Power Density Simulation Report

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Table of Content

1. Numerical modeling for Power Density (PD) calculations
    1.1 Full-wave numerical computation tool
    1.2 Full-wave simulation setup
        1.2.1 Simulation model
        1.2.2 Mesh settings and solution setup
        1.2.3 Time-averaged PD calculation
2. Simulation and modeling validation
    2.1 Comparison between simulation and measurement
    2.2 Calculated PD per beam ID
3. References

1. Numerical modeling for Power Density (PD) calculations

1.1 Full-wave numerical computation tool

To calculate the Power Density (PD) of the phone at FR2 frequencies, a commercial software called HFSS [1], which is a part of ANSYS Electronics Desktop 2022 R2 package, is used. This software is a 3D full-wave electromagnetic (EM) computational solver based on Finite Element Method (FEM).

1.2 Full-wave simulation setup

1.2.1 Simulation model

The device includes one flat type mmWave module that consists of one module (Plane B Module), located at the back side of the device, as shown in Figure 1-1. In order to obtain accurate PD calculations, it is necessary to have accurate modeling of the mmWave antenna, as well as all other components of the device in close proximity to the mmWave antenna. The simulation model therefore must include all components of the device located within a distance of at least one wavelength from the mmWave module. A list of the components included in the simulation model includes housing, mmWave antenna module, sub6 antennas, PCB, shield cans, Flexible Printed Circuits (FPCs), battery, all components having metallic parts, etc.

1.2.2 Mesh settings and solution setup

ANSYS HFSS features an automatic adaptive mesh refinement algorithm that refines the computational mesh iteratively in regions with strong EM fields and thereby generates very accurate high-frequency simulation results. The steps of adaptive mesh refinement algorithm execution are as follows. First, an initial computational mesh is created, based on the solution setup parameters entered by the user, and is then used to obtain the initial solution for the EM fields of the simulation model. The algorithm then adaptively refines the mesh in each subsequent iteration until a desired solution accuracy, specified by the user, is achieved. The solution accuracy is commonly defined by a convergence parameter called ΔS, which is a variation in the magnitude of all S-parameters between the consecutive iterations of the algorithm [1]. The ΔS parameter specified for all PD simulations presented in this report is 0.02. Figure 1-2 shows an example cut surface in the model showing a tetrahedral computational mesh created by the adaptive mesh refinement algorithm in one of the HFSS simulation models. A radiation boundary with Absorbing Boundary Condition (ABC) is assigned to the outer surface of an air-box surrounding the simulation model, which allows the EM waves to propagate outward from the boundary of the domain without generating any reflected EM waves.

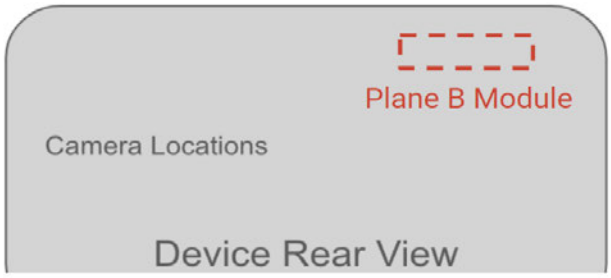

Figure 1-1 Placement of the flat type mmWave module, Plane-B module, at the back side of the device.

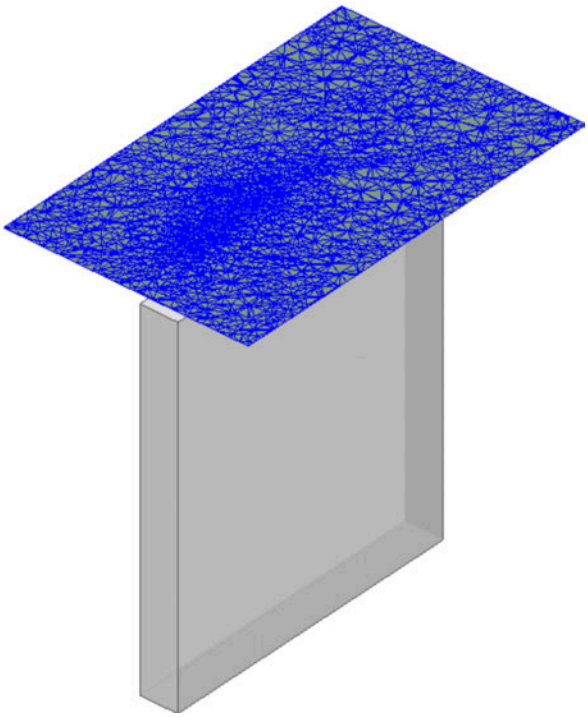

Figure 1-2 An example cut surface in an HFSS simulation model showing the tetrahedral mesh created by the adaptive mesh refinement algorithm.

The FEM simulations are performed for the mmWave module as shown in Figure 1-1. In the simulation, 20 wave-ports are assigned to the feed points of the mmWave antenna arrays. Specifically, ten of them excite the vertical polarization on the antenna array, called V-pol, and the other ten wave-ports excite the horizontal polarization, called H-pol. After the FEM simulations are completed and full-wave EM solutions are obtained, the magnitude and phase values of the 20 wave-ports excitation signals are sequentially assigned for each of the beams in the codebook. This is accomplished as a post-processing step by using the “Edit post process

sources” tab in the HFSS environment, as shown in Figure 1-3 for one of the beams from the codebook.

	Source	Type	Magnitude	Unit	Phase	Unit
1	HFSSDesign1_1_1:1	Port	0	W	0	deg
2	HFSSDesign1_1_2:1	Port	0	W	0	deg
3	HFSSDesign1_1_3:1	Port	0	W	0	deg
4	HFSSDesign1_1_4:1	Port	0	W	0	deg
5	HFSSDesign1_1_5:1	Port	0	W	0	deg
6	HFSSDesign1_1_6:1	Port	0	W	0	deg
7	HFSSDesign1_1_7:1	Port	0	W	0	deg
8	HFSSDesign1_1_8:1	Port	0	W	0	deg
9	HFSSDesign1_1_9:1	Port	0	W	0	deg
10	HFSSDesign1_1_10:1	Port	0	W	0	deg
11	HFSSDesign1_1_11:1	Port	0	W	0	deg
12	HFSSDesign1_1_12:1	Port	0	W	0	deg
13	HFSSDesign1_1_13:1	Port	0	W	0	deg
14	HFSSDesign1_1_14:1	Port	0	W	0	deg
15	HFSSDesign1_1_15:1	Port	0	W	0	deg
16	HFSSDesign1_1_16:1	Port	0	W	0	deg
17	HFSSDesign1_1_17:1	Port	0	W	0	deg
18	HFSSDesign1_1_18:1	Port	0	W	0	deg
19	HFSSDesign1_1_19:1	Port	0	W	0	deg
20	HFSSDesign1_1_20:1	Port	0	W	0	deg

Figure 1-3 An example of magnitude and phase assignments to the wave-ports in the “Edit post process sources” tab in the HFSS environment.

1.2.3 Time-averaged PD calculation

After the convergence criterion is achieved in the last iterative pass, that is Max{|ΔS|} is smaller than the specified value of the convergence parameter ΔS (that being 0.02 in this report, as mentioned above), the values of the electric and magnetic field vectors [redacted] and [redacted] respectively, are calculated, and then used to calculate the *PD* by the following formula:

$$PD = \frac{1}{2}\left|Re\left\{\vec{E} \times \vec{H}^{*}\right\}\right|$$

Based on the calculated *PD*, the time-averaged *PD* (PD_{ave}) over a surface *A* can be obtained as:

$$PD_{ave} = \frac{1}{2A}\int_{A}\left|Re\left\{\vec{E}\times\vec{H}^{*}\right\}\right|\cdot dS$$

In order to determine the RF exposure from the mmW antennas in the device, the values of the electric and magnetic field vectors at the six surfaces S1, S2, S3, S4, S5, and S6 shown in Figure 1-4 are needed. Depending on the simulation or measurement setting, the distance from these six surfaces to the device is set to be either 2 mm or 10 mm. As long as the distance between mmWave sub-module and any six surfaces is greater than 25mm, the surface integration terms in the above formula for the PD_{ave} corresponding to some of these six surfaces are negligible, and thus can be excluded from the PD_{ave} calculation. Using square markings, Table 1-1 specifies which one of the six surfaces needs to be used in the above formula for the PD_{ave} calculation. As seen, the surfaces S1, S2, S3, and S5 need to be used in the PD_{ave} calculations.

In the spatially averaged power density calculations, the surface *A* is a circle in the evaluation plane with an area of 4 cm^2. Furthermore, PD_{ave} is calculated at the points of a grid with λ/4 mm step size defined in the evaluation plane.

