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

For
SMARTPHONE

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Model Name: A2649

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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: 14040867-S1V1.

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.

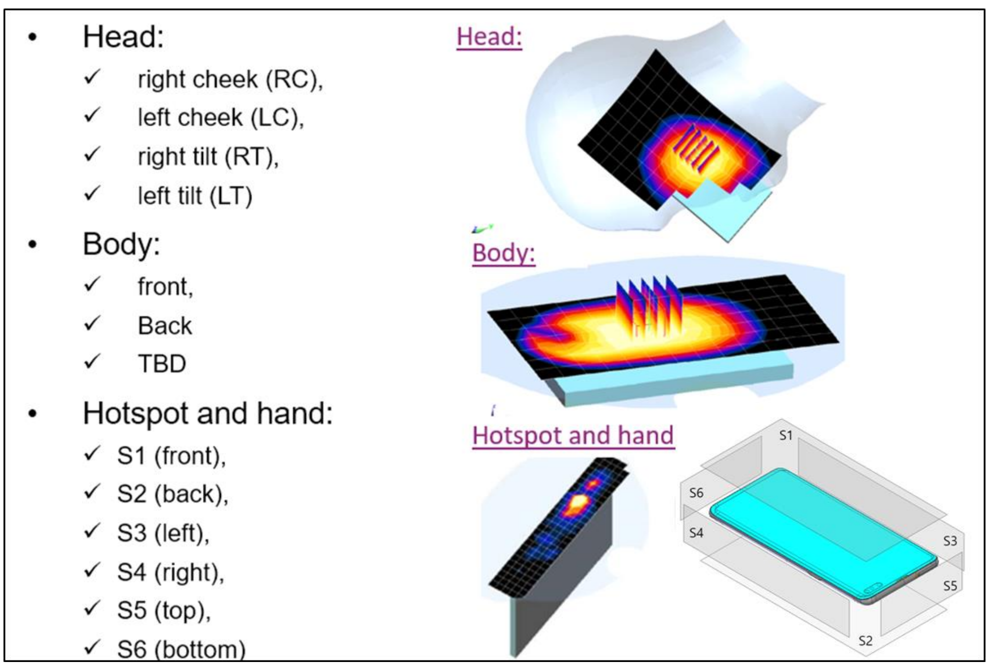

Figure 2-1: SAR evaluation for smartphone application

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)

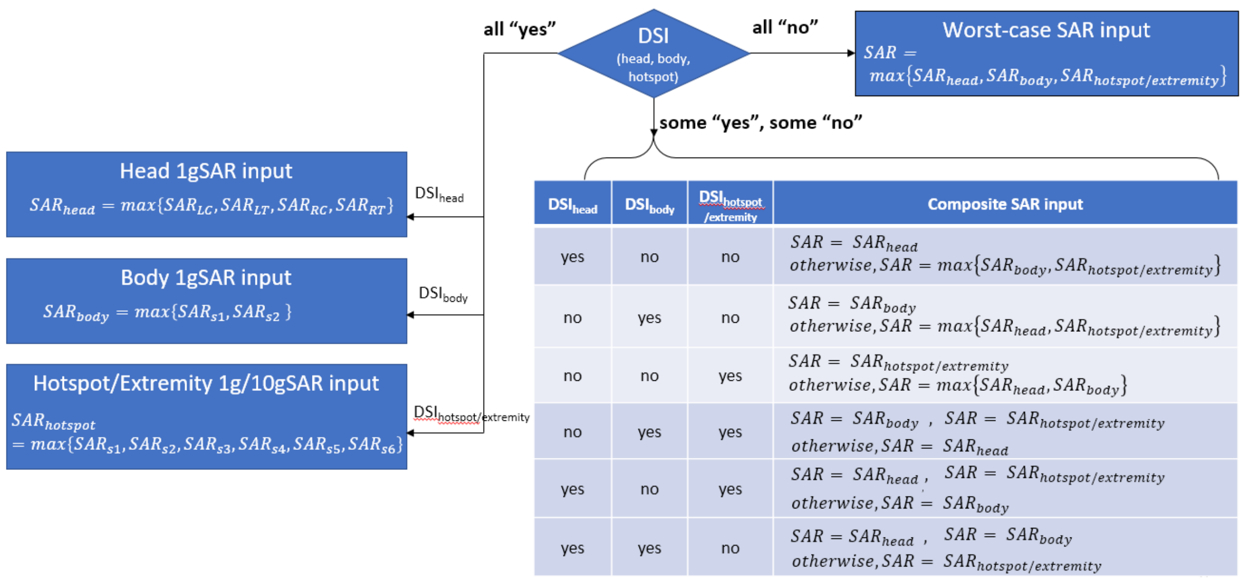

Figure 2-2: Worst-case SAR determination based on DSI

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) + Uncertainty (dBm)		
	Head	Body & Hotspot	Hotspot	Head	Body & Hotspot	Hotspot	Head	Body & Hotspot	Hotspot
	DSI: 0	DSI: 1	DSI: 1	DSI: 0	DSI: 1	DSI: 1	DSI: 0	DSI: 1	DSI: 1
GSM 850 2 slots	ANT 2	ANT 1	ANT 1	0.757	0.942	0.942	29.10	32.00	32.00
GSM 1900 2 slots	ANT 4	ANT 2	ANT 2	0.891	0.935	0.935	24.20	28.20	28.20
W-CDMA B2	ANT 2	ANT 2	ANT 1	0.898	0.895	0.939	20.70	22.20	17.70
W-CDMA B4	ANT 4	ANT 3	ANT 4	0.931	0.770	0.928	20.00	21.00	21.10
W-CDMA B5	ANT 2	ANT 1	ANT 1	0.939	0.679	0.767	23.10	25.70	25.70
LTE Band 5	ANT 2	ANT 1	ANT 1	0.929	0.770	0.770	23.10	25.70	25.70
LTE Band 7	ANT 4	ANT 1	ANT 1	0.948	0.925	0.929	17.40	20.30	20.30
LTE Band 12/17	ANT 2	ANT 2	ANT 1	0.932	0.681	0.744	23.40	24.70	25.70
LTE Band 13	ANT 2	ANT 1	ANT 1	0.888	0.731	0.862	23.80	25.70	25.70
LTE Band 14	ANT 2	ANT 1	ANT 1	0.937	0.740	0.807	23.80	25.70	25.70
LTE Band 25/2	ANT 2	ANT 2	ANT 2	0.945	0.940	0.940	20.70	22.20	22.20
LTE Band 26	ANT 2	ANT 1	ANT 1	0.752	0.772	0.772	23.10	25.70	25.70
LTE Band 30	ANT 2	ANT 3	ANT 1	0.908	0.823	0.948	19.00	20.50	21.80
LTE Band 41	ANT 2	ANT 1	ANT 4	0.782	0.758	0.938	18.70	22.30	21.00
LTE Band 41 (PC2)	ANT 1	N/A	N/A	0.490	N/A	N/A	28.70	N/A	N/A
LTE Band 48	ANT 8	ANT 8	ANT 8	0.949	0.937	0.937	25.00	19.30	19.30
LTE Band 53	ANT 2	ANT 1	ANT 1	0.944	0.914	0.914	17.60	20.70	20.70
LTE Band 66/4	ANT 4	ANT 3	ANT 2	0.926	0.713	0.944	20.00	21.00	20.70
LTE Band 71	ANT 2	ANT 1	ANT 1	0.828	0.634	0.666	24.70	25.70	25.70
NR n5	ANT 2	ANT 1	ANT 1	0.537	0.515	0.567	23.10	25.70	25.70
NR n7	ANT 2	ANT 1	ANT 4	0.822	0.828	0.920	16.90	20.30	19.50
NR n12	ANT 2	ANT 2	ANT 1	0.895	0.652	0.719	23.40	24.70	25.70
NR n14	ANT 2	ANT 1	ANT 1	0.865	0.741	0.770	23.80	25.70	25.70
NR n25/2	ANT 4	ANT 2	ANT 2	0.939	0.878	0.878	18.20	22.20	22.20
NR n26	ANT 2	ANT 1	ANT 1	0.905	0.802	0.802	23.10	25.70	25.70
NR n30	ANT 2	ANT 3	ANT 1	0.895	0.850	0.928	19.00	20.50	21.80
NR n41	ANT 2	ANT 1	ANT 1	0.780	0.831	0.881	16.70	20.30	20.30
NR n53	ANT 2	ANT 2	ANT 2	0.903	0.794	0.937	15.60	17.50	17.50
NR n66	ANT 4	ANT 2	ANT 4	0.839	0.796	0.913	20.00	20.70	21.10
NR n70	ANT 2	ANT 2	ANT 4	0.840	0.739	0.928	20.50	20.70	21.10
NR n71	ANT 2	ANT 2	ANT 1	0.893	0.548	0.630	24.70	24.70	25.70
NR n77	ANT 4	ANT 8	ANT 8	0.911	0.890	0.890	19.70	17.10	17.10

