FCC ID: A3LSMG977U

Power Density Simulation Report

April 4, 2019

SAMSUNG ELECTRONICS

1. Simulation methodology for Power Density (PD)

1.1 Simulation tool

1.1.1 Tool description

For the simulation approach to calculating power density (PD) evaluation for mobile phone with mmWave antenna modules, ANSYS Electromagnetics suite version 19.2 (HFSS) is used. ANSYS HFSS is one of several commercial tools for 3D full-wave electromagnetic simulation used for antenna and RF structure design of high frequency component. ANSYS Electromagnetics suite version 19.2 (HFSS) is implemented based on Finite Element Method (FEM), which operates in the frequency domain.

1.1.2 Mesh and Convergence criteria

To solve the PD analysis using FEM, volume area containing simulated objects should be subdivided into electrically small parts that are called finite elements as the unknown functions. To subdivide system, the adaptive mesh technique in ANSYS Electromagnetics suite version 19.2 (HFSS) is used. ANSYS Electromagnetics suite version 19.2 (HFSS) starts to refine the initial mesh based on wavelength and calculate the error to iterative process for adaptive mesh refinement. The determination parameter of the number of iteration in ANSYS Electromagnetics suite version 19.2 (HFSS) is defined as convergence criteria, delta S, and the iterative adaptive mesh process repeats until the delta S is met. In ANSYS Electromagnetics suite version 19.2 (HFSS), the accuracy of converged results depends on the delta S. Figure 1 is an example of final adaptive mesh of the device (cross-section of top view).

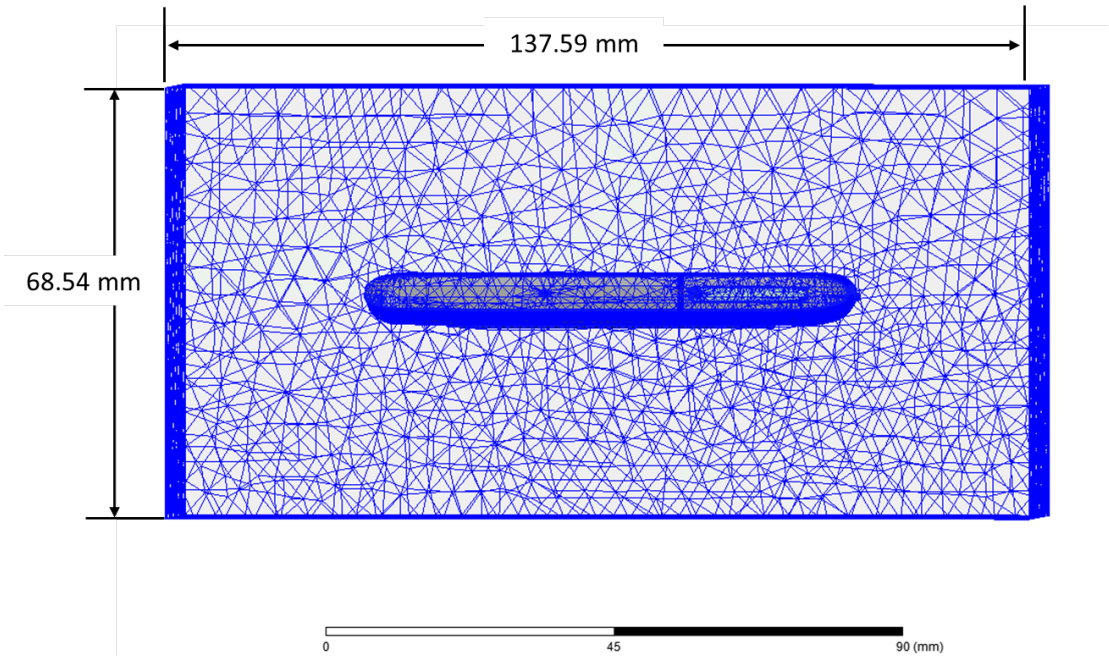


Figure 1 Example of the adaptive mesh technique (Top view)

1.1.3 Power density calculation

After solving 3D full-wave electromagnetic simulation, various kinds of physical quantities can be obtained. To calculate PD evaluation, two physical quantities, an electric field ($\vec{E}$) and a magnetic field ($\vec{H}$) are needed. The actual consumption power can be expressed as the real term of the Poynting vector ($\vec{S}$) from the cross product of $\vec{E}$ and complex conjugation of $\vec{H}$ as shown below:

$$\langle\vec{S}\rangle = \mathrm{Re}\left(\frac{1}{2}\vec{E} \times \vec{H}^{*}\right)$$

$\langle\vec{S}\rangle$ can be expressed as localized power density based on a peak value of each spatial point on mesh grids, and obtained directly from ANSYS Electromagnetics suite version 19.2 (HFSS).

From the localized power density $\langle\vec{S}\rangle$, the spatial-averaged power density (PD_{av}) on an evaluated area (A) can be derived as shown below:

$$\mathrm{PD}_{av} = \frac{1}{A}\int_{A} \langle\vec{S}\rangle \cdot ds = \frac{1}{2A}\int_{A} \left|Re(\vec{E} \times \vec{H}^{*})\right| \cdot ds$$

, where the spatial-averaged power density (PD_{av}) is total power density value considering on x, y and z components of localized power density $\langle\vec{S}\rangle$ and the evaluated area (A) is $4\mathrm{cm}^2$.

1.2 Simulation setup

1.2.1 3D modeling

Figure 2 shows the simulation model which is mounted three mmWave antenna modules. The simulation modeling includes most of the entire structure of device itself such as PCB, metal frame, battery, cables, and legacy antennas as well as mmWave antenna modules called as Ant J, Ant K and Ant L. On the back side view, Ant J is placed at the top side and antennas are facing the backside of the device. Ant K is placed on the left side and antennas are facing the left side, and Ant L is placed on the right side and antennas are facing the right side of the device.

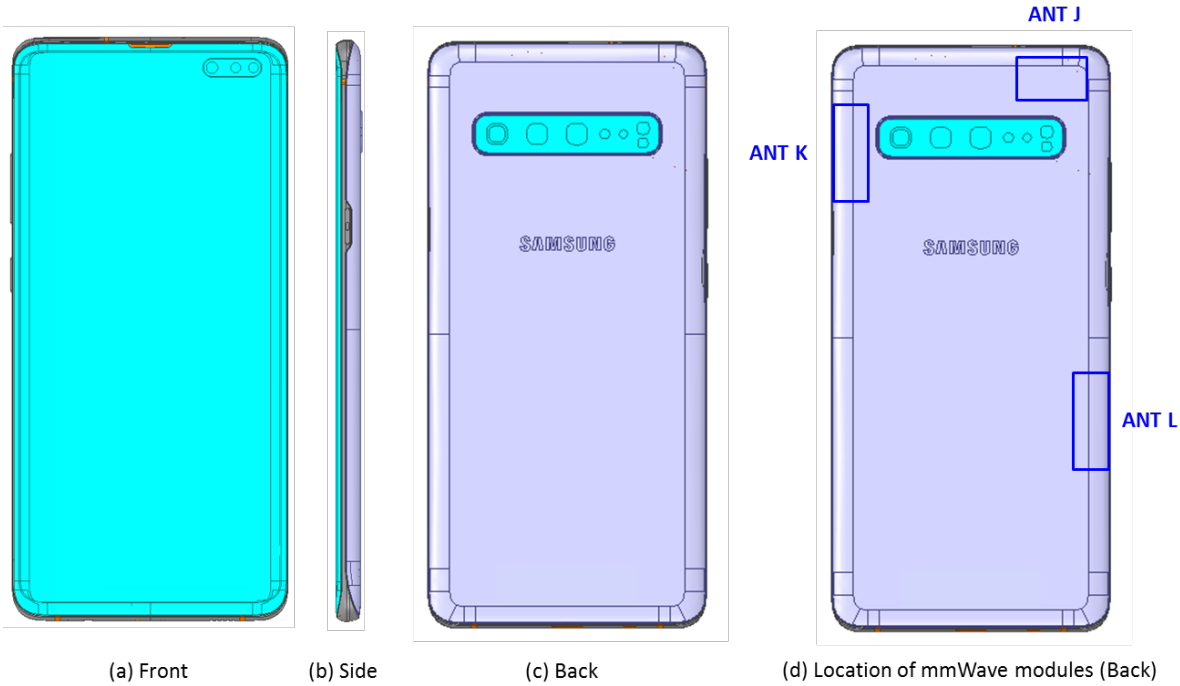


Figure 2 Simulation model which is mounted three mmWave antenna modules

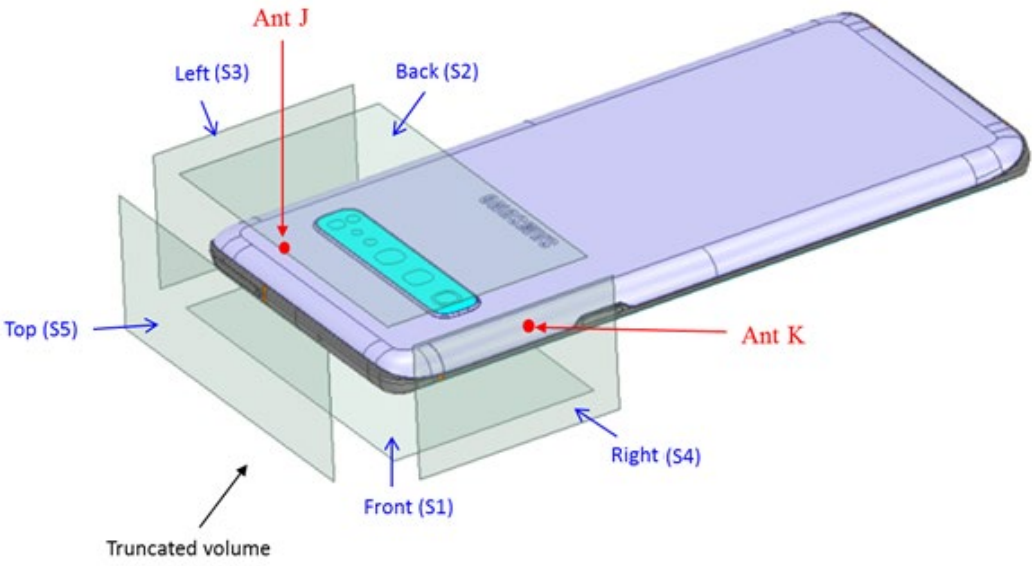
1.2.2 PD evaluation planes

Table 1 shows the PD evaluation planes for each mmWave antenna module and Figure 3 shows the PD evaluation planes and truncation area of the simulation model to find worst case of beamforming cases. In Ant J and Ant K cases, five PD evaluation planes except bottom side are set up. Ant J and Ant K are placed at the upper of the device and the bottom side is excluded from the worst case because the distance from the bottom side is more than 10 lambda at 28GHz. In Ant L case, five PD evaluation planes except top side are set up, Ant L is placed at the lower of the device and the top side is excluded from the worst case for the same reason as Ant J and Ant K.

