Part 0: SAR and Power Density Characterization
EUT RF Exposure Compliance Test Report

For
SMARTPHONE

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Rev.	Date	Revisions	Revised By
V1	7/20/2021	Initial Issue	--
V2	7/21/2021	1. Updated §2.2 with the appropriate descriptions 2. Updated §2.4 with the correct P_{limit} values	

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1. Introduction

The equipment under test (EUT) is a smart phone. It contains the Qualcomm modem supporting 2G/3G/4G WWAN technologies and mmW 5G NR bands. These WWAN modems enable Qualcomm's Smart Transmit feature to control and manage transmitting power, in real time, and to ensure the time-averaged RF exposure is always in compliance with the FCC requirement.

In this report, Part 0, the EUT SAR and power density (PD) are characterized for WWAN radios (2G/3G/4G/5G mmW NR) to determine the power limit that corresponds to the exposure design target after accounting for all device design related uncertainties, i.e., $SAR_{Design\ Target}$ (< FCC SAR limit) for Sub-6 GHz radio and $PD_{Design\ Target}$ (< FCC PD limit) for mmW radio. The SAR Characterization and PD Characterization are denoted as *SAR Char* and *PD Char*.

SAR Char and *PD Char* will be used as input for Qualcomm Smart Transmit to operate. Both *SAR Char* and *PD Char* will be loaded and stored in the EUT via the *Embedded File System* (EFS).

The EUT supports WLAN/BT radio(s) as well, but the WLAN/BT modem is not enabled with Qualcomm's Smart Transmit feature.

All Sub-6 GHz SAR data referenced within this report has been extracted from UL's SAR report: 13571607-S1.

2. SAR Characterization

SAR Char is generated to cover all radio configurations and usage scenarios that are reported in the initial FCC submission.

2.1. Worst-case SAR Determination

Based on FCC KDBs, in general, for a smartphone, the SAR evaluation is required for the exposure scenarios shown in Figure 2-1.

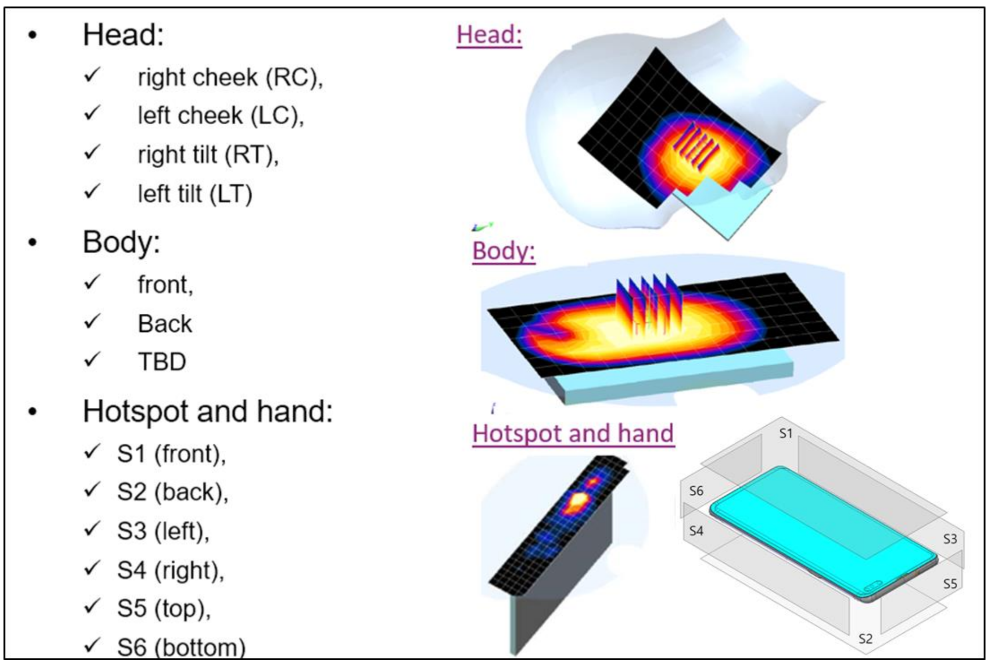

Figure 2-1: SAR evaluation for smartphone application

The *Device State Index* (DSI) used in Figure 2-2 represents each exposure scenario. Depending on the detection scheme implemented in the smartphone, the worst-case SAR is further grouped and determined for each or combined exposure scenario(s). Note, for the 1-g SAR versus 10-g SAR exposure scenario, the worst-case is determined in term of exposure ratio (i.e., exposure level relative to the corresponding 1-g or 10-g SAR limit).

- If the device does not have any detection mechanism (**all "no"** in Figure 2-2), then the worst-case SAR is determined by taking the maximum SAR value among all exposure scenarios, i.e., worst-case SAR = *max* $\{SAR_{head}, SAR_{body}, SAR_{hotspot/extremity}\}$
- If the device can distinguish each of the above scenarios (**all "yes"** in Figure 2-2), then the worst-case SAR for each individual exposure scenario is given by corresponding SAR_{head}, SAR_{body}, and $SAR_{hotspot/extremity}$
- If the device can only distinguish a subset of the scenarios (**some "yes", some "no"** in Figure 2-2), then the worst-case SAR is given by:
  - Corresponding SAR for each exposure scenario that can be distinguished (DSI=yes)
  - Worst-case SAR among all other exposure scenario(s) that cannot be distinguished (DSI=no)

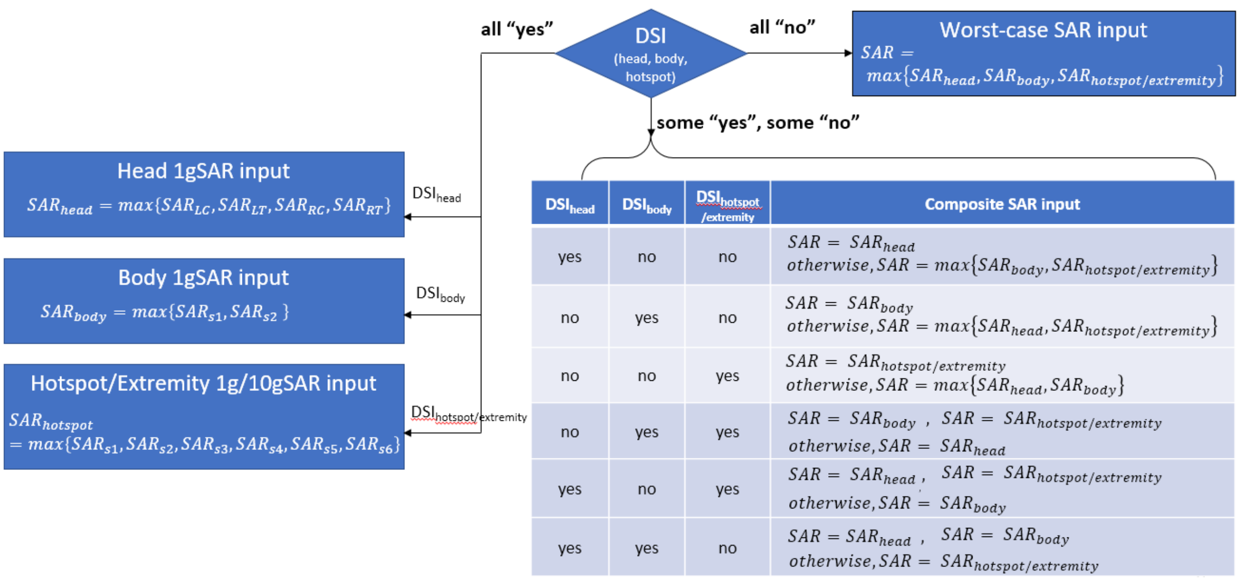

Figure 2-2: Worst-case SAR determination based on DSI

2.2. Usage Scenarios in SAR Evaluation

The EUT has a detection mechanism to distinguish Head, Body-worn, and Hotspot exposure conditions, which is represented using *DSI 0* and *1*. These *DSI* states were used to determine the power limit for Smart Transmit to operate; where the exposure scenario is managed as same DSI state, all other exposures which cannot be distinguished, in this particular instance and based on the worst-case SAR determination criteria described in §2.1, the maximum SAR (or the minimum P_{limit}) among all remaining exposure scenarios (i.e., Body-worn 1-g SAR evaluation at a specified test separation distance, phablet extremity 10-g SAR evaluation at a specified test separation distance, and maximum RF tune-up power (P_{max}) supported by the device if SAR measurement is not performed for this tech/band/antenna because of meeting SAR test exclusion criteria) is used to determine the power limit for Smart Transmit to operate.

The corresponding usage scenarios supported by EUT are summarized in Table 2-1:

Table 2-1: Usage/Exposure Scenario

Scenario	DSI State	Description	SAR Definition	Worst-case SAR
Head	0	▪ Device positioned next to head ▪ 1-g SAR evaluated in four positions (left/right touch/tilt)	$SAR_{head} = max\ \{SAR_{LC}, SAR_{LT}, SAR_{RC}, SAR_{RT}\}$	SAR_{head}
Body-worn/Hotspot	1	▪ Device state is either Body-worn or Hotspot at 5 mm ▪ 1-g SAR is evaluated for all six surfaces of the EUT (S1-S6 as shown in Figure 2-1) at 5 mm test separation distance relative to the flat phantom	$SAR_{body\_DSI=1} = max\ \{SAR_{body\_DSI=1}, SAR_{body\_DSI=1}, SAR_{body\_DSI=1}, SAR_{body\_DSI=1}, SAR_{body\_DSI=1}, SAR_{body\_DSI=1}\}$	$SAR_{body\_DSI=1}$

2.3. $SAR_{Design\ Target}$

The total device design and related uncertainties of the EUT is shown below (in dB), which includes TxAGC and device to device variation.