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.

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

The SAR Char is listed in Table 2-3.

Table 2-3: SAR Characterization

Exposure Scenario		Duty Cycle	Head				Body & Hotspot				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_{design} (dBm)	P_{limit} + Tolerance (dBm)	P_{design} (dBm)	P_{limit} + Tolerance (dBm)	P_{design} (dBm)	P_{limit} + Tolerance (dBm)	P_{design} (dBm)	P_{limit} + Tolerance (dBm)	P_{design} (dBm)	P_{limit} + Tolerance (dBm)	P_{design} (dBm)	P_{limit} + Tolerance (dBm)		
			Burst Average		Frame Average		Burst Average		Frame Average		Burst Average		Frame Average		Burst Average	Frame Average
ANT 1	GSM 850 2 slots	25.0%	37.59	32.50	31.57	26.48	32.26	32.00	26.24	25.98	32.26	32.00	26.24	25.98	32.50	26.48
	GSM 1900 2 slots	25.0%	39.06	31.00	33.04	24.98	26.55	23.70	20.52	17.68	24.30	23.70	18.28	17.68	31.00	24.98
	W-CDMA B2	100.0%	32.59	25.30	32.59	25.30	20.11	17.70	20.11	17.70	17.98	17.70	17.98	17.70	25.70	25.70
	W-CDMA B4	100.0%	27.50	23.70	27.50	23.70	20.45	17.40	20.45	17.40	17.78	17.40	17.78	17.40	25.70	25.70
	W-CDMA B5	100.0%	30.96	25.70	30.96	25.70	27.38	25.70	27.38	25.70	26.85	25.70	26.85	25.70	25.70	25.70
	LTE Band 5	100.0%	31.02	25.70	31.02	25.70	26.84	25.70	26.84	25.70	26.84	25.70	26.84	25.70	25.70	25.70
	LTE Band 7	100.0%	27.38	25.70	27.38	25.70	20.64	20.30	20.64	20.30	20.62	20.30	20.62	20.30	25.70	25.70
	LTE Band 12/17	100.0%	33.20	25.70	33.20	25.70	27.74	25.70	27.74	25.70	26.98	25.70	26.98	25.70	25.70	25.70
	LTE Band 13	100.0%	31.47	25.70	31.47	25.70	27.06	25.70	27.06	25.70	26.35	25.70	26.35	25.70	25.70	25.70
	LTE Band 14	100.0%	31.77	25.70	31.77	25.70	27.01	25.70	27.01	25.70	26.63	25.70	26.63	25.70	25.70	25.70
	LTE Band 25/2	100.0%	29.84	25.30	29.84	25.30	19.82	17.70	19.82	17.70	18.34	17.70	18.34	17.70	25.70	25.70
	LTE Band 26	100.0%	31.28	25.70	31.28	25.70	26.82	25.70	26.82	25.70	26.82	25.70	26.82	25.70	25.70	25.70
	LTE Band 30	100.0%	27.21	25.70	27.21	25.70	22.91	21.80	22.91	21.80	22.03	21.80	22.03	21.80	25.70	25.70
	LTE Band 41	63.3%	30.07	25.70	28.08	23.71	23.50	22.30	21.52	20.31	22.78	22.30	20.80	20.31	25.70	23.71
	LTE Band 41 (PC2)	43.3%	32.70	28.70	29.07	25.06	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	28.70	25.06
	LTE Band 53	63.3%	28.79	20.70	26.81	18.71	21.09	20.70	19.10	18.71	21.09	20.70	19.10	18.71	20.70	18.71
	LTE Band 66/4	100.0%	28.29	23.70	28.29	23.70	20.14	17.40	20.14	17.40	17.73	17.40	17.73	17.40	25.70	25.70
	LTE Band 71	100.0%	33.40	25.70	33.40	25.70	27.68	25.70	27.68	25.70	27.47	25.70	27.47	25.70	25.70	25.70
	NR n5	100.0%	32.08	25.70	32.08	25.70	28.58	25.70	28.58	25.70	28.17	25.70	28.17	25.70	25.70	25.70
	NR n7	100.0%	27.29	25.70	27.29	25.70	21.12	20.30	21.12	20.30	20.92	20.30	20.92	20.30	25.70	25.70
	NR n12	100.0%	31.98	25.70	31.98	25.70	28.04	25.70	28.04	25.70	27.13	25.70	27.13	25.70	25.70	25.70
	NR n14	100.0%	31.20	25.70	31.20	25.70	27.00	25.70	27.00	25.70	26.83	25.70	26.83	25.70	25.70	25.70
	NR n25/2	100.0%	31.26	25.30	31.26	25.30	21.25	17.70	21.25	17.70	18.33	17.70	18.33	17.70	25.70	25.70
	NR n26	100.0%	32.10	25.70	32.10	25.70	26.66	25.70	26.66	25.70	26.66	25.70	26.66	25.70	25.70	25.70
	NR n30	100.0%	28.63	25.70	28.63	25.70	22.51	21.80	22.51	21.80	22.12	21.80	22.12	21.80	25.70	25.70
	NR n41	100.0%	31.48	25.70	31.48	25.70	21.10	20.30	21.10	20.30	20.85	20.30	20.85	20.30	25.70	25.70
	NR n53	100.0%	27.40	20.70	27.40	20.70	21.68	18.90	21.68	18.90	21.24	18.90	21.24	18.90	20.70	20.70
	NR n66	100.0%	28.17	23.70	28.17	23.70	20.83	17.40	20.83	17.40	18.92	17.40	18.92	17.40	25.70	25.70
	NR n70	100.0%	30.58	23.70	30.58	23.70	19.77	17.40	19.77	17.40	17.79	17.40	17.79	17.40	25.70	25.70
	NR n71	100.0%	32.75	25.70	32.75	25.70	28.44	25.70	28.44	25.70	27.71	25.70	27.71	25.70	25.70	25.70
ANT 2	GSM 850 2 slots	25.0%	30.31	29.10	24.29	23.08	32.79	31.50	26.77	25.48	32.79	31.50	26.77	25.48	31.50	25.48
	GSM 1900 2 slots	25.0%	27.58	26.70	21.56	20.68	28.49	28.20	22.47	22.18	28.49	28.20	22.47	22.18	28.50	22.48
	W-CDMA B2	100.0%	21.17	20.70	21.17	20.70	22.68	22.20	22.68	22.20	22.68	22.20	22.68	22.20	23.40	23.40
	W-CDMA B4	100.0%	20.98	20.50	20.98	20.50	22.23	20.70	22.23	20.70	21.47	20.70	21.47	20.70	23.40	23.40
	W-CDMA B5	100.0%	23.38	23.10	23.38	23.10	26.51	24.70	26.51	24.70	26.51	24.70	26.51	24.70	24.70	24.70
	LTE Band 5	100.0%	23.42	23.10	23.42	23.10	28.04	24.70	28.04	24.70	28.04	24.70	28.04	24.70	24.70	24.70
	LTE Band 7	100.0%	17.15	16.90	17.15	16.90	20.02	18.30	20.02	18.30	19.83	18.30	19.83	18.30	23.20	23.20
	LTE Band 12/17	100.0%	23.71	23.40	23.71	23.40	26.37	24.70	26.37	24.70	26.37	24.70	26.37	24.70	24.70	24.70
	LTE Band 13	100.0%	24.32	23.80	24.32	23.80	27.43	24.70	27.43	24.70	27.43	24.70	27.43	24.70	24.70	24.70
	LTE Band 14	100.0%	24.08	23.80	24.08	23.80	26.08	24.70	26.08	24.70	26.08	24.70	26.08	24.70	24.70	24.70
	LTE Band 25/2	100.0%	20.95	20.70	20.95	20.70	22.47	22.20	22.47	22.20	22.47	22.20	22.47	22.20	23.40	23.40
	LTE Band 26	100.0%	24.34	23.10	24.34	23.10	26.97	24.70	26.97	24.70	26.97	24.70	26.97	24.70	24.70	24.70
	LTE Band 30	100.0%	19.42	19.00	19.42	19.00	21.37	20.50	21.37	20.50	21.37	20.50	21.37	20.50	23.20	23.20
	LTE Band 41	63.3%	19.77	18.70	17.78	16.71	22.00	19.80	20.01	17.81	21.14	19.80	19.16	17.81	25.70	23.71
	LTE Band 53	63.3%	17.85	17.60	15.86	15.61	20.16	19.50	18.17	17.51	19.89	19.50	17.90	17.51	20.70	18.71
	LTE Band 66/4	100.0%	21.21	20.50	21.21	20.50	22.20	20.70	22.20	20.70	20.95	20.70	20.95	20.70	25.70	25.70
	LTE Band 71	100.0%	25.52	24.70	25.52	24.70	27.78	24.70	27.78	24.70	27.78	24.70	27.78	24.70	24.70	24.70
	NR n5	100.0%	25.80	23.10	25.80	23.10	28.40	24.70	28.40	24.70	28.40	24.70	28.40	24.70	24.70	24.70
	NR n7	100.0%	17.75	16.90	17.75	16.90	20.54	18.30	20.54	18.30	19.94	18.30	19.94	18.30	23.20	23.20
	NR n12	100.0%	23.88	23.40	23.88	23.40	26.56	24.70	26.56	24.70	26.56	24.70	26.56	24.70	24.70	24.70
	NR n14	100.0%	24.43	23.80	24.43	23.80	26.23	24.70	26.23	24.70	26.23	24.70	26.23	24.70	24.70	24.70
	NR n25/2	100.0%	22.12	20.70	22.12	20.70	22.76	22.20	22.76	22.20	22.76	22.20	22.76	22.20	23.40	23.40
	NR n26	100.0%	23.54	23.10	23.54	23.10	28.21	24.70	28.21	24.70	28.21	24.70	28.21	24.70	24.70	24.70
	NR n30	100.0%	19.48	19.00	19.48	19.00	21.94	20.50	21.94	20.50	21.94	20.50	21.94	20.50	23.20	23.20
	NR n41	100.0%	17.78	16.70	17.78	16.70	20.42	17.80	20.42	17.80	19.32	17.80	19.32	17.80	25.70	25.70
	NR n53	100.0%	16.04	15.60	16.04	15.60	18.50	17.50	18.50	17.50	17.78	17.50	17.78	17.50	20.70	20.70
	NR n66	100.0%	21.27	20.50	21.27	20.50	21.69	20.70	21.69	20.70	21.58	20.70	21.58	20.70	25.70	25.70
	NR n70	100.0%	21.26	20.50	21.26	20.50	22.01	20.70	22.01	20.70	21.21	20.70	21.21	20.70	25.70	25.70
	NR n71	100.0%	25.19	24.70	25.19	24.70	27.31	24.70	27.31	24.70	27.31	24.70	27.31	24.70	24.70	24.70