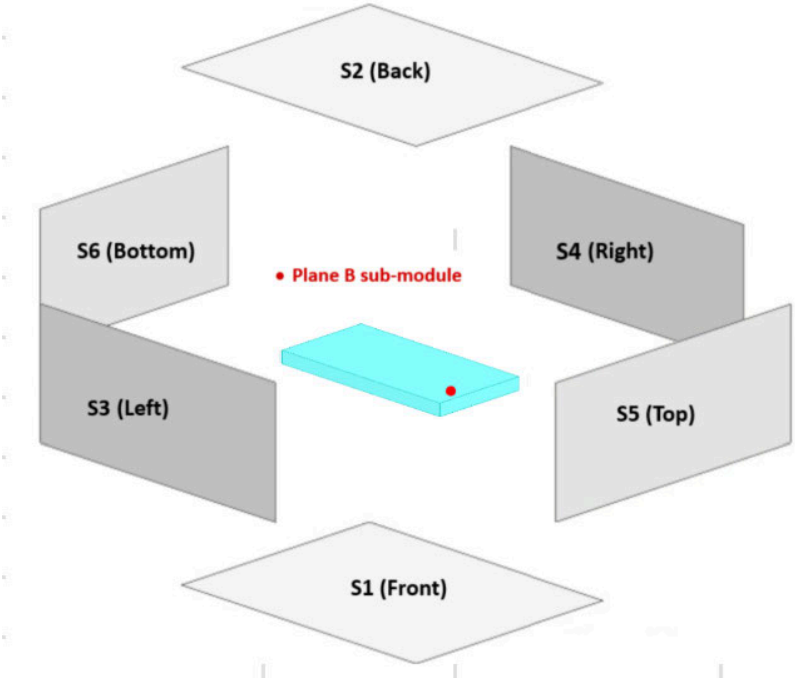

Figure 1-4 *PD* evaluation surfaces. Averaged power densities (PD_{ave}) are calculated and measured on the specified surfaces (S1, S2, S3, and S5) surrounding the phone.

Table 1-1 *PD* evaluation surfaces considered for each mmWave module in the device.

	S1 (front)	S2 (back)	S3 (left)	S4 (right)	S5 (top)	S6 (bottom)

Plane B Module	☑	☑	☑	✗	☑	✗

2. Simulation and modeling validation

2.1 Comparison between simulation and measurement

Following the time-average *PD* calculation procedure described in section 1.2.3, the distributions of *PD* and PD_{ave} are calculated in the evaluation plane and are compared with the measurements for a selected number of beams, with the highest PD_{ave} values compared to the other beams, whose IDs are listed in Table 2-1. Also shown in this table are simulated and measured results for the PD_{ave} for both n258, n260 and n261 frequency bands, as well as Horizontal, Vertical, and Horizontal + Vertical (Simultaneous Transmit) polarizations, denoted as H, V and H+V, respectively. For Plane B Module, PD_{ave} of 2mm from DUT is used for calculating minimum target power while PD_{ave} of 2mm from Camera Bump (CB) is used to derive the correction factor. Figure 2-1 shows orientation of the device for the *PD* and PD_{ave} distribution plots presented in Figures 2-2 to 2-37. The presented plots demonstrate a good agreement between simulated and measured results for both *PD* and PD_{ave}.

Table 2-1 Simulated and measured PD_{ave} for selected beams with 17dBm input power setting for H+V polarization.

Band	Module/Plane	Polarity	Beam ID	Surface	Channel	Freq. (GHz)	Test Distance	Ref. Plane	4cm2 avg. PD (W/m2)		Delta
									Measured	Simulated	Sim. - Meas. (dB)
n258	B-Plane	H	1	S2 (Back)	Mid	24.75	2 mm	CB	11.50	5.13	**-3.51**
		V	4	S2 (Back)			2 mm	CB	11.00	6.74	**-2.13**
		H+V	1	S2 (Back)			2 mm	CB	22.70	17.09	**-1.23**
n260	B-Plane	H	3	S2 (Back)	Mid	38.5	2 mm	CB	4.08	5.28	**1.12**
		V	3	S2 (Back)			2 mm	CB	7.06	5.45	**-1.12**
		H+V	3	S2 (Back)			2 mm	CB	8.01	11.95	**1.74**
n261	B-Plane	H	3	S2 (Back)	Mid	27.925	2 mm	CB	8.46	6.99	**-0.83**
		V	4	S2 (Back)			2 mm	CB	7.15	7.67	**0.30**
		H+V	4	S2 (Back)			2 mm	CB	13.20	16.15	**0.88**

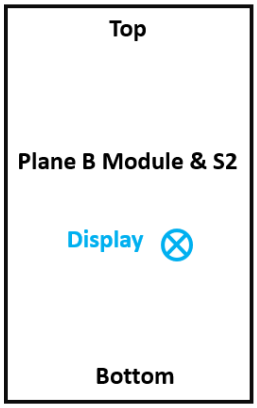

Figure 2-1 Orientation of the device for the *PD* distribution plots.

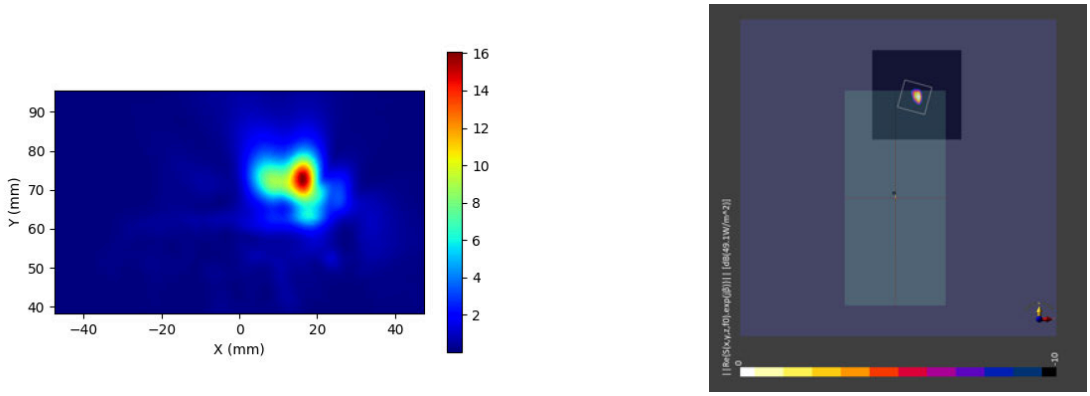

Figure 2-8 Simulated (left) and measured (right) *PD* distribution for the following configuration: Band n258, MID Channel, Beam ID 1, H polarization, Plane B Module, plotted on the surface S2 (back) with 2mm separation distance to the camera bump.

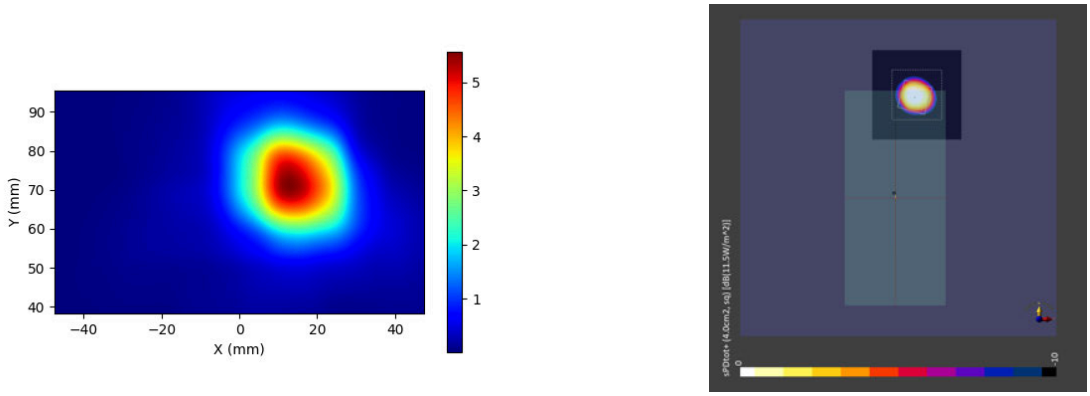

Figure 2-9 Simulated (left) and measured (right) averaged *PD* distribution for the following configuration: Band n258, MID Channel, Beam ID 1, H polarization, Plane B Module, plotted on the surface S2 (back) with 2mm separation distance to the camera bump.

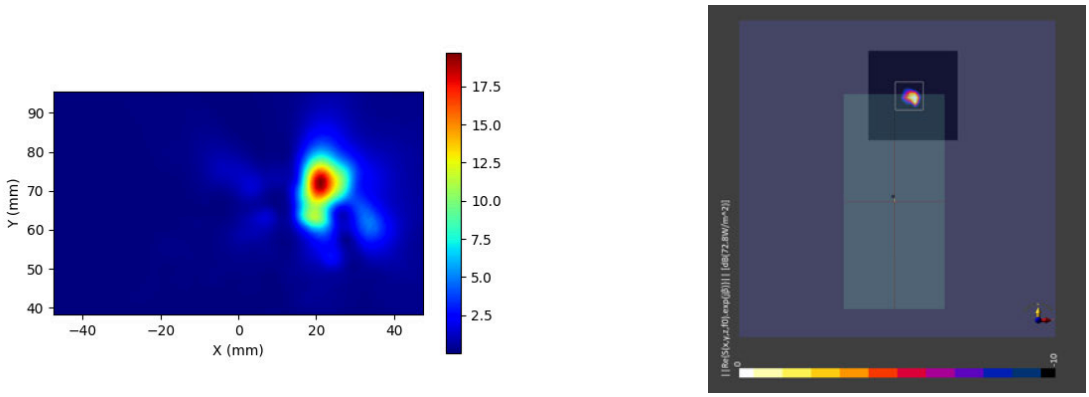

Figure 2-10 Simulated (left) and measured (right) *PD* distribution for the following configuration: Band n258, MID Channel, Beam ID 4, V polarization, Plane B Module, plotted on the surface S2 (back) with 2mm separation distance to the camera bump.