To account for the total uncertainty, $SAR_{Design\ Target}$ needs to be:

$$SAR_{Design\ Target} < SAR_{Design\ Limit} \times 10^{\frac{-total\ uncertainty}{10}}$$

For the FCC SAR requirement of 1.6 W/kgand 4.0 W/kg, 1-g and 10-g SAR respectively, the $SAR_{Design\ Target}$ for the EUT is determined as:

Total Uncertainty (dB)	$SAR_{Design\ Target}$ (1-g W/kg)	$SAR_{Design\ Target}$ (10-g W/kg)	$SAR_{Design\ Limit}$ (1-g W/kg)	$SAR_{Design\ Limit}$ (10-g W/kg)
1.00	0.8	2.0	1.0	2.5

2.4. SAR Characterization

Referring to the initial FCC submission, the worst-case *reported* SAR for each antenna/technology/band/DSI is summarized in Table 2-2:

Table 2-2: Worst-case *reported* SAR

Tech/Band	Antenna			Worst-case SAR (W/kg)			P_{limit} Max Tune-up Power (dBm)		
	Head	Body-worn	Hotspot	Head	Body-worn	Hotspot	Head	Body-worn	Hotspot
	DSI: 0	DSI: 1	DSI: 1	DSI: 0	DSI: 1	DSI: 1	DSI: 0	DSI: 1	DSI: 1
GSM850	ANT2	ANT1	ANT1	0.883	0.917	0.917	31.00	32.50	32.50
GSM1900	ANT2	ANT2	ANT3	0.955	0.893	0.957	28.50	28.50	26.60
W-CDMA B2	ANT4	ANT2	ANT4	0.864	0.886	0.958	20.50	21.20	21.20
W-CDMA B4	ANT2	ANT2	ANT1	0.833	0.912	0.920	22.10	22.10	19.50
W-CDMA B5	ANT2	ANT1	ANT1	0.883	0.860	0.860	24.70	25.20	25.20
CDMA BC0	ANT2	ANT1	ANT1	0.705	0.461	0.560	23.00	23.50	23.50
CDMA BC1	ANT2	ANT2	ANT1	0.925	0.902	0.903	20.90	21.20	19.50
CDMA BC10	ANT2	ANT1	ANT1	0.955	0.950	0.950	24.70	25.20	25.20
LTE B5	ANT2	ANT1	ANT1	0.834	0.910	0.910	24.70	25.20	25.20
LTE B7	ANT2	ANT2	ANT1	0.959	0.915	0.940	17.70	19.30	19.30
LTE B12/17	ANT2	ANT1	ANT1	0.923	0.737	0.737	24.60	25.70	25.70
LTE B13	ANT2	ANT1	ANT1	0.699	0.672	0.765	24.70	25.70	25.70
LTE B14	ANT2	ANT1	ANT1	0.733	0.676	0.745	24.70	25.70	25.70
LTE B25/2	ANT2	ANT3	ANT3	0.958	0.921	0.921	20.90	20.60	20.60
LTE B26	ANT2	ANT1	ANT1	0.759	0.955	0.955	24.70	25.20	25.20
LTE B30	ANT4	ANT3	ANT3	0.959	0.958	0.958	21.20	18.90	18.90
LTE B41	ANT3	ANT2	ANT1	0.941	0.854	0.957	25.20	21.40	21.50
LTE B48	ANT4	ANT7	ANT7	0.884	0.951	0.951	22.50	20.40	20.40
LTE B66/4	ANT4	ANT2	ANT3	0.927	0.888	0.936	20.50	22.10	22.30
LTE B71	ANT2	ANT2	ANT2	0.714	0.522	0.522	24.70	24.70	24.70
FR1 n5	ANT2	ANT1	ANT1	0.617	0.545	0.545	24.70	25.20	25.20
FR1 n7	ANT4	ANT2	ANT2	0.801	0.803	0.803	21.50	19.30	19.30
FR1 n12	ANT2	ANT1	ANT1	0.326	0.431	0.431	24.60	25.70	25.70
FR1 n25/n2	ANT2	ANT3	ANT3	0.944	0.898	0.898	20.90	20.60	20.60
FR1 n30	ANT2	ANT2	ANT1	0.849	0.758	0.844	20.90	21.80	20.10
FR1 n41	ANT2	ANT2	ANT2	0.823	0.683	0.749	17.50	19.40	19.40
FR1 n66	ANT2	ANT2	ANT4	0.872	0.781	0.785	22.10	22.10	22.00
FR1 n71	ANT2	ANT1	ANT1	0.404	0.272	0.272	24.70	25.70	25.70
FR1 n77	ANT4	ANT8	ANT4	0.820	0.915	0.925	20.00	20.70	21.50

Using the reported SAR listed in Table 2-2, and following the procedure described in §3.1, the *SAR Char* of this EUT, i.e., P_{limit} corresponding to $SAR_{Design\ Target}$, is determined for each supported antenna/technology/band/DSI as:

1. For DSI = 0, P_{limit} is calculated based on 1-g SAR head exposure evaluation.
2. For DSI = 1, P_{limit} is calculated based on 1-g SAR body-worn/hotspot exposure evaluation at 5 mm spacing.

$$\begin{gathered} P_{limit} = \min\{\, \mathrm{P}_{limit} \text{ corresponding to body worn 1gSAR evaluation at 5mm spacing,} \\ P_{limit} \text{ corresponding to 10-g SAR extremity evaluation at 2mm spacing,} \\ P_{max} \text{maximum RF tuneup power for the case that the SAR test is excluded} \} \end{gathered}$$

The SAR Char is listed in Table 2-3.

Table 2-3: SAR Characterization

Exposure Scenario		Duty Cycle	Head				Body worn				Hotspot				P_{max} (dBm)	
Spatial average			1 g				1 g				1 g					
Test Distance			0 mm				5 mm				5 mm					
Power Mode (DSI)			DSI: 0				DSI: 1				DSI: 1					
Antenna	Tech/Band		P_{es} (dBm)	P_m (dBm)	P_{es} (dBm)	P_m (dBm)	P_{es} (dBm)	P_m (dBm)	P_{es} (dBm)	P_m (dBm)	P_{es} (dBm)	P_m (dBm)	P_{es} (dBm)	P_m (dBm)		
			Burst Average		Frame Average		Burst Average		Frame Average		Burst Average		Frame Average		Burst Average	Frame Average
ANT1	GSM 850 2 slots	25.0%	38.00	32.50	31.98	26.48	31.87	32.50	25.85	26.48	31.87	32.50	25.85	26.48	32.50	26.48
	GSM 1900 2 slots	25.0%	35.01	31.00	28.99	24.98	27.26	25.50	21.24	19.48	25.46	25.50	19.44	19.48	31.00	24.98
	W CDMA B2	00.0%	28.16	25.70	28.16	25.70	20.24	19.50	20.24	19.50	18.77	19.50	18.77	19.50	25.70	25.70
	W CDMA B4	00.0%	30.53	25.40	30.53	25.40	20.55	19.50	20.55	19.50	18.86	19.50	18.86	19.50	25.70	25.70
	W CDMA B5	00.0%	30.00	25.70	30.00	25.70	24.85	25.20	24.85	25.20	24.85	25.20	24.85	25.20	25.70	25.70
	CDMA BC0	00.0%	29.72	23.50	29.72	23.50	25.87	23.50	25.87	23.50	25.02	23.50	25.02	23.50	23.50	23.50
	CDMA BC1	00.0%	28.68	25.70	28.68	25.70	20.24	19.50	20.24	19.50	18.94	19.50	18.94	19.50	25.70	25.70
	CDMA BC10	00.0%	30.21	25.70	30.21	25.70	24.42	25.20	24.42	25.20	24.42	25.20	24.42	25.20	25.70	25.70
	LTE Band 5	00.0%	29.28	25.70	29.28	25.70	24.61	25.20	24.61	25.20	24.61	25.20	24.61	25.20	25.70	25.70
	LTE Band 7	00.0%	24.56	24.30	24.56	24.30	20.15	19.30	20.15	19.30	18.57	19.30	18.57	19.30	25.70	25.70
	LTE Band 12/17	00.0%	30.14	25.70	30.14	25.70	26.02	25.70	26.02	25.70	26.02	25.70	26.02	25.70	25.70	25.70
	LTE Band 13	00.0%	30.81	25.70	30.81	25.70	26.43	25.70	26.43	25.70	25.86	25.70	25.86	25.70	25.70	25.70
	LTE Band 14	00.0%	30.38	25.70	30.38	25.70	26.40	25.70	26.40	25.70	25.98	25.70	25.98	25.70	25.70	25.70
	LTE Band 25/2	00.0%	28.61	25.70	28.61	25.70	20.38	19.50	20.38	19.50	18.93	19.50	18.93	19.50	25.70	25.70
	LTE Band 26	00.0%	29.54	25.70	29.54	25.70	24.40	25.20	24.40	25.20	24.40	25.20	24.40	25.20	25.70	25.70
	LTE Band 30	00.0%	24.55	24.60	24.55	24.60	19.64	20.10	19.64	20.10	19.31	20.10	19.31	20.10	24.60	24.60
	LTE Band 41	63.3%	29.50	25.70	27.51	23.71	22.69	21.50	20.71	19.51	20.69	21.50	18.70	19.51	25.70	23.71
	LTE Band 66/4	00.0%	32.39	25.40	32.39	25.40	20.77	19.50	20.77	19.50	19.15	19.50	19.15	19.50	25.70	25.70
	LTE Band 71	00.0%	32.76	25.70	32.76	25.70	27.64	25.70	27.64	25.70	27.64	25.70	27.64	25.70	25.70	25.70
	NR n5	00.0%	32.25	25.70	32.25	25.70	26.84	25.20	26.84	25.20	26.84	25.20	26.84	25.20	25.70	25.70
	NR n7	00.0%	29.82	24.30	29.82	24.30	20.14	19.30	20.14	19.30	20.14	19.30	20.14	19.30	25.70	25.70
	NR n12	00.0%	33.07	25.70	33.07	25.70	28.35	25.70	28.35	25.70	28.35	25.70	28.35	25.70	25.70	25.70
	NR n25/2	00.0%	31.50	25.70	31.50	25.70	21.43	19.50	21.43	19.50	20.72	19.50	20.72	19.50	25.70	25.70
	NR n30	00.0%	28.89	24.60	28.89	24.60	21.85	20.10	21.85	20.10	19.84	20.10	19.84	20.10	24.60	24.60
	NR n41	63.3%	30.31	23.70	28.32	21.71	21.76	19.50	19.77	17.51	21.76	19.50	19.77	17.51	25.70	23.71
	NR n66	00.0%	33.33	25.40	33.33	25.40	21.32	19.50	21.32	19.50	19.61	19.50	19.61	19.50	25.70	25.70
	NR n71	00.0%	33.61	25.70	33.61	25.70	30.36	25.70	30.36	25.70	30.36	25.70	30.36	25.70	25.70	25.70
ANT2	GSM 850 2 slots	25.0%	30.54	31.00	24.52	24.98	31.69	31.00	25.67	24.98	31.69	31.00	25.67	24.98	31.00	24.98
	GSM 1900 2 slots	25.0%	27.70	28.50	21.68	22.48	27.99	28.50	21.97	22.48	27.99	28.50	21.97	22.48	28.50	22.48
	W CDMA B2	00.0%	20.60	20.90	20.60	20.90	20.73	21.20	20.73	21.20	20.73	21.20	20.73	21.20	23.70	23.70
	W CDMA B4	00.0%	21.89	22.10	21.89	22.10	21.50	22.10	21.50	22.10	21.50	22.10	21.50	22.10	23.70	23.70
	W CDMA B5	00.0%	24.24	24.70	24.24	24.70	26.54	24.70	26.54	24.70	26.54	24.70	26.54	24.70	24.70	24.70
	CDMA BC0	00.0%	23.52	23.00	23.52	23.00	25.96	23.00	25.96	23.00	25.96	23.00	25.96	23.00	23.00	23.00
	CDMA BC1	00.0%	20.24	20.90	20.24	20.90	20.65	21.20	20.65	21.20	20.65	21.20	20.65	21.20	23.70	23.70
	CDMA BC10	00.0%	23.90	24.70	23.90	24.70	27.17	24.70	27.17	24.70	27.17	24.70	27.17	24.70	24.70	24.70
	LTE Band 5	00.0%	24.49	24.70	24.49	24.70	25.56	24.70	25.56	24.70	25.56	24.70	25.56	24.70	24.70	24.70
	LTE Band 7	00.0%	16.88	17.70	16.88	17.70	18.68	19.30	18.68	19.30	18.68	19.30	18.68	19.30	23.20	23.20
	LTE Band 12/17	00.0%	23.95	24.60	23.95	24.60	27.55	24.70	27.55	24.70	27.55	24.70	27.55	24.70	24.70	24.70
	LTE Band 13	00.0%	25.26	24.70	25.26	24.70	26.72	24.70	26.72	24.70	26.72	24.70	26.72	24.70	24.70	24.70
	LTE Band 14	00.0%	25.05	24.70	25.05	24.70	26.50	24.70	26.50	24.70	26.50	24.70	26.50	24.70	24.70	24.70
	LTE Band 25/2	00.0%	20.09	20.90	20.09	20.90	20.78	21.20	20.78	21.20	20.78	21.20	20.78	21.20	23.70	23.70
	LTE Band 26	00.0%	24.89	24.70	24.89	24.70	26.13	24.70	26.13	24.70	26.13	24.70	26.13	24.70	24.70	24.70
	LTE Band 30	00.0%	20.16	20.90	20.16	20.90	21.22	21.80	21.22	21.80	21.22	21.80	21.22	21.80	23.20	23.20
	LTE Band 41	63.3%	18.82	19.50	16.83	17.51	21.09	21.40	19.10	19.41	20.84	21.40	18.85	19.41	25.00	23.01
	LTE Band 66/4	00.0%	21.66	22.10	21.66	22.10	21.62	22.10	21.62	22.10	21.62	22.10	21.62	22.10	23.70	23.70
	LTE Band 71	00.0%	25.16	24.70	25.16	24.70	26.52	24.70	26.52	24.70	26.52	24.70	26.52	24.70	24.70	24.70
	NR n5	00.0%	25.80	24.70	25.80	24.70	27.71	24.70	27.71	24.70	27.71	24.70	27.71	24.70	24.70	24.70
	NR n7	00.0%	17.70	17.70	17.70	17.70	19.25	19.30	19.25	19.30	19.25	19.30	19.25	19.30	23.20	23.20
	NR n12	00.0%	28.47	24.60	28.47	24.60	29.92	24.70	29.92	24.70	29.92	24.70	29.92	24.70	24.70	24.70
	NR n25/2	00.0%	20.15	20.90	20.15	20.90	21.25	21.20	21.25	21.20	21.25	21.20	21.25	21.20	23.70	23.70
	NR n30	00.0%	20.61	20.90	20.61	20.90	22.00	21.80	22.00	21.80	22.00	21.80	22.00	21.80	23.20	23.20
	NR n41	63.3%	17.35	17.50	15.36	15.51	20.05	19.40	18.07	17.41	19.65	19.40	17.67	17.41	25.70	23.71
	NR n66	00.0%	21.69	22.10	21.69	22.10	22.17	22.10	22.17	22.10	22.17	22.10	22.17	22.10	23.70	23.70
	NR n71	00.0%	27.63	24.70	27.63	24.70	29.89	24.70	29.89	24.70	29.89	24.70	29.89	24.70	24.70	24.70