Exposure Scenario		Duty Cycle	Head				Body & Hotspot				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_{design} (dBm)	P_{limit} + Tolerance (dBm)	P_{design} (dBm)	P_{limit} + Tolerance (dBm)	P_{design} (dBm)	P_{limit} + Tolerance (dBm)	P_{design} (dBm)	P_{limit} + Tolerance (dBm)	P_{design} (dBm)	P_{limit} + Tolerance (dBm)	P_{design} (dBm)	P_{limit} + Tolerance (dBm)		
			Burst Average		Frame Average		Burst Average		Frame Average		Burst Average		Frame Average		Burst Average	Frame Average
ANT 3	GSM 1900 2 slots	25.0%	32.65	30.40	26.63	24.38	26.29	25.80	20.27	19.78	26.11	25.80	20.09	19.78	30.40	24.38
	W-CDMA B2	100.0%	25.70	25.00	25.70	25.00	21.28	20.20	21.28	20.20	20.89	20.20	20.89	20.20	25.20	25.20
	W-CDMA B4	100.0%	27.44	24.80	27.44	24.80	22.14	21.00	22.14	21.00	22.14	21.00	22.14	21.00	25.20	25.20
	LTE Band 7	100.0%	27.12	23.60	27.12	23.60	21.66	19.40	21.66	19.40	19.72	19.40	19.72	19.40	25.00	25.00
	LTE Band 25/2	100.0%	26.34	25.00	26.34	25.00	21.28	20.20	21.28	20.20	20.55	20.20	20.55	20.20	25.20	25.20
	LTE Band 30	100.0%	27.11	23.10	27.11	23.10	21.35	20.50	21.35	20.50	21.35	20.50	21.35	20.50	23.10	23.10
	LTE Band 41	63.3%	28.47	25.40	26.48	23.41	23.32	20.80	21.33	18.81	21.94	20.80	19.96	18.81	25.70	23.71
	LTE Band 66/4	100.0%	27.26	24.80	27.26	24.80	22.47	21.00	22.47	21.00	21.32	21.00	21.32	21.00	25.20	25.20
	NR n7	100.0%	26.76	23.60	26.76	23.60	22.01	19.40	22.01	19.40	20.36	19.40	20.36	19.40	25.00	25.00
	NR n25/2	100.0%	26.33	25.00	26.33	25.00	21.07	20.20	21.07	20.20	20.88	20.20	20.88	20.20	25.20	25.20
	NR n30	100.0%	27.18	23.10	27.18	23.10	21.20	20.50	21.20	20.50	21.07	20.50	21.07	20.50	23.10	23.10
	NR n41	100.0%	26.58	23.40	26.58	23.40	22.22	18.80	22.22	18.80	20.17	18.80	20.17	18.80	25.70	25.70
	NR n66	100.0%	27.10	24.80	27.10	24.80	22.71	21.00	22.71	21.00	21.68	21.00	21.68	21.00	25.20	25.20
	NR n70	100.0%	28.14	24.80	28.14	24.80	23.52	21.00	23.52	21.00	21.55	21.00	21.55	21.00	25.20	25.20
ANT 4	GSM 1900 2 slots	25.0%	24.70	24.20	18.68	18.18	26.88	25.70	20.86	19.68	26.20	25.70	20.18	19.68	28.00	21.98
	W-CDMA B2	100.0%	19.55	18.20	19.55	18.20	21.54	19.70	21.54	19.70	20.00	19.70	20.00	19.70	22.60	22.60
	W-CDMA B4	100.0%	20.31	20.00	20.31	20.00	23.22	21.10	23.22	21.10	21.43	21.10	21.43	21.10	22.60	22.60
	LTE Band 7	100.0%	17.63	17.40	17.63	17.40	22.84	19.50	22.84	19.50	19.94	19.50	19.94	19.50	23.20	23.20
	LTE Band 25/2	100.0%	18.63	18.20	18.63	18.20	22.28	19.70	22.28	19.70	20.41	19.70	20.41	19.70	22.60	22.60
	LTE Band 30	100.0%	18.49	18.00	18.49	18.00	22.00	18.10	22.00	18.10	18.50	18.10	18.50	18.10	23.20	23.20
	LTE Band 41	63.3%	21.25	19.70	19.26	17.71	23.78	21.00	21.79	19.01	21.28	21.00	19.29	19.01	25.70	23.71
	LTE Band 48	63.3%	20.80	20.50	18.81	18.51	24.66	22.00	22.67	20.01	22.43	22.00	20.44	20.01	25.00	23.01
	LTE Band 66/4	100.0%	20.33	20.00	20.33	20.00	24.46	21.10	24.46	21.10	21.52	21.10	21.52	21.10	24.20	24.20
	NR n7	100.0%	18.74	17.40	18.74	17.40	20.64	19.50	20.64	19.50	19.86	19.50	19.86	19.50	23.20	23.20
	NR n25/2	100.0%	18.47	18.20	18.47	18.20	21.90	19.70	21.90	19.70	20.43	19.70	20.43	19.70	22.60	22.60
	NR n30	100.0%	18.83	18.00	18.83	18.00	21.34	18.10	21.34	18.10	18.71	18.10	18.71	18.10	23.20	23.20
	NR n41	100.0%	19.41	17.70	19.41	17.70	21.99	19.00	21.99	19.00	19.65	19.00	19.65	19.00	25.70	25.70
	NR n66	100.0%	19.26	18.50	19.26	18.50	22.09	20.00	22.09	20.00	20.40	20.00	20.40	20.00	25.00	25.00
	NR n70	100.0%	20.76	20.00	20.76	20.00	24.26	21.10	24.26	21.10	21.42	21.10	21.42	21.10	24.20	24.20
	NR n77	100.0%	20.11	19.70	20.11	19.70	21.79	18.50	21.79	18.50	19.55	18.50	19.55	18.50	25.00	25.00
ANT 7	LTE Band 48	63.3%	31.48	26.00	29.49	24.01	24.48	22.50	22.49	20.51	23.16	22.50	21.18	20.51	26.00	24.01
	NR n77	100.0%	34.41	24.00	34.41	24.00	23.24	19.60	23.24	19.60	22.13	19.60	22.13	19.60	25.70	25.70
ANT 8	LTE Band 48	63.3%	25.23	25.00	23.24	23.01	19.58	19.30	17.60	17.31	19.58	19.30	17.60	17.31	26.00	24.01
	NR n77	100.0%	22.71	21.60	22.71	21.60	17.61	17.10	17.61	17.10	17.61	17.10	17.61	17.10	25.70	25.70
ANT 9	LTE Band 48	63.3%	25.60	21.70	23.61	19.71	21.97	19.70	19.98	17.71	20.04	19.70	18.06	17.71	21.70	19.71
	NR n77	100.0%	28.08	21.90	28.08	21.90	17.92	15.80	17.92	15.80	16.36	15.80	16.36	15.80	25.70	25.70