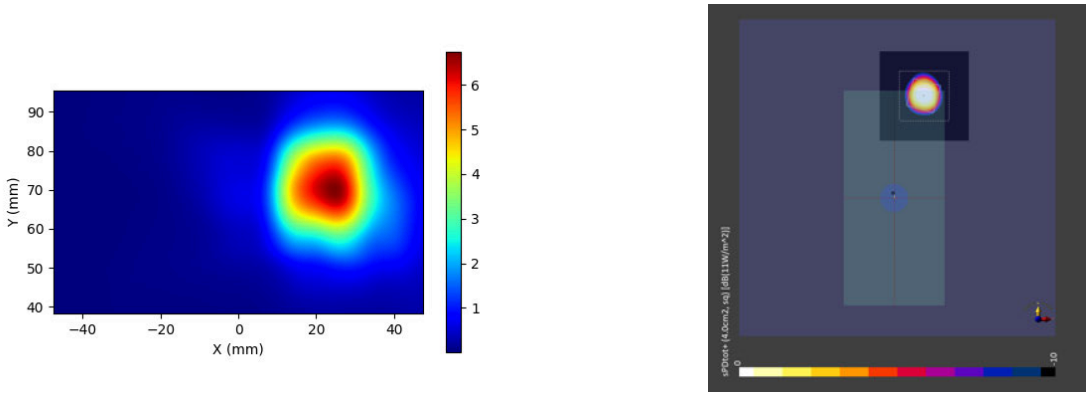

Figure 2-11 Simulated (left) and measured (right) averaged *PD* distribution for the following configuration: Band n258, MID Channel, Beam ID 4, V polarization, Plane B Module, plotted on the surface S2 (back) with 2mm separation distance to the camera bump.

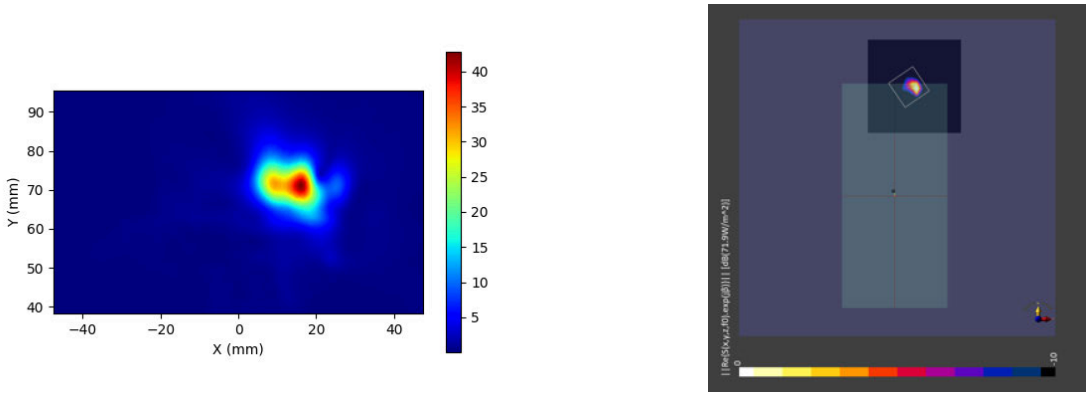

Figure 2-12 Simulated (left) and measured (right) *PD* distribution for the following configuration: Band n258, MID Channel, Beam ID 1, H+V polarization, Plane B Module, plotted on the surface S2 (back) with 2mm separation distance to the camera bump.

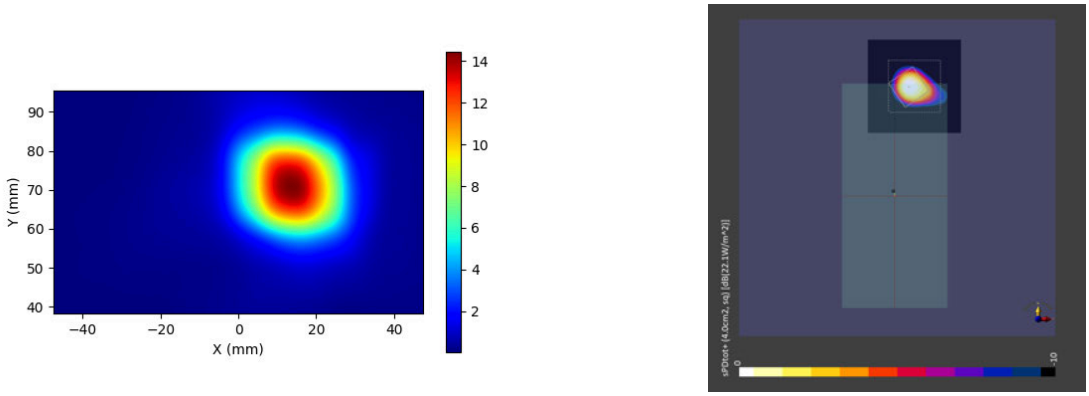

Figure 2-13 Simulated (left) and measured (right) averaged *PD* distribution for the following configuration: Band n258, MID Channel, Beam ID 1, H+V polarization, Plane B Module, plotted on the surface S2 (back) with 2mm separation distance to the camera bump.

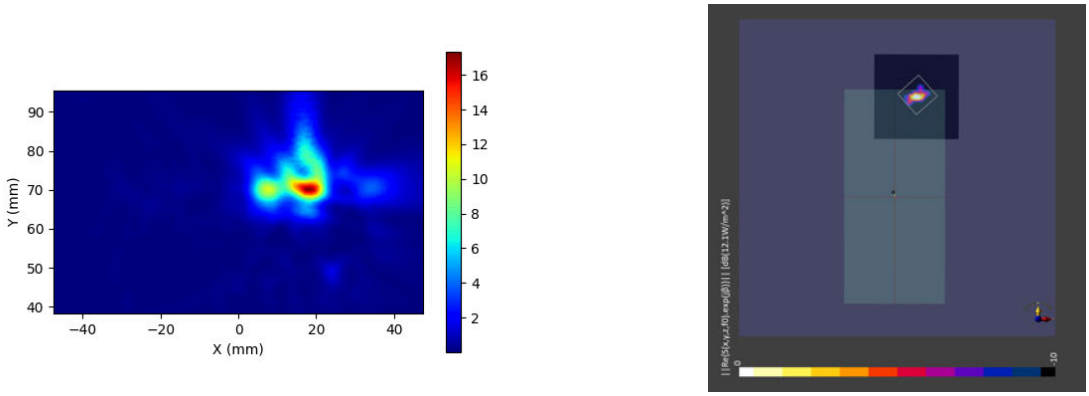

Figure 2-20 Simulated (left) and measured (right) *PD* distribution for the following configuration: Band n260, MID Channel, Beam ID 3, H polarization, Plane B Module, plotted on the surface S2 (back) with 2mm separation distance to the camera bump.

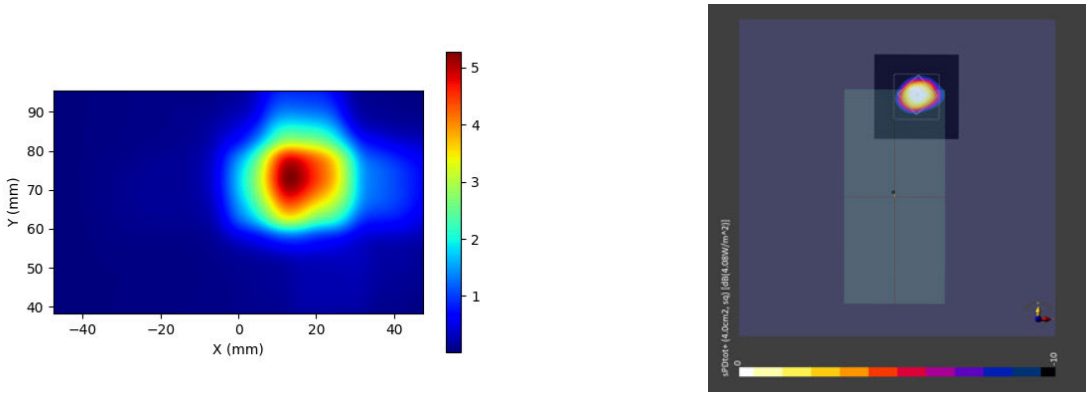

Figure 2-21 Simulated (left) and measured (right) averaged *PD* distribution for the following configuration: Band n260, MID Channel, Beam ID 3, H polarization, Plane B Module, plotted on the surface S2 (back) with 2mm separation distance to the camera bump.

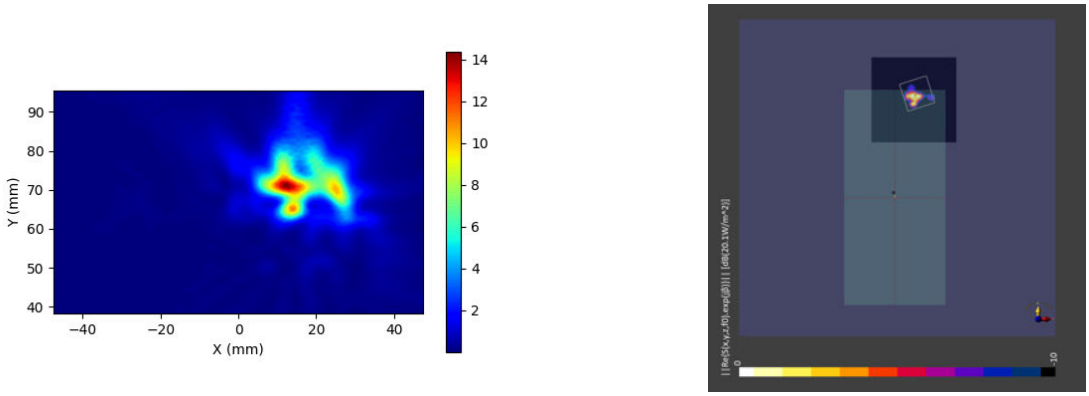

Figure 2-22 Simulated (left) and measured (right) *PD* distribution for the following configuration: Band n260, MID Channel, Beam ID 3, V polarization, Plane B Module, plotted on the surface S2 (back) with 2mm separation distance to the camera bump.