Exposure Scenario		Duty Cycle	Head				Body worn				Hotspot				P_{max} (dBm)	
Spatial average			1 g				1 g				1 g					
Test Distance			0 mm				5 mm				5 mm					
Power Mode (DSI)			DSI: 0				DSI: 1				DSI: 1					
Antenna	Tech/Band		P_{es} (dBm)	P_m (dBm)	P_{es} (dBm)	P_m (dBm)	P_{es} (dBm)	P_m (dBm)	P_{es} (dBm)	P_m (dBm)	P_{es} (dBm)	P_m (dBm)	P_{es} (dBm)	P_m (dBm)		
			Burst Average		Frame Average		Burst Average		Frame Average		Burst Average		Frame Average		Burst Average	Frame Average
ANT3	GSM 1900 2 slots	25.0%	35.98	30.00	29.96	23.98	26.12	26.60	20.10	20.58	25.79	26.60	19.77	20.58	30.00	23.98
	W CDMA B2	00.0%	26.97	24.50	26.97	24.50	20.78	20.60	20.78	20.60	19.97	20.60	19.97	20.60	25.20	25.20
	W CDMA B4	00.0%	28.86	25.20	28.86	25.20	24.51	22.30	24.51	22.30	21.98	22.30	21.98	22.30	25.20	25.20
	LTE Band 7	00.0%	23.12	23.40	23.12	23.40	17.94	18.40	17.94	18.40	17.88	18.40	17.88	18.40	25.20	25.20
	LTE Band 25/2	00.0%	26.71	24.50	26.71	24.50	19.96	20.60	19.96	20.60	19.96	20.60	19.96	20.60	25.20	25.20
	LTE Band 30	00.0%	20.91	21.60	20.91	21.60	18.09	18.90	18.09	18.90	18.09	18.90	18.09	18.90	21.60	21.60
	LTE Band 41	63.3%	24.46	25.20	22.48	23.21	19.82	19.70	17.84	17.71	19.12	19.70	17.13	17.71	25.70	23.71
	LTE Band 66/4	00.0%	29.50	25.20	29.50	25.20	23.22	22.30	23.22	22.30	21.59	22.30	21.59	22.30	25.20	25.20
	NR n7	00.0%	28.74	23.40	28.74	23.40	19.19	18.40	19.19	18.40	18.91	18.40	18.91	18.40	25.20	25.20
	NR n25/2	00.0%	27.78	24.50	27.78	24.50	20.07	20.60	20.07	20.60	20.07	20.60	20.07	20.60	25.20	25.20
	NR n30	00.0%	27.72	21.60	27.72	21.60	19.68	18.90	19.68	18.90	19.68	18.90	19.68	18.90	21.60	21.60
	NR n41	63.3%	29.64	23.20	27.65	21.21	20.12	17.70	18.13	15.71	20.12	17.70	18.13	15.71	24.70	22.71
	NR n66	00.0%	30.26	25.20	30.26	25.20	24.58	22.30	24.58	22.30	22.91	22.30	22.91	22.30	25.20	25.20
ANT4	GSM 1900 2 slots	25.0%	25.72	26.50	19.70	20.48	28.45	26.20	22.42	20.18	26.71	26.20	20.69	20.18	28.00	21.98
	W CDMA B2	00.0%	20.13	20.50	20.13	20.50	22.19	21.20	22.19	21.20	20.39	21.20	20.39	21.20	23.70	23.70
	W CDMA B4	00.0%	20.32	20.50	20.32	20.50	22.98	22.00	22.98	22.00	21.48	22.00	21.48	22.00	23.70	23.70
	LTE Band 7	00.0%	21.08	21.50	21.08	21.50	21.12	21.70	21.12	21.70	21.07	21.70	21.07	21.70	23.20	23.20
	LTE Band 25/2	00.0%	19.72	20.50	19.72	20.50	22.67	21.20	22.67	21.20	20.63	21.20	20.63	21.20	23.70	23.70
	LTE Band 30	00.0%	20.38	21.20	20.38	21.20	23.74	21.80	23.74	21.80	21.08	21.80	21.08	21.80	23.20	23.20
	LTE Band 41	63.3%	22.64	22.70	20.65	20.71	24.94	23.00	22.95	21.01	22.25	23.00	20.27	21.01	25.00	23.01
	LTE Band 48	63.3%	22.04	22.50	20.05	20.51	21.49	21.20	19.51	19.21	21.15	21.20	19.17	19.21	22.50	20.51
	LTE Band 66/4	00.0%	19.83	20.50	19.83	20.50	21.77	22.00	21.77	22.00	21.36	22.00	21.36	22.00	23.70	23.70
	NR n7	00.0%	21.46	21.50	21.46	21.50	24.16	21.70	24.16	21.70	22.17	21.70	22.17	21.70	23.20	23.20
	NR n25/2	00.0%	20.19	20.50	20.19	20.50	22.67	21.20	22.67	21.20	20.69	21.20	20.69	21.20	23.70	23.70
	NR n30	00.0%	20.99	21.20	20.99	21.20	24.50	21.80	24.50	21.80	24.50	21.80	24.50	21.80	23.20	23.20
	NR n41	63.3%	21.11	20.70	19.13	18.71	23.64	21.00	21.65	19.01	23.27	21.00	21.28	19.01	25.70	23.71
	NR n66	00.0%	20.82	20.50	20.82	20.50	22.62	22.00	22.62	22.00	22.05	22.00	22.05	22.00	23.70	23.70
	NR n77	63.3%	19.86	20.00	17.88	18.01	21.22	21.50	19.24	19.51	20.84	21.50	18.85	19.51	23.50	21.51
ANT7	LTE Band 48	63.3%	28.22	23.50	26.23	21.51	19.62	20.40	17.63	18.41	19.62	20.40	17.63	18.41	23.50	21.51
	NR n77	63.3%	28.35	25.70	26.36	23.71	19.01	19.50	17.02	17.51	19.01	19.50	17.02	17.51	25.70	23.71
ANT8	LTE Band 48	63.3%	27.12	23.00	25.14	21.01	20.87	21.40	18.88	19.41	20.87	21.40	18.88	19.41	23.00	21.01
	NR n77	63.3%	24.49	24.00	22.50	22.01	20.09	20.70	18.10	18.71	20.09	20.70	18.10	18.71	24.00	22.01
ANT9	LTE Band 48	63.3%	33.10	25.20	31.12	23.21	24.89	23.00	22.90	21.01	23.91	23.00	21.92	21.01	25.20	23.21
	NR n77	63.3%	30.24	24.60	28.25	22.61	18.78	19.20	16.79	17.21	18.78	19.20	16.79	17.21	25.70	23.71

3. Power Density Characterization

The EUT's 5G mmW NR contains two Qualcomm SDX-60M mmW antenna modules (module 0 and 1), denoted as ANT M1 and ANT M0 (module 0), and ANT M2 (module 1), which are installed at three different locations as shown in the operational description. There is a total of 135 antenna array configurations per band. In this chapter, a hybrid approach of using electromagnetic (EM) simulation and actual measurements to efficiently, and conservatively, characterize the power density profile for the EUT.

3.1. Exposure Scenarios in PD Evaluation

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

For this EUT, the 4cm^2 spatially-averaged PD is evaluated along the surfaces (*S1=front, S2=back, S3=left, S4=right, S5=top,* and *S6=bottom* as shown in Figure 3-1) and the worst-case PD is determined by taking the maximum PD among all the evaluated surfaces for each beam/band.

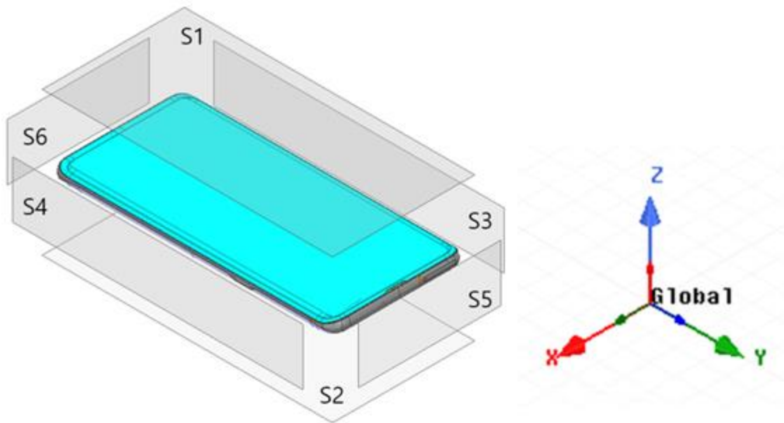

Figure 3-1: EUT surface definition

3.2. PD Characterization Overview

Parameters used in PD Characterization:

- The EUT supports a total of 135 beams per band, where 90 beams are single beams (SISO) and 45 are beam pairs (MIMO) where 2 single beams are excited at the same time.
- ***PD****Design Target*: The design target for PD compliance as defined in the summary report. It should be less than the FCC PD limit to account for all device design related uncertainties.
- ***input.power.limit***: For a PD characterized wireless device, the input power level at antenna port(s) for each beam corresponding to *PD_design_target*.
- **PD Characterization**: The table that contains the *input.power.limit* fed to antenna port(s) for all supported beams.