3. Power Density Characterization

The EUT's 5G mmW NR contains two Qualcomm SDX-65 mmW antenna modules (module 0 and 1), denoted as ANT M2 and ANT M1 (module 0), and ANT M3 (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.

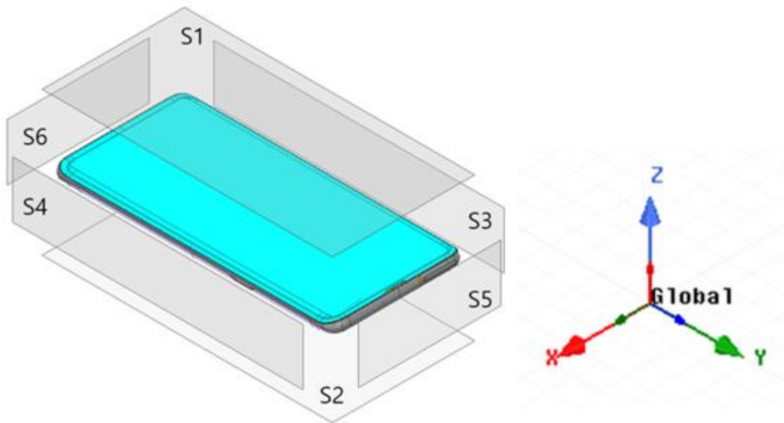

Figure 3-1: EUT surface definition

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.