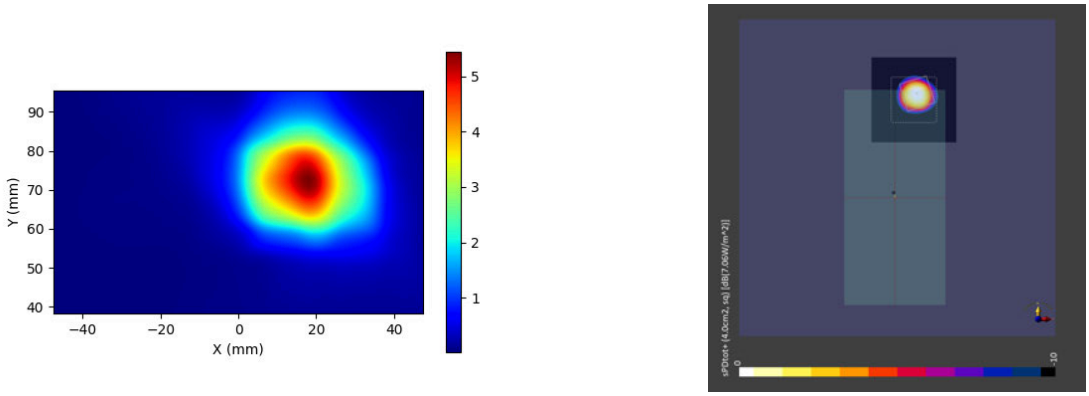

Figure 2-23 Simulated (left) and measured (right) averaged *PD* distribution for the following configuration: Band n260, MID Channel, Beam ID 3, V polarization, Plane B Module, plotted on the surface S2 (back) with 2mm separation distance to the camera bump.

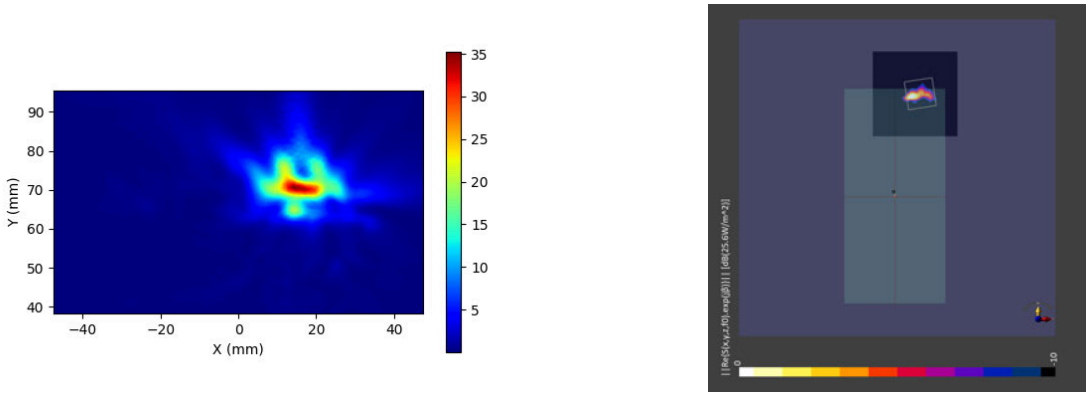

Figure 2-24 Simulated (left) and measured (right) *PD* distribution for the following configuration: Band n260, MID Channel, Beam ID 3, H+V polarization, Plane B Module, plotted on the surface S2 (back) with 2mm separation distance to the camera bump.

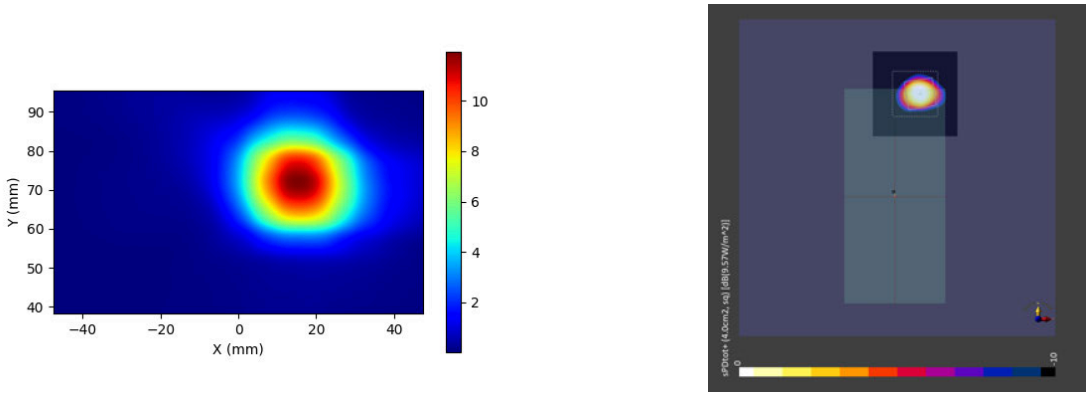

Figure 2-25 Simulated (left) and measured (right) averaged *PD* distribution for the following configuration: Band n260, MID Channel, Beam ID 3, H+V polarization, Plane B Module, plotted on the surface S2 (back) with 2mm separation distance to the camera bump.

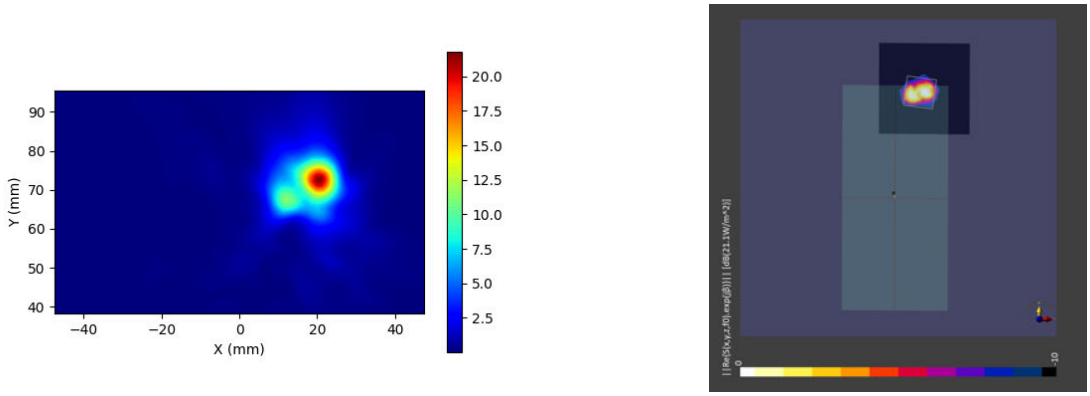

Figure 2-32 Simulated (left) and measured (right) *PD* distribution for the following configuration: Band n261, MID Channel, Beam ID 3, H polarization, Plane B Module, plotted on the surface S2 (back) with 2mm separation distance to the camera bump.

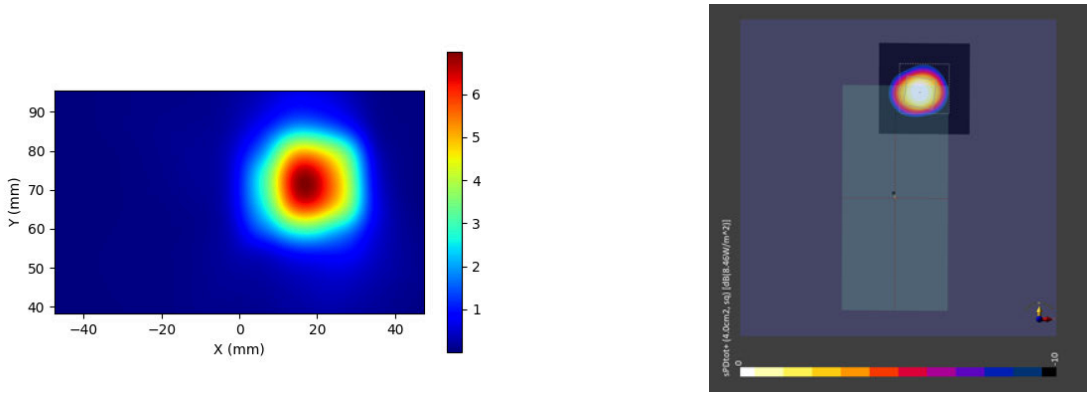

Figure 2-33 Simulated (left) and measured (right) averaged *PD* distribution for the following configuration: Band n261, MID Channel, Beam ID 3, H polarization, Plane B Module, plotted on the surface S2 (back) with 2mm separation distance to the camera bump.