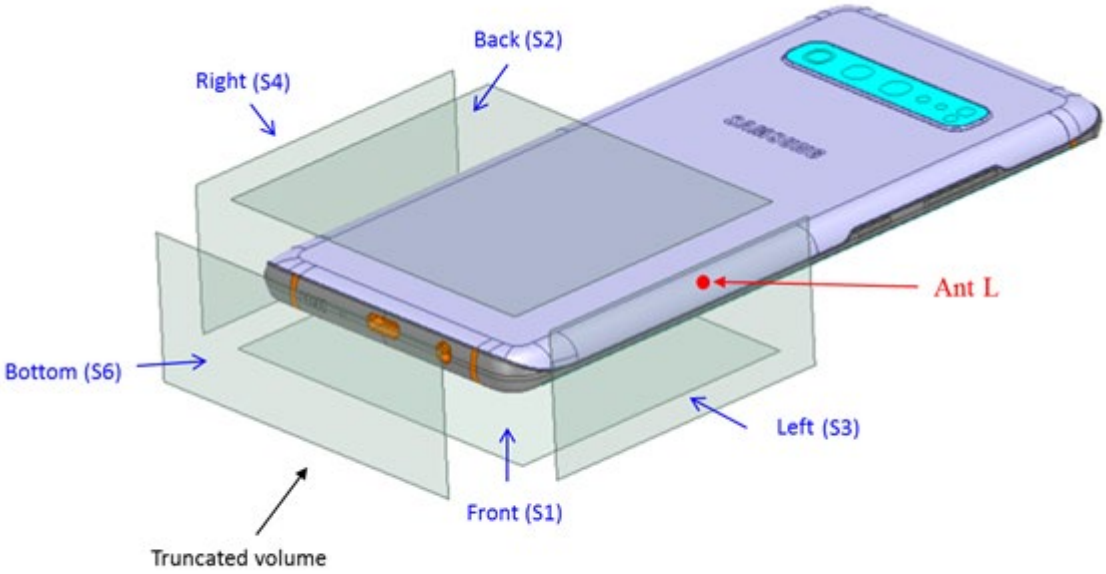
Please note that the “right” and “left” edge of mentioned in this report are defined from the perspective of looking at the device from the back side.

Table 1. PD evaluation planes

	Front	Back	Left From Front View	Right From Front View	Top	Bottom
	S1	S2	S3	S4	S5	S6
Ant J	O	O	O	O	O	X
Ant K	O	O	O	O	O	X
Ant L	O	O	O	O	X	O



(a) Ant J and Ant K



(b) Ant L

Figure 3. PD evaluation planes

1.2.3 Boundary condition

To simulate electromagnetic tool based on FEM, the boundary condition allows electromagnetic waves to be electrically open at the boundary and radiated far away without reflection. ANSYS Electromagnetics suite version 19.2 (HFSS) can support the absorbing boundary condition (ABC) for radiation boundary and make normally a quarter wave length from the radiating structure. In this report, to cover all beamforming cases of mmWave antenna modules, the three wavelength spacing from the device is used.

1.2.4 Source excitation condition

The number of antenna ports of ANT J, ANT K, and ANT L for source excitation consists of 16, 8, and 8, respectively. The antenna port of ANT J is divided into 8 ports for 1 x 4 patch array antennas and 8 ports for 1 x 4 dipole array antennas. In the 8 ports included in each patch antenna, 4 ports are divided into vertical polarization feeding, and the other 4 ports are divided into horizontal polarization feeding. The dipole array antennas consist of 4 antenna elements and each element uses two ports as a source excitation. All antenna ports of ANT K and ANT L are for patch array antennas and are similar to those of ANT J.

Figure 4 shows the ANT J module structure and surrounding structure. The ANT J module is encrypted in the ANSYS Electromagnetics suite (HFSS) and can only check the feeding position.

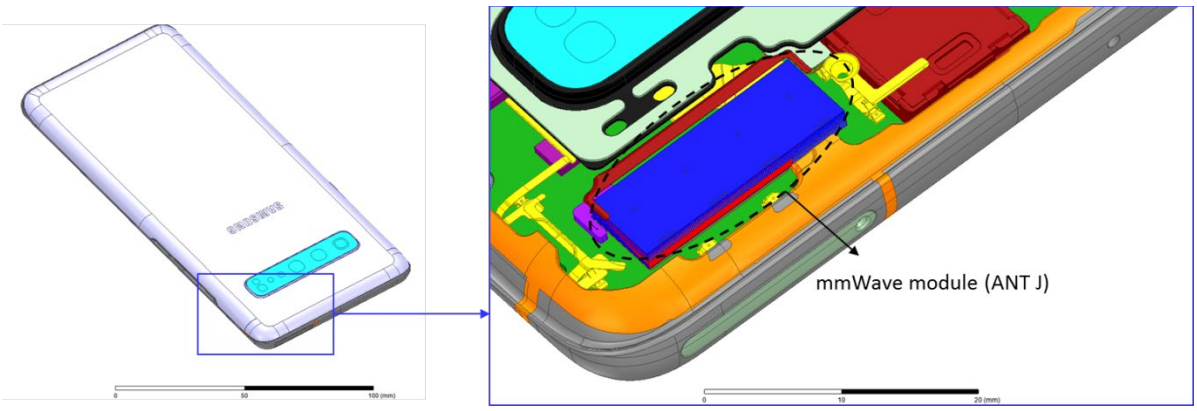


Figure 4. mmWave module (ANT J)

After finishing 3D full wave electromagnetic simulation of modeling structure, the magnitude and phase information can be loaded for each port by using “Edit Sources” function in ANSYS Electromagnetics suite (HFSS). Figure 5 shows an example of antenna port excitations.

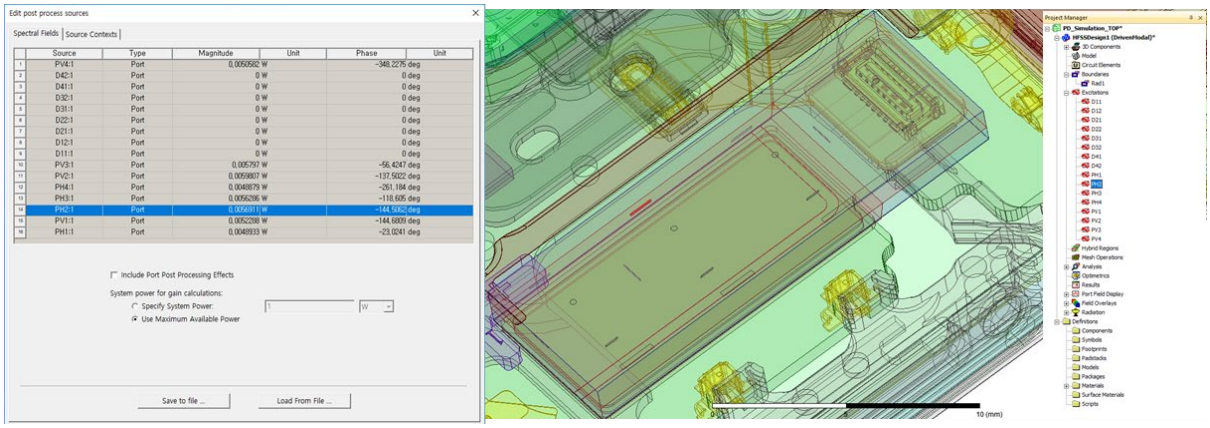


Figure 5. An example of port excitation (ANT J)

Since ANSYS Electromagnetics suite (HFSS) uses FEM solver based on frequency domain analysis method, the input source for the port excitation applies sinusoidal waveform for each frequency.

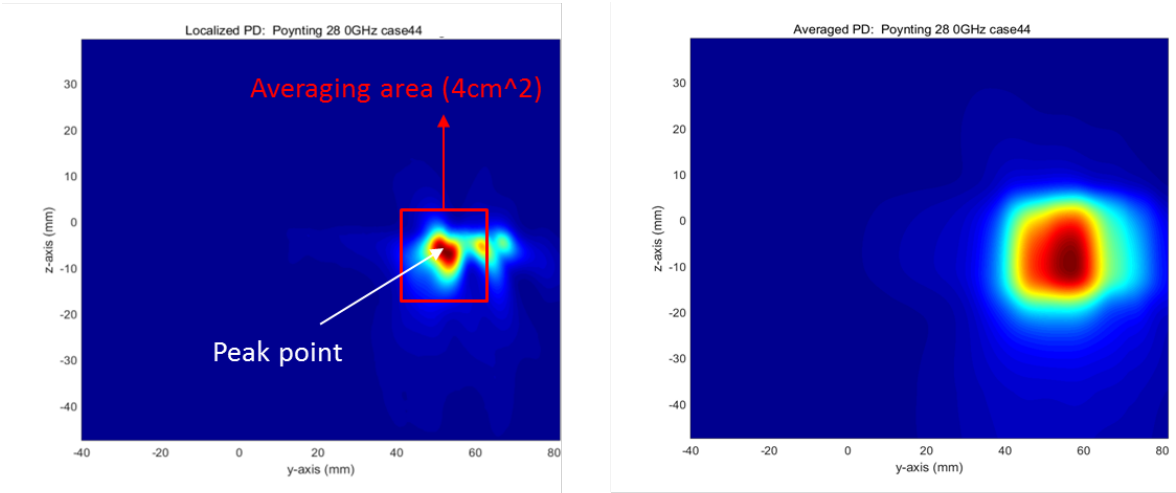
1.2.5 Condition of simulation completion

The simulation completion condition of ANSYS Electromagnetics suite (HFSS) is defined as delta S. The ANSYS Electromagnetics suite (HFSS) calculates the S-parameter for the mesh conditions of each step and determines whether to proceed with the operation of the next step by comparing the difference between the S-parameters in the previous step. A difference between the previous step and the current step of S-parameter is expressed as delta S, and the delta S generally sets 0.02. The simulation result of this report is the result of setting delta S to 0.02.

2. Simulation verification

2.1 Spatial-averaged power density

As mentioned in the previous chapter, the Poynting vector ($\vec{S}$) can be obtained through cross product of an electric field ($\vec{E}$) and complex conjugate of a magnetic field ($\vec{H}$). The real term of the Poynting vector can be described as the localized power density or peak power density. Using the localized power density, the spatial-averaged power density can be obtained by the integral of 4 cm^2 at 2.5 mm intervals of the localized power density result. Figure 6 shows examples of the distribution plot of localized power density and the averaged power density.



(a) Localized power density (b) Averaged power density

Figure 6. Power density distribution

2.2 Comparison between simulation and measurement

In this section, the simulated-power density distributions and measured-power density distributions are compared to each mmWave antenna.

Based on comparison of power density distributions, simulated power density and measured power density have a good correlation. Measurement uncertainty in mmWave frequency in measurement side and inaccuracy of material properties in mmWave frequency in the simulation side are considered as error factors.

The input powers per each active port are below for both Simulation and Measurement. For Simulation, these values were entered directly into HFSS model. For measurement, FTM S/W was used to input these values for each active port also. The maximum device output rating was determined to meet regulatory limits.

