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Power Density Simulation Report

Revision A

June 05, 2022

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 2021.R2 (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 2021.R2 (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 2021.R2 (HFSS) is used. ANSYS Electromagnetics suite version 2021.R2 (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 2021.R2 (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 2021.R2 (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).

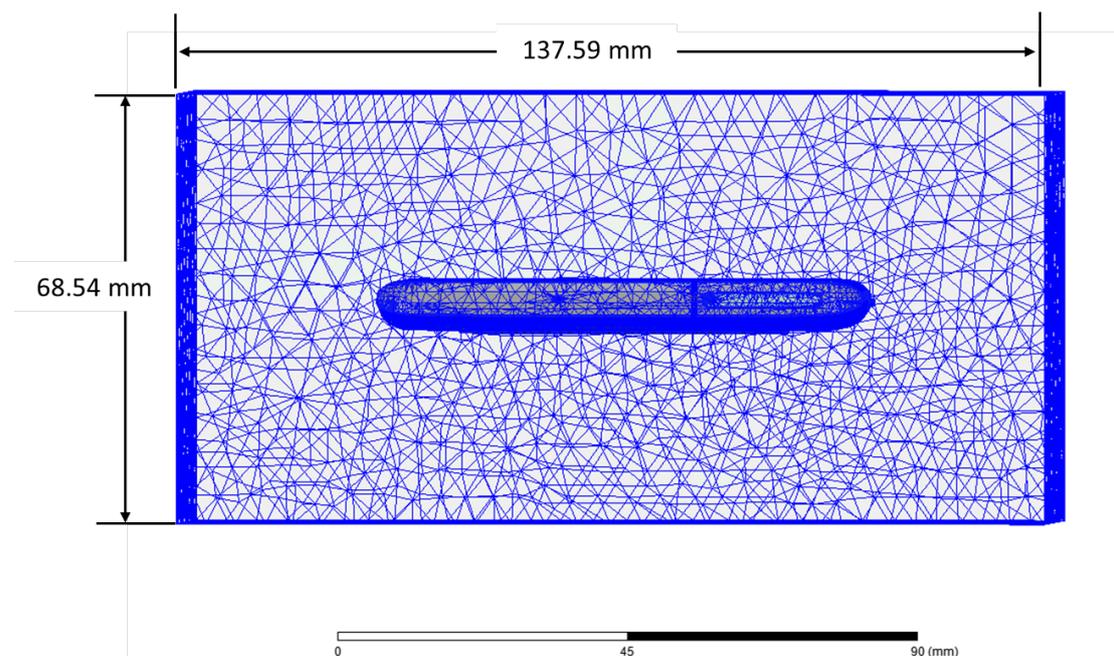


Figure 1 Example of the adaptive mesh technique (Top view)

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:

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

$\langle \vec{S} \rangle$ can be expressed as point power density based on a peak value of each spatial point on mesh grids, and obtained directly from ANSYS Electromagnetics suite version 2020.R1 (HFSS).

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

$$PD_{av} = \frac{1}{A} \int_A \langle \vec{S} \rangle \cdot ds = \frac{1}{2A_{av}} \iint_{A_{av}} \| \text{Re}\{E \times H^*\} \| dA$$

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

1.2 Simulation setup

1.2.1 3D modeling

Figure 2 shows the simulation model which is mounted two 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 K and Ant J. For a folder open status (Fig. 2-1) and folder close status (Fig. 2-2), Ant K is placed on the right side and antennas are facing the right side, and Ant J is placed on the back side and antennas are facing the back side of the device.

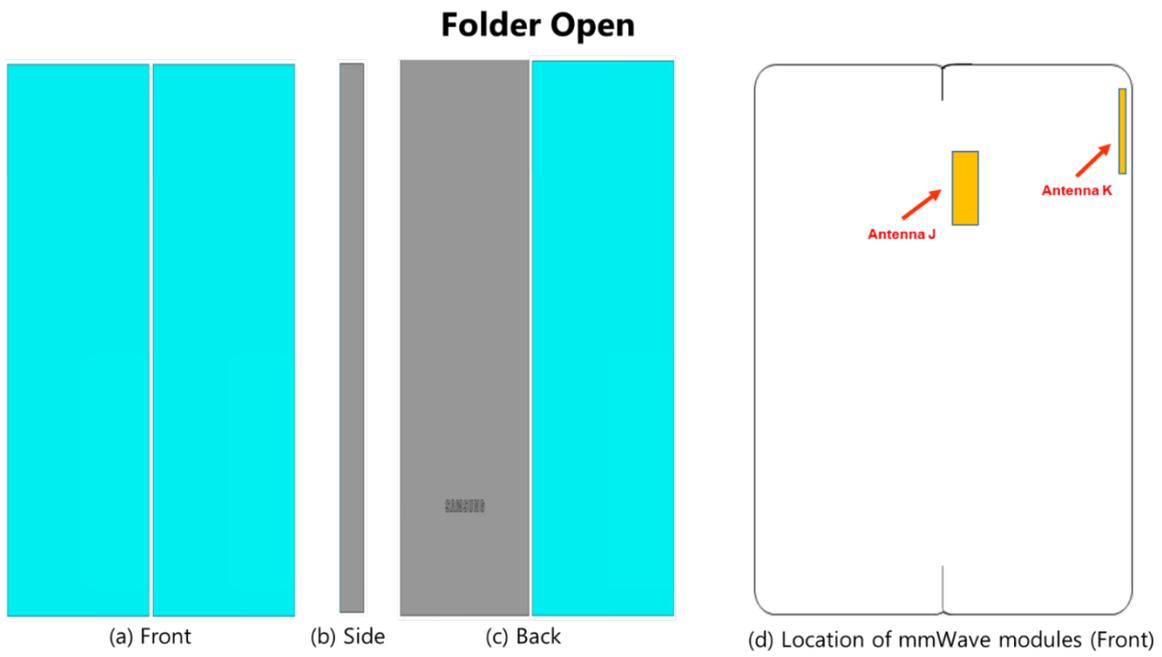


Figure 2-1. Simulation model which is mounted two mmWave antenna modules (Folder Open Status)

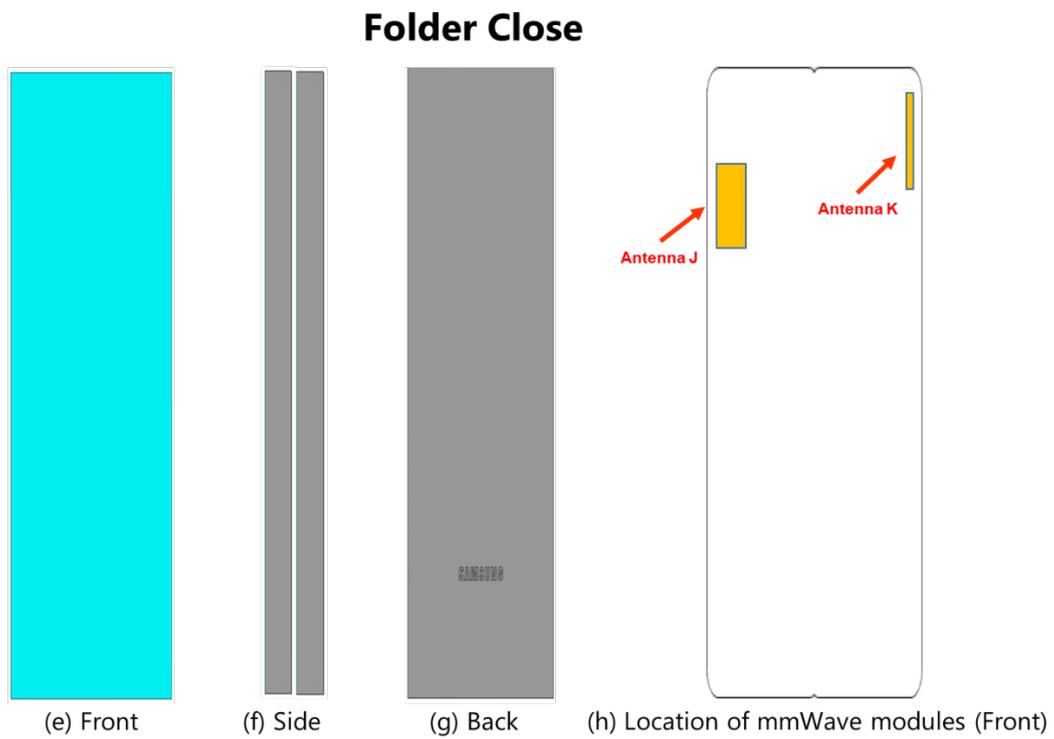


Figure 3-2. Simulation model which is mounted two mmWave antenna modules (Folder Closed Status)

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 whole area of the simulation model to find worst case of beamforming cases.

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 front side.