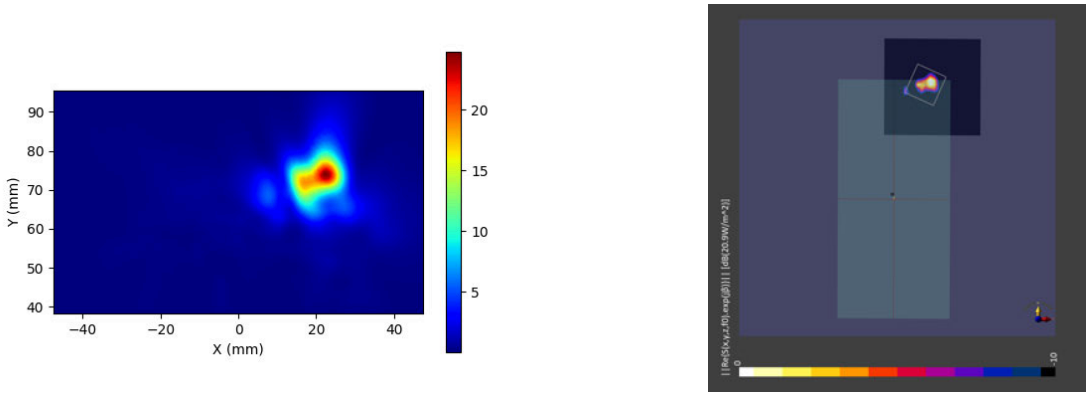

Figure 2-34 Simulated (left) and measured (right) *PD* distribution for the following configuration: Band n261, MID Channel, Beam ID 4, V polarization, Plane B Module, plotted on the surface S2 (back) with 2mm separation distance to the camera bump.

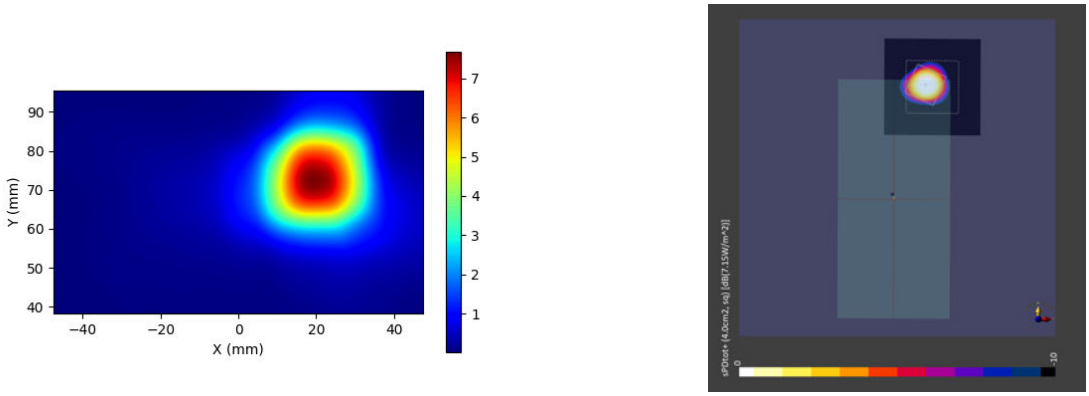

Figure 2-35 Simulated (left) and measured (right) averaged *PD* distribution for the following configuration: Band n261, MID Channel, Beam ID 4, V polarization, Plane B Module, plotted on the surface S2 (back) with 2mm separation distance to the camera bump.

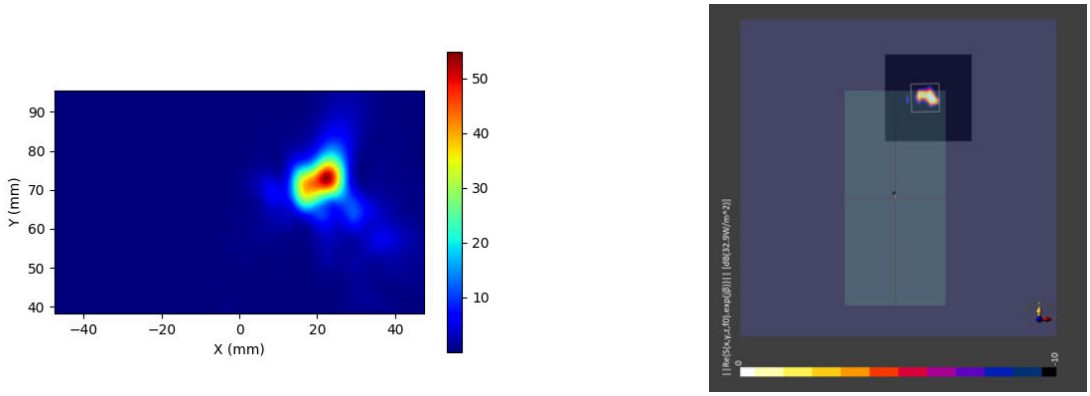

Figure 2-36 Simulated (left) and measured (right) *PD* distribution for the following configuration: Band n261, MID Channel, Beam ID 4, H+V polarization, Plane B Module, plotted on the surface S2 (back) with 2mm separation distance to the camera bump.

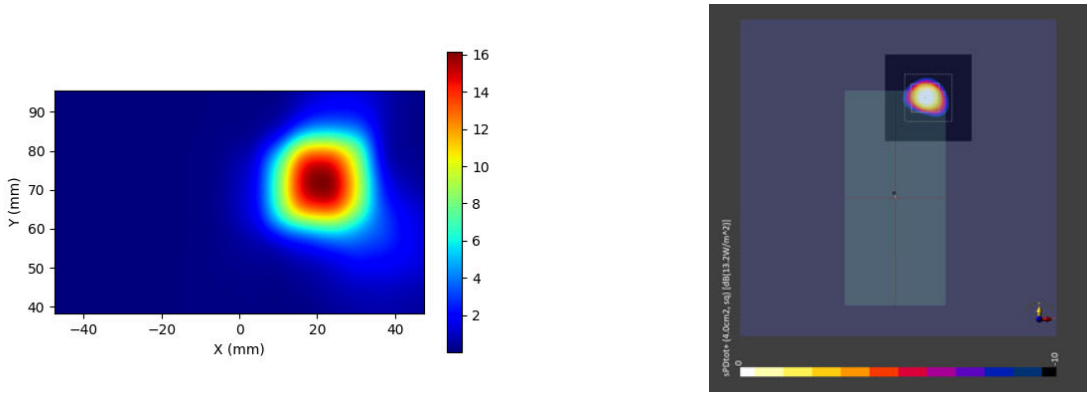

Figure 2-37 Simulated (left) and measured (right) averaged *PD* distribution for the following configuration: Band n261, MID Channel, Beam ID 4, H+V polarization, Plane B Module, plotted on the surface S2 (back) with 2mm separation distance to the camera bump.

2.2 Calculated PD per beam ID

The simulated time-average *PD* calculated for the selected evaluation planes for all beams in the codebook are presented in this section. The calculations are done for the LOW, MID, and HIGH channels of n260, n261 and n258 frequency band. Since the beams of H+V configuration are not phase coherent, the relative phase difference between the corresponding H+V beams with vertical and horizontal polarizations is swept from 0° to 360° in 5° steps, and the PD_{ave} is calculated for all of these phase difference values in order to capture the largest possible PD_{ave} value. The PD_{ave} values for every beam ID are reported in Table 2-2 to Table 2-10. For H+V

configuration, the largest possible PD_{ave} values calculated using this relative phase difference sweeping method are reported.

Table 2-2 Simulated averaged PD over 4 [cm^2] area on Plane B Module - n258 Low Channel.

PD Simulation(W/m^2)		Low channel												
		2mm					10.11%	30.66%	56.13%	10mm				64.48%
		S1	S2	S2	S3	S5	S1/S2	S3/S2	S5/S2	S1	S2	S3	S5	S2/S2
Pol	Beam ID	Front	Back	Back(CB)	Left	Top				Front	Back	Left	Top	10mm/2mm
H	0	0.24	7.63	4.87	2.34	2.32	0.03	0.31	0.30	0.12	3.20	1.58	0.84	0.42
H	1	0.23	6.63	4.83	1.95	2.60	0.04	0.29	0.39	0.09	3.61	1.16	1.04	0.54
H	2	0.40	7.84	4.39	0.40	3.03	0.05	0.05	0.39	0.22	2.59	0.25	1.42	0.33
H	3	0.48	6.92	4.24	0.63	2.85	0.07	0.09	0.41	0.29	2.78	0.33	1.52	0.40
H	4	0.55	5.45	3.61	1.01	1.88	0.10	0.19	0.34	0.21	2.57	0.35	0.79	0.47
H	5	0.16	7.57	5.04	0.29	2.29	0.02	0.04	0.30	0.05	3.45	0.18	1.03	0.46
H	6	0.39	6.50	3.41	1.01	2.01	0.06	0.15	0.31	0.11	2.24	0.52	0.76	0.34
V	0	0.29	9.01	4.80	2.03	1.96	0.03	0.23	0.22	0.09	2.58	1.30	0.63	0.29
V	1	0.26	9.12	5.63	1.54	2.09	0.03	0.17	0.23	0.07	3.47	0.99	0.96	0.38
V	2	0.39	4.89	3.88	0.46	2.32	0.08	0.09	0.47	0.17	3.15	0.24	1.04	0.64
V	3	0.34	6.90	5.48	0.26	3.87	0.05	0.04	0.56	0.19	4.16	0.16	2.06	0.60
V	4	0.31	9.62	6.35	1.20	3.24	0.03	0.13	0.34	0.16	4.22	0.82	1.49	0.44
V	5	0.21	5.93	3.94	0.47	1.80	0.04	0.08	0.30	0.06	2.74	0.30	0.66	0.46
V	6	0.23	7.60	4.28	1.41	1.58	0.03	0.19	0.21	0.08	2.47	0.92	0.68	0.32
H+V	0	0.79	21.73	13.78	6.65	7.39	0.04	0.31	0.34	0.32	8.82	4.54	2.35	0.41
H+V	1	0.56	22.58	16.50	5.69	7.76	0.02	0.25	0.34	0.21	11.42	3.59	3.27	0.51
H+V	2	1.36	15.81	10.45	1.34	6.38	0.09	0.08	0.40	0.71	7.18	0.73	3.23	0.45
H+V	3	1.38	15.41	10.13	1.36	8.15	0.09	0.09	0.53	0.86	8.35	0.72	4.74	0.54
H+V	4	1.11	20.30	14.35	3.23	6.55	0.05	0.16	0.32	0.63	10.44	1.72	3.27	0.51
H+V	5	0.46	20.72	15.32	1.25	6.91	0.02	0.06	0.33	0.14	10.79	0.77	2.86	0.52
H+V	6	0.81	19.57	10.85	3.83	6.22	0.04	0.20	0.32	0.33	7.12	2.24	2.31	0.36