Mode/Band	Antenna	Input Power (in dBm) SISO	Input Power (in dBm) MIMO
5G NR n261	J Dipole	6.5	4.5
	J Patch	6.5	4.5
	K Patch	8	6
	L Patch	8	6

* The below simulation and measurement result were performed at 2mm Distance and 27.92GHz

Ant J Patch

Side	Beam ID	Channel	Measured PD (100% DC) mW/cm^2	Measured PD (25% DC) mW/cm^2	Simulated PD (100% DC) mW/cm^2	Simulated PD (25% DC) mW/cm^2
Back	152	Mid	1.19	0.30	3.00	0.75
Back	24	Mid	1.31	0.33	2.68	0.67
Back	41/167	Mid	1.42	0.36	3.69	0.92
Back	24/156	Mid	1.65	0.41	3.56	0.89
Back	25/155	Mid	1.42	0.36	3.61	0.90
Back	27/152	Mid	1.48	0.37	3.56	0.89

Ant J Dipole

Side	Beam ID	Channel	Measured PD (100% DC) mW/cm^2	Measured PD (25% DC) mW/cm^2	Simulated PD (100% DC) mW/cm^2	Simulated PD (25% DC) mW/cm^2
Back	133	Mid	0.698	0.17	2.14	0.53
Back	16	Mid	1.07	0.27	2.35	0.59
Back	4/133	Mid	1.03	0.26	2.48	0.62
Back	4	Mid	1.07	0.27	2.21	0.55
Back	5	Mid	0.976	0.24	2.35	0.59
Back	17	Mid	0.656	0.16	1.84	0.46

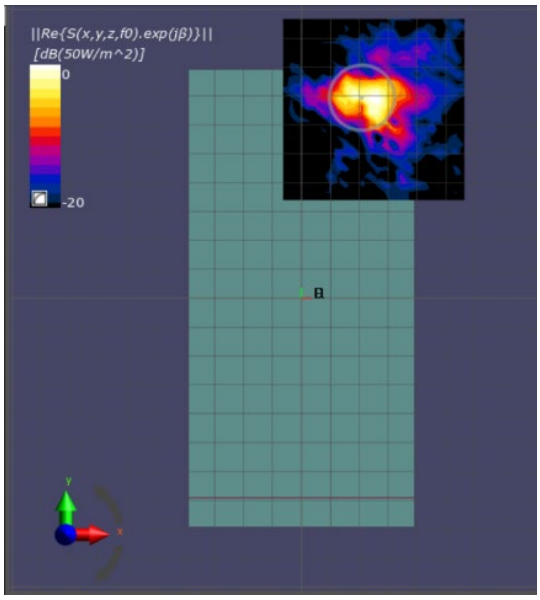
Ant K Patch

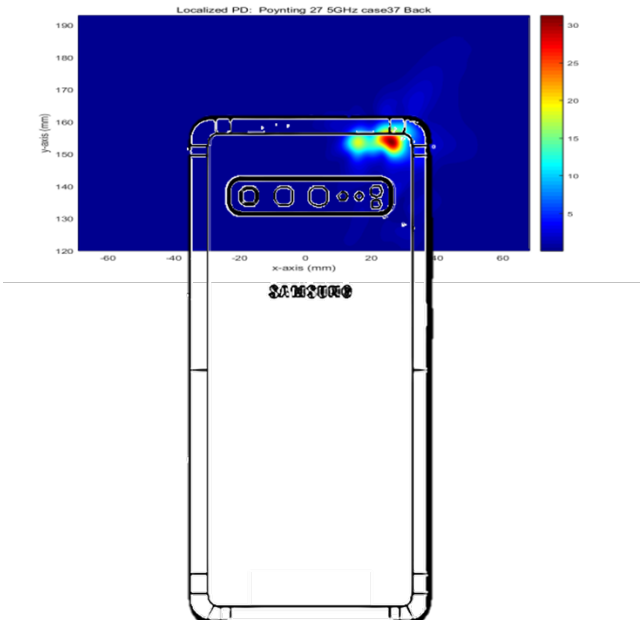
Side	Beam ID	Channel	Measured PD (100% DC) mW/cm^2	Measured PD (25% DC) mW/cm^2	Simulated PD (100% DC) mW/cm^2	Simulated PD (25% DC) mW/cm^2
Right	157	Mid	1.26	0.32	1.90	0.47
Right	44	Mid	2.18	0.55	3.67	0.92
Right	45/172	Mid	2.05	0.51	3.66	0.91
Right	31	Mid	2.37	0.59	3.64	0.91
Right	30	Mid	1.93	0.48	3.61	0.90
Right	45	Mid	2.1	0.53	3.58	0.89

Ant L Patch

Side	Beam ID	Channel	Measured PD (100% DC) mW/cm^2	Measured PD (25% DC) mW/cm^2	Simulated PD (100% DC) mW/cm^2	Simulated PD (25% DC) mW/cm^2
Left	164	Mid	1.04	0.26	2.10	0.53
Left	49	Mid	1.64	0.41	3.40	0.85
Left	49/176	Mid	1.67	0.42	3.57	0.89
Left	36/163	Mid	1.61	0.40	3.25	0.81
Left	37/164	Mid	1.55	0.39	3.10	0.78
Left	35/165	Mid	1.73	0.43	2.87	0.72

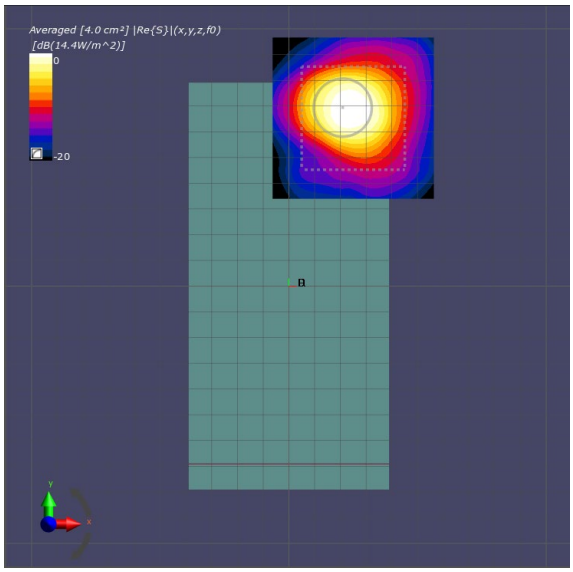
- ANT J-Patch: Low Channel, Beam ID: 24/156, Back

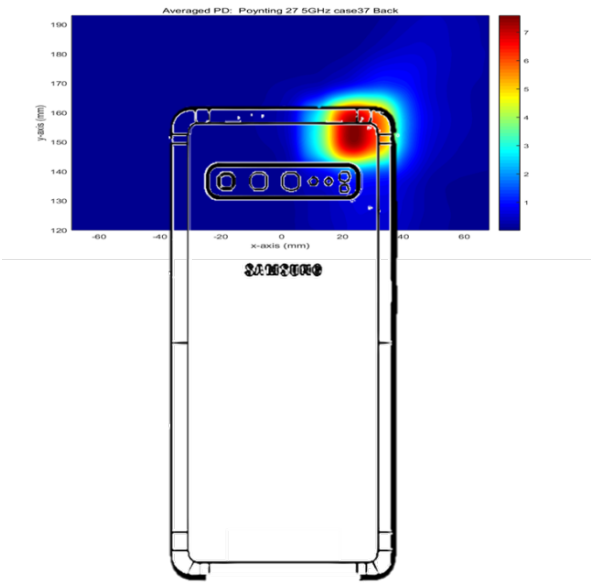




(a) measurement (b) simulation

ANT J patch: Low Channel, Localized power density

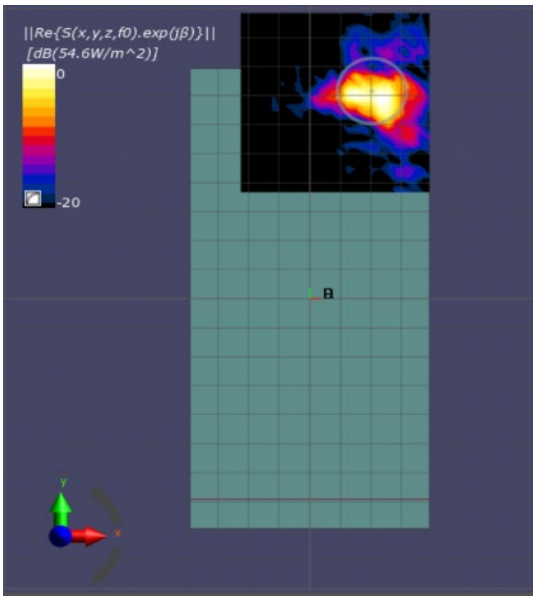


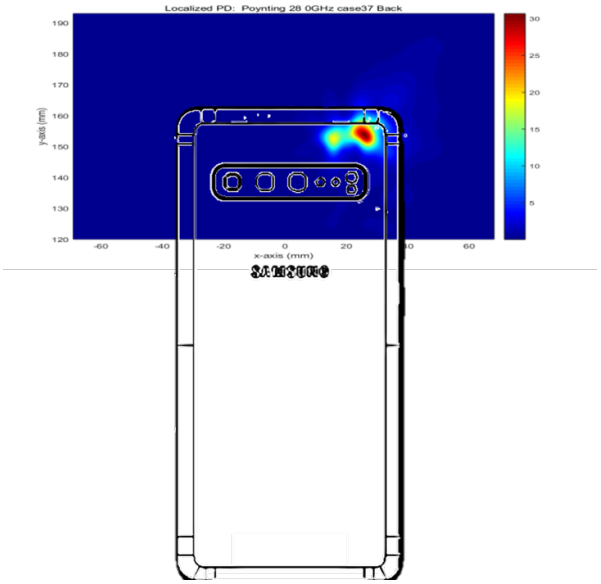


(a) measurement (b) simulation

ANT J patch: Low Channel, averaged power density

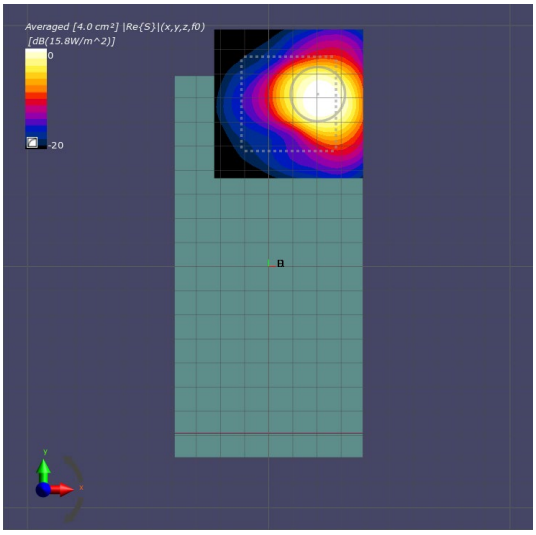
- ANT J-Patch: Mid Channel, Beam ID: 24/156, Back