Table 1. PD evaluation planes

Module	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	O
Ant K	O	O	O	O	O	O

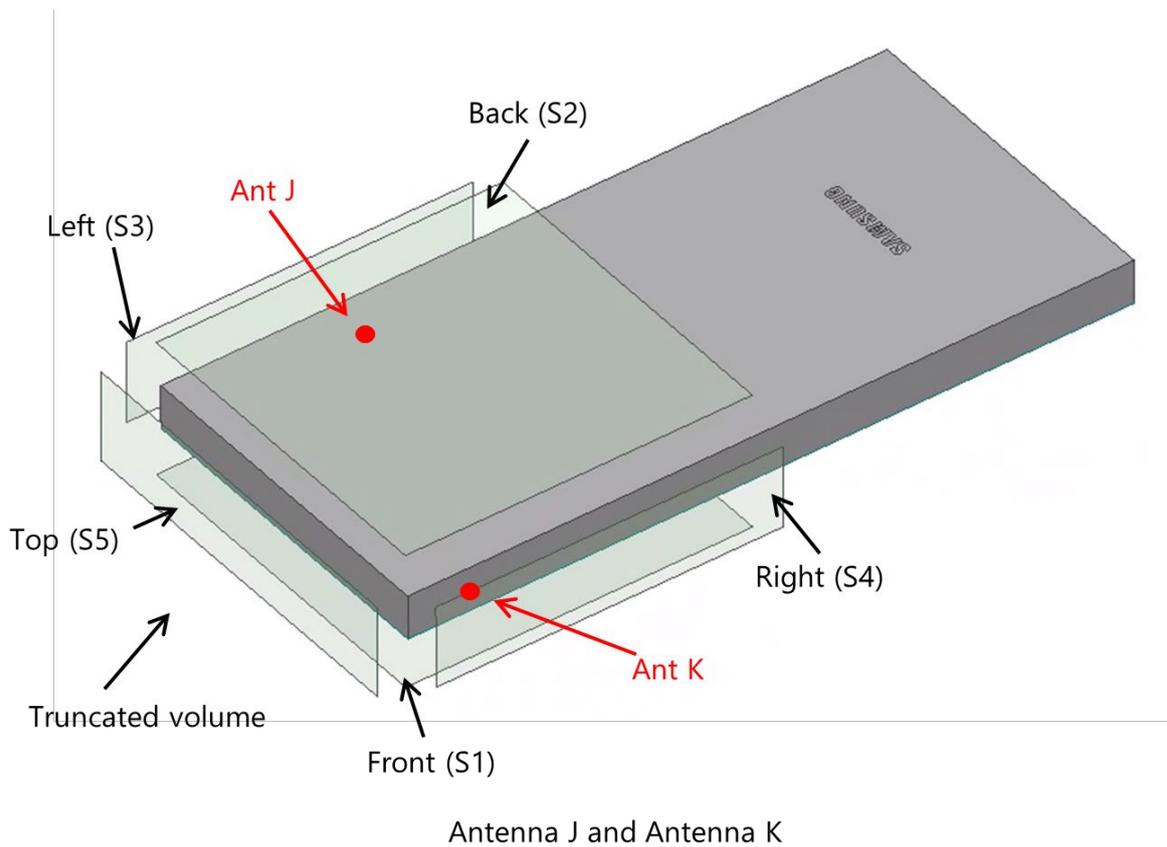


Figure 4. PD evaluation planes

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 2021.R2 (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, 40 mm spacing from each surfaces of the device were used.

1.2.4 Source excitation condition

The number of antenna ports of ANT K and ANT J for source excitation are the same. The antenna port of ANT K and J is divided into 10 ports for n261 1 x 5 patch array antennas, 10 ports for n260 1 x 5 patch array antennas. In the 10 ports included in each patch antenna, 5 ports are divided into vertical polarization feeding, and the other 5 ports are divided into horizontal polarization feeding.

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

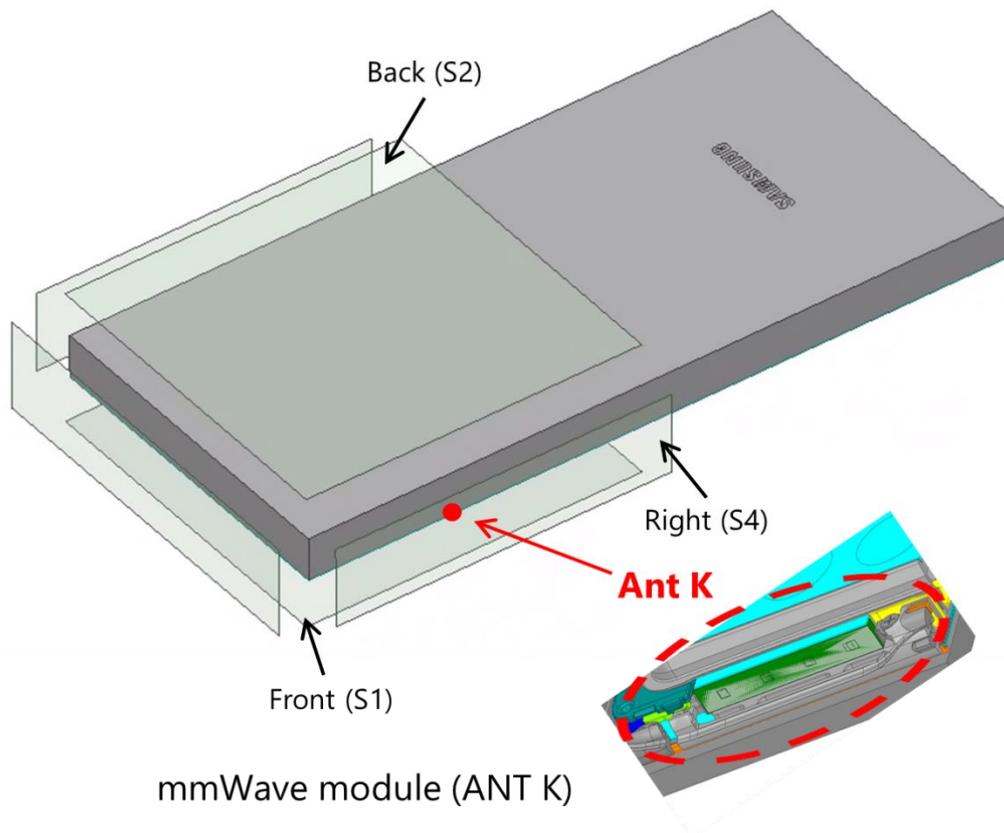


Figure 5. mmWave module (ANT K)

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.

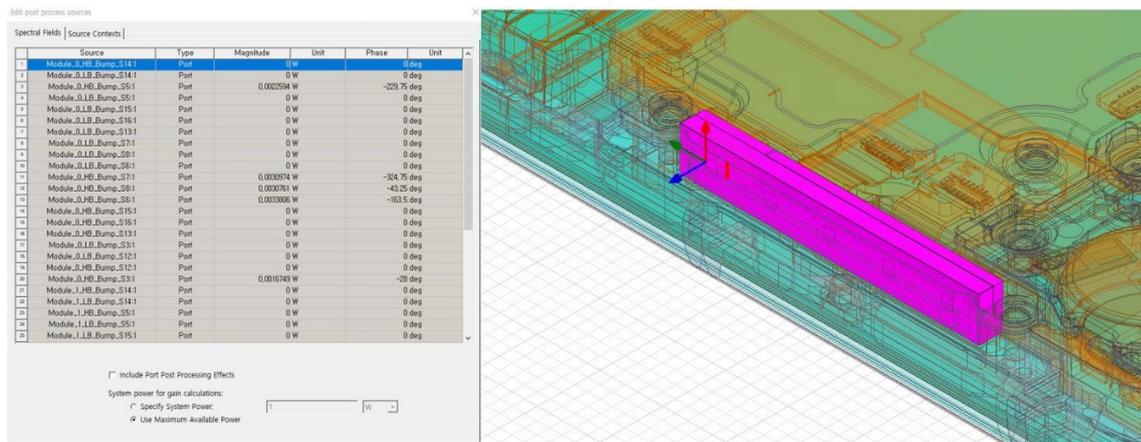


Figure 6. An example of port excitation (ANT K)

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 point power density or peak power density. Using the point power density, the spatial-averaged power density can be obtained by the integral of 4 cm^2 at 2.5 mm intervals of the point power density result. Figure 6 shows examples of the distribution plot of point power density and the averaged power density.