Table 2-3 Simulated averaged PD over 4 [cm^2] area on Plane B Module - n258 Mid Channel

PD Simulation(W/m^2)		Mid channel												
		2mm					8.97%	32.43%	57.34%	10mm				64.77%
		S1	S2	S2	S3	S5	S1/S2	S3/S2	S5/S2	S1	S2	S3	S5	S2/S2
Pol	Beam ID	Front	Back	Back(CB)	Left	Top				Front	Back	Left	Top	10mm/2mm
H	0	0.28	7.40	4.73	2.20	2.43	0.04	0.30	0.33	0.13	3.13	1.47	0.83	0.42
H	1	0.26	6.98	5.13	2.23	2.85	0.04	0.32	0.41	0.12	3.88	1.19	1.16	0.56
H	2	0.42	7.75	4.31	0.57	3.07	0.05	0.07	0.40	0.24	2.52	0.26	1.40	0.33
H	3	0.46	7.28	4.59	0.66	3.04	0.06	0.09	0.42	0.29	2.95	0.33	1.54	0.41
H	4	0.47	5.98	4.21	1.32	2.43	0.08	0.22	0.41	0.25	3.28	0.37	1.03	0.55
H	5	0.21	7.32	5.10	0.43	2.48	0.03	0.06	0.34	0.06	3.54	0.27	0.98	0.48

H	**6**	0.40	6.55	3.38	0.86	1.99	0.06	0.13	0.30	0.12	2.06	0.47	0.62	0.31
V	**0**	0.31	9.80	5.36	2.62	2.45	0.03	0.27	0.25	0.09	3.17	1.77	0.80	0.32
V	**1**	0.33	9.82	6.13	1.77	2.45	0.03	0.18	0.25	0.08	3.83	1.08	1.14	0.39
V	**2**	0.43	6.02	4.80	0.40	3.18	0.07	0.07	0.53	0.20	3.90	0.21	1.44	0.65
V	**3**	0.27	7.86	6.25	0.26	4.51	0.03	0.03	0.57	0.17	4.79	0.15	2.42	0.61
V	**4**	0.25	10.51	6.74	1.33	3.54	0.02	0.13	0.34	0.12	4.44	0.88	1.59	0.42
V	**5**	0.29	6.28	4.35	0.35	2.19	0.05	0.06	0.35	0.10	3.09	0.24	0.89	0.49
V	**6**	0.28	7.77	4.54	1.34	1.80	0.04	0.17	0.23	0.09	2.66	0.88	0.73	0.34
H+V	**0**	0.91	22.29	14.35	7.23	8.22	0.04	0.32	0.37	0.34	9.53	4.99	2.61	0.43
H+V	**1**	0.71	22.89	17.09	6.59	8.16	0.03	0.29	0.36	0.22	12.23	3.78	3.45	0.53
H+V	**2**	1.39	15.48	10.60	1.36	7.77	0.09	0.09	0.50	0.79	7.57	0.77	3.76	0.49
H+V	**3**	1.24	16.47	11.64	1.29	8.58	0.08	0.08	0.52	0.86	9.49	0.70	4.86	0.58
H+V	**4**	0.87	19.96	14.02	3.29	7.34	0.04	0.16	0.37	0.55	10.46	1.61	3.43	0.52
H+V	**5**	0.67	20.40	15.86	1.08	7.30	0.03	0.05	0.36	0.22	11.26	0.63	3.07	0.55
H+V	**6**	0.69	19.65	10.86	3.64	6.23	0.03	0.19	0.32	0.30	6.63	2.27	2.18	0.34

Table 2-4 Simulated averaged PD over 4 [cm^2] area on Plane B Module - n258 High Channel.

PD Simulation(W/m^2)		High channel												
		2mm					7.54%	32.78%	56.51%	10mm				65.52%
		S1	S2	S2	S3	S5	S1/S2	S3/S2	S5/S2	S1	S2	S3	S5	S2/S2
Pol	Beam ID	Front	Back	Back(CB)	Left	Top				Front	Back	Left	Top	10mm/2mm
H	**0**	0.37	8.04	5.08	2.33	2.59	0.05	0.29	0.32	0.16	3.25	1.49	0.94	0.40
H	**1**	0.34	7.32	5.30	2.28	2.83	0.05	0.31	0.39	0.17	3.95	1.12	1.22	0.54
H	**2**	0.41	8.11	4.47	0.79	3.21	0.05	0.10	0.40	0.21	2.62	0.33	1.48	0.32
H	**3**	0.47	8.47	5.16	0.69	3.65	0.06	0.08	0.43	0.29	3.15	0.36	1.99	0.37
H	**4**	0.55	7.49	5.14	1.75	3.18	0.07	0.23	0.42	0.31	3.84	0.56	1.53	0.51
H	**5**	0.33	6.95	4.92	0.36	2.35	0.05	0.05	0.34	0.08	3.38	0.21	0.87	0.49
H	**6**	0.38	7.10	3.69	0.68	1.87	0.05	0.10	0.26	0.09	1.94	0.41	0.56	0.27
V	**0**	0.34	9.32	5.01	2.53	2.44	0.04	0.27	0.26	0.10	2.94	1.72	0.80	0.32
V	**1**	0.28	9.71	6.19	1.75	2.66	0.03	0.18	0.27	0.07	3.92	0.98	1.19	0.40
V	**2**	0.43	7.38	5.95	0.34	4.17	0.06	0.05	0.57	0.20	4.84	0.18	1.99	0.66
V	**3**	0.21	8.79	7.02	0.35	4.90	0.02	0.04	0.56	0.13	5.37	0.17	2.61	0.61
V	**4**	0.25	10.58	6.69	1.43	3.72	0.02	0.14	0.35	0.09	4.50	0.89	1.70	0.43
V	**5**	0.32	6.64	4.89	0.38	2.63	0.05	0.06	0.40	0.12	3.63	0.24	1.07	0.55
V	**6**	0.32	8.29	5.07	1.05	2.19	0.04	0.13	0.26	0.10	2.95	0.66	0.85	0.36
H+V	**0**	1.05	22.80	14.64	7.48	8.49	0.05	0.33	0.37	0.46	9.51	5.02	2.86	0.42
H+V	**1**	0.74	22.35	16.50	6.44	8.31	0.03	0.29	0.37	0.27	11.69	3.52	3.51	0.52
H+V	**2**	1.25	16.62	11.87	1.49	9.10	0.08	0.09	0.55	0.71	9.11	0.80	4.46	0.55
H+V	**3**	1.09	19.70	12.78	1.55	9.06	0.06	0.08	0.46	0.73	10.10	0.78	5.38	0.51
H+V	**4**	0.97	20.20	13.86	3.29	8.62	0.05	0.16	0.43	0.53	10.25	1.63	4.24	0.51
H+V	**5**	0.90	20.21	16.14	1.02	7.49	0.04	0.05	0.37	0.32	11.53	0.53	3.13	0.57
H+V	**6**	0.83	21.15	11.93	2.91	6.49	0.04	0.14	0.31	0.26	7.18	1.91	1.88	0.34

Table 2-5 Simulated averaged PD over 4 [cm^2] area on Plane B Module - n260 Low Channel.