Figure 3-2 outlines the PD Char process.

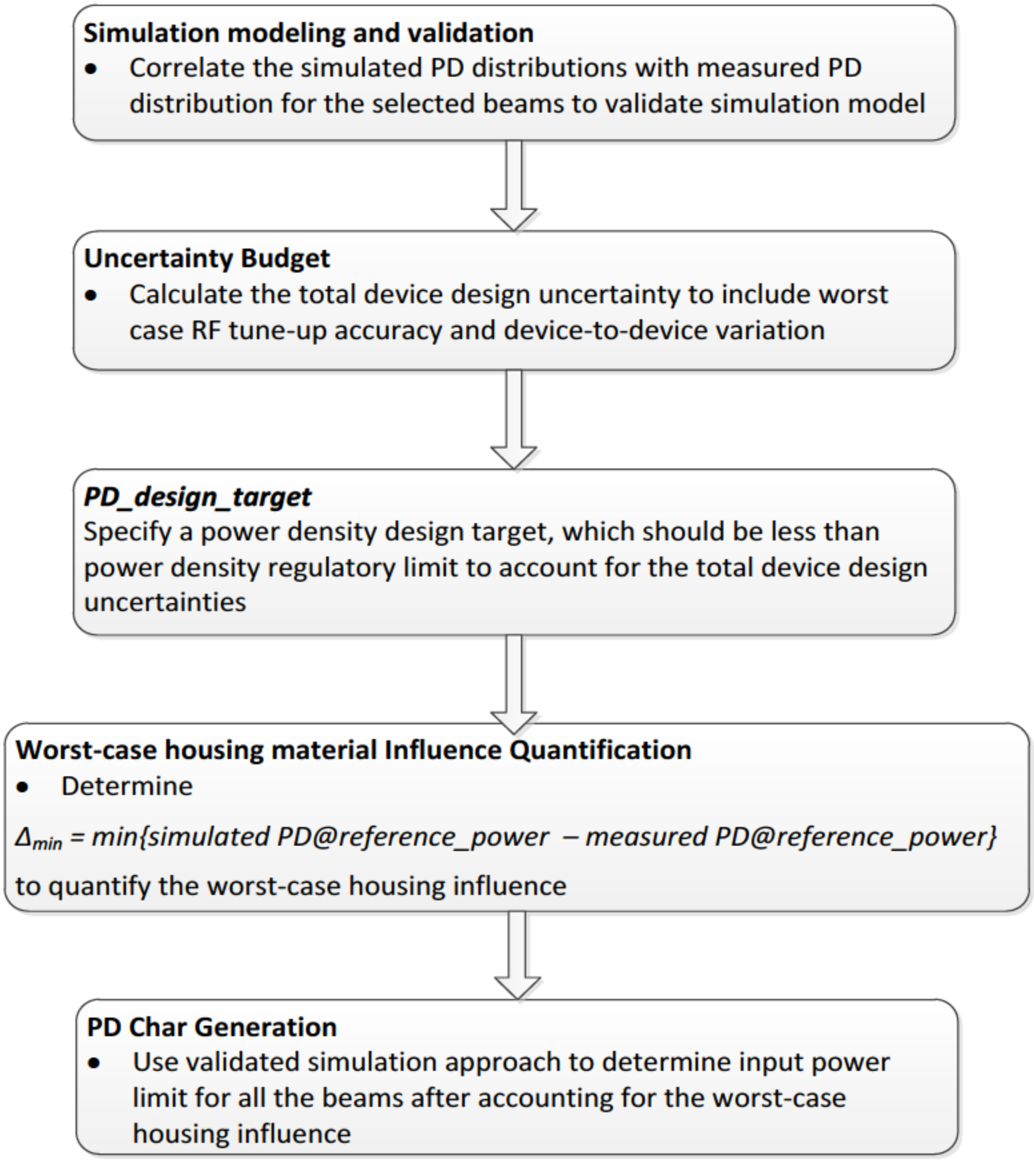

Figure 3-2 High level flow chart for power density characterization

3.3. EUT Codebook

In general, all the beams that the smartphone supports are specified in the pre-defined codebook. The codebook is device design specific and generated after evaluating radiation coverage from this specific device.

Table 3-1 shows all the beams and their relevant information.

The PD evaluation needs to be performed for all the beams listed in Table 3-1.

Table 3-1: EUT Codebook

Band	Beam ID	Paired With	Module	Ant Type	# of Elements
258	0	128	BG1	PATCH	1
	1	129	BG2	PATCH	1
	2	130	SF	PATCH	1
	3	131	BG1	PATCH	1
	4	132	BG2	PATCH	1
	5	133	SF	PATCH	1
	6	134	BG1	PATCH	2
	7	135	BG1	PATCH	2
	8	136	BG1	PATCH	2
	9	137	BG1	PATCH	2
	10	138	BG2	PATCH	2

Band	Beam ID	Paired With	Module	Ant Type	# of Elements
260	0	128	BG1	PATCH	1
	1	129	BG2	PATCH	1
	2	130	SF	PATCH	1
	3	131	BG1	PATCH	1
	4	132	BG2	PATCH	1
	5	133	SF	PATCH	1
	6	134	BG1	PATCH	2
	7	135	BG1	PATCH	2
	8	136	BG1	PATCH	2
	9	137	BG1	PATCH	2
	10	138	BG2	PATCH	2

Band	Beam ID	Paired With	Module	Ant Type	# of Elements
261	0	128	BG1	PATCH	1
	1	129	BG2	PATCH	1
	2	130	SF	PATCH	1
	3	131	BG1	PATCH	1
	4	132	BG2	PATCH	1
	5	133	SF	PATCH	1
	6	134	BG1	PATCH	2
	7	135	BG1	PATCH	2
	8	136	BG1	PATCH	2
	9	137	BG1	PATCH	2
	10	138	BG2	PATCH	2

Band	Beam ID	Paired With	Module	Ant Type	# of Elements
	11	139	BG2	PATCH	2
	12	140	BG2	PATCH	2
	13	141	BG2	PATCH	2
	14	142	SF	PATCH	2
	15	143	SF	PATCH	2
	16	144	SF	PATCH	2
	17	145	SF	PATCH	2
	18	146	BG1	PATCH	2
	19	147	BG1	PATCH	2
	20	148	BG1	PATCH	2
	21	149	BG2	PATCH	2
	22	150	BG2	PATCH	2
	23	151	BG2	PATCH	2
	24	152	SF	PATCH	2
	25	153	SF	PATCH	2
	26	154	SF	PATCH	2
	27	155	BG1	PATCH	4
	28	156	BG1	PATCH	4
	29	157	BG1	PATCH	4
	30	158	BG1	PATCH	4
	31	159	BG1	PATCH	4
	32	160	SF	PATCH	4
	33	161	SF	PATCH	4
	34	162	SF	PATCH	4
	35	163	SF	PATCH	4
	36	164	SF	PATCH	4
	37	165	BG1	PATCH	4
	38	166	BG1	PATCH	4
	39	167	BG1	PATCH	4
	40	168	BG1	PATCH	4
	41	169	SF	PATCH	4
	42	170	SF	PATCH	4
	43	171	SF	PATCH	4
	44	172	SF	PATCH	4
	128	0	BG1	PATCH	1
	129	1	BG2	PATCH	1
	130	2	SF	PATCH	1
	131	3	BG1	PATCH	1
	132	4	BG2	PATCH	1
258	133	5	SF	PATCH	1
	134	6	BG1	PATCH	2
	135	7	BG1	PATCH	2
	136	8	BG1	PATCH	2
	137	9	BG1	PATCH	2
	138	10	BG2	PATCH	2
	139	11	BG2	PATCH	2
	140	12	BG2	PATCH	2
	141	13	BG2	PATCH	2
	142	14	SF	PATCH	2
	143	15	SF	PATCH	2
	144	16	SF	PATCH	2
	145	17	SF	PATCH	2
	146	18	BG1	PATCH	2
	147	19	BG1	PATCH	2
	148	20	BG1	PATCH	2
	149	21	BG2	PATCH	2
	150	22	BG2	PATCH	2
	151	23	BG2	PATCH	2
	152	24	SF	PATCH	2
	153	25	SF	PATCH	2
	154	26	SF	PATCH	2
	155	27	BG1	PATCH	4
	156	28	BG1	PATCH	4
	157	29	BG1	PATCH	4
	158	30	BG1	PATCH	4
	159	31	BG1	PATCH	4
	160	32	SF	PATCH	4
	161	33	SF	PATCH	4
	162	34	SF	PATCH	4
	163	35	SF	PATCH	4
	164	36	SF	PATCH	4
	165	37	BG1	PATCH	4
	166	38	BG1	PATCH	4
	167	39	BG1	PATCH	4
	168	40	BG1	PATCH	4
	169	41	SF	PATCH	4
	170	42	SF	PATCH	4
	171	43	SF	PATCH	4
	172	44	SF	PATCH	4

Band	Beam ID	Paired With	Module	Ant Type	# of Elements
	11	139	BG2	PATCH	2
	12	140	BG2	PATCH	2
	13	141	BG2	PATCH	2
	14	142	SF	PATCH	2
	15	143	SF	PATCH	2
	16	144	SF	PATCH	2
	17	145	SF	PATCH	2
	18	146	BG1	PATCH	2
	19	147	BG1	PATCH	2
	20	148	BG1	PATCH	2
	21	149	BG2	PATCH	2
	22	150	BG2	PATCH	2
	23	151	BG2	PATCH	2
	24	152	SF	PATCH	2
	25	153	SF	PATCH	2
	26	154	SF	PATCH	2
	27	155	BG1	PATCH	4
	28	156	BG1	PATCH	4
	29	157	BG1	PATCH	4
	30	158	BG1	PATCH	4
	31	159	BG1	PATCH	4
	32	160	SF	PATCH	4
	33	161	SF	PATCH	4
	34	162	SF	PATCH	4
	35	163	SF	PATCH	4
	36	164	SF	PATCH	4
	37	165	BG1	PATCH	4
	38	166	BG1	PATCH	4
	39	167	BG1	PATCH	4
	40	168	BG1	PATCH	4
	41	169	SF	PATCH	4
	42	170	SF	PATCH	4
	43	171	SF	PATCH	4
	44	172	SF	PATCH	4
	128	0	BG1	PATCH	1
	129	1	BG2	PATCH	1
	130	2	SF	PATCH	1
	131	3	BG1	PATCH	1
	132	4	BG2	PATCH	1
260	133	5	SF	PATCH	1
	134	6	BG1	PATCH	2
	135	7	BG1	PATCH	2
	136	8	BG1	PATCH	2
	137	9	BG1	PATCH	2
	138	10	BG2	PATCH	2
	139	11	BG2	PATCH	2
	140	12	BG2	PATCH	2
	141	13	BG2	PATCH	2
	142	14	SF	PATCH	2
	143	15	SF	PATCH	2
	144	16	SF	PATCH	2
	145	17	SF	PATCH	2
	146	18	BG1	PATCH	2
	147	19	BG1	PATCH	2
	148	20	BG1	PATCH	2
	149	21	BG2	PATCH	2
	150	22	BG2	PATCH	2
	151	23	BG2	PATCH	2
	152	24	SF	PATCH	2
	153	25	SF	PATCH	2
	154	26	SF	PATCH	2
	155	27	BG1	PATCH	4
	156	28	BG1	PATCH	4
	157	29	BG1	PATCH	4
	158	30	BG1	PATCH	4
	159	31	BG1	PATCH	4
	160	32	SF	PATCH	4
	161	33	SF	PATCH	4
	162	34	SF	PATCH	4
	163	35	SF	PATCH	4
	164	36	SF	PATCH	4
	165	37	BG1	PATCH	4
	166	38	BG1	PATCH	4
	167	39	BG1	PATCH	4
	168	40	BG1	PATCH	4
	169	41	SF	PATCH	4
	170	42	SF	PATCH	4
	171	43	SF	PATCH	4
	172	44	SF	PATCH	4