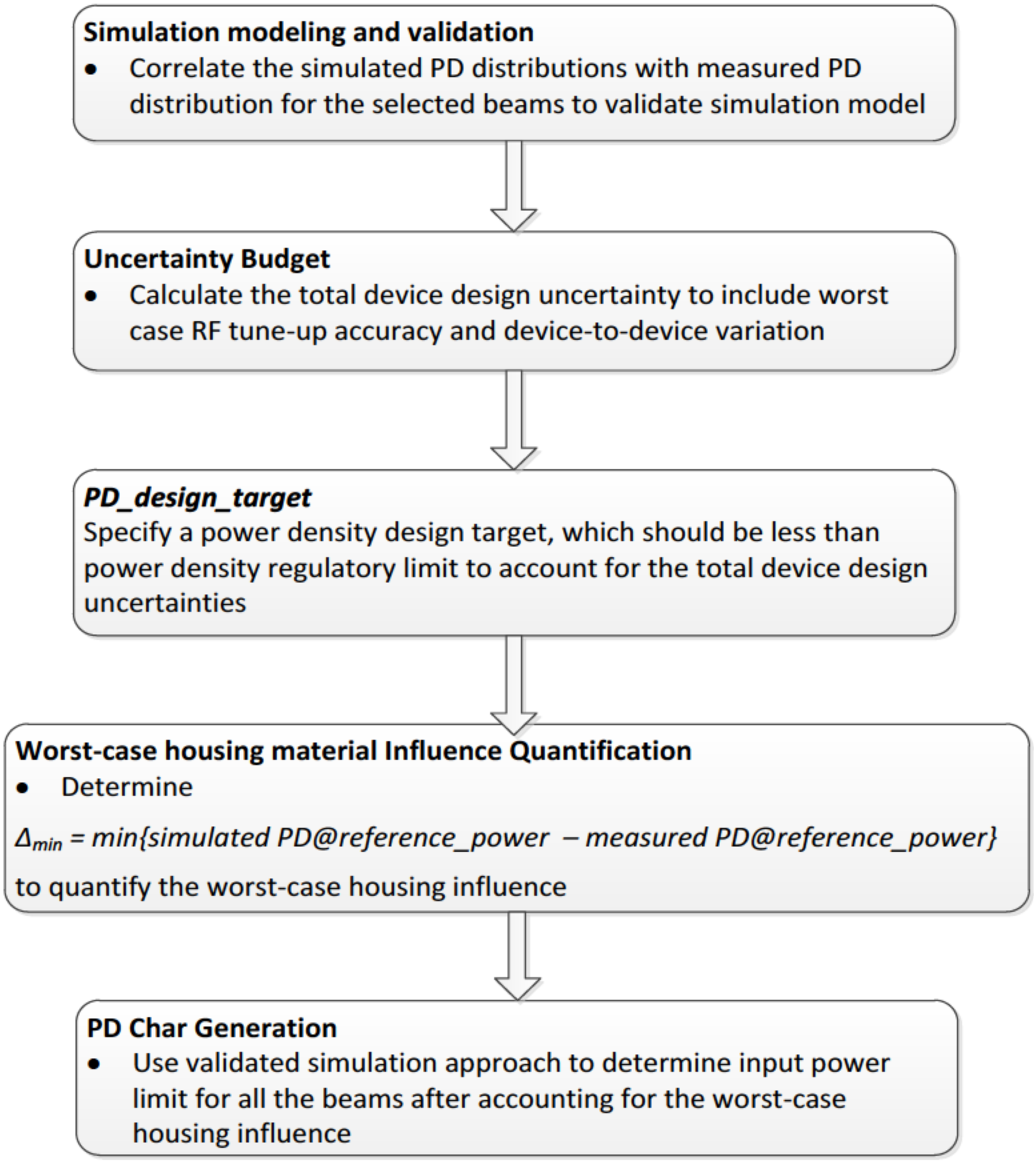

Figure 3-2 High level flow chart for power density characterization

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

n258					n260					n261				
Beam ID	Paired With	Module	Ant Type	# of Elements	Beam ID	Paired With	Module	Ant Type	# of Elements	Beam ID	Paired With	Module	Ant Type	# of Elements
0	128	M2	PATCH	1	0	128	M2	PATCH	1	0	128	M2	PATCH	1
1	129	M1	PATCH	1	1	129	M1	PATCH	1	1	129	M1	PATCH	1
2	130	M3	PATCH	1	2	130	M3	PATCH	1	2	130	M3	PATCH	1
3	131	M2	PATCH	1	3	131	M2	PATCH	1	3	131	M2	PATCH	1
4	132	M1	PATCH	1	4	132	M1	PATCH	1	4	132	M1	PATCH	1
5	133	M3	PATCH	1	5	133	M3	PATCH	1	5	133	M3	PATCH	1
6	134	M2	PATCH	1	6	134	M2	PATCH	1	6	134	M2	PATCH	1
7	135	M3	PATCH	1	7	135	M3	PATCH	1	7	135	M3	PATCH	1
8	136	M2	PATCH	1	8	136	M2	PATCH	1	8	136	M2	PATCH	1
9	137	M3	PATCH	1	9	137	M3	PATCH	1	9	137	M3	PATCH	1
10	138	M2	PATCH	1	10	138	M2	PATCH	1	10	138	M2	PATCH	1

n258				
Beam ID	Paired With	Module	Ant Type	# of Elements
11	139	M3	PATCH	1
12	140	M2	PATCH	2
13	141	M2	PATCH	2
14	142	M2	PATCH	2
15	143	M2	PATCH	2
16	144	M1	PATCH	2
17	145	M1	PATCH	2
18	146	M1	PATCH	2
19	147	M1	PATCH	2
20	148	M3	PATCH	2
21	149	M3	PATCH	2
22	150	M3	PATCH	2
23	151	M3	PATCH	2
24	152	M2	PATCH	2
25	153	M2	PATCH	2
26	154	M2	PATCH	2
27	155	M1	PATCH	2
28	156	M1	PATCH	2
29	157	M1	PATCH	2
30	158	M3	PATCH	2
31	159	M3	PATCH	2
32	160	M3	PATCH	2
33	161	M2	PATCH	4
34	162	M2	PATCH	4
35	163	M2	PATCH	4
36	164	M2	PATCH	4
37	165	M2	PATCH	4
38	166	M3	PATCH	4
39	167	M3	PATCH	4
40	168	M3	PATCH	4
41	169	M3	PATCH	4
42	170	M3	PATCH	4
43	171	M2	PATCH	4
44	172	M2	PATCH	4
45	173	M2	PATCH	4
46	174	M2	PATCH	4
47	175	M3	PATCH	4
48	176	M3	PATCH	4
49	177	M3	PATCH	4
50	178	M3	PATCH	4
128	0	M2	PATCH	1
129	1	M1	PATCH	1
130	2	M3	PATCH	1
131	3	M2	PATCH	1
132	4	M1	PATCH	1
133	5	M3	PATCH	1
134	6	M2	PATCH	1
135	7	M3	PATCH	1
136	8	M2	PATCH	1
137	9	M3	PATCH	1
138	10	M2	PATCH	1
139	11	M3	PATCH	1
140	12	M2	PATCH	2
141	13	M2	PATCH	2
142	14	M2	PATCH	2
143	15	M2	PATCH	2
144	16	M1	PATCH	2
145	17	M1	PATCH	2
146	18	M1	PATCH	2
147	19	M1	PATCH	2
148	20	M3	PATCH	2
149	21	M3	PATCH	2
150	22	M3	PATCH	2
151	23	M3	PATCH	2
152	24	M2	PATCH	2
153	25	M2	PATCH	2
154	26	M2	PATCH	2
155	27	M1	PATCH	2
156	28	M1	PATCH	2
157	29	M1	PATCH	2
158	30	M3	PATCH	2
159	31	M3	PATCH	2
160	32	M3	PATCH	2
161	33	M2	PATCH	4
162	34	M2	PATCH	4
163	35	M2	PATCH	4
164	36	M2	PATCH	4
165	37	M2	PATCH	4
166	38	M3	PATCH	4
167	39	M3	PATCH	4
168	40	M3	PATCH	4
169	41	M3	PATCH	4
170	42	M3	PATCH	4
171	43	M2	PATCH	4
172	44	M2	PATCH	4
173	45	M2	PATCH	4
174	46	M2	PATCH	4
175	47	M3	PATCH	4
176	48	M3	PATCH	4
177	49	M3	PATCH	4
178	50	M3	PATCH	4