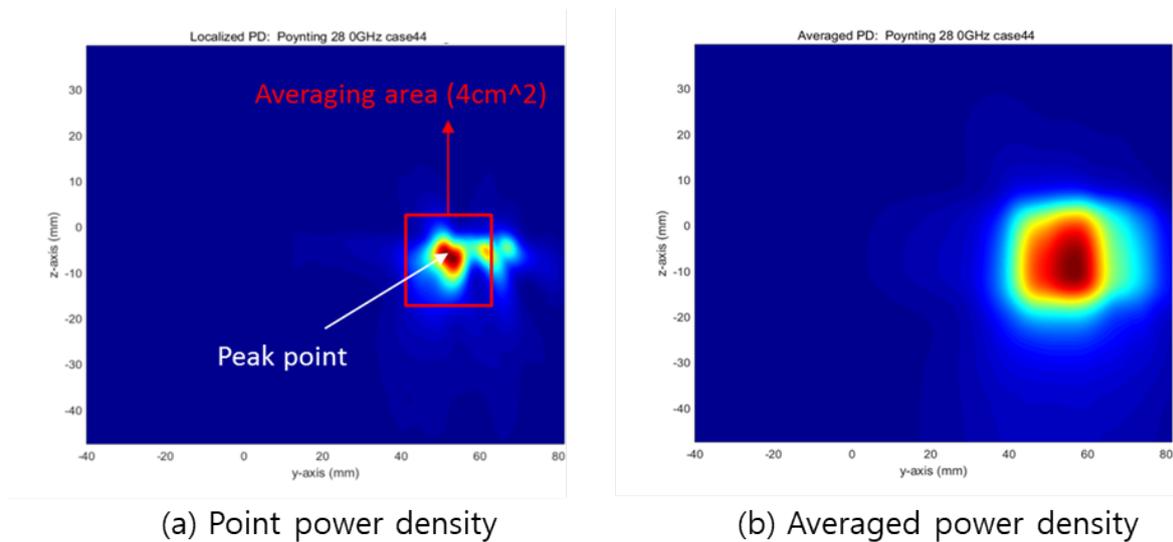


Figure 7. Power density distribution (Example)

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. The discrepancy in amplitude between simulated 4cm^2 averaged power density and measured 4cm^2 averaged power density is considered as housing influence and used in determining input power limit for each beam for RF exposure compliance.

The input powers per each active port are listed below for both Simulation and Measurement validation and power density characterization. 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.

Mode/Band	Antenna	Input Power (dBm) SISO	Input Power (dBm) MIMO
5G NR n261	J Patch	6.0	6.0
	K Patch	6.0	6.0
5G NR n260	J Patch	6.0	6.0
	K Patch	6.0	6.0
5G NR n258	J Patch	6.0	6.0
	K Patch	6.0	6.0

* The below simulation and measurement result were performed at 2mm evaluation distance and 28GHz / 38.5GHz / 24.8 GHz. The *input.power.limit* was determined based on below results in RF Exposure Part 0 Report.

Band	Beam ID	Antenna	Surface	Channel	4cm ² avg.PD (mW/cm ²)	
					Meas.	Sim.
n261	26	J (patch)	Back (S2)	Mid	1.03	2.086
	162		Back (S2)	Mid	1.16	1.870
	38	K (patch)	Back (S2)	Mid	0.38	0.786
	33		Right (S4)	Mid	0.582	1.195
	40		Front (S1)	Mid	0.63	0.849
	169		Back (S2)	Mid	0.748	1.695
	167		Right (S4)	Mid	0.659	1.101
n260	28	J (patch)	Back (S2)	Mid	0.387	1.273
	165		Back (S2)	Mid	0.35	1.040
	31	K (patch)	Back (S2)	Mid	0.573	0.788
	33		Right (S4)	Mid	0.295	1.248
	166		Back (S2)	Mid	0.287	0.807
			Right (S4)	Mid	0.7	1.242
n258	26	J (patch)	Back (S2)	Mid	1.07	1.551
	152		Back (S2)	Mid	0.941	1.629
	41	K (patch)	Back (S2)	Mid	0.381	0.607
			Right (S4)	Mid	0.814	1.280
	32		Front (S1)	Mid	0.59	0.716
	166		Back (S2)	Mid	1.45	1.956
			Right (S4)	Mid	0.941	1.602

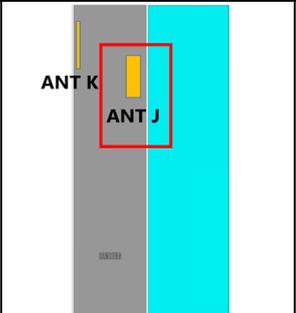
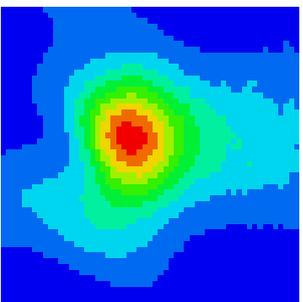
(a) Measured PD for Folder Open Status

Band	Beam ID	Antenna	Surface	Channel	4cm ² avg.PD (mW/cm2)	
					Meas.	Sim.
n261	26	J (patch)	Back (S2)	Mid	1.02	1.994
			Left (S3)	Mid	0.59	1.408
	156	K (patch)	Back (S2)	Mid	0.984	1.852
	38		Back (S2)	Mid	0.366	0.703
	33		Right (S4)	Mid	0.515	1.128
	169		Back (S2)	Mid	0.673	1.640
	167		Right (S4)	Mid	0.703	1.110
n260	28	J (patch)	Back (S2)	Mid	0.361	1.211
			Left (S3)	Mid	0.269	0.687
	165	K (patch)	Back (S2)	Mid	0.363	1.064
	31		Back (S2)	Mid	0.561	0.792
	33		Right (S4)	Mid	0.314	1.295
	160		Back (S2)	Mid	0.239	0.822
	166		Right (S4)	Mid	0.675	1.246
n258	35	J (patch)	Back (S2)	Mid	1.05	1.496
	26		Left (S3)	Mid	0.481	1.100
	152		Back (S2)	Mid	0.945	1.614
	41	K (patch)	Back (S2)	Mid	0.37	0.565
			Right (S4)	Mid	0.801	1.176
	166		Back (S2)	Mid	1.4	1.910
Right (S4)			Mid	0.92	1.533	

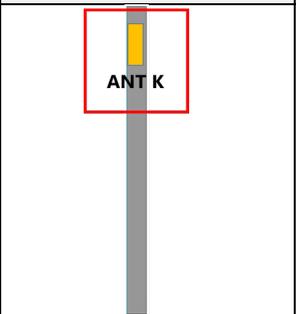
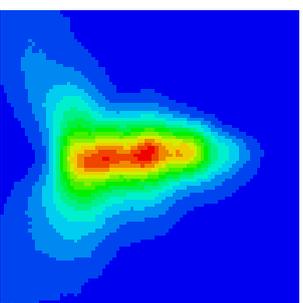
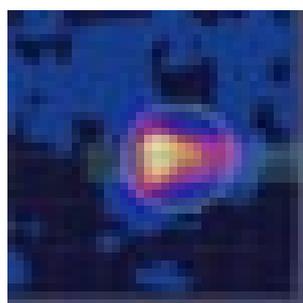
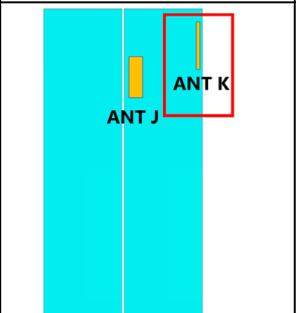
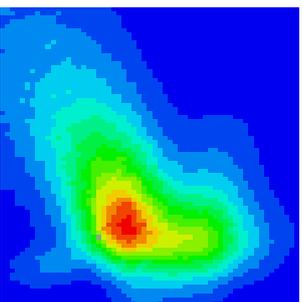
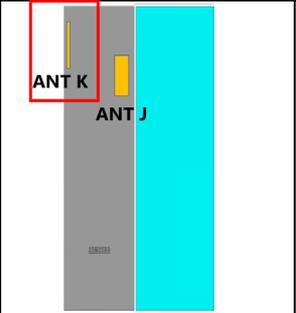
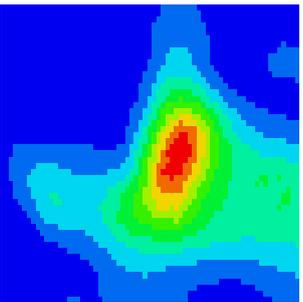
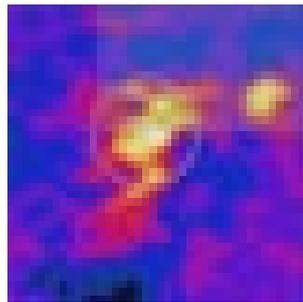
(b) Measured PD for Folder Closed Status

[Folder Open Status]

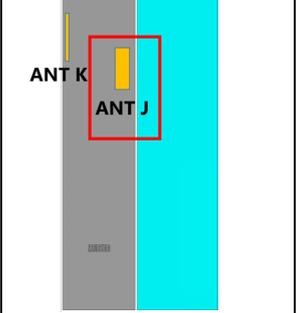
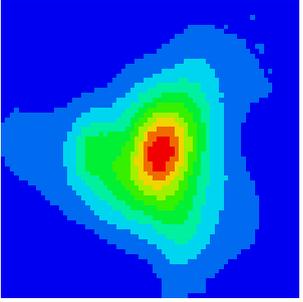
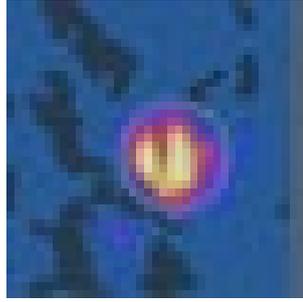
- Table 2-1, n258 ANT J-Patch: Mid Channel, Beam ID 26 for selected surfaces

Beam ID	Surface	View	Simulated PD	Measured PD
26	S2 (Rear)			