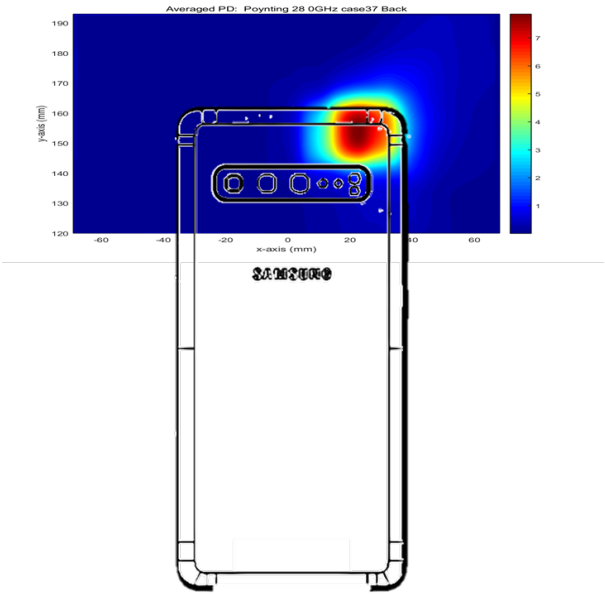




(a) measurement (b) simulation

ANT J patch: Mid Channel, Localized power density

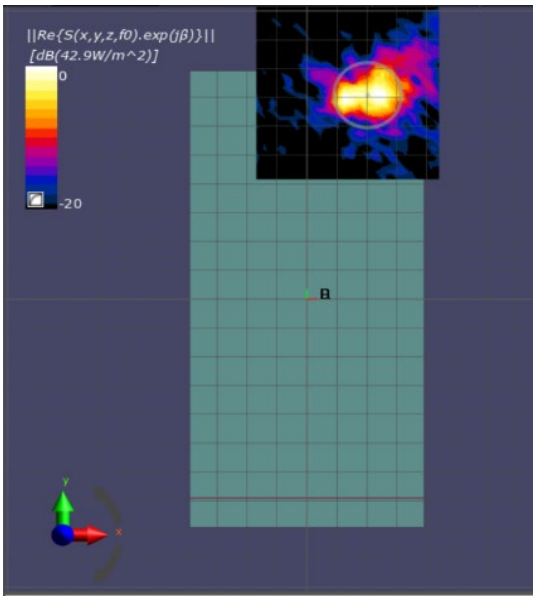


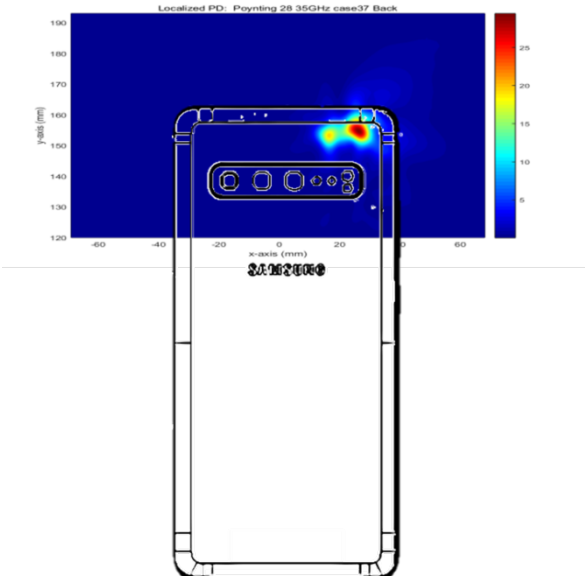


(a) measurement (b) simulation

ANT J patch: Mid Channel, averaged power density

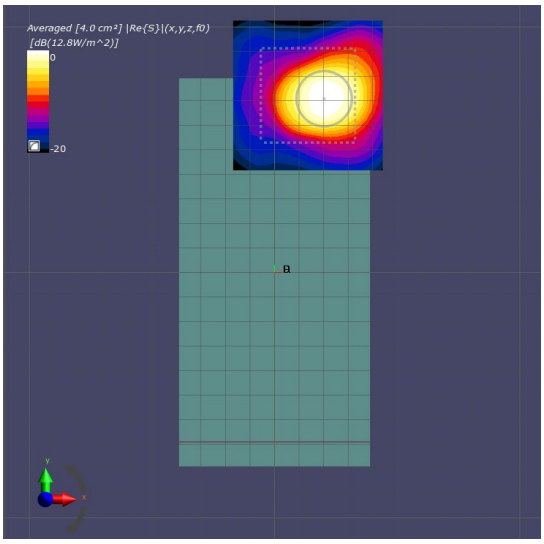
- ANT J-Patch: High Channel, Beam ID: 24/156, Back