Band	Beam ID	Paired With	Module	Ant Type	# of Elements
	11	139	BG2	PATCH	2
	12	140	BG2	PATCH	2
	13	141	BG2	PATCH	2
	14	142	SF	PATCH	2
	15	143	SF	PATCH	2
	16	144	SF	PATCH	2
	17	145	SF	PATCH	2
	18	146	BG1	PATCH	2
	19	147	BG1	PATCH	2
	20	148	BG1	PATCH	2
	21	149	BG2	PATCH	2
	22	150	BG2	PATCH	2
	23	151	BG2	PATCH	2
	24	152	SF	PATCH	2
	25	153	SF	PATCH	2
	26	154	SF	PATCH	2
	27	155	BG1	PATCH	4
	28	156	BG1	PATCH	4
	29	157	BG1	PATCH	4
	30	158	BG1	PATCH	4
	31	159	BG1	PATCH	4
	32	160	SF	PATCH	4
	33	161	SF	PATCH	4
	34	162	SF	PATCH	4
	35	163	SF	PATCH	4
	36	164	SF	PATCH	4
	37	165	BG1	PATCH	4
	38	166	BG1	PATCH	4
	39	167	BG1	PATCH	4
	40	168	BG1	PATCH	4
	41	169	SF	PATCH	4
	42	170	SF	PATCH	4
	43	171	SF	PATCH	4
	44	172	SF	PATCH	4
	128	0	BG1	PATCH	1
	129	1	BG2	PATCH	1
	130	2	SF	PATCH	1
	131	3	BG1	PATCH	1
	132	4	BG2	PATCH	1
261	133	5	SF	PATCH	1
	134	6	BG1	PATCH	2
	135	7	BG1	PATCH	2
	136	8	BG1	PATCH	2
	137	9	BG1	PATCH	2
	138	10	BG2	PATCH	2
	139	11	BG2	PATCH	2
	140	12	BG2	PATCH	2
	141	13	BG2	PATCH	2
	142	14	SF	PATCH	2
	143	15	SF	PATCH	2
	144	16	SF	PATCH	2
	145	17	SF	PATCH	2
	146	18	BG1	PATCH	2
	147	19	BG1	PATCH	2
	148	20	BG1	PATCH	2
	149	21	BG2	PATCH	2
	150	22	BG2	PATCH	2
	151	23	BG2	PATCH	2
	152	24	SF	PATCH	2
	153	25	SF	PATCH	2
	154	26	SF	PATCH	2
	155	27	BG1	PATCH	4
	156	28	BG1	PATCH	4
	157	29	BG1	PATCH	4
	158	30	BG1	PATCH	4
	159	31	BG1	PATCH	4
	160	32	SF	PATCH	4
	161	33	SF	PATCH	4
	162	34	SF	PATCH	4
	163	35	SF	PATCH	4
	164	36	SF	PATCH	4
	165	37	BG1	PATCH	4
	166	38	BG1	PATCH	4
	167	39	BG1	PATCH	4
	168	40	BG1	PATCH	4
	169	41	SF	PATCH	4
	170	42	SF	PATCH	4
	171	43	SF	PATCH	4
	172	44	SF	PATCH	4

3.4. Simulation and modeling validation

3.4.1. Modeling for Simulation

Device modeling is described in the operational description.

3.4.2. Modeling Validation

To validate modeling and simulation:

1. Select one beam (i.e., antenna array configuration) per antenna type (dipole/patch) and per antenna module. All three antennas contain only patch arrays. Therefore, the beam selection criteria for each mmW antenna are:

   a) Two beams from each antenna module.

   Note: Since the relative phase between two single beams in a beam pair is uncontrolled and could vary from run to run, for the validation purpose, the selection is limited to the single beam antenna array configuration. Additionally, single beam containing a higher number of active antenna elements is selected. For example, a single beam with four active patches should be selected over beam with a single active patch antenna beam. The beams selected for modeling validation are highlighted in grey in Table 3-1.

2. For a given input power, perform both PD simulation and PD measurement to obtain the simulated PD distributions and measured PD distributions on the surface in front of the antenna array.

3. Validate modeling and simulation by correlating the simulated PD distribution and measured PD distribution for all antenna array configurations selected in Step 1 and for all surfaces selected in Step 2.

4. The modeling validation is performed through correlating the simulated 4 cm^2-average PD distribution to measured 4 cm^2-average PD distribution.

5. These discrepancies in PD magnitude will be used to determine the worst-case housing influence (due to non-metal material property uncertainty) in §4.6. The worst-case housing influence will be accounted for in PD Characterization generation for conservative RF exposure assessment, see §4.7 for details.

Based on the selection criteria described in Step 1 and Step 2, the beams and surfaces selected for modeling validation of the EUT are listed in Table 3-2.

Table 3-2: Beams and surfaces selection for PD correlation

Band	Beam ID	Antenna	Pol	Surface
n258	31	M1	V	Back
	157		H	Back
	12	M0	V	Back
	140		H	Back
	44	M2	V	Right
	169		H	Right
n260	38	M1	V	Back
	156		H	Back
	22	M0	V	Back
	140		H	Back
	42	M2	V	Right
	162		H	Right
n261	28	M1	V	Back
	167		H	Back
	22	M0	V	Back
	151		H	Back
	36	M2	V	Right
	169		H	Right

With an input power of 6.0 dBm (which will be referred to as P_{ref}) for bands n258, n260, and n261PD measurement and PD simulation are conducted for all beams and surfaces listed in Table 3-2. Both PD measurement and PD simulation are performed at mid channel of each mmW beam, PD measurement is conducted with CW modulation.

- PD distribution:

  Please refer to the operational description.

- 4cm^2-averaged PD value

  Table 3-3 lists the measured 4cm^2-averaged PD and simulated 4cm^2-averaged PD for all selected beams and surfaces for n258, n260, n261 bands. The discrepancy between simulated and measured PD value will be used to determine worst-case housing influence for conservative assessment (see §4.6).

Table 3-3: Measured and simulated 4 cm^2 averaged PD for selected beams with 6 dBm input power for selected bands

Band	Beam ID	Antenna	Pol	Surface	4cm^2 avg. PD (W/m^2)		Delta[1]
					Meas.	Sim	
n258	31	M1	V	Back	17.00	17.84	**0.21**
	157		H	Back	11.80	22.68	**2.84**
	12	M0	V	Back	4.76	6.74	**1.51**
	140		H	Back	3.84	6.23	**2.10**
	36	M2	V	Right	15.40	19.85	**1.10**
	169		H	Right	11.80	20.93	**2.49**
n260	38	M1	V	Back	13.10	13.23	**0.04**
	156		H	Back	10.20	4.17	**-3.88**
	22	M0	V	Back	2.32	2.43	**0.20**
	140		H	Back	3.30	2.24	**-1.68**
	42	M2	V	Right	15.50	10.99	**-1.49**
	162		H	Right	16.90	10.97	**-1.88**
n261	28	M1	V	Back	14.40	19.58	**1.33**
	167		H	Back	12.30	23.36	**2.79**
	22	M0	V	Back	4.14	6.60	**2.03**
	151		H	Back	3.79	5.86	**1.89**
	36	M2	V	Right	30.10	18.89	**-2.02**
	169		H	Right	14.60	20.24	**1.42**

[1]Delta = Sim - Meas (dB)

3.4.3. Simulation for power density

The model is validated in §4.4.3, the PD exposure of EUT can be reliably assessed using the validated simulation approach.

In general, all six surfaces of the EUT, as shown in Figure 3-1, should be assessed for RF exposure from the mmW radio and the worst-case PD should be determined by:

$$\boldsymbol{PD}_{\textbf{worst-case}} = \max\{PD_{s1}, PD_{s2}, PD_{s3}, PD_{s4}, PD_{s5}, PD_{s6}\} \quad (1)$$

where $PD_{s1}, PD_{s2}, PD_{s3}, PD_{s4}, PD_{s5}, PD_{s6}$ are the highest 4cm^2-avgeraged PD on surface S1, S2, S3, S4, S5 and S6 of the device. respectively.

However, depending on the location of the mmW module and the antenna array orientation relative to the surface of the device, one or more surface(s) can be excluded for PD calculation as the PD value(s) on the excluded surface(s) will be undoubtedly lower when comparing to other surfaces; thus, the exclusion will have no impact for the worst-case PD determined using Equation 1.

For this EUT, based on the location of M1, M0, and M2 (shown in the operational description) and the type of antenna array (containing in each a millimeter wave antenna), the surface planes identified for PD evaluation to determine the worst-case PD are selected and listed in Table 3-4.

Table 3-4: PD evaluation plane

n258	Front	Back	Left	Right	Top	Bottom
	S1	S2	S3	S4	S5	S6
M1	No	Yes	Yes	No	No	No
M0	No	Yes	Yes	No	Yes	No
M2	Yes	Yes	No	Yes	No	No

n260	Front	Back	Left	Right	Top	Bottom
	S1	S2	S3	S4	S5	S6
M1	No	Yes	Yes	No	No	No
M0	No	Yes	Yes	No	Yes	No
M2	Yes	Yes	No	Yes	No	No

n261	Front	Back	Left	Right	Top	Bottom
	S1	S2	S3	S4	S5	S6
M1	No	Yes	Yes	No	No	No
M0	No	Yes	Yes	No	Yes	No
M2	Yes	Yes	No	Yes	No	No

The EM simulation is performed to characterize PD at low, mid, and high channels for each supported band. The simulation setup (mesh, convergence criteria, and radiation boundary settings) as described in the operational description, ensures the accurate and reliable result for PD simulation on the planes identified. Both point PD and 4cm^2-averaged PD distributions on the worst surface plane (i.e., the surface having highest PD value for the beam tested) are plotted and provided in the operational description to show that the PD hotspots are captured in this analysis.