PD Simulation(W/m^2)		Low channel												
		2mm					5.64%	25.72%	44.55%	10mm				46.91%
		S1	S2	S2	S3	S5	S1/S2	S3/S2	S5/S2	S1	S2	S3	S5	S2/S2
Pol	Beam ID	Front	Back	Back(CB)	Left	Top				Front	Back	Left	Top	10mm/2mm
H	0	0.15	7.33	3.99	1.11	2.04	0.02	0.15	0.28	0.11	2.46	0.61	0.93	0.34
H	1	0.28	6.41	3.97	1.44	2.50	0.04	0.22	0.39	0.19	2.43	0.84	1.28	0.38
H	2	0.14	6.81	4.75	0.48	2.37	0.02	0.07	0.35	0.09	3.20	0.28	1.58	0.47
H	3	0.22	7.39	4.95	0.74	3.05	0.03	0.10	0.41	0.15	3.15	0.29	1.78	0.43
H	4	0.21	6.85	4.74	0.39	2.83	0.03	0.06	0.41	0.16	3.20	0.16	1.71	0.47
H	5	0.25	8.49	4.30	1.17	1.65	0.03	0.14	0.19	0.12	2.69	0.67	0.79	0.32
H	6	0.27	8.32	3.92	1.95	1.63	0.03	0.23	0.20	0.12	2.33	1.17	0.79	0.28
V	0	0.24	7.25	3.20	1.42	1.95	0.03	0.20	0.27	0.10	1.64	0.71	0.74	0.23
V	1	0.19	7.41	3.86	1.47	1.56	0.02	0.20	0.21	0.07	2.21	0.75	0.92	0.30
V	2	0.22	6.97	4.49	1.15	3.06	0.03	0.17	0.44	0.16	2.90	0.66	2.04	0.42
V	3	0.28	7.54	4.63	0.47	2.96	0.04	0.06	0.39	0.19	2.90	0.26	1.71	0.39
V	4	0.18	6.64	3.95	1.02	1.98	0.03	0.15	0.30	0.12	2.42	0.47	1.16	0.37
V	5	0.22	7.05	4.12	0.73	2.82	0.03	0.10	0.40	0.13	2.38	0.43	1.55	0.34
V	6	0.36	7.07	4.00	1.30	3.15	0.05	0.18	0.45	0.20	2.23	0.67	1.48	0.32
H+V	0	0.39	14.88	7.88	3.38	4.19	0.03	0.23	0.28	0.25	4.67	1.61	2.05	0.31
H+V	1	0.70	14.97	8.65	3.10	4.51	0.05	0.21	0.30	0.37	5.37	1.90	2.45	0.36
H+V	2	0.54	16.40	10.67	1.97	6.58	0.03	0.12	0.40	0.38	6.68	1.12	4.73	0.41
H+V	3	0.89	15.77	9.90	1.57	6.45	0.06	0.10	0.41	0.63	6.44	0.68	4.62	0.41
H+V	4	0.58	14.65	9.22	1.75	5.34	0.04	0.12	0.36	0.44	5.76	0.91	3.66	0.39
H+V	5	0.68	16.38	10.00	3.08	5.27	0.04	0.19	0.32	0.24	6.79	1.92	2.92	0.41
H+V	6	0.70	17.85	10.13	4.59	5.01	0.04	0.26	0.28	0.35	6.47	2.74	2.56	0.36

Table 2-6 Simulated averaged PD over 4 [cm^2] area on Plane B Module - n260 Mid Channel.

PD Simulation(W/m^2)		Mid channel												
		2mm					6.70%	30.53%	49.28%	10mm				51.34%
		S1	S2	S2	S3	S5	S1/S2	S3/S2	S5/S2	S1	S2	S3	S5	S2/S2
Pol	Beam ID	Front	Back	Back(CB)	Left	Top				Front	Back	Left	Top	10mm/2mm
H	0	0.31	6.43	3.65	1.62	1.78	0.05	0.25	0.28	0.14	2.58	0.83	0.82	0.40
H	1	0.36	7.31	4.48	2.23	3.59	0.05	0.30	0.49	0.22	2.91	1.37	2.00	0.40
H	2	0.23	7.28	4.69	0.62	2.48	0.03	0.09	0.34	0.11	3.53	0.26	1.51	0.48
H	3	0.28	7.08	5.28	0.91	3.06	0.04	0.13	0.43	0.16	3.63	0.46	1.80	0.51
H	4	0.25	6.60	4.56	0.46	3.25	0.04	0.07	0.49	0.18	3.11	0.19	2.00	0.47
H	5	0.39	6.26	3.43	1.71	1.46	0.06	0.27	0.23	0.16	2.24	1.07	0.91	0.36
H	6	0.33	7.76	3.78	2.00	1.88	0.04	0.26	0.24	0.20	2.13	1.12	0.83	0.27
V	0	0.27	7.00	3.25	1.26	1.55	0.04	0.18	0.22	0.10	1.76	0.74	0.79	0.25
V	1	0.14	6.27	4.14	1.42	1.90	0.02	0.23	0.30	0.06	2.74	0.59	1.15	0.44

V	2	0.37	6.94	4.59	0.74	3.15	0.05	0.11	0.45	0.19	3.08	0.39	2.03	0.44
V	3	0.35	7.66	5.45	0.45	3.32	0.05	0.06	0.43	0.21	3.69	0.24	2.11	0.48
V	4	0.27	6.15	4.17	0.91	2.05	0.04	0.15	0.33	0.15	2.75	0.42	1.14	0.45
V	5	0.33	6.85	4.19	0.79	2.88	0.05	0.11	0.42	0.17	2.51	0.41	1.74	0.37
V	6	0.29	6.11	3.52	1.45	2.72	0.05	0.24	0.44	0.14	2.17	0.70	1.26	0.36
H+V	0	0.69	14.22	7.50	3.81	3.67	0.05	0.27	0.26	0.26	4.57	2.12	1.77	0.32
H+V	1	0.78	15.82	10.23	4.56	6.68	0.05	0.29	0.42	0.40	6.96	2.51	3.92	0.44
H+V	2	0.97	15.47	10.93	1.87	6.56	0.06	0.12	0.42	0.48	7.66	0.96	4.31	0.50
H+V	3	1.12	16.73	11.95	1.82	7.35	0.07	0.11	0.44	0.70	8.53	0.79	4.68	0.51
H+V	4	0.83	13.76	9.57	1.86	5.94	0.06	0.14	0.43	0.57	6.61	0.69	3.68	0.48
H+V	5	0.90	13.84	8.67	3.83	5.48	0.07	0.28	0.40	0.41	5.22	2.32	3.48	0.38
H+V	6	0.56	14.64	7.93	4.47	4.06	0.04	0.31	0.28	0.38	5.07	2.47	2.14	0.35

Table 2-7 Simulated averaged PD over 4 [cm^2] area on Plane B Module - n260 High Channel.

PD Simulation(W/m^2)		High channel												
		2mm					6.73%	23.67%	44.00%	10mm				57.59%
		S1	S2	S2	S3	S5	S1/S2	S3/S2	S5/S2	S1	S2	S3	S5	S2/S2
Pol	Beam ID	Front	Back	Back(CB)	Left	Top				Front	Back	Left	Top	10mm/2mm
H	0	0.30	6.82	4.40	1.55	2.18	0.04	0.23	0.32	0.16	3.21	0.70	1.01	0.47
H	1	0.21	6.95	3.73	1.46	2.11	0.03	0.21	0.30	0.14	2.46	0.89	1.25	0.35
H	2	0.24	7.74	5.57	0.65	2.66	0.03	0.08	0.34	0.09	4.06	0.31	1.35	0.53
H	3	0.37	7.76	5.73	0.89	3.19	0.05	0.11	0.41	0.16	4.30	0.46	1.78	0.55
H	4	0.43	6.80	4.69	0.64	2.99	0.06	0.09	0.44	0.17	3.31	0.30	1.53	0.49
H	5	0.27	7.29	4.93	1.22	2.22	0.04	0.17	0.30	0.10	3.67	0.71	1.24	0.50
H	6	0.33	7.59	4.28	1.64	1.79	0.04	0.22	0.24	0.24	2.67	0.90	1.10	0.35
V	0	0.23	7.14	3.46	1.20	2.03	0.03	0.17	0.28	0.11	1.97	0.61	0.86	0.28
V	1	0.14	5.79	4.02	1.33	2.01	0.02	0.23	0.35	0.07	2.80	0.48	1.14	0.48
V	2	0.27	6.91	5.03	0.86	2.79	0.04	0.12	0.40	0.14	3.66	0.44	1.85	0.53
V	3	0.31	8.54	6.64	0.95	3.57	0.04	0.11	0.42	0.16	4.90	0.57	2.01	0.57
V	4	0.25	6.51	4.02	0.85	2.04	0.04	0.13	0.31	0.14	2.88	0.42	1.08	0.44
V	5	0.38	7.55	5.07	0.60	2.86	0.05	0.08	0.38	0.21	3.22	0.29	1.60	0.43
V	6	0.36	7.30	4.09	0.98	2.95	0.05	0.13	0.40	0.23	2.37	0.48	1.55	0.33
H+V	0	0.77	15.99	8.65	3.41	4.70	0.05	0.21	0.29	0.24	5.26	1.92	2.08	0.33
H+V	1	0.57	14.19	8.95	3.36	5.14	0.04	0.24	0.36	0.36	6.63	2.11	2.92	0.47
H+V	2	0.82	16.85	12.84	1.68	6.23	0.05	0.10	0.37	0.38	9.43	0.76	4.04	0.56
H+V	3	1.25	18.63	14.53	2.07	7.70	0.07	0.11	0.41	0.58	10.73	1.12	4.79	0.58
H+V	4	0.97	15.04	9.55	1.76	5.70	0.06	0.12	0.38	0.50	6.49	0.93	2.72	0.43
H+V	5	0.89	16.55	11.47	2.39	6.69	0.05	0.14	0.40	0.41	7.79	1.34	3.91	0.47
H+V	6	0.54	16.40	9.24	3.53	6.20	0.03	0.22	0.38	0.44	5.49	1.90	3.32	0.33

Table 2-8 Simulated averaged PD over 4 [cm^2] area on Plane B Module - n261 Low Channel.