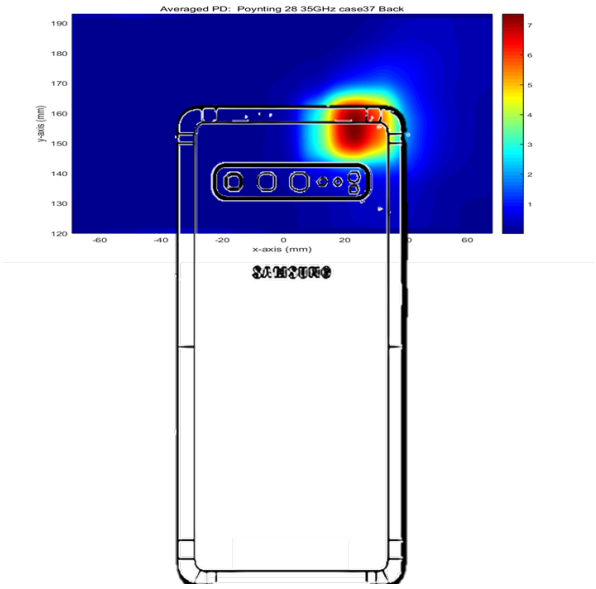




(a) measurement (b) simulation

ANT J patch: High Channel, Localized power density

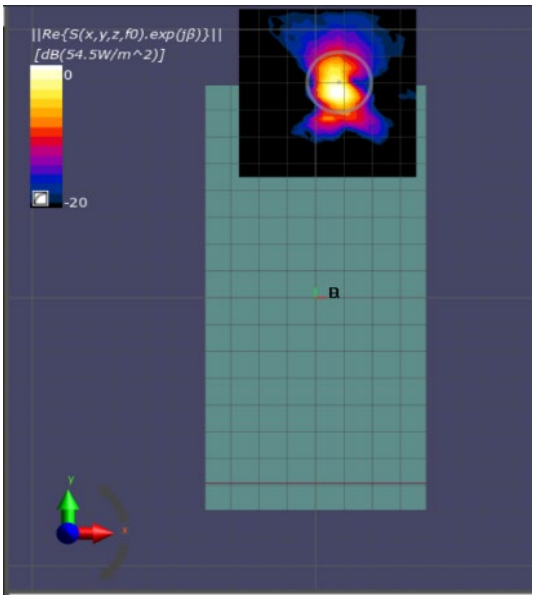




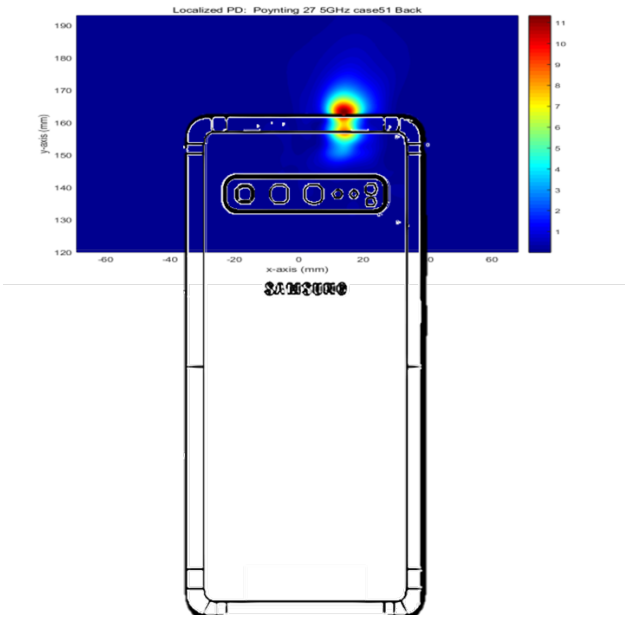
(a) measurement (b) simulation

ANT J patch: High Channel, averaged power density

- ANT J-Dipole: Low Channel, Beam ID 16, Back

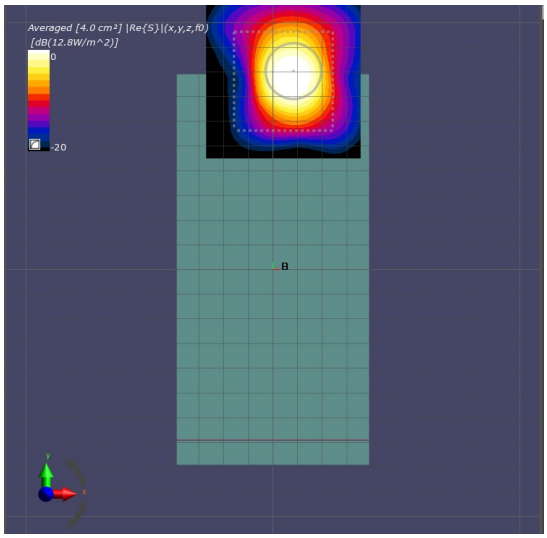


(a) measurement

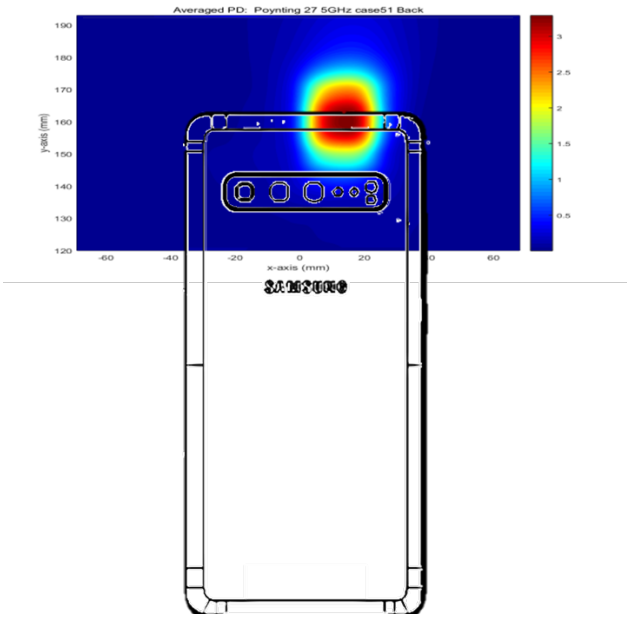


(b) simulation

ANT J-Dipole: Low Channel, Localized power density



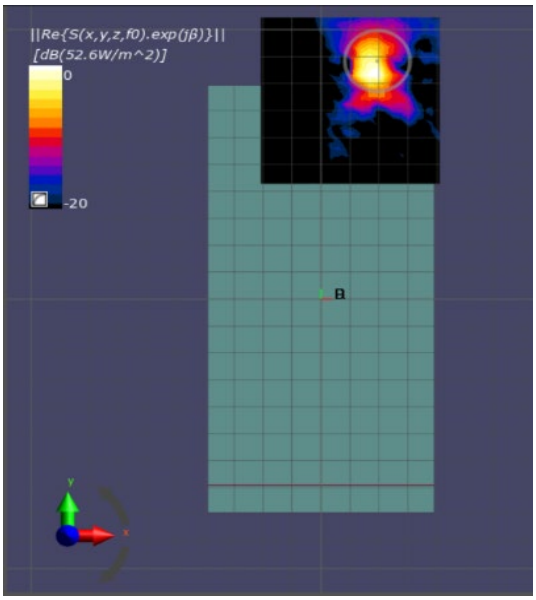
(a) measurement

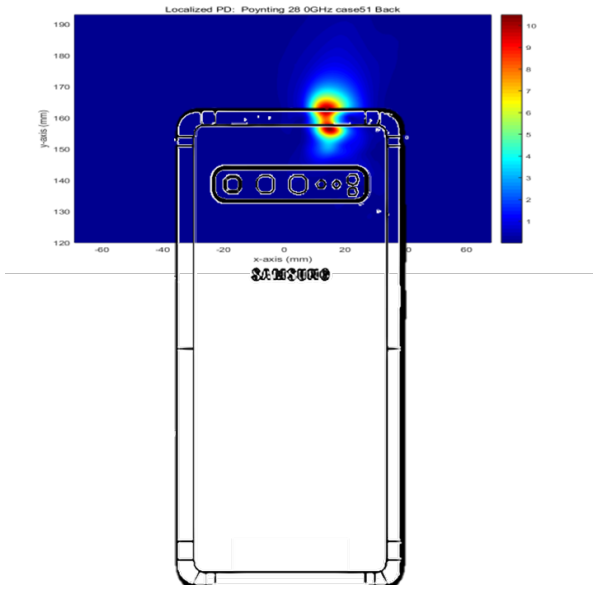


(b) simulation

ANT J-Dipole: Low Channel, averaged power density

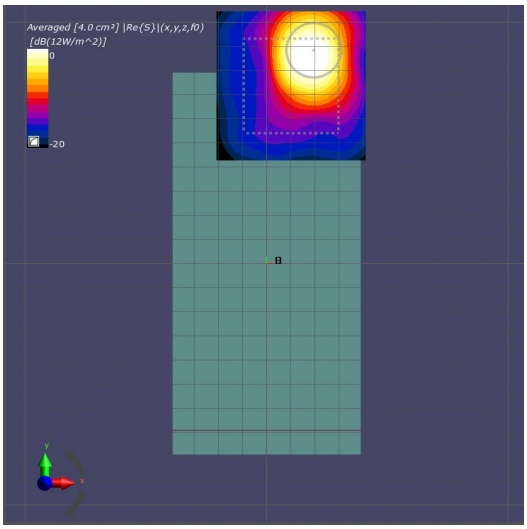
- ANT J-Dipole: Mid Channel, Beam ID 16, Back

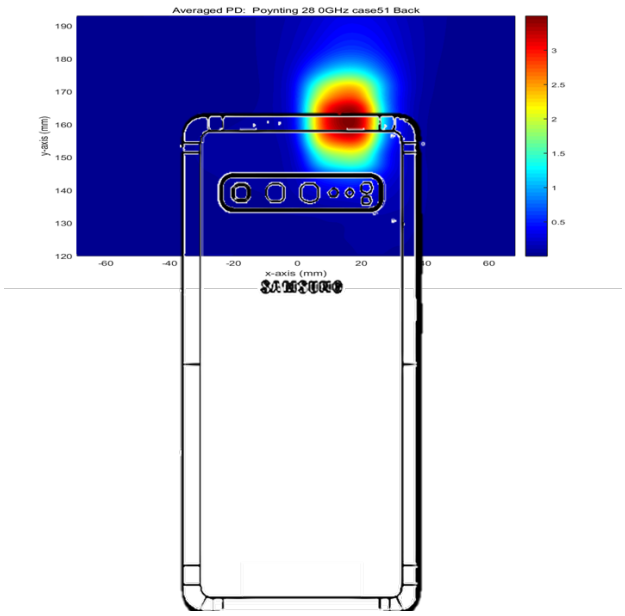




(a) measurement (b) simulation

ANT J-Dipole: Mid Channel, Localized power density

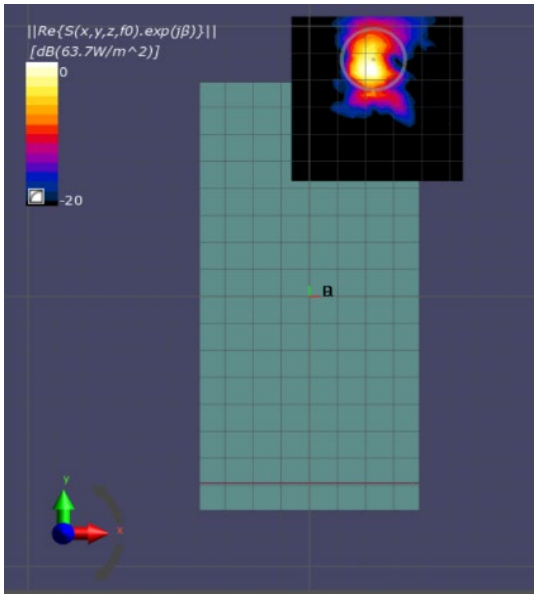


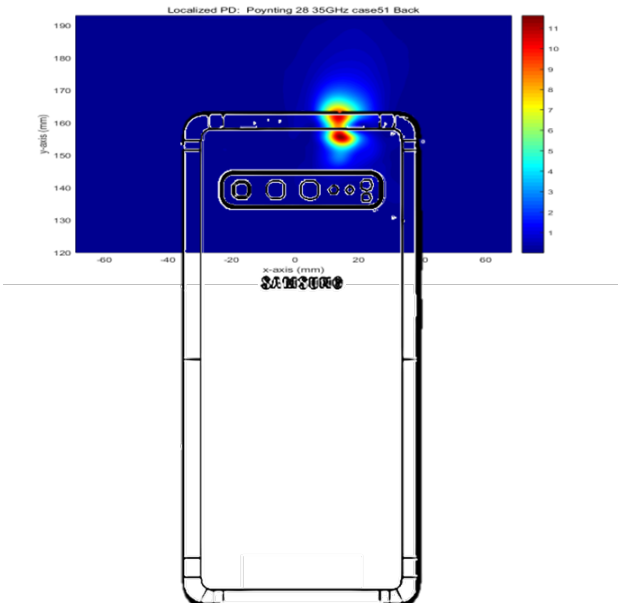


(a) measurement (b) simulation

ANT J-Dipole: Mid Channel, averaged power density

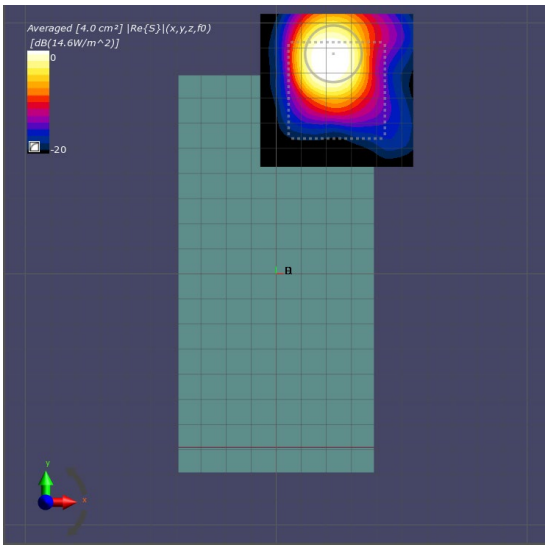
- ANT J-Dipole: High Channel, Beam ID 16, Back