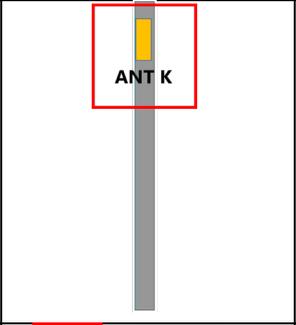
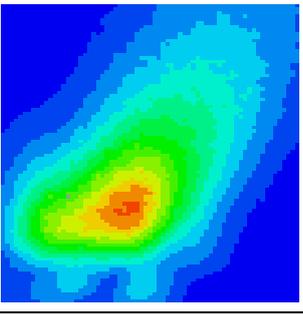
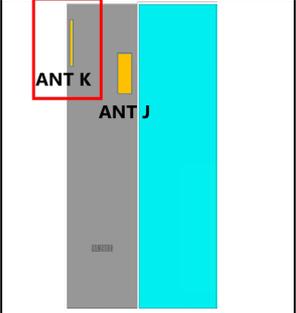
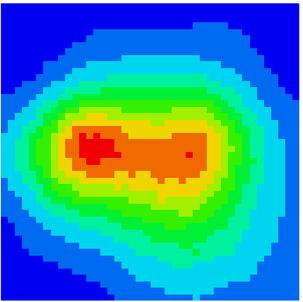
- Table 2-2, n258 ANT K-Patch: Mid Channel, Beam ID 32 and 41 for selected surfaces

Beam ID	Surface	View	Simulated PD	Measured PD
41	S4 (Right)			
32	S1 (Front)			
41	S2 (Rear)			

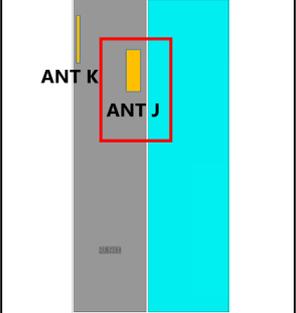
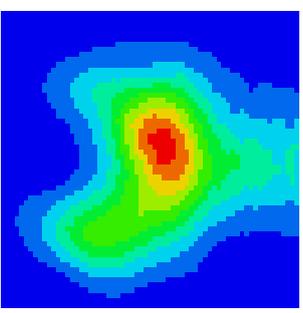
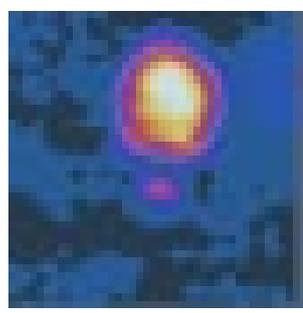
- Table 2-3, n258 ANT J-Patch: Mid Channel, Beam ID 152 for selected surfaces

Beam ID	Surface	View	Simulated PD	Measured PD
152	S2 (Rear)			

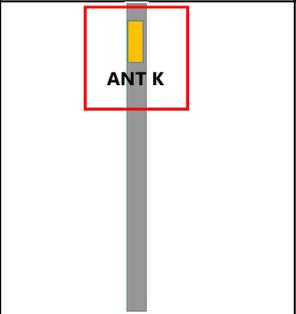
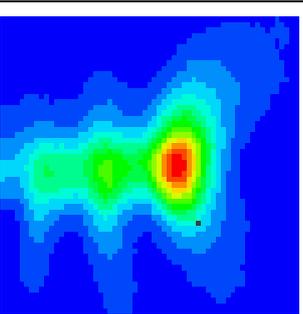
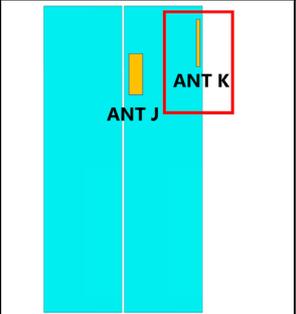
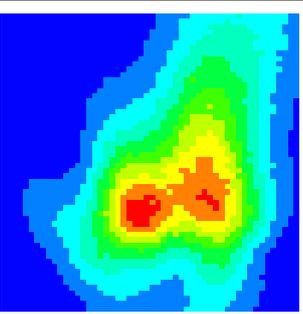
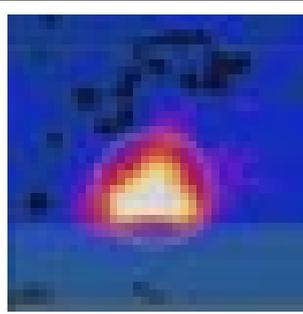
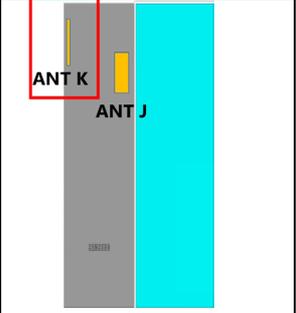
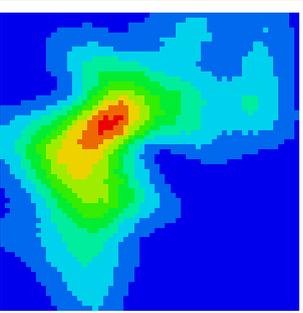
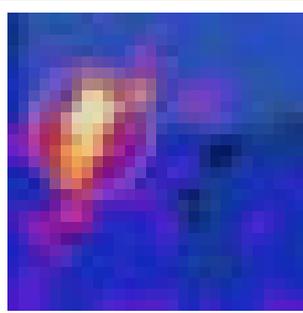
- Table 2-4, n258 ANT K-Patch: Mid Channel, Beam ID 166 for selected surfaces

Beam ID	Surface	View	Simulated PD	Measured PD
166	S4 (Right)			
	S2 (Rear)			

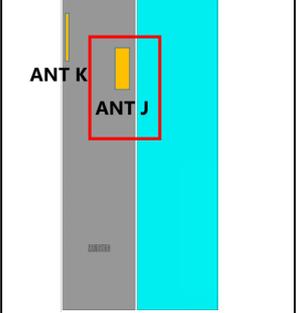
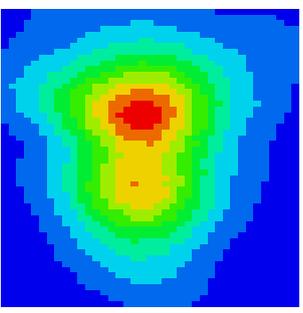
- Table 2-5, n261 ANT J-Patch: Mid Channel, Beam ID 26 for selected surfaces

Beam ID	Surface	View	Simulated PD	Measured PD
26	S2 (Rear)			

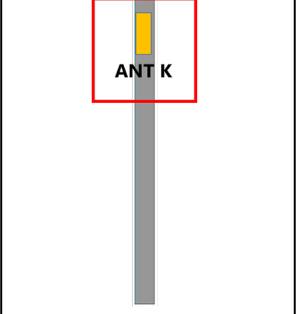
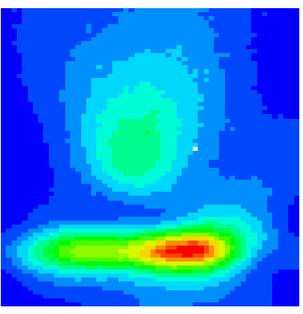
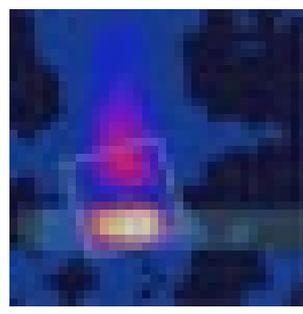
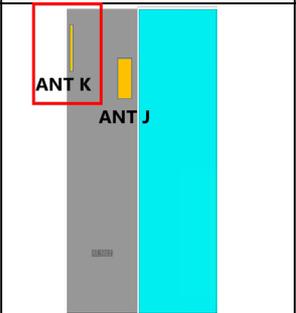
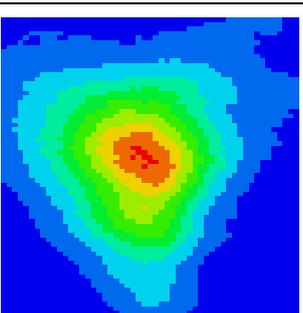
- Table 2-6, n261 ANT K-Patch: Mid Channel, Beam ID 33, 38 and 40 for selected surfaces

Beam ID	Surface	View	Simulated PD	Measured PD
33	S4 (Right)			
40	S1 (Front)			
38	S2 (Rear)			

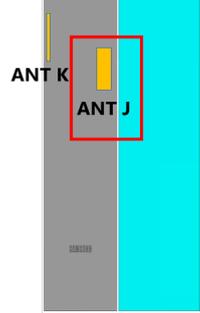
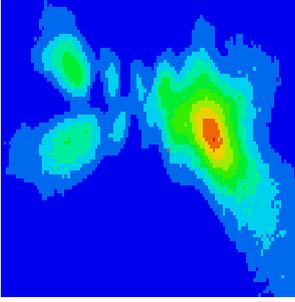
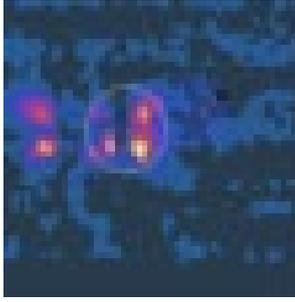
- Table 2-7, n261 ANT J-Patch: Mid Channel, Beam ID 162 for selected surfaces