n260				
Beam ID	Paired With	Module	Ant Type	# of Elements
11	139	M3	PATCH	1
12	140	M2	PATCH	2
13	141	M2	PATCH	2
14	142	M2	PATCH	2
15	143	M2	PATCH	2
16	144	M1	PATCH	2
17	145	M1	PATCH	2
18	146	M1	PATCH	2
19	147	M1	PATCH	2
20	148	M3	PATCH	2
21	149	M3	PATCH	2
22	150	M3	PATCH	2
23	151	M3	PATCH	2
24	152	M2	PATCH	2
25	153	M2	PATCH	2
26	154	M2	PATCH	2
27	155	M1	PATCH	2
28	156	M1	PATCH	2
29	157	M1	PATCH	2
30	158	M3	PATCH	2
31	159	M3	PATCH	2
32	160	M3	PATCH	2
33	161	M2	PATCH	4
34	162	M2	PATCH	4
35	163	M2	PATCH	4
36	164	M2	PATCH	4
37	165	M2	PATCH	4
38	166	M3	PATCH	4
39	167	M3	PATCH	4
40	168	M3	PATCH	4
41	169	M3	PATCH	4
42	170	M3	PATCH	4
43	171	M2	PATCH	4
44	172	M2	PATCH	4
45	173	M2	PATCH	4
46	174	M2	PATCH	4
47	175	M3	PATCH	4
48	176	M3	PATCH	4
49	177	M3	PATCH	4
50	178	M3	PATCH	4
128	0	M2	PATCH	1
129	1	M1	PATCH	1
130	2	M3	PATCH	1
131	3	M2	PATCH	1
132	4	M1	PATCH	1
133	5	M3	PATCH	1
134	6	M2	PATCH	1
135	7	M3	PATCH	1
136	8	M2	PATCH	1
137	9	M3	PATCH	1
138	10	M2	PATCH	1
139	11	M3	PATCH	1
140	12	M2	PATCH	2
141	13	M2	PATCH	2
142	14	M2	PATCH	2
143	15	M2	PATCH	2
144	16	M1	PATCH	2
145	17	M1	PATCH	2
146	18	M1	PATCH	2
147	19	M1	PATCH	2
148	20	M3	PATCH	2
149	21	M3	PATCH	2
150	22	M3	PATCH	2
151	23	M3	PATCH	2
152	24	M2	PATCH	2
153	25	M2	PATCH	2
154	26	M2	PATCH	2
155	27	M1	PATCH	2
156	28	M1	PATCH	2
157	29	M1	PATCH	2
158	30	M3	PATCH	2
159	31	M3	PATCH	2
160	32	M3	PATCH	2
161	33	M2	PATCH	4
162	34	M2	PATCH	4
163	35	M2	PATCH	4
164	36	M2	PATCH	4
165	37	M2	PATCH	4
166	38	M3	PATCH	4
167	39	M3	PATCH	4
168	40	M3	PATCH	4
169	41	M3	PATCH	4
170	42	M3	PATCH	4
171	43	M2	PATCH	4
172	44	M2	PATCH	4
173	45	M2	PATCH	4
174	46	M2	PATCH	4
175	47	M3	PATCH	4
176	48	M3	PATCH	4
177	49	M3	PATCH	4
178	50	M3	PATCH	4

n261				
Beam ID	Paired With	Module	Ant Type	# of Elements
11	139	M3	PATCH	1
12	140	M2	PATCH	2
13	141	M2	PATCH	2
14	142	M2	PATCH	2
15	143	M2	PATCH	2
16	144	M1	PATCH	2
17	145	M1	PATCH	2
18	146	M1	PATCH	2
19	147	M1	PATCH	2
20	148	M3	PATCH	2
21	149	M3	PATCH	2
22	150	M3	PATCH	2
23	151	M3	PATCH	2
24	152	M2	PATCH	2
25	153	M2	PATCH	2
26	154	M2	PATCH	2
27	155	M1	PATCH	2
28	156	M1	PATCH	2
29	157	M1	PATCH	2
30	158	M3	PATCH	2
31	159	M3	PATCH	2
32	160	M3	PATCH	2
33	161	M2	PATCH	4
34	162	M2	PATCH	4
35	163	M2	PATCH	4
36	164	M2	PATCH	4
37	165	M2	PATCH	4
38	166	M3	PATCH	4
39	167	M3	PATCH	4
40	168	M3	PATCH	4
41	169	M3	PATCH	4
42	170	M3	PATCH	4
43	171	M2	PATCH	4
44	172	M2	PATCH	4
45	173	M2	PATCH	4
46	174	M2	PATCH	4
47	175	M3	PATCH	4
48	176	M3	PATCH	4
49	177	M3	PATCH	4
50	178	M3	PATCH	4
128	0	M2	PATCH	1
129	1	M1	PATCH	1
130	2	M3	PATCH	1
131	3	M2	PATCH	1
132	4	M1	PATCH	1
133	5	M3	PATCH	1
134	6	M2	PATCH	1
135	7	M3	PATCH	1
136	8	M2	PATCH	1
137	9	M3	PATCH	1
138	10	M2	PATCH	1
139	11	M3	PATCH	1
140	12	M2	PATCH	2
141	13	M2	PATCH	2
142	14	M2	PATCH	2
143	15	M2	PATCH	2
144	16	M1	PATCH	2
145	17	M1	PATCH	2
146	18	M1	PATCH	2
147	19	M1	PATCH	2
148	20	M3	PATCH	2
149	21	M3	PATCH	2
150	22	M3	PATCH	2
151	23	M3	PATCH	2
152	24	M2	PATCH	2
153	25	M2	PATCH	2
154	26	M2	PATCH	2
155	27	M1	PATCH	2
156	28	M1	PATCH	2
157	29	M1	PATCH	2
158	30	M3	PATCH	2
159	31	M3	PATCH	2
160	32	M3	PATCH	2
161	33	M2	PATCH	4
162	34	M2	PATCH	4
163	35	M2	PATCH	4
164	36	M2	PATCH	4
165	37	M2	PATCH	4
166	38	M3	PATCH	4
167	39	M3	PATCH	4
168	40	M3	PATCH	4
169	41	M3	PATCH	4
170	42	M3	PATCH	4
171	43	M2	PATCH	4
172	44	M2	PATCH	4
173	45	M2	PATCH	4
174	46	M2	PATCH	4
175	47	M3	PATCH	4
176	48	M3	PATCH	4
177	49	M3	PATCH	4
178	50	M3	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	44	M2	V	S2
	164		H	S2
	16	M1	V	S2
	156		H	S2
	42	M3	V	S3
	170		H	S3
n260	33	M2	V	S2
	174		H	S2
	18	M1	V	S2
	147		H	S2
	50	M3	V	S3
	177		H	S3
n261	34	M2	V	S2
	174		H	S2
	28	M1	V	S2
	155		H	S2
	42	M3	V	S3
	166		H	S3

With an input power of 6 dBm (which will be referred to as P_{ref}) for bands n258, n260, and n261, respectively, PD 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 §3.6).

