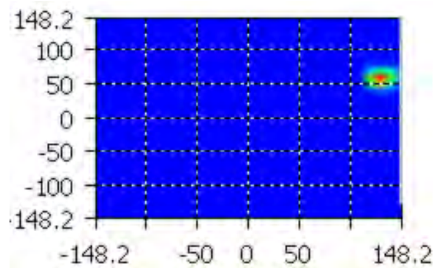
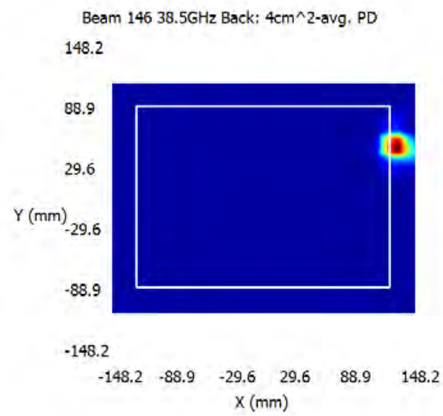
As shown in Table C.9, the *combined* measured *PD* at the worst location ≤ *PD_design_target* uncertainty at reference power level. Thus, the verification 3 is competed for this program.

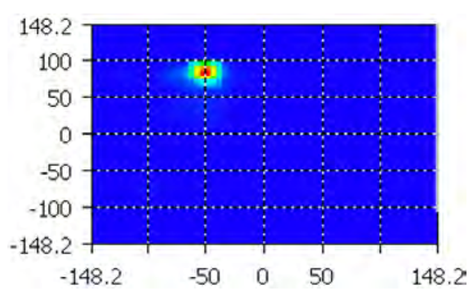
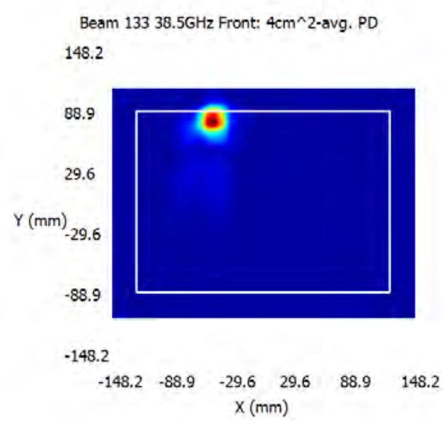
Table C.7 - Simulated PD distributions for selected beams

Beam ID	Surface	Simulated Point PD (from CST Studio Suite)	Simulated Point PD (from MG Script)
166	**S5**		

	S1		
	S2		

Beam ID	Surface	Simulated Point PD (from CST Studio Suite)	Simulated Point PD (from MG Script)
146	**S6**		

	S1		
	S2		

Beam ID	Surface	Simulated Point PD (from CST Studio Suite)	Simulated Point PD (from MG Script)
133	**S1**		

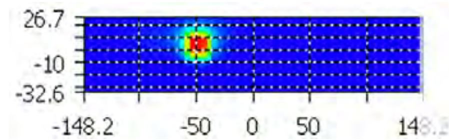
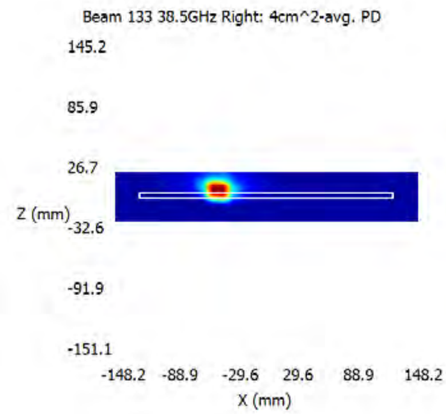
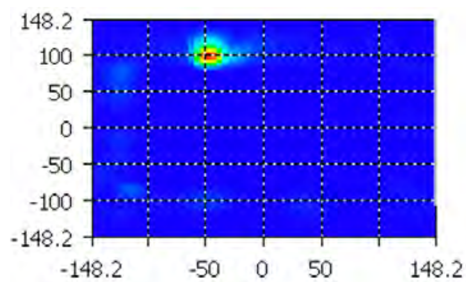
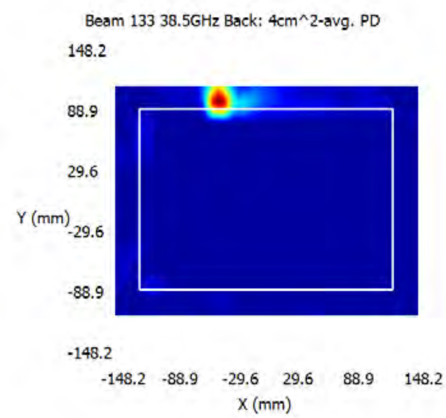
	S4		
	S2		