Beam ID	Surface	View	Simulated PD	Measured PD
162	S2 (Rear)			

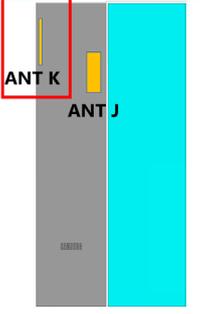
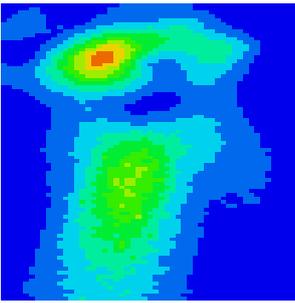
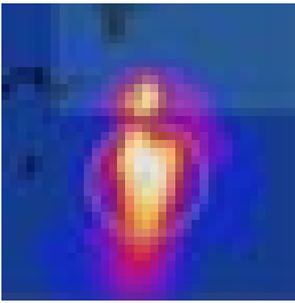
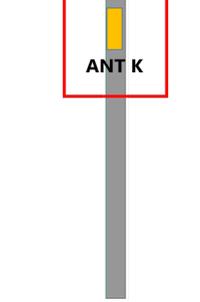
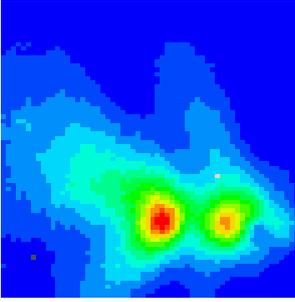
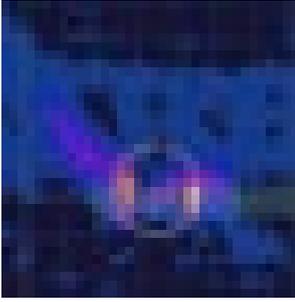
- Table 2-8, n261 ANT K-Patch: Mid Channel, Beam ID 167 and 169 for selected surfaces

Beam ID	Surface	View	Simulated PD	Measured PD
167	S4 (Right)			
169	S2 (Rear)			

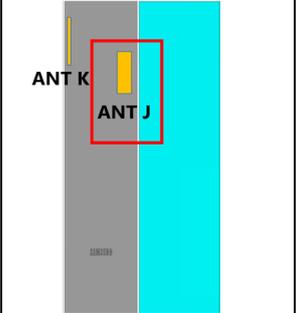
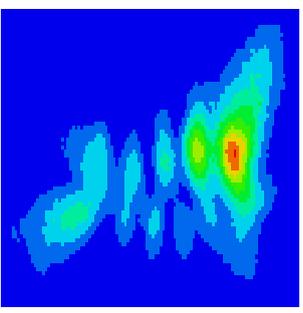
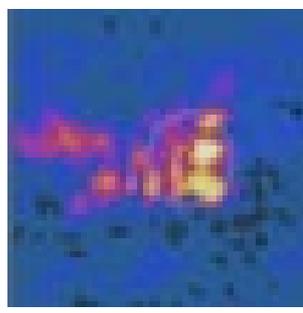
- Table 2-9, n260 ANT J-Patch: Mid Channel, Beam ID 28 for selected surfaces

Beam ID	Surface	View	Simulated PD	Measured PD
28	S2 (Rear)			

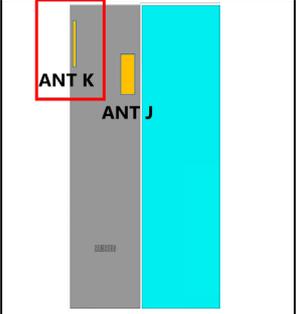
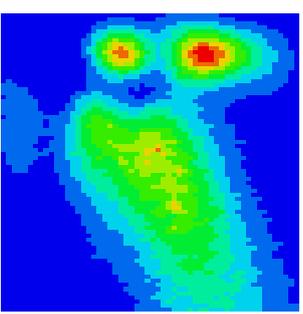
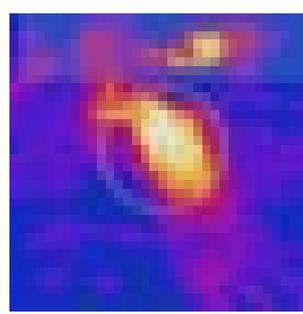
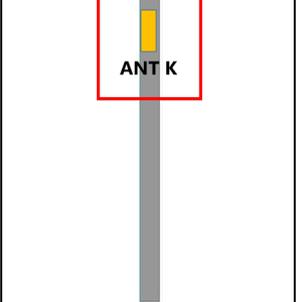
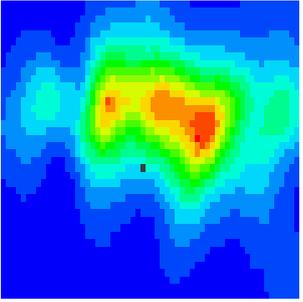
- Table 2-10, n260 ANT K-Patch: Mid Channel, Beam ID 31 and 33 for selected surfaces

Beam ID	Surface	View	Simulated PD	Measured PD
31	S2 (Rear)			
33	S4 (Right)			

- Table 2-11, n260 ANT J-Patch: Mid Channel, Beam ID 165 for selected surfaces

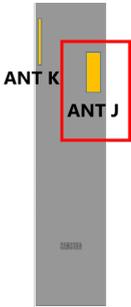
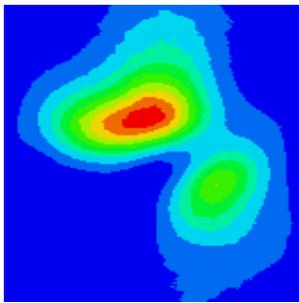
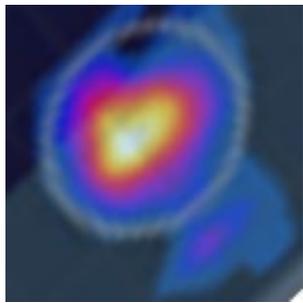
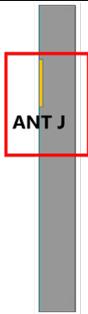
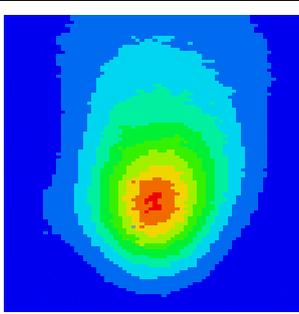
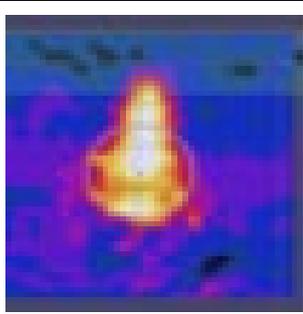
Beam ID	Surface	View	Simulated PD	Measured PD
165	S2 (Rear)			

- Table 2-12, n260 ANT K-Patch: Mid Channel, Beam ID 166 for selected surfaces

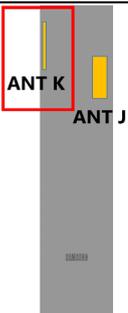
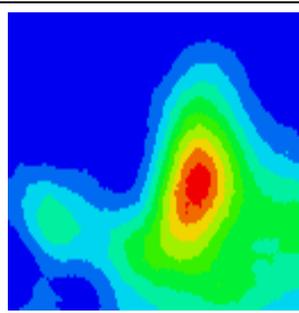
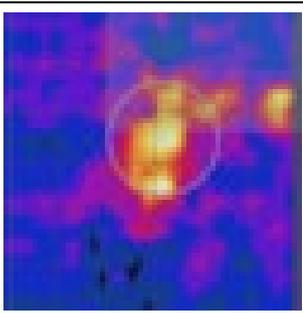
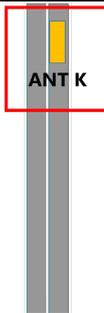
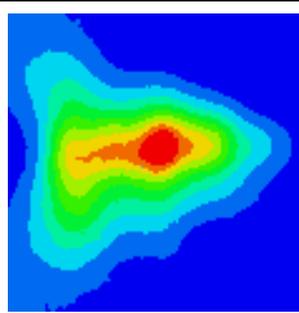
Beam ID	Surface	View	Simulated PD	Measured PD
166	S2 (Rear)			
	S4 (Right)			

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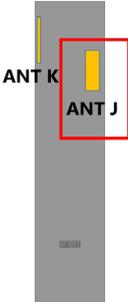
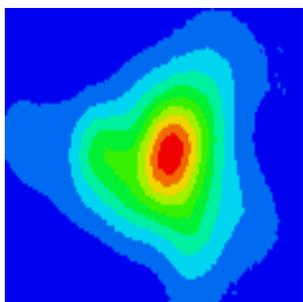
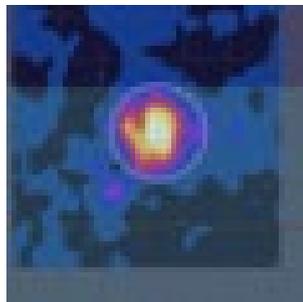
- Table 2-13, n258 ANT J-Patch: Mid Channel, Beam ID 35 and 26 for selected surfaces