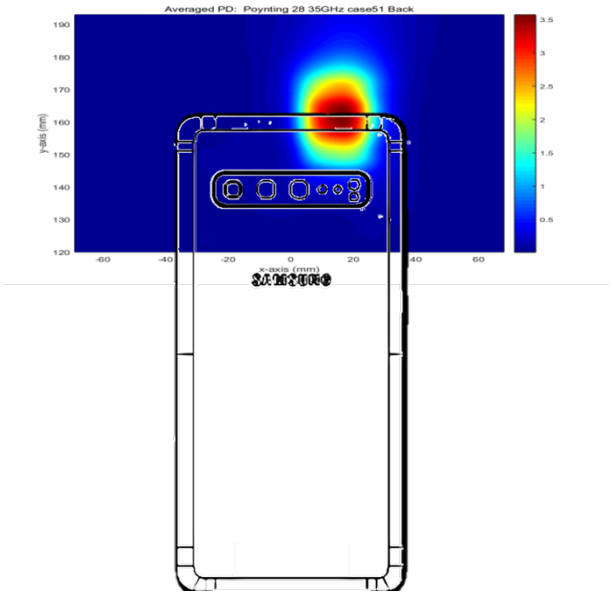




(a) measurement (b) simulation

ANT J-Dipole: High Channel, Localized power density

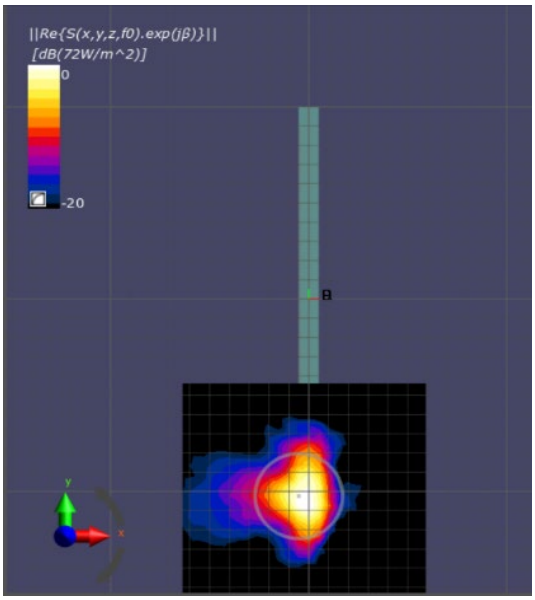


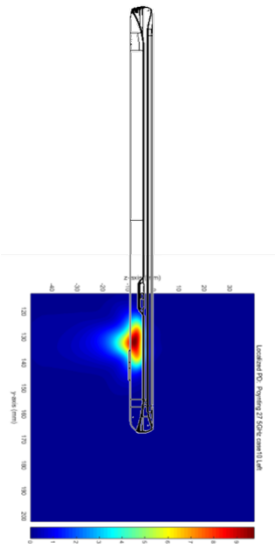


(a) measurement (b) simulation

ANT J-Dipole: High Channel, averaged power density

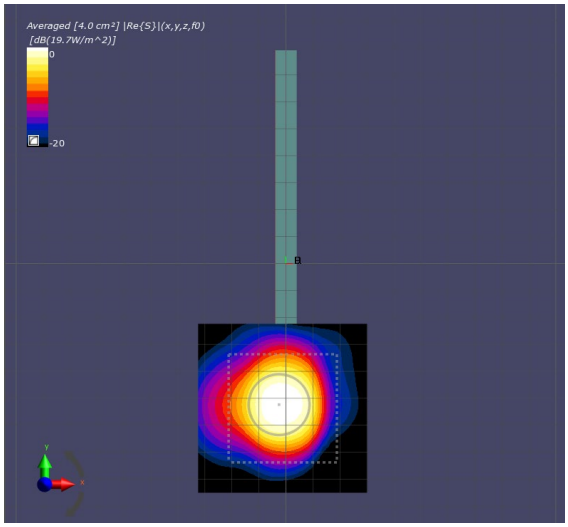
- ANT K: Low Channel, Beam ID 31, Right

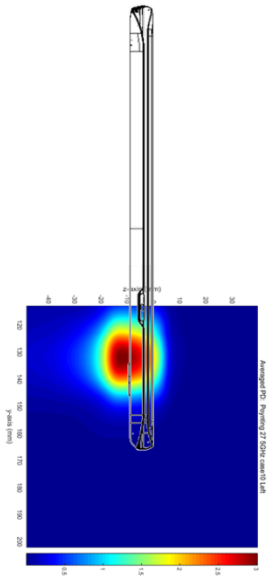




(a) measurement (b) simulation

ANT K: Low Channel, Localized power density

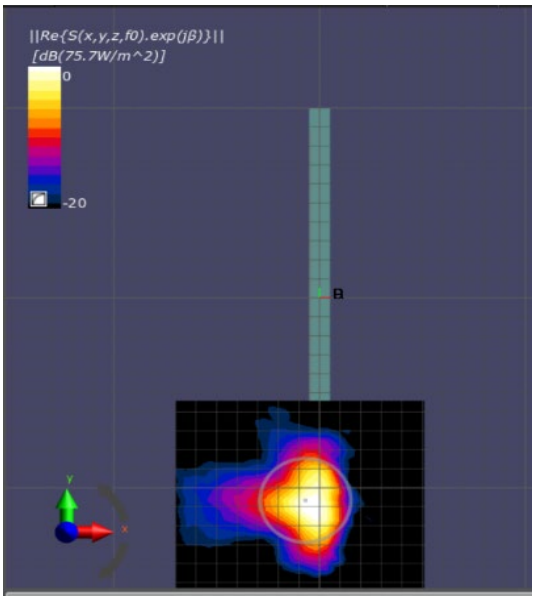


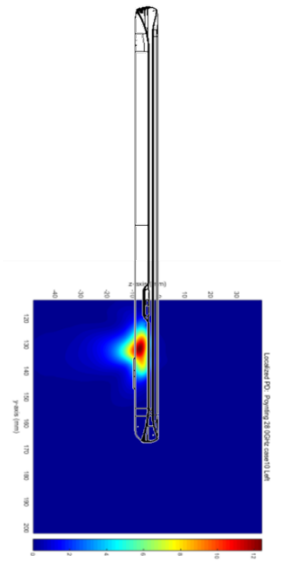


(a) measurement (b) simulation

ANT K: Low Channel, Averaged power density

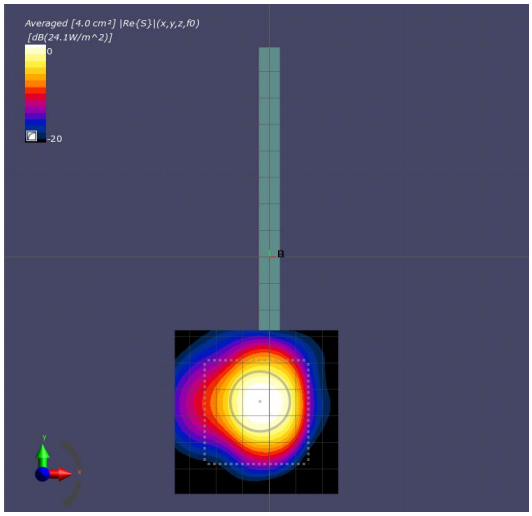
- ANT K: Mid Channel, Beam ID 31, Right

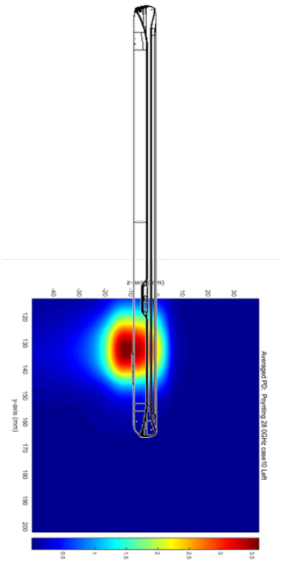




(a) measurement (b) simulation

ANT K: Mid Channel, Localized power density

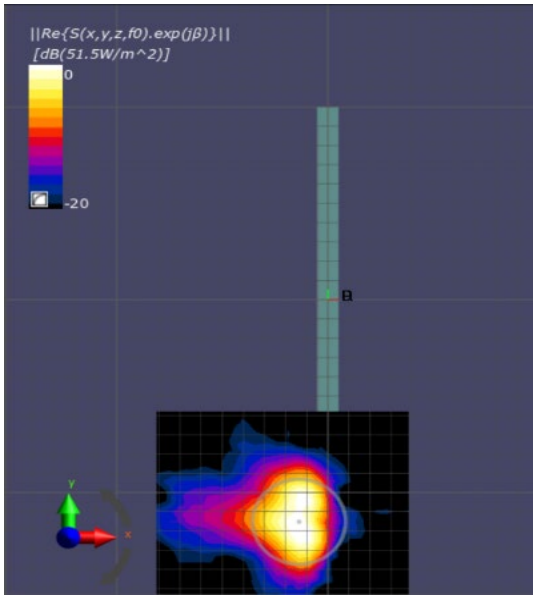


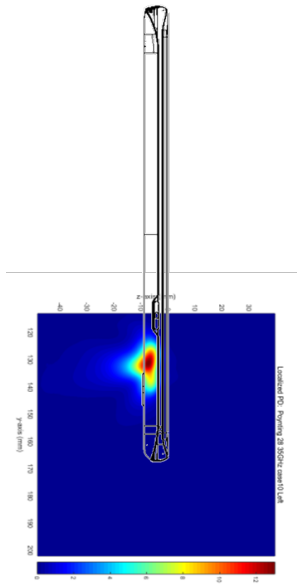


(a) measurement (b) simulation

ANT K: Mid Channel, averaged power density

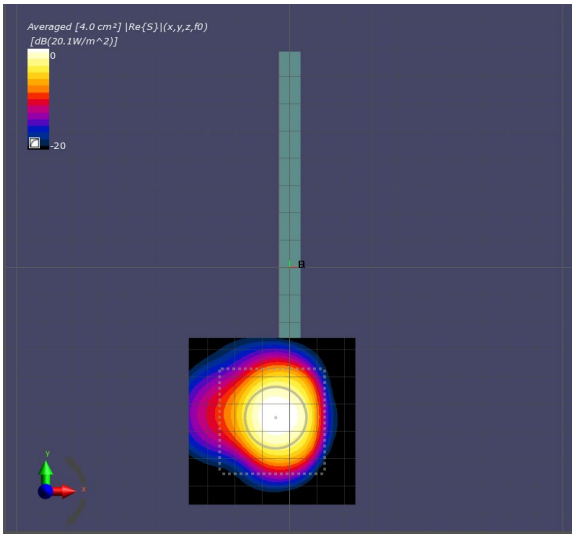
- ANT K: High Channel, Beam ID 31, Right

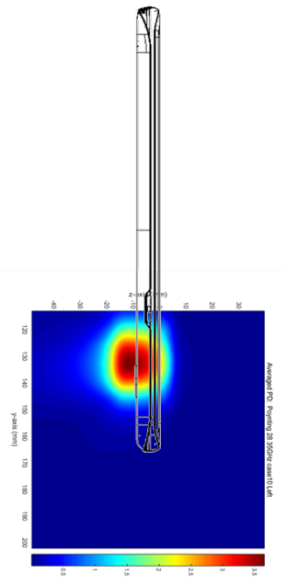




(a) measurement (b) simulation

ANT K: High Channel, Localized power density

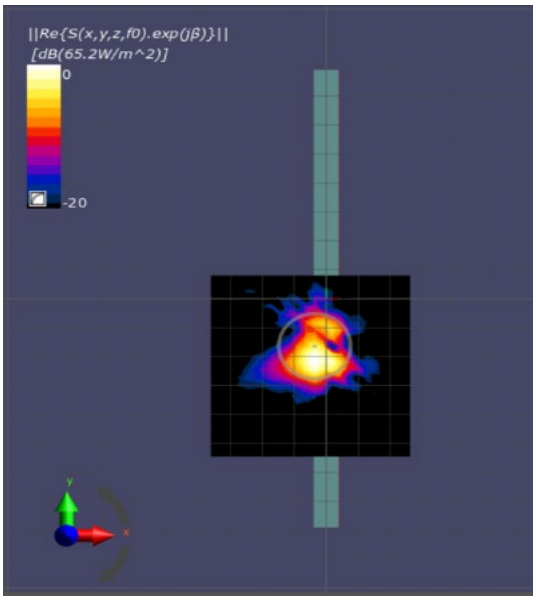


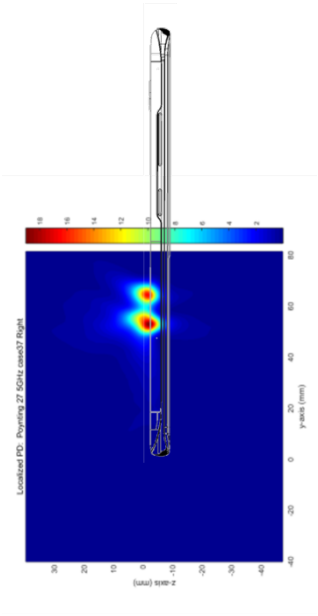


(a) measurement (b) simulation

ANT K: High Channel, averaged power density

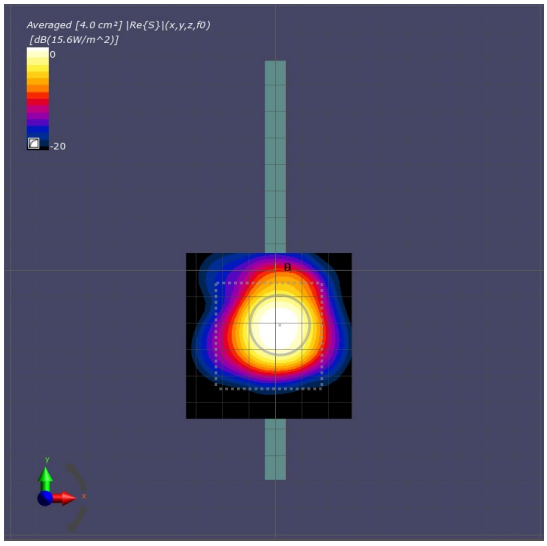
- ANT L: Low Channel, Beam ID 35/165, Left