Table C.8 - Contribution factors from Qualcomm MG script and from CST Studio Suite for selected beams, and normalized combined PD verification, for device with 3 antenna modules

Worse-case surface					S1 (front surface)	
Worst-case location *(x,y,z)* in meters					(-0.04982, 0.08074, 0.00200)	
PD_design_target (W/m^2)					4.5	
Value printed by MG Script					Value by EM tool	
Module #	Beam ID	*c(i ,j)*, *i*=beam ID, *j*=module #	Backoff factor b_j	$verification.sim.power_{limit}$ (before backoffs) [dBm]	Simulated 4cm^2 PD at (-0.04982, 0.08074, 0.00200) with $verification.sim.power_{limit}$ on S1 (W/m^2)	$c_{simulated}(i\ ,j)$
0	166	0.0051	0.9772	-0.07	0.0235	0.0235/4.5 = 0.0052

1	146	0.0161	0.9772	4.14	0.0723	0.0723/4.5 = 0.0161
2	133	1.0000	0.9772	6.46	4.6108	4.6108/4.5 = 1.0246
Verify 1	$c(i,j)=c_{simulated}(i,j)$, i = 166, 146, 133; j = 0, 1, 2					
Verify 2	b_0 x $c(166,0)$ + b_1 x $c(146,1)$ + b_2 x $c(133,2)$ = 0.9772 x 0.0051+ 0.9772 x 0.0161+ 0.9772 x 1.0000 = 0.9979 ≤ 1					

Table C.9: Measured 4cm^2 PD on worst surface and combined PD at worst-case location for device with 3 antenna modules

Module#	Beam ID	Dominant Surface	Measured 4cm^2 PD at input.power.limit on dominant surface (W/m^2)
0	166	S5	2.54
1	146	S6	3.62
2	133	S1	2.23
combined PD at the worst-case location (*x,y,z*)			*c(166,0)* x meas.4cm^{2}PD*(166,0)* + *c(146,1)* x meas.4cm^{2}PD*(146,1)* + *c(133,2)* x meas.4cm^{2}PD*(133,2)* = 0.0051x 2.54+ 0.0161 x 3.62+ 1.0000x 2.23= 2.30 W/m^2
PD_design_target + uncertainty at reference power level of 1 dB			= 4.5*10$^{(+1/10)}$ = 5.66 W/m^2
Verify			combined PD < PD_design_target + uncertainty at reference power level

Note *c(i,j)* is obtained from Table C.8.

References

1. *Qualcomm Module Group (MG) Script Rev B User Guide.*
2. S. Pfeifer , E. Carrasco, P. Crespo-Valero, E. Neufeld, S. Kuhn, T. Samaras, A. Christ, M. H. Capstick, and N. Kuster, *"Total field reconstruction in the near field using pseudo-vector E-field measurement,"* IEEE Trans. Electromagnetic Compatibility, vol. 61, no. 2, pp. 476–486, Apr. 2019.
3. IEC/IEEE 62704-1:2017 *"Determining the peak spatial-average specific absorption rate (SAR) in the human body from wireless communications devices, 30 MHz to 6 GHz - Part 1: General requirements for using the finite difference time-domain (FDTD) method for SAR calculations"*
4. *5G mmW NR Enabled QRD SAR Char and PD Char for Qualcomm Smart Transmit PD Char Requirements for 2nd Generation of Smart Transmit (GEN2).*