3.5. PD$_{\text{Design Target}}$

The manufacturer has their own internal controls for managing uncertainty and declared 2.20 dB uncertainty for use in determining the PD$_{\text{Design Target}}$ using Qualcomm's SDX-60M modem.
To account for the total design related uncertainty, PD$_{\text{Design Target}}$ needs to be:

$$PD_{Design\ Target} < PD_{Design\ Limit} \times 10^{\frac{-total\ uncertainty}{10}}$$

With FCC's 4cm^2-averaged PD requirement of 10 W/m^2 and with the manufacturer's declared device design related uncertainty, the PD$_{\text{Design Target}}$ is determined as:

Total Uncertainty (dB)	PD$_{\text{Design Target}}$ (W/m^2)	PD$_{\text{Design Limit}}$ (W/m^2)
2.20	6.0	10.0

3.6. Worst-case Housing Influence Determination

For non-metal material, the material property cannot be accurately characterized at mmW frequencies to date. The estimated material property for the device housing is used in the simulation model, which could influence the accuracy in simulation for PD amplitude quantification. Since the housing influence on PD could vary from surface to surface where the EM field propagates through, the most underestimated surface is used to quantify the worst-case housing influence for conservative assessment.

Since the mmW antenna modules are placed at different locations, as shown in the operational description, only material/housing have an impact on EM field propagation, and, in turn, impact on power density. Furthermore, depending on the type of antenna array, i.e., dipole antenna array or patch antenna array, the nature of EM field propagation in the near field is different. Therefore, the worst-case housing influence is determined per antenna module and per antenna type.

For this EUT, when comparing a simulated 4cm^2-avgeraged PD and measured 4 cm^2-avgerated PD, the worst error introduced for each type of antenna array and antenna module when using the estimated material property in the simulation is accented in bold numbers in Table 3-5. Thus, the worst-case housing influence, denoted as $\Delta_{min} = \mathrm{Sim.PD} - \mathrm{Meas.PD}$, is determined as:

Table 3-5: Δ_{min} for ANT M1, ANT M0, and ANT M2

Band	Ant	Pol	Δ_{min} (dB)
n258	M1 (Patch Beam)	V	**0.21**
		H	**2.84**
	M0 (Patch Beam)	V	**1.51**
		H	**2.10**
	M2 (Patch Beam)	V	**1.10**
		H	**2.49**
n260	M1 (Patch Beam)	V	**0.04**
		H	**-3.88**
	M0 (Patch Beam)	V	**0.20**
		H	**-1.68**
	M2 (Patch Beam)	V	**-1.49**
		H	**-1.88**
n260	M1 (Patch Beam)	V	**1.33**
		H	**2.79**
	M0 (Patch Beam)	V	**2.03**
		H	**1.89**
	M2 (Patch Beam)	V	**-2.02**
		H	**1.42**

Δ_{min} represents the worst case where RF exposure is underestimated the most in simulation when using the estimated material property for glass/plastics of the housing. For conservative assessment, the Δ_{min} is used as the worst-case factor and applied to all the beams in the corresponding beam group to determine input power limits in PD char for compliance (see §4.7.3 for details).

3.7. PD Characterization

This section describes the PD Characterization generation that complies with the $PD_{Design\ Target}$ determined in §4.5 and complies the regulatory power density limit.

3.7.1. Scaling Factor for Single Beams

To determine the input power limit at each antenna port, perform the simulation at low, mid, and high channel for each mmW band supported, with a given input power per active port:

1. Obtain $PD_{surface}$ value (the worst PD among all identified surfaces of the EUT) at all three channels for all single beams specified in the codebook of Table 3-1.

2. Derive a scaling factor at low, mid and high channel, $s(i)_{low\_or\_mid\_or\_high}$, by:

$$s(i)_{low\_or\_mid\_or\_high} = \frac{PD\ design\ target}{sim.PD_{surface}(i)},\ i \in single\ beams \quad (2)$$

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

$$s(i) = min\left\{s_{low}(i), s_{mid}(i), s_{high}(i)\right\},\ i \in single\ beams \quad (3)$$

and this scaling factor applies to the input power at each antenna port.

3.7.2. Scaling Factor for Beam Pairs

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

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

For a given beam pair containing $beam_a$ and $beam_b$, and for a given channel, let relative phase between $beam_a$ and $beam_b$ = ∅, and the total PD of the beam pair can be expressed as:

$$total\ PD\ (\emptyset) = \frac{1}{2}\sqrt{Re\{PD_x(\emptyset)\}^2 + Re\{PD_y(\emptyset)\}^2 + Re\{PD_z(\emptyset)\}^2}$$
$$= \frac{1}{2} Re\left\{\left(\overrightarrow{E_a} + \overrightarrow{E_b e^{j\omega\emptyset}}\right) \times \left(\overrightarrow{H_a} + \overrightarrow{H_b e^{j\omega\emptyset}}\right)^*\right\} \quad (4)$$

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

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

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

$$s(i)_{low\_or\_mid\_or\_high} = \frac{PD\ design\ target}{total\ PD\ (\emptyset(i)_{worstcase})}, i \in beam\ pairs \quad (5)$$

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

$$s(i) = min\left\{s_{low}(i), s_{mid}(i), s_{high}(i)\right\},\ i \in beam\ pairs \quad (6)$$

3.7.3. Input Power Limit

The PD Characterization specifies the limit of input power at an antenna port that corresponds to $PD_{Design\ Target}$ for all beams.

Ideally, if there is no uncertainty associated with hardware design, the input power limit, denoted as $input.power.limit(i)$, for beam *i* can be obtained after accounting for the housing influence (Δ_{min}) determined in Table 3-6 of §4.6, given by:

$$input.power.limit(i) = P_{ref} + 10 * \log\left(s(i)\right) + \Delta_{min},\ i \in all\ beams \quad (7)$$

where P_{ref} is the input power using in simulation; $s(i)$ is the scaling factor obtained from Eq. (3) or Eq. (6) for beam *i*; Δ_{min} is the worst-case housing influence factor (determined in Table 3-6) for beam *i*.

If simulation overestimates the housing influence, then Δ_{min} (= simulated PD – measured PD) is negative, which means that the measured PD would be higher than the simulated PD. The input power to antenna elements determined via simulation must be decreased for compliance.

Similarly, if simulation underestimates the loss, then Δ_{min} is positive (measured PD would be lower than the simulated value). Input power to antenna elements determined via simulation can be increased and still be PD compliant.

The hardware design has uncertainty which must be properly considered. In §4.6, the TxAGC uncertainty is embedded in the process of Δ_{min} determination. Since TxAGC uncertainty is already accounted for in $PD_{Design\ Target}$ (see §4.5), it needs to be removed to avoid double counting this uncertainty.

Thus, Equation 7 is modified to:

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

$$input.power.limit(i) = P_{ref} + 10 * \log\big(s(i)\big),\ i \in all\ beams \quad (8)$$

else if Δ_{min} < -TxAGC uncertainty,

$$input.power.limit(i) = P_{ref} + 10 * \log\big(s(i)\big) + \Delta_{min}, i \in all\ beams \quad (9)$$

else if Δ_{min} > TxAGC uncertainty,

$$input.power.limit(i) = P_{ref} + 10 * \log\big(s(i)\big) + (\Delta_{min} - \text{TxAGC uncertainty}), i \in all\ beams \quad (10)$$

Following the logic above, the *input.power.limit* for this EUT can be calculated using Equations (8), (9) and (10), i.e.,

Table 3-6: *input.power.limit* calculation

Band	Ant	Pol	Δ_{min} (dB)	*Input.power.limit* Equation (dBm)	Notes
n258	BG1	V	**0.21**	6 dBm + 10 * log(s(i))	Using Eq. 8
		H	**2.84**	6 dBm + 10 * log(s(i)) + 1.84	Using Eq. 10
	BG2	V	**1.51**	6 dBm + 10 * log(s(i)) + 0.51	Using Eq. 10
		H	**2.10**	6 dBm + 10 * log(s(i)) + 1.1	Using Eq. 10
	SF	V	**1.10**	6 dBm + 10 * log(s(i)) + 0.1	Using Eq. 10
		H	**2.49**	6 dBm + 10 * log(s(i)) + 1.49	Using Eq. 10
n260	BG1	V	**0.04**	6 dBm + 10 * log(s(i))	Using Eq. 8
		H	**-3.88**	6 dBm + 10 * log(s(i)) + -3.88	Using Eq. 9
	BG2	V	**0.20**	6 dBm + 10 * log(s(i))	Using Eq. 8
		H	**-1.68**	6 dBm + 10 * log(s(i)) + -1.68	Using Eq. 9
	SF	V	**-1.49**	6 dBm + 10 * log(s(i)) + -1.49	Using Eq. 9
		H	**-1.88**	6 dBm + 10 * log(s(i)) + -1.88	Using Eq. 9
n261	BG1	V	**6.75**	6 dBm + 10 * log(s(i)) + 5.75	Using Eq. 10
		H	**2.79**	6 dBm + 10 * log(s(i)) + 1.79	Using Eq. 10
	BG2	V	**-3.39**	6 dBm + 10 * log(s(i)) + -3.39	Using Eq. 9
		H	**1.89**	6 dBm + 10 * log(s(i)) + 0.89	Using Eq. 10
	SF	V	**-2.02**	6 dBm + 10 * log(s(i)) + -2.02	Using Eq. 9
		H	**1.42**	6 dBm + 10 * log(s(i)) + 0.42	Using Eq. 10

Thus, the EUT PD Char for n258, n260, and n261 bands are as shown in Table 3-7.

Table 3-7: PD Characterization

n258			n260			n261		
Paired ID (Beam Pair)	Beam ID	Input Power Limit (dBm)	Paired ID (Beam Pair)	Beam ID	Input Power Limit (dBm)	Paired ID (Beam Pair)	Beam ID	Input Power Limit (dBm)
N/A	0	6.2	N/A	0	8.6	N/A	0	8.8
	1	8.9		1	13.8		1	9.2
	2	7.9		2	7.7		2	4.2
	3	6.9		3	9.2		3	9.2
	4	8.8		4	11.7		4	10.5
	5	6.5		5	7.0		5	5.2
	6	3.9		6	8.0		6	4.3
	7	2.9		7	5.0		7	5.4
	8	5.3		8	5.3		8	4.5
	9	5.4		9	8.1		9	5.7
	10	6.3		10	9.8		10	7.4
	11	6.3		11	9.9		11	6.7
	12	6.0		12	10.0		12	6.4
	13	6.0		13	9.7		13	6.5
	14	4.8		14	3.8		14	2.3
	15	4.6		15	4.5		15	1.9
	16	4.3		16	5.5		16	2.9
	17	4.2		17	4.9		17	2.7
	18	2.7		18	5.7		18	4.3
	19	4.2		19	6.2		19	4.0
	20	4.8		20	7.9		20	5.4
	21	6.3		21	10.0		21	7.2
	22	6.1		22	9.9		22	6.6
	23	6.0		23	9.7		23	6.6
	24	3.9		24	4.1		24	2.6
	25	4.1		25	4.8		25	1.8
	26	4.2		26	5.5		26	1.7
	27	-0.3		27	4.8		27	0.4
	28	0.4		28	2.5		28	1.2
	29	1.6		29	2.5		29	2.4
	30	2.1		30	3.1		30	2.6
	31	1.3		31	5.1		31	2.4
	32	0.9		32	1.7		32	-0.6
	33	1.7		33	1.7		33	-0.8
	34	1.7		34	2.0		34	-0.4
	35	1.1		35	3.1		35	-0.5
	36	1.2		36	2.3		36	-1.0
	37	0.2		37	2.7		37	1.0
	38	1.2		38	2.6		38	1.4
	39	1.6		39	2.5		39	3.4
	40	1.5		40	3.9		40	2.1
	41	1.2		41	1.7		41	-1.1
	42	1.6		42	1.9		42	-0.5
	43	1.6		43	2.7		43	-0.4
	44	0.9		44	2.6		44	-0.9
	128	7.6		128	4.7		128	9.8
	129	8.9		129	11.9		129	9.1
	130	7.7		130	6.4		130	6.6