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	44	M2	V	S2	18.20	24.21	**1.24**
	164		H	S2	17.60	22.81	**1.13**
	16	M1	V	S2	3.15	5.96	**2.77**
	156		H	S2	4.33	7.24	**2.23**
	42	M3	V	S3	17.10	22.92	**1.27**
	170		H	S3	15.80	23.54	**1.73**
n260	33	M2	V	S2	8.67	17.05	**2.94**
	174		H	S2	10.60	16.34	**1.88**
	18	M1	V	S2	2.70	4.81	**2.51**
	147		H	S2	2.36	6.51	**4.41**
	50	M3	V	S3	13.70	18.30	**1.26**
	177		H	S3	14.70	18.30	**0.95**
n261	34	M2	V	S2	18.10	23.10	**1.06**
	174		H	S2	16.50	23.61	**1.56**
	28	M1	V	S2	5.00	5.02	**0.02**
	155		H	S2	5.65	7.05	**0.96**
	42	M3	V	S3	16.20	7.05	**-3.61**
	166		H	S3	14.80	21.28	**1.58**

[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:

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

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

ANT	Front	Back	Left	Right	Top	Bottom
	S1	S2	S3	S4	S5	S6
M2	No	Yes	Yes	No	No	No
M1	No	Yes	Yes	No	Yes	No
M3	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. $PD_{Design\ Target}$

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

Total Uncertainty (dB)	$PD_{Design\ Target}$ (W/m^2)	$PD_{Design\ Limit}$ (W/m^2)
1.00	6.4	8.0

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	M2	V	**1.24**
		H	**1.13**
	M1	V	**2.77**
		H	**2.23**
	M3	V	**1.27**
		H	**1.73**
n260	M2	V	**2.94**
		H	**1.88**
	M1	V	**2.51**
		H	**4.41**
	M3	V	**1.26**
		H	**0.95**
n261	M2	V	**1.06**
		H	**1.56**
	M1	V	**0.02**
		H	**0.96**
	M3	V	**-3.61**
		H	**1.58**

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:

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

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,

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

else if Δ_{min} < -TxAGC uncertainty,

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

else if Δ_{min} > TxAGC uncertainty,

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

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	M2	V	**1.24**	6 dBm + 10 * log(s(i)) + 0.24	Using Eq. 10
		H	**1.13**	6 dBm + 10 * log(s(i)) + 0.13	Using Eq. 10
	M1	V	**2.77**	6 dBm + 10 * log(s(i)) + 1.77	Using Eq. 10
		H	**2.23**	6 dBm + 10 * log(s(i)) + 1.23	Using Eq. 10
	M3	V	**1.27**	6 dBm + 10 * log(s(i)) + 0.27	Using Eq. 10
		H	**1.73**	6 dBm + 10 * log(s(i)) + 0.73	Using Eq. 10
n260	M2	V	**2.94**	6 dBm + 10 * log(s(i)) + 1.94	Using Eq. 10
		H	**1.88**	6 dBm + 10 * log(s(i)) + 0.88	Using Eq. 10
	M1	V	**2.51**	6 dBm + 10 * log(s(i)) + 1.51	Using Eq. 10
		H	**4.41**	6 dBm + 10 * log(s(i)) + 3.41	Using Eq. 10
	M3	V	**1.26**	6 dBm + 10 * log(s(i)) + 0.26	Using Eq. 10
		H	**0.95**	6 dBm + 10 * log(s(i))	Using Eq. 8
n261	M2	V	**1.06**	6 dBm + 10 * log(s(i)) + 0.06	Using Eq. 10
		H	**1.56**	6 dBm + 10 * log(s(i)) + 0.56	Using Eq. 10
	M1	V	**0.02**	6 dBm + 10 * log(s(i))	Using Eq. 8
		H	**0.96**	6 dBm + 10 * log(s(i))	Using Eq. 8
	M3	V	**-3.61**	6 dBm + 10 * log(s(i)) + -2.61	Using Eq. 9
		H	**1.58**	6 dBm + 10 * log(s(i)) + 0.58	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	6.3	N/A	0	9.7	N/A	0	6.5
	1	11.0		1	11.3		1	11.0
	2	5.8		2	6.5		2	5.3
	3	7.4		3	9.4		3	6.7
	4	10.1		4	10.3		4	9.7
	5	6.1		5	8.8		5	8.3
	6	6.4		6	9.1		6	6.4
	7	6.2		7	8.2		7	6.1
	8	6.5		8	8.7		8	6.3
	9	6.0		9	8.1		9	7.7
	10	6.9		10	9.6		10	7.2
	11	8.0		11	7.3		11	6.3
	12	4.0		12	6.2		12	3.5
	13	3.8		13	6.7		13	3.4
	14	3.6		14	6.9		14	3.7
	15	4.2		15	6.0		15	4.7
	16	7.1		16	7.5		16	6.9
	17	7.0		17	8.0		17	7.0
	18	8.3		18	8.3		18	7.7
	19	8.2		19	7.7		19	7.5
	20	4.4		20	4.3		20	4.2
	21	4.3		21	5.7		21	3.8
	22	3.6		22	4.7		22	3.5
	23	3.7		23	4.1		23	3.7
	24	4.9		24	6.3		24	3.5
	25	3.5		25	5.8		25	3.6
	26	4.0		26	6.0		26	4.0
	27	7.0		27	7.5		27	6.9
	28	7.3		28	8.7		28	7.4
	29	8.1		29	7.7		29	8.0
	30	3.2		30	5.0		30	4.1
	31	3.4		31	5.8		31	3.5
	32	3.0		32	5.1		32	3.5
	33	-0.3		33	2.5		33	-0.6
	34	-0.2		34	2.6		34	-0.4
	35	-0.4		35	3.3		35	-0.1

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)
N/A	36	-0.5	N/A	36	2.5	N/A	36	0.5
	37	-0.4		37	3.1		37	-0.6
	38	0.3		38	2.3		38	0.2
	39	0.3		128	2.1		128	0.8
	40	0.6		129	1.3		129	0.3
	41	0.2		130	1.0		130	0.3
	42	-0.6		131	1.8		131	-0.5
	43	-0.1		132	2.6		132	-0.6
	44	-0.6		133	2.9		133	-0.2
	45	-0.6		134	2.8		134	0.3
	46	-0.6		135	2.9		135	-0.3
	47	0.0		136	2.2		136	0.6
	48	0.8		137	2.0		137	0.4
	49	0.4		138	1.5		138	0.6
	50	-0.3		139	0.6		139	-0.2
	128	6.6		140	8.3		140	6.9
	129	9.0		141	12.9		141	8.5
	130	6.6		142	7.6		142	6.4
	131	6.3		143	8.8		143	7.5
	132	7.4		144	11.5		144	7.5
	133	7.2		145	7.2		145	7.0
	134	6.9		146	8.5		146	6.8
	135	6.9		147	7.8		147	7.7
	136	6.8		148	8.0		148	7.5
	137	7.2		149	7.6		149	7.0
	138	8.2		150	9.1		150	8.6
	139	8.2		151	7.0		151	8.0
	140	3.8		152	5.3		152	4.7
	141	3.3		153	5.6		153	3.9
	142	4.5		154	5.5		154	3.6
	143	4.2		155	5.1		155	4.0
	144	4.6		156	8.0		156	4.8
	145	4.7		157	10.2		157	4.6
	146	5.3		158	10.8		158	4.8
	147	6.2		159	7.7		159	5.0
	148	5.3		160	5.8		160	4.0
	149	3.7		161	5.0		161	4.0
	150	3.6		162	4.3		162	3.6
	151	4.0		163	4.6		163	3.5
	152	3.7		164	5.5		164	5.1
	153	4.1		165	5.4		165	3.7
	154	3.7		166	5.9		166	5.3