Beam ID	Surface	View	Simulated PD	Measured PD
35	S2 (Rear)			
26	S3 (Left)			

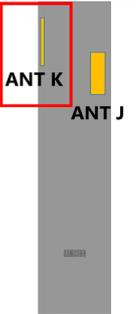
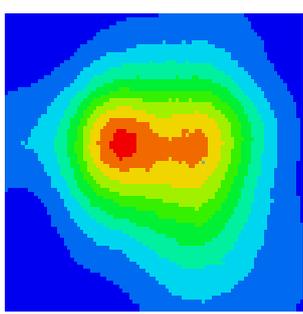
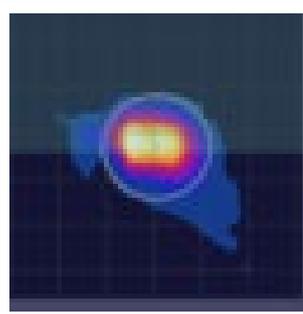
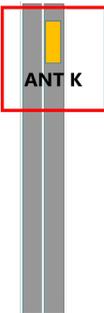
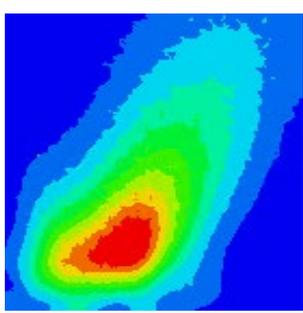
- Table 2-14, n258 ANT K-Patch: Mid Channel, Beam ID 41 for selected surfaces

Beam ID	Surface	View	Simulated PD	Measured PD
41	S2 (Rear)			
	S4 (Right)			

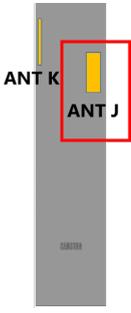
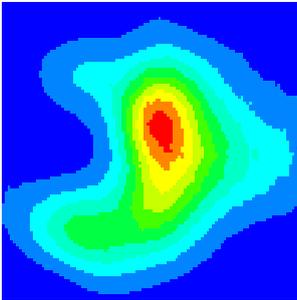
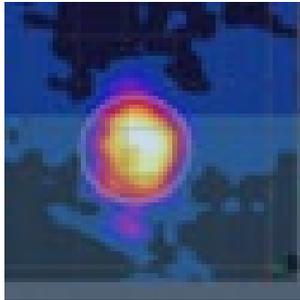
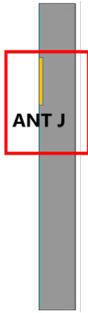
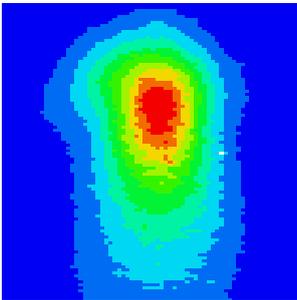
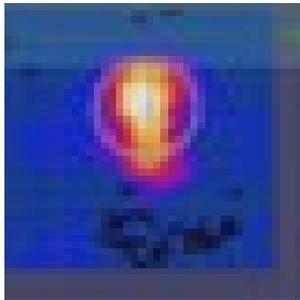
- Table 2-15, n258 ANT J-Patch: Mid Channel, Beam ID 152 for selected surfaces

Beam ID	Surface	View	Simulated PD	Measured PD
152	S2 (Rear)			

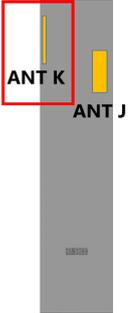
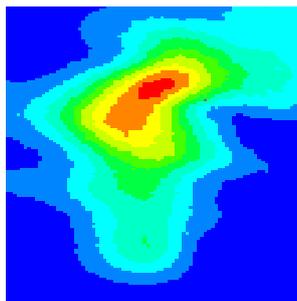
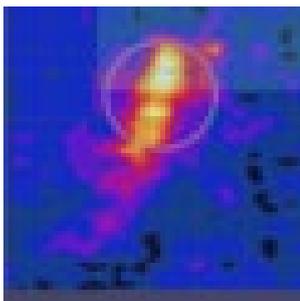
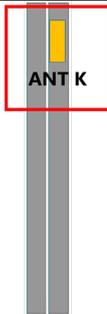
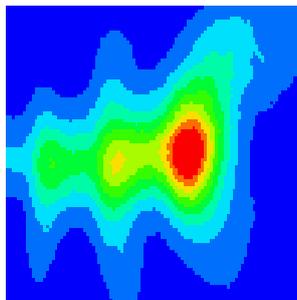
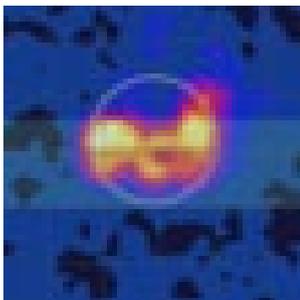
- Table 2-16, n258 ANT K-Patch: Mid Channel, Beam ID 166 for selected surfaces

Beam ID	Surface	View	Simulated PD	Measured PD
166	S2 (Rear)			
	S4 (Right)			

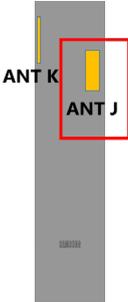
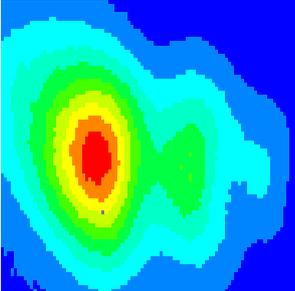
- Table 2-17, n261. ANT J-Patch: Mid Channel, Beam ID 26 for selected surfaces

Beam ID	Surface	View	Simulated PD	Measured PD
26	S2 (Rear)			
	S3 (Left)			

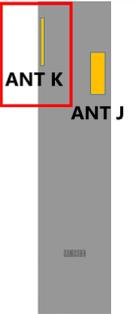
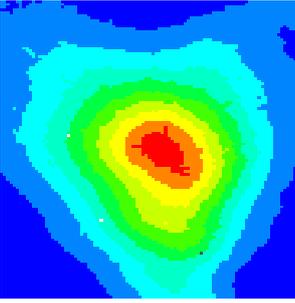
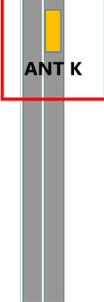
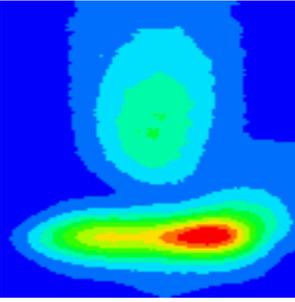
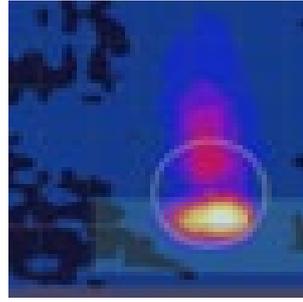
- Table 2-18, n261 ANT K-Patch: Mid Channel, Beam ID 33 and 38 for selected surfaces

Beam ID	Surface	View	Simulated PD	Measured PD
38	S2 (Rear)			
33	S4 (Right)			

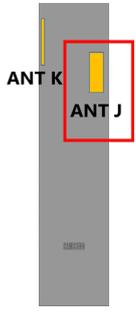
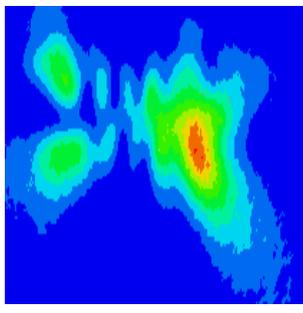
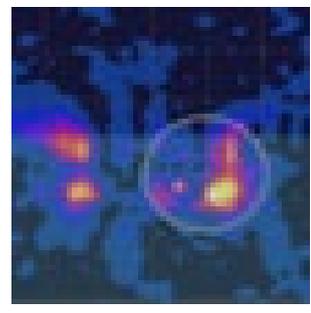
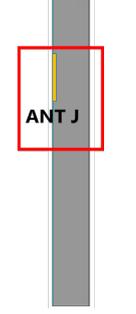
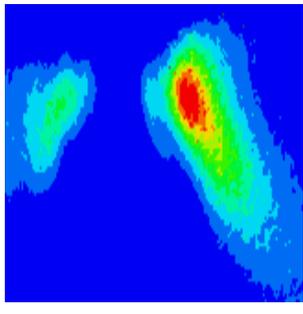
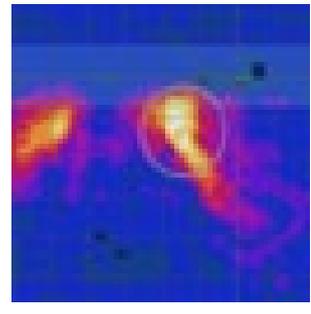
- Table 2-19, n261 ANT J-Patch: Mid Channel, Beam ID 156 for selected surfaces

Beam ID	Surface	View	Simulated PD	Measured PD
156	S2 (Rear)			