n258			n260			n261		
Paired ID (Beam Pair)	Beam ID	Input Power Limit (dBm)	Paired ID (Beam Pair)	Beam ID	Input Power Limit (dBm)	Paired ID (Beam Pair)	Beam ID	Input Power Limit (dBm)
N/A	131	9.6	N/A	131	5.9	N/A	131	9.5
	132	10.0		132	10.9		132	10.3
	133	8.9		133	6.2		133	7.9
	134	6.9		134	4.0		134	5.9
	135	5.1		135	4.7		135	6.6
	136	5.0		136	3.1		136	4.3
	137	6.1		137	4.4		137	6.6
	138	7.1		138	8.2		138	6.8
	139	7.2		139	8.1		139	7.5
	140	6.9		140	8.6		140	7.5
	141	6.6		141	9.0		141	6.7
	142	5.0		142	4.2		142	4.1
	143	5.3		143	4.2		143	4.5
	144	5.7		144	4.1		144	4.4
	145	5.0		145	4.3		145	4.1
	146	5.1		146	4.3		146	9.0
	147	5.2		147	3.0		147	5.6
	148	5.6		148	2.3		148	5.1
	149	7.2		149	8.1		149	7.1
	150	7.0		150	8.3		150	7.5
	151	6.7		151	9.0		151	7.0
	152	5.2		152	4.6		152	4.0
	153	5.4		153	4.2		153	4.4
	154	5.0		154	4.1		154	4.2
	155	2.7		155	-0.1		155	6.3
	156	2.1		156	3.7		156	2.9
	157	2.1		157	-1.4		157	2.1
	158	1.7		158	-1.7		158	1.8
	159	2.4		159	0.3		159	2.4
	160	1.7		160	2.5		160	1.0
	161	2.8		161	1.8		161	1.6
	162	3.1		162	1.5		162	2.1
	163	3.0		163	1.9		163	1.8
	164	1.9		164	1.9		164	1.2
	165	2.1		165	1.7		165	4.2
	166	2.2		166	0.7		166	2.4
	167	1.8		167	-1.5		167	1.9
	168	1.8		168	-0.9		168	1.8
	169	2.1		169	2.5		169	1.1
	170	3.1		170	1.4		170	1.9
	171	3.1		171	1.6		171	2.2
	172	2.3		172	1.8		172	1.3
128	0	2.7	128	0	1.2	128	0	5.6
129	1	5.1	129	1	8.4	129	1	5.3
130	2	4.2	130	2	3.6	130	2	1.1
131	3	3.9	131	3	2.2	131	3	4.9
132	4	6.1	132	4	7.1	132	4	6.4
133	5	4.2	133	5	3.4	133	5	1.6
134	6	1.9	134	6	0.4	134	6	1.1
135	7	-0.2	135	7	-0.6	135	7	2.1
136	8	1.0	136	8	-1.1	136	8	0.2
137	9	1.9	137	9	0.5	137	9	1.6
138	10	2.8	138	10	4.5	138	10	3.2
139	11	3.1	139	11	4.7	139	11	3.1

n258			n260			n261		
Paired ID (Beam Pair)	Beam ID	Input Power Limit (dBm)	Paired ID (Beam Pair)	Beam ID	Input Power Limit (dBm)	Paired ID (Beam Pair)	Beam ID	Input Power Limit (dBm)
140	12	2.6	140	12	5.2	140	12	3.5
141	13	2.6	141	13	5.2	141	13	2.9
142	14	1.6	142	14	0.4	142	14	-1.2
143	15	1.2	143	15	0.9	143	15	-1.4
144	16	1.0	144	16	1.1	144	16	-0.7
145	17	0.8	145	17	1.4	145	17	-1.1
146	18	-0.5	146	18	-0.4	146	18	2.2
147	19	0.5	147	19	-0.7	147	19	0.7
148	20	1.2	148	20	-0.5	148	20	1.3
149	21	2.9	149	21	4.6	149	21	2.9
150	22	3.0	150	22	5.0	150	22	3.1
151	23	2.5	151	23	5.2	151	23	2.9
152	24	1.1	152	24	1.4	152	24	-1.4
153	25	1.4	153	25	0.9	153	25	-1.0
154	26	0.8	154	26	2.2	154	26	-1.6
155	27	-3.0	155	27	-3.3	155	27	-1.2
156	28	-2.8	156	28	-2.7	156	28	-2.1
157	29	-2.2	157	29	-4.8	157	29	-1.7
158	30	-2.5	158	30	-4.4	158	30	-2.0
159	31	-2.3	159	31	-2.4	159	31	-1.6
160	32	-2.5	160	32	-1.1	160	32	-4.5
161	33	-1.7	161	33	-2.1	161	33	-4.4
162	34	-1.6	162	34	-2.0	162	34	-3.9
163	35	-1.8	163	35	-1.0	163	35	-4.3
164	36	-2.3	164	36	-1.4	164	36	-4.8
165	37	-2.9	165	37	-3.5	165	37	-1.6
166	38	-2.4	166	38	-3.9	166	38	-2.0
167	39	-2.5	167	39	-4.5	167	39	-1.7
168	40	-2.6	168	40	-3.7	168	40	-2.2
169	41	-2.3	169	41	-1.6	169	41	-4.8
170	42	-1.7	170	42	-2.1	170	42	-4.2
171	43	-1.5	171	43	-1.2	171	43	-4.0
172	44	-2.3	172	44	-1.2	172	44	-4.7

A Worst Phase Derivation for Beam Pair

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

Assuming E-field and H-field of $beam_a$ are {$Ex_{\_a}$, $Ey_{\_a}$, $Ez_{\_a}$} and {$Hx_{\_a}$, $Hy_{\_a}$, $Hz_{\_a}$}, respectively; E-field and H-field of $beam_b$ are {$Ex_{\_b}$, $Ey_{\_b}$, $Ez_{\_b}$} and {$Hx_{\_b}$, $Hy_{\_b}$, $Hz_{\_b}$}, respectively; and the relative phase is ∅, for beam pair consisting of $beam_a$ and $beam_b$, the combined E- and H-fields, {$Ex_{\_pair\_i}$, $Ey_{\_pair\_i}$, $Ez_{\_pair\_i}$} and {$Hx_{\_pair\_i}$, $Hy_{\_pair\_i}$, $Hz_{\_pair\_i}$}, can be expressed as:

$$Ex(\emptyset)_{\_pair\_i} = E_{x\_a} + E_{x\_b} \times e^{-j\omega\emptyset}$$
$$Ey(\emptyset)_{\_pair\_i} = E_{y\_a} + E_{y\_b} \times e^{-j\omega\emptyset}$$
$$Ez(\emptyset)_{\_pair\_i} = E_{z\_a} + E_{z\_b} \times e^{-j\omega\emptyset}$$

$$Hx(\emptyset)_{\_pair\_i} = H_{x\_a} + H_{x\_b} \times e^{-j\omega\emptyset}$$
$$Hy(\emptyset)_{\_pair\_i} = H_{y\_a} + H_{y\_b} \times e^{-j\omega\emptyset}$$
$$Hz(\emptyset)_{\_pair\_i} = H_{z\_a} + H_{z\_b} \times e^{-j\omega\emptyset}$$

The combined PD can then be calculated:

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

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

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

B Simulated Input Power Limit

Table B-1 lists input power limit per channel per band for all the beams that EUT supports.

Table B-1: Simulated *input.power.limit* for bands n258, n260, and n261

n258				
Paired ID (Beam Pair)	Beam ID	Low	Mid	High
N/A	0	5.11	5.77	5.24
	1	1.91	3.37	3.47
	2	3.70	3.20	4.29
	3	4.88	3.89	3.17
	4	1.94	3.52	2.45
	5	5.96	3.36	4.66
	6	9.62	8.70	7.52
	7	12.18	10.91	9.81
	8	7.07	4.14	3.23
	9	6.95	6.11	5.42
	10	3.62	6.33	5.97
	11	2.51	6.32	6.09
	12	2.89	6.74	5.84
	13	4.87	6.73	5.14
	14	5.38	8.03	8.74
	15	6.77	8.61	9.07
	16	8.65	9.91	9.74
	17	7.85	6.83	9.99
	18	12.94	10.04	6.79
	19	9.17	7.38	6.42
	20	7.92	7.33	6.44
	21	3.10	6.28	6.07
	22	2.42	6.58	6.03
	23	3.35	6.80	5.66
	24	9.92	6.80	10.89
	25	9.75	9.01	10.40
	26	7.85	6.83	9.99
	27	25.86	23.13	21.16
	28	21.67	17.19	14.88
	29	16.51	12.97	10.68
	30	14.57	11.93	12.37
	31	16.51	17.84	17.34
	32	15.49	16.81	21.41
	33	17.04	15.24	18.07
	34	16.85	14.78	17.83
	35	17.23	18.78	20.42
	36	14.90	18.00	19.85
	37	22.86	19.20	17.34
	38	18.29	13.64	11.13
	128	16.40	14.04	12.82
	129	16.31	16.25	17.00
	130	17.56	17.13	19.91
	131	16.93	14.78	18.11
	132	16.66	16.51	18.19
	133	16.80	19.78	21.45
	134	6.31	5.13	5.03
	135	1.54	3.95	3.04
	136	2.41	3.03	5.71
	137	4.02	3.83	3.50
	138	3.11	2.60	2.41
	139	2.12	3.14	4.31
	140	7.39	6.41	5.59
	141	11.32	11.18	11.15
	142	11.44	10.94	8.97
	143	8.96	8.38	7.64
	144	3.64	6.01	5.84
	145	3.52	5.92	5.08
	146	5.61	6.23	4.51
	147	4.88	6.70	5.88
	148	6.00	5.89	10.59
	149	4.99	6.87	9.88
	150	5.61	6.63	9.05