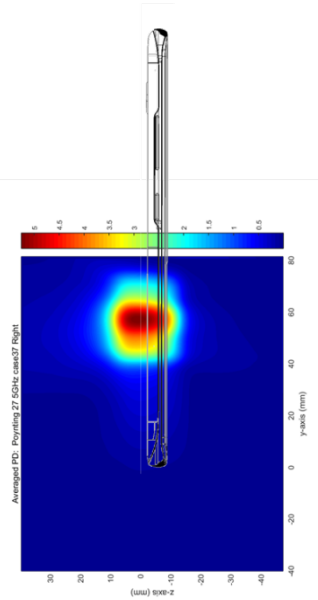




(a) measurement (b) simulation

ANT L: Low Channel, Localized power density

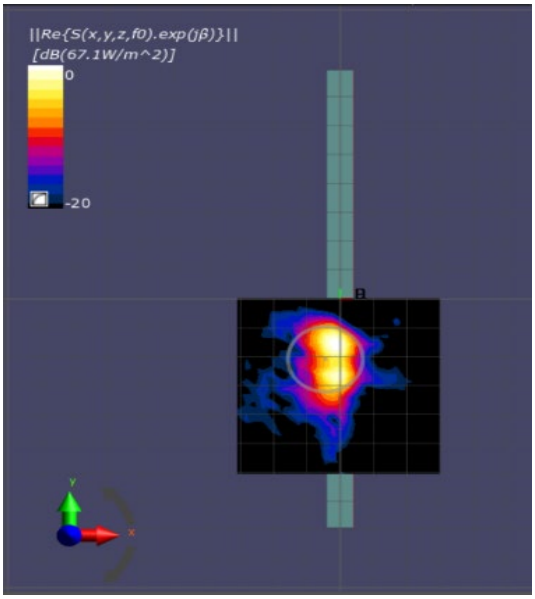


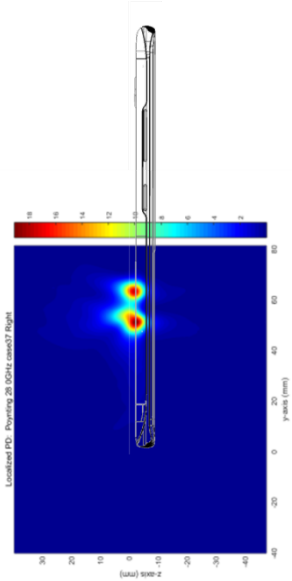


(a) measurement (b) simulation

ANT L: Low Channel, Averaged power density

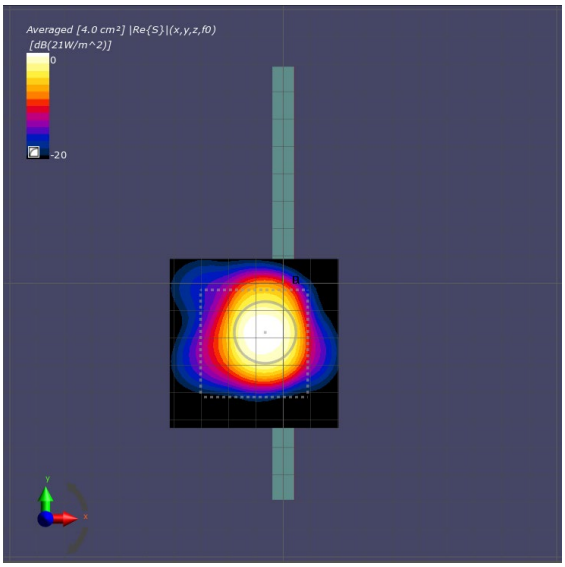
- ANT L: Mid Channel, Beam ID 35/165, Left

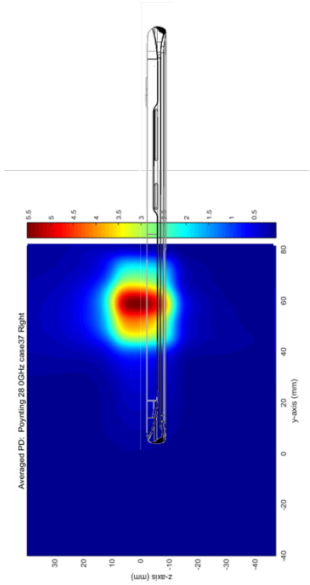




(a) measurement (b) simulation

ANT L: Mid Channel, Localized power density

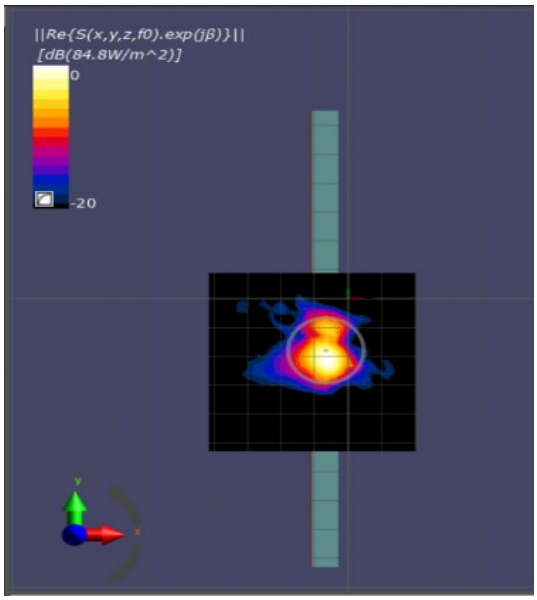


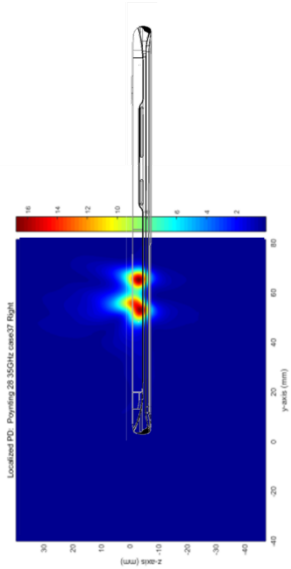


(a) measurement (b) simulation

ANT L: Mid Channel, averaged power density

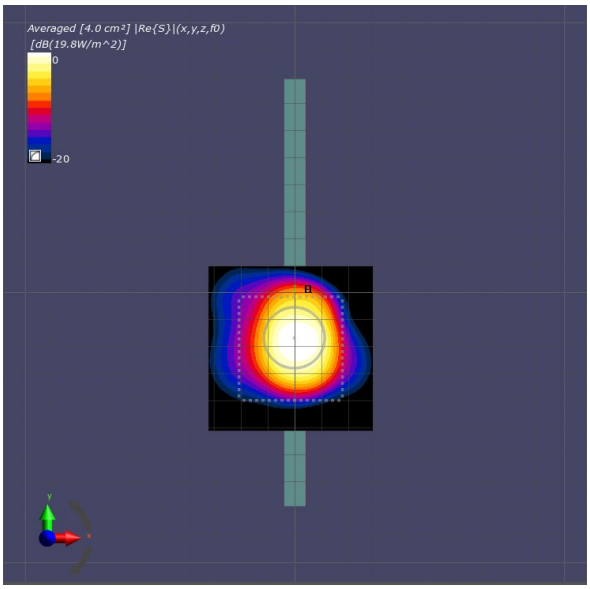
- ANT L: High Channel, Beam ID 35/165, Left

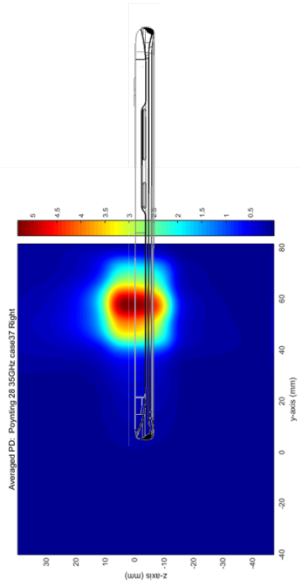




(a) measurement (b) simulation

ANT L: High Channel, Localized power density





(a) measurement (b) simulation

ANT L: High Channel, averaged power density

3. Simulation results

3.1 PD for Mid Channel at 28GHz

3.1.1 Ant J – Patch/Dipole Antenna

Table 2 shows the PD simulation evaluation of Ant J patch/dipole antenna at 28GHz for each evaluation plane. The input power for each port is shown below.

Table 2. PD of Ant J – patch/dipole antenna (28GHz)

PD Simulation (mW/cm^2)			@ Operating Target Tx Power			M-CH						
						2 mm					10mm	15mm
						S4	S3	S5	S1	S4	S4	S4
	Patch/ Dipole	SISO/MIMO & Polarization	Target Tx Power (dBm)	BEAM ID		Right from Front	Left from Front	Top	Front	Rear	Rear	Rear
ANT-J	Patch	Single beam H-pol	6.5		24	0.0101	0.3089	0.4441	0.0215	2.6826	1.3260	0.9534
			6.5		25	0.0101	0.0390	0.4588	0.0197	2.6374	1.4862	1.1747
			6.5		26	0.0034	0.0288	0.3041	0.0126	2.3957	1.4386	1.2041
			6.5		27	0.0412	0.0687	0.4312	0.0737	2.4315	1.0220	0.7494
			6.5		28	0.0516	0.2666	0.3043	0.0678	1.7219	0.7746	0.5347
			6.5		39	0.0099	0.2403	0.4551	0.0238	2.6624	1.3825	0.9972
			6.5		40	0.0085	0.0361	0.2774	0.0122	2.3656	1.4106	1.1858
			6.5		41	0.0199	0.0472	0.4935	0.0619	2.5650	1.3885	1.0546
			6.5		42	0.0494	0.1862	0.3830	0.0756	2.4436	0.9460	0.6492
		Single beam V-pol	6.5		156	0.0186	0.3451	0.3802	0.0091	2.6669	1.0636	0.6986
			6.5		155	0.0028	0.0885	0.3429	0.0155	2.9072	1.4983	1.0828
			6.5		153	0.0093	0.0863	0.3765	0.0175	2.8788	1.6863	1.2972
			6.5		152	0.0179	0.1550	0.4399	0.0227	3.0030	1.4986	1.0886
			6.5		154	0.0053	0.0440	0.3292	0.0100	2.8799	1.7263	1.3096
			6.5		170	0.0127	0.2498	0.3797	0.0061	2.9038	1.2882	0.9177
			6.5		168	0.0086	0.1012	0.3044	0.0107	2.7933	1.6921	1.2112
			6.5		167	0.0120	0.1178	0.4228	0.0176	2.8458	1.6444	1.2074
			6.5		169	0.0035	0.0729	0.3607	0.0100	2.9195	1.6636	1.2507
		Paired beam	4.5	24	156	0.0174	0.6477	0.5071	0.0083	3.5589	1.4871	1.0684
			4.5	25	155	0.0115	0.1603	0.4552	0.0086	3.6137	2.1360	1.6036
			4.5	26	153	0.0167	0.0904	0.3362	0.0198	3.2836	1.9824	1.6282
			4.5	27	152	0.0309	0.0874	0.4578	0.0429	3.5587	1.6389	1.1292
			4.5	28	154	0.0351	0.2014	0.3672	0.0424	3.1068	1.3225	0.9305
			4.5	39	170	0.0178	0.4887	0.4765	0.0168	3.4233	1.6167	1.1820
			4.5	40	168	0.0127	0.1143	0.3787	0.0124	3.1399	1.9675	1.5455
			4.5	41	167	0.0263	0.0998	0.5519	0.0655	3.6879	2.0531	1.4773
			4.5	42	169	0.0383	0.1326	0.3166	0.0472	3.0061	1.3073	0.9490
	Dipole	Single beam H-pol	6.5		0	0.0033	0.0373	0.5923	0.0320	1.0821	0.2523	0.1750
			6.5		4	0.0165	0.0311	1.4906	0.0357	2.2138	0.8404	0.5819
			6.5		6	0.0299	0.1202	0.8084	0.0794	1.4388	0.3816	0.2500
			6.5		5	0.0137	0.0556	1.4500	0.0819	2.3459	0.8178	0.5461
			6.5		17	0.0194	0.1041	1.0992	0.0944	1.8355	0.6067	0.4001
			6.5		16	0.0223	0.0329	1.5346	0.0574	2.3515	0.8890	0.6309
		Single beam V-pol	6.5		128	0.0043	0.1073	0.4665	0.0223	0.9469	0.2030	0.1460
			6.5		133	0.0007	0.0809	1.1777	0.0140	2.1373	0.6752	0.4297
			6.5		132	0.0125	0.2189	0.9643	0.0198	1.5833	0.5597	0.3557
			6.5		134	0.0011	0.4684	0.9938	0.0706	1.6661	0.5800	0.3764
			6.5		144	0.0078	0.0967	1.1366	0.0379	1.9581	0.6795	0.4315
			6.5		145	0.0008	0.3155	1.1456	0.0536	1.9823	0.6609	0.4257
		Paired Beam	4.5	128	0	0.0014	0.0264	0.7934	0.0349	1.3956	0.4532	0.3236
			4.5	133	4	0.0146	0.0703	1.5830	0.0311	2.4780	0.9496	0.6832
			4.5	132	6	0.0259	0.1661	1.4206	0.0540	1.9945	0.8064	0.5863
			4.5	134	5	0.0089	0.2710	1.0144	0.0779	1.6996	0.5751	0.3651
			4.5	144	17	0.0286	0.0700	1.5934	0.0672	2.3802	0.9482	0.7481
			4.5	145	16	0.0064	0.2892	1.1344	0.0468	1.7419	0.7148	0.4997