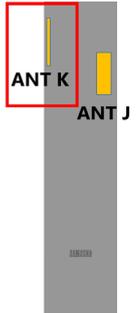
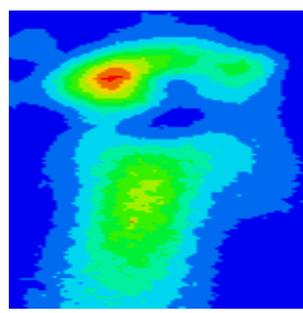
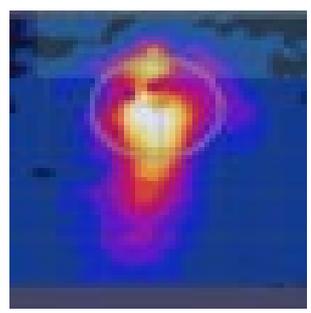
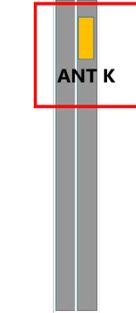
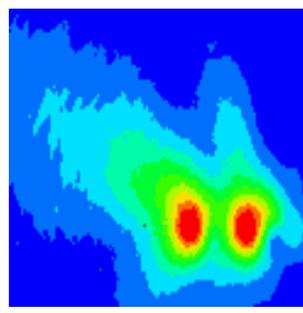
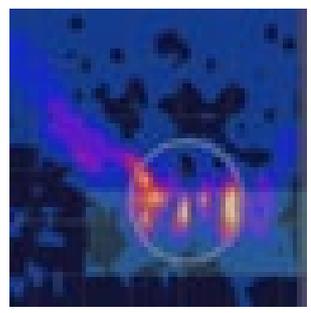
- Table 2-20, n261 ANT K-Patch: Mid Channel, Beam ID 167 and 169 for selected surfaces

Beam ID	Surface	View	Simulated PD	Measured PD
169	S2 (Rear)			
167	S4 (Right)			

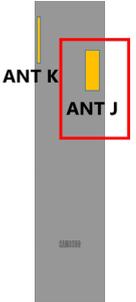
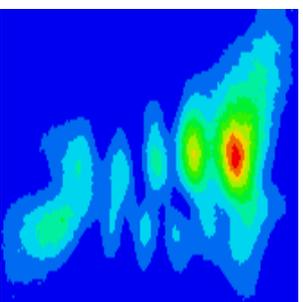
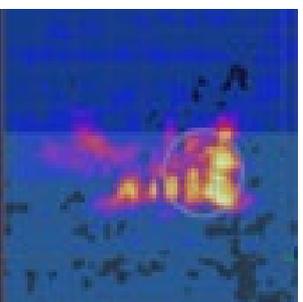
- Table 2-21, n260 ANT J-Patch: Mid Channel, Beam ID 28 for selected surfaces

Beam ID	Surface	View	Simulated PD	Measured PD
28	S2 (Rear)			
	S3 (Left)			

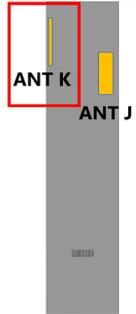
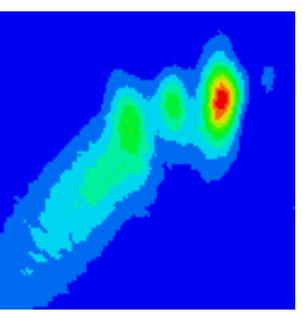
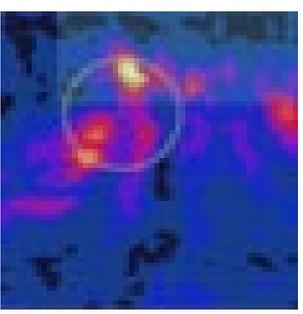
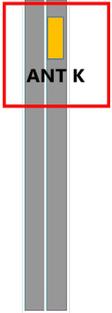
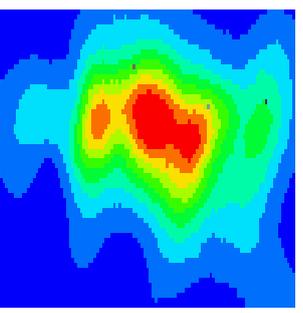
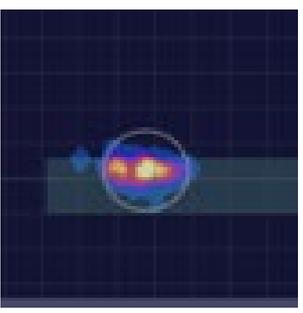
- Table 2-22, n260 ANT K-Patch: Mid Channel, Beam ID 31 and 33 for selected surfaces

Beam ID	Surface	View	Simulated PD	Measured PD
31	S2 (Rear)			
33	S4 (Right)			

- Table 2-23, n260 ANT J-Patch: Mid Channel, Beam ID 165 for selected surfaces

Beam ID	Surface	View	Simulated PD	Measured PD
165	S2 (Rear)			

- Table 2-24, n260 ANT K-Patch: Mid Channel, Beam ID 160 and 166 for selected surfaces

Beam ID	Surface	View	Simulated PD	Measured PD
160	S2 (Rear)			
166	S4 (Right)			

3 Simulation results

This section shows the PD simulation results of Ant J and Ant K at 24GHz, 28GHz and 39GHz for each evaluation plane specified in Table 1 at two separation distances of 2mm and 10mm for open condition and for closed conditions. The ratio of PD exposure from front surface to the worst surface at 2mm, and the ratio of PD exposure from 2mm to 10mm (open and closed) evaluation distance for each beam are also reported in this section to support RF exposure analysis for simultaneous transmission scenarios performed in the Part 1 Near Field PD report.

The relative phase between beam pairs is not controlled in the chipset design. Therefore, the relative phase between each beam pair was considered mathematically to identify the worst case conditions. The below MIMO results represent the highest reported MIMO simulation results after sweeping across the relative phase between beams a 5° step interval from 0° to 360°.

The worst-case simulated PD determined from the tables in this section were used for conservativeness in *input.power.limit* determination in RF Exposure Part 0 Report.

3.1 PD for Low/Mid/High Channel at 24GHz / 28GHz / 39GHz

3.1.1 Ant J– Patch Antenna

Table 3 & Table 4 & Table 5 show the PD simulation evaluation of Ant J patch antenna at 24GHz / 28GHz / 39GHz for the corresponding evaluation planes specified in Table 1.

- J-patch High CH

No.	Module	Type	Beam #1	Beam #2	Feed #1	new code set of all beams												new code set of all beams											
						J-patch						J-patch						J-patch						J-patch					
						Gain	Loss	Efficiency	Power	Temperature	Frequency	Gain	Loss	Efficiency	Power	Temperature	Frequency	Gain	Loss	Efficiency	Power	Temperature	Frequency	Gain	Loss	Efficiency	Power	Temperature	Frequency
1	1	1	1	1	1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00				

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- J-patch Low CH

No.	Module	Type	Beam #1	Beam #2	Feed #1	new code set of all beams												new code set of all beams											
						J-patch						J-patch						J-patch						J-patch					
						Gain	Loss	Efficiency	Power	Temperature	Frequency	Gain	Loss	Efficiency	Power	Temperature	Frequency	Gain	Loss	Efficiency	Power	Temperature	Frequency	Gain	Loss	Efficiency	Power	Temperature	Frequency
1	1	1	1	1	1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00				