n260				
Paired ID (Beam Pair)	Beam ID	Low	Mid	High
N/A	0	3.26	3.02	2.57
	1	0.99	0.98	0.60
	2	2.59	2.90	2.47
	3	2.78	2.87	2.23
	4	1.63	1.28	1.10
	5	2.28	2.96	3.40
	6	3.81	3.60	2.69
	7	7.57	7.04	6.37
	8	7.13	6.78	5.26
	9	3.70	3.39	2.95
	10	2.50	2.18	1.35
	11	2.43	2.08	1.94
	12	2.41	2.18	2.10
	13	2.55	2.33	1.49
	14	4.62	6.21	7.00
	15	4.77	5.45	6.07
	16	4.78	4.65	3.95
	17	3.97	4.56	5.52
	18	6.43	5.90	5.48
	19	5.73	5.64	4.68
	20	3.90	3.56	2.97
	21	2.41	2.08	2.08
	22	2.43	2.21	2.05
	23	2.55	2.32	1.41
	24	4.93	5.99	6.66
	25	5.57	5.55	5.37
	26	4.75	4.64	4.58
	27	7.95	7.89	6.33
	28	13.48	11.90	11.24
	29	13.56	12.95	10.84
	30	11.57	10.46	8.22
	31	6.96	7.39	5.89
	32	8.06	8.77	11.40
	33	9.75	10.36	11.56
	34	9.95	10.67	9.46
	35	7.78	8.38	8.39
	36	7.07	9.29	10.07
	37	12.97	11.37	9.98
	38	13.23	12.41	11.04
	128	13.37	11.68	9.46
	129	9.67	9.41	7.27
	130	9.33	9.67	11.57
	131	10.05	10.99	10.91
	132	8.29	9.10	8.08
	133	7.27	8.95	9.30
	134	3.29	2.59	2.48
	135	1.04	1.03	0.89
	136	2.80	3.54	2.88
	137	2.51	2.10	2.09
	138	1.31	1.11	0.60
	139	3.69	3.60	2.16
	140	3.91	3.47	3.27
	141	3.33	2.62	2.46
	142	4.73	3.52	3.03
	143	3.54	2.93	3.02
	144	2.47	2.14	1.42
	145	2.49	2.18	1.70
	146	2.24	2.08	1.66
	147	2.06	1.95	1.22
	148	5.50	5.89	3.98
	149	5.19	5.93	4.99
	150	5.99	4.80	5.78

n261				
Paired ID (Beam Pair)	Beam ID	Low	Mid	High
N/A	0	3.41	2.93	2.74
	1	3.10	3.66	2.88
	2	5.67	5.28	3.04
	3	3.10	2.48	2.14
	4	2.22	2.67	2.13
	5	3.58	4.57	3.96
	6	9.49	8.65	6.92
	7	7.50	7.06	6.00
	8	9.19	7.67	6.16
	9	6.93	5.96	5.29
	10	5.24	5.55	5.18
	11	4.54	6.48	4.71
	12	4.84	6.88	4.53
	13	5.32	6.73	4.59
	14	8.56	8.76	7.73
	15	9.71	9.69	6.90
	16	7.37	7.69	5.98
	17	6.57	8.01	6.47
	18	9.55	6.98	7.11
	19	10.19	8.34	6.44
	20	7.50	6.61	5.76
	21	4.90	5.83	5.16
	22	4.59	6.60	4.63
	23	5.41	6.60	4.62
	24	6.81	8.32	6.17
	25	9.36	9.83	6.09
	26	8.66	10.11	6.28
	27	23.77	21.23	18.13
	28	19.58	17.25	15.35
	29	14.94	12.71	9.45
	30	14.03	10.07	9.62
	31	14.88	14.11	8.94
	32	17.10	16.65	13.95
	33	17.58	18.05	11.48
	34	14.44	16.31	10.36
	35	15.80	16.74	10.72
	36	17.17	18.89	12.95
	37	20.65	18.33	16.82
	38	18.69	16.51	12.50
	128	11.89	8.77	8.80
	129	15.77	13.88	9.79
	130	19.53	19.39	14.16
	131	15.40	16.69	10.30
	132	14.56	16.38	10.48
	133	17.39	18.35	11.57
	134	3.81	3.50	3.17
	135	2.75	3.64	2.76
	136	4.31	5.75	2.98
	137	4.05	3.61	3.16
	138	2.76	2.62	2.33
	139	3.80	4.25	3.23
	140	9.29	8.42	6.51
	141	7.94	6.67	6.04
	142	13.42	12.84	11.35
	143	7.93	7.75	7.18
	144	5.26	6.15	4.48
	145	5.11	5.27	4.57
	146	5.03	5.24	4.84
	147	5.48	6.32	5.17
	148	8.39	10.18	7.56
	149	7.68	9.24	5.93
	150	7.82	9.66	6.26

n258					n260					n261				
Paired ID (Beam Pair)	Beam ID	Low	Mid	High	Paired ID (Beam Pair)	Beam ID	Low	Mid	High	Paired ID (Beam Pair)	Beam ID	Low	Mid	High
N/A	151	5 52	5 34	10.73	N/A	151	5.79	4 53	5.02	N/A	151	7.41	10.35	8.57
	152	11.18	10 02	9.17		152	3.61	2 83	2.70		152	4.54	4.04	3.19
	153	11 00	10 24	8 60		153	4.84	3.71	3.52		153	10.02	9.97	9.03
	154	9 51	10 00	8 26		154	5.77	4.79	4.47		154	11.09	8.44	8.55
	155	3 54	5 93	5 68		155	2.51	2.18	1.60		155	5.13	5.76	4.44
	156	5 05	6.11	4 02		156	2.39	2.13	1.77		156	5.04	5.20	4.76
	157	5.14	6 62	5 54		157	2.05	1 98	1.31		157	5.24	5.86	5.20
	158	5.17	6 90	10 06		158	5.42	4.72	4.52		158	6.97	10.37	7.28
	159	4 97	5 58	9.70		159	5.92	5 28	5.56		159	8.29	9.46	8.26
	160	5.43	5 30	10 59		160	5.46	6 09	4.40		160	8.03	10.11	6.30
	161	19 59	14 69	15 56		161	10.07	8 68	8.13		161	7.77	8.38	5.77
	162	22 62	21 01	20.41		162	4.17	3 54	2.93		162	18.38	16.90	13.28
	163	22 67	22 68	20.74		163	13.42	10.62	9.17		163	22.06	21.07	19.47
	164	24.41	24 08	22.15		164	14.39	11.09	8.96		164	23.81	22.97	21.13
	165	20 86	16 86	11 92		165	9.10	7.5	7.43		165	20.51	18.64	16.91
	166	12 31	13 98	22 63		166	8.64	8.63	7.84		166	16.42	21.12	13.96

n258					n260					n260				
Paired ID (Beam Pair)	Beam ID	Worst Case Sim Beam Pair MPE			Paired ID (Beam Pair)	Beam ID	Worst Case Sim Beam Pair MPE			Paired ID (Beam Pair)	Beam ID	Worst Case Sim Beam Pair MPE		
		Low	Mid	High			Low	Mid	High			Low	Mid	High
128	0	12 86	11 59	12 28	128	0	7.36	5 98	5.36	128	0	7.16	6.33	6.16
129	1	4.15	8 38	7.64	129	1	2.18	2 32	1.78	129	1	6.79	8.74	6 39
130	2	8.72	7 21	10.14	130	2	6.40	6 81	6.39	130	2	11.81	11.68	8.43
131	3	9 83	7 64	6.38	131	3	5.95	5 62	4.78	131	3	8.32	6.66	5 31
132	4	6 33	6 55	6.20	132	4	3.15	2.44	2.03	132	4	5.55	6.73	4 85
133	5	9.79	8 54	10.13	133	5	7.16	7 03	5.82	133	5	8.74	10.41	7.71
134	6	15.46	14 25	13.18	134	6	8.85	8 21	6.90	134	6	19.80	17.26	14.17
135	7	24 92	23.74	21 92	135	7	11.15	10.38	9.16	135	7	15.94	14.53	13.12
136	8	18.77	15 93	12.79	136	8	12.58	10.71	8.90	136	8	24.40	21.19	18.19
137	9	15 34	14 51	13 24	137	9	8.64	6 57	6.63	137	9	17.67	16.69	13.69
138	10	8 53	13 29	13 96	138	10	5.69	5 05	2.80	138	10	12.12	14.03	11.50
139	11	7.48	13 22	13 08	139	11	5.52	4 80	4.08	139	11	11.15	14.46	10.91
140	12	9.16	14 64	12.18	140	12	4.93	4 56	4.61	140	12	11.82	12.97	10.16
141	13	10.44	14 65	13 05	141	13	4.85	4 61	3.58	141	13	12.03	15.19	10.71
142	14	10 67	13 56	18.45	142	14	12.18	14.08	12.19	142	14	16.34	19.92	16.38
143	15	15.19	18 87	19 88	143	15	11.86	12.53	12 07	143	15	20.65	20.62	14.52
144	16	17.13	20 95	19 36	144	16	12.06	10.95	11 50	144	16	15.31	17.52	11.84
145	17	17 34	13 31	22.14	145	17	11.13	10.26	10 68	145	17	16.70	19.39	15.17
146	18	26.78	21 31	16 85	146	18	10.67	9.11	8.52	146	18	15.72	11.55	10.45
147	19	21 36	18 67	16 01	147	19	11.44	10.33	9.07	147	19	21.13	22.05	16.62
148	20	18 03	17 80	14 63	148	20	10.91	8.76	8.52	148	20	18.99	16.18	15.01
149	21	7 87	13 29	13 87	149	21	5.56	4.79	4.23	149	21	11.80	14.93	11.81
150	22	8 52	13 56	10.75	150	22	5.17	4 55	4.77	150	22	11.54	14.33	10.77
151	23	8 85	15 06	13 22	151	23	4.87	4 61	3.67	151	23	12.28	14.90	10.92
152	24	14 63	13 65	20 66	152	24	10.87	10.31	11.18	152	24	17.44	20.99	13.80
153	25	14 23	14.16	19 07	153	25	12.56	11.47	10 80	153	25	15.67	18.83	13.45
154	26	17 57	13 28	22 23	154	26	8.35	9.41	8.87	154	26	20.44	21.86	13.78
155	27	47 97	40.74	41 57	155	27	21.06	18.02	15 83	155	27	34.01	31.72	25.85
156	28	45.11	40.43	39.18	156	28	18.09	16.09	14 55	156	28	42.13	38.07	30.88
157	29	39 95	39.42	34.48	157	29	29.50	26.80	21 94	157	29	37.79	36.70	29.78
158	30	42.40	38.44	39 51	158	30	26.60	22.82	17.19	158	30	41.19	37.98	32.86
159	31	40 53	38.46	32 66	159	31	16.83	15.93	14 69	159	31	37.72	37.15	27.49
160	32	31 98	39.18	47 00	160	32	19.21	18.54	19 96	160	32	41.37	42.19	28.82
161	33	36.77	35.40	39.18	161	33	25.11	24.16	23.78	161	33	40.20	41.90	25.45
162	34	34.72	31 21	38 08	162	34	24.48	22.79	21 30	162	34	35.47	37.33	23.80
163	35	36 51	36 21	39 99	163	35	18.72	19.47	18 07	163	35	39.00	40.72	25.16
164	36	32.11	39 34	45.17	164	36	18.11	21.33	20 80	164	36	40.90	45.00	28.68
165	36	46 55	41 24	41 84	165	36	21.79	18.85	17 07	165	36	37.66	35.30	28.12
166	36	41 55	36 96	32 85	166	36	24.08	21.25	19 22	166	36	41.08	39.20	31.35
167	39	42 27	41 56	39 92	167	39	27.67	24.75	20.12	167	39	38.50	35.22	31.71
168	40	43.70	41 94	38 30	168	40	22.65	18.79	16.77	168	40	42.23	42.55	32.26
169	41	37 29	40 56	44 81	169	41	22.22	20.52	22 00	169	41	44.54	45.93	29.16
170	42	35 66	32.75	38 94	170	42	24.74	25.21	24.45	170	42	37.31	39.32	23.62
171	43	35 08	33 06	37 08	171	43	19.39	20.47	18.49	171	43	35.20	37.66	23.88
172	44	36.15	40 32	45 05	172	44	17.98	19.61	20 50	172	44	42.85	44.89	27.41