3.1.2 Ant K – Patch Antenna

Table 3 shows the PD simulation evaluation of Ant K patch antenna at 28GHz for each evaluation plane. The input power for each port is shown below.

Table 3. PD of Ant K – patch antenna (28GHz)

PD Simulation (mW/cm^2)			@ Operating Target Tx Power			M-CH								
						2 mm					10mm		15mm	
						S2	S3	S5	S1	S4	S4	S2	S4	S2
	Patch/ Dipole	SISO/MIMO & Polarization	Target Tx Power (dBm)	BEAM ID		Rear	Left from Front	Top	Front	Right from Front	Right from Front	Rear	Right from Front	Rear
ANT-K	Patch	Single beam H-pol	8	29		2.2487	0.0044	0.1542	0.1778	2.2487	0.5030	0.5700	0.2164	0.0976
			8	32		2.6736	0.0033	0.0510	0.2372	3.0684	1.8082	1.3691	1.3726	0.9846
			8	33		2.0676	0.0078	0.1417	0.2796	1.1011	0.9814	0.8033	0.6679	0.5352
			8	31		3.0679	0.0022	0.0254	0.2154	3.6363	2.1591	1.6168	1.6838	1.1987
			8	30		2.9507	0.0017	0.0324	0.3011	3.6101	1.9068	1.5272	1.2231	0.9318
			8	45		2.9813	0.0021	0.0618	0.2538	3.5761	2.1498	1.5545	1.6475	1.1854
			8	43		2.6247	0.0025	0.0855	0.2648	2.7426	1.1588	0.9856	0.6445	0.5340
			8	46		2.2177	0.0066	0.1024	0.1753	1.0353	1.0851	0.9494	0.7908	0.6529
			8	44		3.0224	0.0021	0.0098	0.2591	3.6680	2.1456	1.5919	1.6133	1.1938
		Single beam V-pol	8	157		0.7023	0.0049	0.0520	0.3620	1.8989	0.5895	0.2673	0.3097	0.1369
			8	159		1.3464	0.0089	0.0509	0.4542	1.4535	1.0987	0.7204	0.8661	0.5883
			8	161		0.6864	0.0056	0.0415	0.3068	1.4208	0.6857	0.4687	0.4749	0.2043
			8	158		1.8242	0.0106	0.0195	0.5175	1.5267	0.9606	1.1169	0.7756	0.3357
			8	160		0.8241	0.0047	0.0536	0.3975	1.8266	0.9933	0.4542	0.7315	0.2480
			8	172		1.6381	0.0109	0.0256	0.5082	1.7746	1.1667	0.9553	0.9215	0.6805
			8	171		1.3434	0.0164	0.0217	0.4615	1.4491	0.8380	0.7841	0.6373	0.6150
			8	174		0.7916	0.0050	0.0478	0.3534	1.6763	0.8653	0.4875	0.6304	0.3960
			8	173		1.1191	0.0101	0.0834	0.4321	1.4669	1.0132	0.4304	0.7657	0.3943
		Paired beam	6	29	157	2.3243	0.0058	0.1773	0.4135	3.1760	0.8666	0.4898	0.3716	0.1379
			6	32	159	2.4751	0.0116	0.0544	0.4046	2.6206	1.6967	1.2148	1.2958	0.6822
			6	33	161	2.1219	0.0062	0.1181	0.2924	2.8084	1.3917	0.8882	1.0268	0.3202
			6	31	158	2.9877	0.0081	0.0379	0.5008	3.3842	1.9626	1.0783	1.5241	0.3073
			6	30	160	2.7334	0.0033	0.0542	0.3364	3.3783	1.7111	1.3019	1.0611	0.8162
			6	45	172	3.2012	0.0091	0.0723	0.4798	3.6589	2.0914	1.3684	1.6026	0.5097
			6	43	171	2.5901	0.0180	0.0731	0.3293	2.5535	0.9394	1.0843	0.5311	0.7701
			6	46	174	3.0242	0.0030	0.1307	0.3046	3.4198	1.7353	1.1734	1.2264	0.7804
			6	44	173	3.0125	0.0112	0.0430	0.3667	3.4830	2.0508	1.5472	1.5078	0.3152

3.1.3 Ant L – Patch Antenna

Table 4 shows the PD simulation evaluation of Ant L patch antenna at 28GHz for each evaluation plane. The input power for each port is shown below.

Table 4. PD of Ant L – patch antenna (28GHz)

PD Simulation (mW/cm^2)			@ Operating Target Tx Power		M-CH								
					2mm					10mm		15mm	
					S4	S6	S1	S2	S3	S2	S3	S2	S3
	Patch/ Dipole	SISO/MIMO & Polarization	Target Tx Power (dBm)	BEAM ID	Right from Front	Bottom	Front	Rear	Left from Front	Rear	Left from Front	Rear	Left from Front
ANT-L	Patch	Single beam H-pol	8	35	0.0035	0.0296	0.0308	3.0332	3.3240	1.5179	1.9189	1.1152	1.4068
			8	36	0.0014	0.0022	0.2105	3.0085	3.3326	1.5726	1.9446	1.1631	1.4484
			8	34	0.0168	0.0062	0.2499	2.9014	2.9740	1.3891	1.5892	0.9624	1.1428
			8	38	0.0152	0.0658	0.0689	2.6502	2.3487	1.0031	1.0498	0.5716	0.6099
			8	37	0.0035	0.0110	0.2332	3.1048	3.2988	1.4880	1.7090	1.1103	1.2202
			8	48	0.0009	0.0201	0.0297	3.0330	3.3534	1.5337	1.9718	1.1382	1.4620
			8	49	0.0009	0.0062	0.2230	3.1128	3.4028	1.6182	1.8277	1.0449	1.3940
			8	47	0.0105	0.0168	0.2083	2.9784	3.1838	1.5179	1.7722	1.0649	1.3462
			8	50	0.0120	0.0393	0.2385	2.9080	2.8473	1.3218	1.4179	0.8704	0.9687
		Single beam V-pol	8	165	0.0545	0.0105	0.4545	1.2909	1.5742	0.4007	1.0809	0.2990	0.8428
			8	163	0.0485	0.0018	0.6780	0.8334	1.8330	0.4957	1.3152	0.3853	1.0413
			8	166	0.0289	0.0045	0.2683	0.6863	1.3252	0.3655	0.6783	0.2776	0.4936
			8	162	0.0289	0.0078	0.1564	1.7397	0.9669	0.3600	0.4637	0.2817	0.2509
			8	164	0.0933	0.0057	0.6626	1.3349	2.1025	0.7001	1.3469	0.5124	1.0714
			8	177	0.0708	0.0107	0.6172	1.6557	1.6409	0.5123	1.2987	0.3808	1.0304
			8	176	0.1073	0.0016	0.7247	1.0832	2.0477	0.6433	1.4176	0.4651	1.1496
			8	178	0.0490	0.0044	0.3436	0.6298	1.4469	0.4926	0.7813	0.3810	0.5772
			8	175	0.0095	0.0037	0.3096	0.0037	1.2906	0.3222	0.5020	0.2346	0.4500
		Paired beam	6	35 165	0.0378	0.0433	0.5100	2.6956	2.8749	1.0970	1.8258	0.8376	1.3367
			6	36 163	0.0305	0.0026	0.5965	2.7792	3.2455	1.2182	1.8678	0.7857	1.4235
			6	34 166	0.0214	0.0118	0.3697	1.9669	2.3164	0.8066	1.1584	0.4951	0.7743
			6	38 162	0.0219	0.0371	0.3324	2.2563	2.5180	0.7976	1.1630	0.4614	0.7693
			6	37 164	0.0826	0.0024	0.5254	2.5215	3.1040	0.9282	1.4464	0.6632	1.0110
			6	48 177	0.0441	0.0425	0.5990	2.8661	2.7267	1.1494	2.0323	0.7606	1.5040
			6	49 176	0.0683	0.0055	0.6012	2.7221	3.5738	1.2448	2.0974	0.8041	1.6064
			6	47 178	0.0373	0.0193	0.4232	2.1434	2.7208	0.8746	1.3384	0.5652	0.8786
			6	50 175	0.0163	0.0154	0.3562	2.6018	2.8677	1.0480	1.5563	0.6362	1.1155

4. Uncertainty

The amplitude level of PD simulation is biased due to material property parameter configuration in device housing at high frequencies. Material property is difficult to model due to complexity of material and operating frequency. Therefore, it is not possible to assign an exact uncertainty for simulation result. However, for this RF exposure evaluation, simulation results were only used to select highest beam ID measurement. Power Density results for measurement and simulation showed similar trend to justify selection of Beam ID used for measurement. All final power density evaluation were performed on measurement system with uncertainty approximately 1.48dB.