- K-patch Mid CH

No.	Model	Type	Beam C1	Beam C2	Feed no.	4002 PDR(m=2)						4002 PDR(m=2) at 30mm evaluation distance																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
						1549pt	1544pt	1551pt	1568mm	1570mm	1576mm	100.0%		4.0%		6.0%		2.0%		0.5%		100.0%		1549pt	1554pt	1561mm	1568mm	1570mm	1576mm	1583mm	1589mm	1595mm	1601mm	1607mm	1613mm	1619mm	1625mm	1631mm	1637mm	1643mm	1649mm	1655mm	1661mm	1667mm	1673mm	1679mm	1685mm	1691mm	1697mm	1703mm	1709mm	1715mm	1721mm	1727mm	1733mm	1739mm	1745mm	1751mm	1757mm	1763mm	1769mm	1775mm	1781mm	1787mm	1793mm	1799mm	1805mm	1811mm	1817mm	1823mm	1829mm	1835mm	1841mm	1847mm	1853mm	1859mm	1865mm	1871mm	1877mm	1883mm	1889mm	1895mm	1901mm	1907mm	1913mm	1919mm	1925mm	1931mm	1937mm	1943mm	1949mm	1955mm	1961mm	1967mm	1973mm	1979mm	1985mm	1991mm	1997mm	2003mm	2009mm	2015mm	2021mm	2027mm	2033mm	2039mm	2045mm	2051mm	2057mm	2063mm	2069mm	2075mm	2081mm	2087mm	2093mm	2099mm	2105mm	2111mm	2117mm	2123mm	2129mm	2135mm	2141mm	2147mm	2153mm	2159mm	2165mm	2171mm	2177mm	2183mm	2189mm	2195mm	2201mm	2207mm	2213mm	2219mm	2225mm	2231mm	2237mm	2243mm	2249mm	2255mm	2261mm	2267mm	2273mm	2279mm	2285mm	2291mm	2297mm	2303mm	2309mm	2315mm	2321mm	2327mm	2333mm	2339mm	2345mm	2351mm	2357mm	2363mm	2369mm	2375mm	2381mm	2387mm	2393mm	2399mm	2405mm	2411mm	2417mm	2423mm	2429mm	2435mm	2441mm	2447mm	2453mm	2459mm	2465mm	2471mm	2477mm	2483mm	2489mm	2495mm	2501mm	2507mm	2513mm	2519mm	2525mm	2531mm	2537mm	2543mm	2549mm	2555mm	2561mm	2567mm	2573mm	2579mm	2585mm	2591mm	2597mm	2603mm	2609mm	2615mm	2621mm	2627mm	2633mm	2639mm	2645mm	2651mm	2657mm	2663mm	2669mm	2675mm	2681mm	2687mm	2693mm	2699mm	2705mm	2711mm	2717mm	2723mm	2729mm	2735mm	2741mm	2747mm	2753mm	2759mm	2765mm	2771mm	2777mm	2783mm	2789mm	2795mm	2801mm	2807mm	2813mm	2819mm	2825mm	2831mm	2837mm	2843mm	2849mm	2855mm	2861mm	2867mm	2873mm	2879mm	2885mm	2891mm	2897mm	2903mm	2909mm	2915mm	2921mm	2927mm	2933mm	2939mm	2945mm	2951mm	2957mm	2963mm	2969mm	2975mm	2981mm	2987mm	2993mm	2999mm	3005mm	3011mm	3017mm	3023mm	3029mm	3035mm	3041mm	3047mm	3053mm	3059mm	3065mm	3071mm	3077mm	3083mm	3089mm	3095mm	3101mm	3107mm	3113mm	3119mm	3125mm	3131mm	3137mm	3143mm	3149mm	3155mm	3161mm	3167mm	3173mm	3179mm	3185mm	3191mm	3197mm	3203mm	3209mm	3215mm	3221mm	3227mm	3233mm	3239mm	3245mm	3251mm	3257mm	3263mm	3269mm	3275mm	3281mm	3287mm	3293mm	3299mm	3305mm	3311mm	3317mm	3323mm	3329mm	3335mm	3341mm	3347mm	3353mm	3359mm	3365mm	3371mm	3377mm	3383mm	3389mm	3395mm	3401mm	3407mm	3413mm	3419mm	3425mm	3431mm	3437mm	3443mm	3449mm	3455mm	3461mm	3467mm	3473mm	3479mm	3485mm	3491mm	3497mm	3503mm	3509mm	3515mm	3521mm	3527mm	3533mm	3539mm	3545mm	3551mm	3557mm	3563mm	3569mm	3575mm	3581mm	3587mm	3593mm	3599mm	3605mm	3611mm	3617mm	3623mm	3629mm	3635mm	3641mm	3647mm	3653mm	3659mm	3665mm	3671mm	3677mm	3683mm	3689mm	3695mm	3701mm	3707mm	3713mm	3719mm	3725mm	3731mm	3737mm	3743mm	3749mm	3755mm	3761mm	3767mm	3773mm	3779mm	3785mm	3791mm	3797mm	3803mm	3809mm	3815mm	3821mm	3827mm	3833mm	3839mm	3845mm	3851mm	3857mm	3863mm	3869mm	3875mm	3881mm	3887mm	3893mm	3899mm	3905mm	3911mm	3917mm	3923mm	3929mm	3935mm	3941mm	3947mm	3953mm	3959mm	3965mm	3971mm	3977mm	3983mm	3989mm	3995mm	4001mm	4007mm	4013mm	4019mm	4025mm	4031mm	4037mm	4043mm	4049mm	4055mm	4061mm	4067mm	4073mm	4079mm	4085mm	4091mm	4097mm	4103mm	4109mm	4115mm	4121mm	4127mm	4133mm	4139mm	4145mm	4151mm	4157mm	4163mm	4169mm	4175mm	4181mm	4187mm	4193mm	4199mm	4205mm	4211mm	4217mm	4223mm	4229mm	4235mm	4241mm	4247mm	4253mm	4259mm	4265mm	4271mm	4277mm	4283mm	4289mm	4295mm	4301mm	4307mm	4313mm	4319mm	4325mm	4331mm	4337mm	4343mm	4349mm	4355mm	4361mm	4367mm	4373mm	4379mm	4385mm	4391mm	4397mm	4403mm	4409mm	4415mm	4421mm	4427mm	4433mm	4439mm	4445mm	4451mm	4457mm	4463mm	4469mm	4475mm	4481mm	4487mm	4493mm	4499mm	4505mm	4511mm	4517mm	4523mm	4529mm	4535mm	4541mm	4547mm	4553mm	4559mm	4565mm	4571mm	4577mm	4583mm	4589mm	4595mm	4601mm	4607mm	4613mm	4619mm	4625mm	4631mm	4637mm	4643mm	4649mm	4655mm	4661mm	4667mm	4673mm	4679mm	4685mm	4691mm	4697mm	4703mm	4709mm	4715mm	4721mm	4727mm	4733mm	4739mm	4745mm	4751mm	4757mm	4763mm	4769mm	4775mm	4781mm	4787mm	4793mm	4799mm	4805mm	4811mm	4817mm	4823mm	4829mm	4835mm	4841mm	4847mm	4853mm	4859mm	4865mm	4871mm	4877mm	4883mm	4889mm	4895mm	4901mm	4907mm	4913mm	4919mm	4925mm	4931mm	4937mm	4943mm	4949mm	4955mm	4961mm	4967mm	4973mm	4979mm	4985mm	4991mm	4997mm	5003mm	5009mm	5015mm	5021mm	5027mm	5033mm	5039mm	5045mm	5051mm	5057mm	5063mm	5069mm	5075mm	5081mm	5087mm	5093mm	5099mm	5105mm	5111mm	5117mm	5123mm	5129mm	5135mm	5141mm	5147mm	5153mm	5159mm	5165mm	5171mm	5177mm	5183mm	5189mm	5195mm	5201mm	5207mm	5213mm	5219mm	5225mm	5231mm	5237mm	5243mm	5249mm	5255mm	5261mm	5267mm	5273mm	5279mm	5285mm	5291mm	5297mm	5303mm	5309mm	5315mm	5321mm	5327mm	5333mm	5339mm	5345mm	5351mm	5357mm	5363mm	5369mm	5375mm	5381mm	5387mm	5393mm	5399mm	5405mm	5411mm	5417mm	5423mm	5429mm	5435mm	5441mm	5447mm	5453mm	5459mm	5465mm	5471mm	5477mm	5483mm	5489mm	5495mm	5501mm	5507mm	5513mm	5519mm	5525mm	5531mm	5537mm	5543mm	5549mm	5555mm	5561mm	5567mm	5573mm	5579mm	5585mm	5591mm	5597mm	5603mm	5609mm	5615mm	5621mm	5627mm	5633mm	5639mm	5645mm	5651mm	5657mm	5663mm	5669mm	5675mm	5681mm	5687mm	5693mm	5699mm	5705mm	5711mm	5717mm	5723mm	5729mm	5735mm	5741mm	5747mm	5753mm	5759mm	5765mm	5771mm	5777mm	5783mm	5789mm	5795mm	5801mm	5807mm	5813mm	5819mm	5825mm	5831mm	5837mm	5843mm	5849mm	5855mm	5861mm	5867mm	5873mm	5879mm	5885mm	5891mm	5897mm	5903mm	5909mm	5915mm	5921mm	5927mm	5933mm	5939mm	5945mm	5951mm	5957mm	5963mm	5969mm	5975mm	5981mm	5987mm	5993mm	5999mm	6005mm	6011mm	6017mm	6023mm	6029mm	6035mm	6041mm	6047mm	6053mm	6059mm	6065mm	6071mm	6077mm	6083mm	6089mm	6095mm	6101mm	6107mm	6113mm	6119mm	6125mm	6131mm	6137mm	6143mm	6149mm	6155mm	6161mm	6167mm	6173mm	6179mm	6185mm	6191mm	6197mm	6203mm	6209mm	6215mm	6221mm	6227mm	6233mm	6239mm	6245mm	6251mm	6257mm	6263mm	6269mm	6275mm	6281mm	6287mm	6293mm	6299mm	6305mm	6311mm	6317mm	6323mm	6329mm	6335mm	6341mm	6347mm	6353mm	6359mm	6365mm	6371mm	6377mm	6383mm	6389mm	6395mm	6401mm	6407mm	6413mm	6419mm	6425mm	6431mm	6437mm	6443mm	6449mm	6455mm	6461mm	6467mm	6473mm	6479mm	6485mm	6491mm	6497mm	6503mm	6509mm	6515mm	6521mm	6527mm	6533mm	6539mm	6545mm	6551mm	6557mm	6563mm	6569mm	6575mm	6581mm	6587mm	6593mm	6599mm	6605mm	6611mm	6617mm	6623mm	6629mm	6635mm	6641mm	6647mm	6653mm	6659mm	6665mm	6671mm	6677mm	6683mm	6689mm	669