PD Simulation(W/m^2)		Low channel												
		2mm					4.46%	33.91%	64.09%	10mm				68.04%
		S1	S2	S2	S3	S5	S1/S2	S3/S2	S5/S2	S1	S2	S3	S5	S2/S2
Pol	Beam ID	Front	Back	Back(CB)	Left	Top				Front	Back	Left	Top	10mm/2mm
H	0	0.34	9.43	4.69	2.78	0.99	0.04	0.29	0.11	0.10	2.71	1.68	0.26	0.29
H	1	0.31	8.97	5.81	2.65	1.92	0.03	0.30	0.21	0.14	3.90	1.77	0.81	0.44
H	2	0.17	9.51	6.19	0.69	4.22	0.02	0.07	0.44	0.05	4.50	0.41	2.34	0.47
H	3	0.28	8.96	6.94	0.20	4.46	0.03	0.02	0.50	0.11	5.36	0.08	2.39	0.60
H	4	0.30	8.70	6.38	2.26	3.20	0.03	0.26	0.37	0.18	4.81	1.03	1.53	0.55
H	5	0.17	7.48	4.62	0.33	3.32	0.02	0.04	0.44	0.10	3.03	0.19	1.54	0.41
H	6	0.20	6.22	3.14	0.45	2.70	0.03	0.07	0.43	0.10	1.81	0.28	0.73	0.29
V	0	0.29	7.20	3.85	1.78	2.86	0.04	0.25	0.40	0.11	2.15	1.18	0.93	0.30
V	1	0.15	8.83	6.12	2.51	4.43	0.02	0.28	0.50	0.08	4.31	1.30	2.06	0.49
V	2	0.19	7.87	5.73	0.22	3.67	0.02	0.03	0.47	0.11	4.42	0.14	1.87	0.56
V	3	0.17	8.17	6.64	0.52	4.87	0.02	0.06	0.60	0.08	5.11	0.32	2.67	0.63
V	4	0.11	9.84	7.56	0.90	5.66	0.01	0.09	0.57	0.05	5.91	0.36	3.12	0.60
V	5	0.35	8.33	5.93	0.26	2.52	0.04	0.03	0.30	0.16	4.33	0.15	1.18	0.52
V	6	0.21	8.41	5.44	0.37	1.96	0.02	0.04	0.23	0.07	3.66	0.18	0.73	0.44
H+V	0	0.87	19.42	10.63	5.95	4.99	0.04	0.31	0.26	0.36	6.13	4.08	1.92	0.32
H+V	1	0.68	21.43	15.69	7.27	8.79	0.03	0.34	0.41	0.32	11.11	4.24	4.24	0.52
H+V	2	0.47	18.46	14.70	1.25	10.58	0.03	0.07	0.57	0.24	11.82	0.67	5.50	0.64
H+V	3	0.74	19.38	15.76	0.96	12.42	0.04	0.05	0.64	0.23	13.19	0.49	6.65	0.68
H+V	4	0.53	21.64	16.24	3.64	10.36	0.02	0.17	0.48	0.25	12.60	2.00	5.12	0.58
H+V	5	0.76	19.39	14.28	0.75	8.71	0.04	0.04	0.45	0.36	10.16	0.29	3.88	0.52
H+V	6	0.59	20.75	13.05	1.16	8.16	0.03	0.06	0.39	0.23	8.80	0.55	2.31	0.42

Table 2-9 Simulated averaged PD over 4 [cm^2] area on Plane B Module - n261 Mid Channel.

PD Simulation(W/m^2)		Mid channel												
		2mm					4.71%	36.87%	60.07%	10mm				67.00%
		S1	S2	S2	S3	S5	S1/S2	S3/S2	S5/S2	S1	S2	S3	S5	S2/S2
Pol	Beam ID	Front	Back	Back(CB)	Left	Top				Front	Back	Left	Top	10mm/2mm
H	0	0.31	7.86	3.87	2.31	0.83	0.04	0.29	0.11	0.15	2.21	1.41	0.33	0.28
H	1	0.29	8.40	5.49	2.43	1.91	0.03	0.29	0.23	0.15	3.83	1.64	0.79	0.46
H	2	0.16	9.38	6.33	0.55	4.21	0.02	0.06	0.45	0.03	4.66	0.33	2.38	0.50
H	3	0.28	8.96	6.99	0.18	4.41	0.03	0.02	0.49	0.11	5.46	0.08	2.30	0.61
H	4	0.30	8.58	6.36	2.24	3.26	0.04	0.26	0.38	0.18	4.81	0.94	1.62	0.56
H	5	0.17	8.17	5.22	0.40	3.76	0.02	0.05	0.46	0.10	3.53	0.24	1.96	0.43
H	6	0.21	6.21	3.20	0.49	2.69	0.03	0.08	0.43	0.09	1.79	0.32	0.77	0.29
V	0	0.31	7.30	3.99	1.76	2.88	0.04	0.24	0.39	0.12	2.25	1.16	0.97	0.31
V	1	0.14	9.21	6.42	2.64	4.55	0.02	0.29	0.49	0.07	4.52	1.34	2.14	0.49
V	2	0.21	7.98	5.87	0.24	3.79	0.03	0.03	0.47	0.11	4.59	0.12	1.94	0.58
V	3	0.24	8.33	6.62	0.57	4.59	0.03	0.07	0.55	0.10	5.08	0.34	2.52	0.61

V	**4**	0.11	10.04	7.67	0.72	5.60	0.01	0.07	0.56	0.06	5.96	0.35	3.13	0.59
V	**5**	0.29	8.77	6.12	0.25	2.50	0.03	0.03	0.29	0.15	4.37	0.13	1.16	0.50
V	**6**	0.23	8.66	5.51	0.32	1.83	0.03	0.04	0.21	0.08	3.66	0.15	0.66	0.42
H+V	**0**	0.89	18.92	10.45	5.92	5.35	0.05	0.31	0.28	0.44	5.97	4.07	1.78	0.32
H+V	**1**	0.64	19.93	14.96	7.35	8.59	0.03	0.37	0.43	0.35	11.11	4.20	4.09	0.56
H+V	**2**	0.55	19.15	15.05	1.21	10.63	0.03	0.06	0.56	0.18	12.09	0.72	5.55	0.63
H+V	**3**	0.90	19.29	15.58	1.16	11.58	0.05	0.06	0.60	0.27	12.92	0.58	6.01	0.67
H+V	**4**	0.51	21.32	16.15	3.30	10.44	0.02	0.15	0.49	0.25	12.78	1.86	5.22	0.60
H+V	**5**	0.61	20.21	14.73	0.69	8.91	0.03	0.03	0.44	0.33	10.49	0.39	4.01	0.52
H+V	**6**	0.66	21.31	13.00	1.05	7.82	0.03	0.05	0.37	0.24	8.56	0.48	2.20	0.40

Table 2-10 Simulated averaged *PD* over 4 [cm^2] area on Plane B Module - n261 High Channel.

PD Simulation(W/m^2)		High channel												
		2mm					5.73%	36.92%	54.44%	10mm				64.04%
		S1	S2	S2	S3	S5	S1/S2	S3/S2	S5/S2	S1	S2	S3	S5	S2/S2
Pol	Beam ID	Front	Back	Back(CB)	Left	Top				Front	Back	Left	Top	10mm/2mm
H	**0**	0.28	6.55	3.25	1.77	1.18	0.04	0.27	0.18	0.15	1.66	1.08	0.41	0.25
H	**1**	0.27	7.61	5.04	2.16	1.98	0.04	0.28	0.26	0.15	3.54	1.51	0.76	0.47
H	**2**	0.18	9.19	6.62	0.46	4.29	0.02	0.05	0.47	0.04	4.97	0.27	2.38	0.54
H	**3**	0.28	9.00	6.96	0.23	4.47	0.03	0.03	0.50	0.11	5.50	0.10	2.34	0.61
H	**4**	0.29	8.23	6.04	2.10	3.13	0.04	0.26	0.38	0.18	4.54	0.97	1.47	0.55
H	**5**	0.18	8.81	5.78	0.46	4.25	0.02	0.05	0.48	0.10	4.02	0.28	2.36	0.46
H	**6**	0.21	6.66	3.59	0.54	2.72	0.03	0.08	0.41	0.10	2.03	0.35	0.86	0.31
V	**0**	0.29	7.36	4.25	1.84	3.04	0.04	0.25	0.41	0.11	2.49	1.23	1.08	0.34
V	**1**	0.15	9.49	6.60	2.66	4.58	0.02	0.28	0.48	0.07	4.58	1.27	2.25	0.48
V	**2**	0.24	8.18	6.22	0.30	3.97	0.03	0.04	0.49	0.12	4.91	0.15	2.05	0.60
V	**3**	0.35	8.05	6.34	0.62	4.25	0.04	0.08	0.53	0.13	4.90	0.33	2.21	0.61
V	**4**	0.18	9.63	7.29	0.57	5.24	0.02	0.06	0.54	0.06	5.64	0.34	2.91	0.59
V	**5**	0.25	8.89	6.46	0.23	2.96	0.03	0.03	0.33	0.13	4.68	0.12	1.44	0.53
V	**6**	0.25	8.58	5.64	0.38	2.10	0.03	0.04	0.24	0.09	3.78	0.20	0.80	0.44
H+V	**0**	0.84	18.59	10.11	5.19	5.95	0.05	0.28	0.32	0.43	5.71	3.58	1.84	0.31
H+V	**1**	0.54	18.48	14.03	6.82	8.29	0.03	0.37	0.45	0.34	10.26	3.50	3.88	0.56
H+V	**2**	0.68	19.50	15.19	1.17	10.24	0.03	0.06	0.52	0.23	12.06	0.68	5.32	0.62
H+V	**3**	1.13	19.75	15.58	1.18	10.57	0.06	0.06	0.54	0.34	12.64	0.57	5.40	0.64
H+V	**4**	0.65	20.01	14.86	3.07	9.90	0.03	0.15	0.49	0.28	11.89	1.96	4.91	0.59
H+V	**5**	0.52	21.71	16.10	0.86	10.29	0.02	0.04	0.47	0.30	11.54	0.48	4.84	0.53
H+V	**6**	0.59	21.70	13.67	1.10	8.02	0.03	0.05	0.37	0.23	8.80	0.64	2.38	0.41

3. References

[1] ANSYS HFSS for Antenna Simulation