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	155	4.6	128	0	8.3	128	0	4.5
	156	4.9	129	1	10.9	129	1	4.6
	157	5.8	130	2	9.6	130	2	5.1
	158	4.0	131	3	4.6	131	3	4.5
	159	3.9	132	4	5.7	132	4	3.9
	160	3.7	133	5	4.3	133	5	3.1
	161	-0.4	134	6	2.0	134	6	0.0
	162	-0.3	135	7	1.7	135	7	0.1
	163	-0.5	136	8	1.8	136	8	0.1
	164	-0.5	137	9	2.1	137	9	0.0
	165	0.1	138	10	2.0	138	10	-0.2
	166	0.7	139	11	1.8	139	11	0.3
	167	1.0	140	12	2.1	140	12	1.4
	168	0.8	141	13	1.1	141	13	1.8
	169	0.7	142	14	0.7	142	14	0.5
	170	0.0	143	15	1.7	143	15	-0.6
	171	-0.6	144	16	1.8	144	16	0.1
	172	-0.5	145	17	2.1	145	17	0.3
	173	-0.3	146	18	1.9	146	18	0.0
	174	-0.4	147	19	2.0	147	19	-0.2
	175	0.5	148	20	2.1	148	20	0.6
	176	0.9	149	21	2.6	149	21	1.9
	177	0.8	150	22	0.6	150	22	1.2
	178	0.6	151	23	1.3	151	23	-0.2
128	0	3.6	152	24	5.8	152	24	3.7
129	1	4.1	153	25	8.5	153	25	4.5
130	2	2.2	154	26	3.6	154	26	2.3
131	3	2.9	155	27	5.5	155	27	3.0
132	4	4.1	156	28	7.2	156	28	4.1
133	5	2.7	157	29	4.4	157	29	3.5
134	6	3.1	158	30	5.0	158	30	3.2
135	7	3.0	159	31	5.2	159	31	3.0
136	8	4.0	160	32	4.9	160	32	3.8
137	9	3.0	161	33	4.4	161	33	3.7
138	10	3.4	162	34	4.8	162	34	4.5
139	11	3.7	163	35	3.7	163	35	3.4
140	12	0.1	164	36	2.5	164	36	-0.3
141	13	-0.6	165	37	2.3	165	37	-0.5
142	14	0.5	166	38	3.1	166	38	-0.5
143	15	0.5	143	15	2.1	143	15	0.8
144	16	0.9	144	16	4.3	144	16	1.3
145	17	1.2	145	17	5.2	145	17	1.1

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)
146	18	1.8	146	18	6.0	146	18	1.5
147	19	1.6	147	19	4.0	147	19	1.9
148	20	0.9	148	20	1.2	148	20	0.8
149	21	0.8	149	21	2.2	149	21	0.4
150	22	0.6	150	22	1.4	150	22	0.3
151	23	0.7	151	23	2.2	151	23	0.0
152	24	1.0	152	24	2.7	152	24	0.7
153	25	-0.1	153	25	2.2	153	25	-0.5
154	26	-0.4	154	26	2.7	154	26	0.8
155	27	1.0	155	27	4.3	155	27	1.0
156	28	1.5	156	28	5.8	156	28	1.3
157	29	1.8	157	29	4.7	157	29	1.7
158	30	-0.8	158	30	2.5	158	30	0.6
159	31	-0.7	159	31	2.1	159	31	0.1
160	32	0.1	160	32	1.0	160	32	-0.2
161	33	-4.1	161	33	-1.6	161	33	-4.7
162	34	-3.9	162	34	-1.1	162	34	-3.9
163	35	-4.2	163	35	-0.9	163	35	-3.8
164	36	-4.3	164	36	-1.4	164	36	-3.7
165	37	-4.5	165	37	-1.3	165	37	-4.1
166	38	-3.4	166	38	-1.7	166	38	-3.2
167	39	-3.9	167	39	-2.0	167	39	-2.7
168	40	-3.8	168	40	-2.7	168	40	-2.9
169	41	-4.0	169	41	-2.7	169	41	-3.4
170	42	-5.0	170	42	-2.1	170	42	-4.4
171	43	-4.2	171	43	-1.2	171	43	-4.3
172	44	-4.0	172	44	-1.1	172	44	-3.8
173	45	-4.0	173	45	-1.0	173	45	-3.6
174	46	-4.8	174	46	-1.9	174	46	-4.2
175	47	-4.2	175	47	-1.9	175	47	-3.0
176	48	-3.6	176	48	-1.8	176	48	-2.8
177	49	-3.9	177	49	-2.4	177	49	-2.9
178	50	-4.4	178	50	-2.8	178	50	-4.1

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					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
	0	4.89	4.69	4.72		0	2.15	2.90	3.22		0	4.72	4.08	3.55
	1	1.75	2.43	2.20		1	2.45	1.68	1.55		1	2.20	1.87	1.82
	2	3.98	3.82	5.29		2	4.75	3.57	3.66		2	5.29	5.79	5.84
	3	3.53	3.86	3.79		3	2.78	3.19	3.50		3	3.79	3.88	4.54
	4	3.01	2.87	2.94		4	2.44	3.04	2.11		4	2.94	2.50	2.43
	5	4.89	3.64	2.94		5	2.39	2.76	2.20		5	2.94	2.80	2.64
	6	4.44	2.84	4.81		6	3.08	3.52	3.75		6	4.81	4.61	4.52
	7	4.27	3.36	4.78		7	2.43	3.18	2.44		7	4.78	4.88	4.51
	8	1.81	4.74	4.04		8	3.82	3.97	4.03		8	4.04	4.96	4.62
	9	4.17	4.95	3.40		9	3.24	3.20	3.08		9	3.40	3.09	2.70
	10	2.59	4.34	4.03		10	1.48	2.84	3.29		10	4.03	3.37	3.17
	11	2.52	2.91	3.15		11	3.97	3.05	3.74		11	3.15	3.96	4.72
	12	8.36	8.31	7.65		12	5.55	7.22	6.90		12	9.37	8.69	8.86
	13	8.26	8.84	8.82		13	4.92	6.02	6.50		13	9.61	9.15	9.23
	14	7.12	8.79	9.20		14	4.75	5.65	6.22		14	9.12	9.02	8.91
	15	8.08	6.96	7.53		15	5.19	6.98	7.56		15	6.87	7.15	6.15
	16	5.31	5.96	5.62		16	4.71	5.86	3.98		16	5.62	4.84	4.78
	17	5.32	6.10	5.42		17	3.95	5.22	2.59		17	5.42	4.92	4.76
	18	3.73	4.40	4.49		18	4.81	3.35	3.51		18	4.68	4.10	3.83
	19	4.11	4.58	4.66		19	5.39	5.61	4.90		19	4.94	4.06	3.89
	20	6.00	6.10	7.20		20	7.85	6.16	6.23		20	7.57	7.49	6.99
	21	6.22	7.35	6.31		21	5.51	5.74	5.61		21	7.77	8.01	8.34
	22	7.98	8.59	6.34		22	7.15	6.79	6.85		22	8.88	8.63	7.38
	23	7.03	6.48	8.50		23	8.25	6.20	7.72		23	7.94	8.52	8.19
	24	3.03	6.77	5.66		24	5.03	6.49	7.14		24	9.48	8.89	9.06
N/A	25	8.16	9.31	9.39	N/A	25	7.85	7.36	7.46	N/A	25	9.27	9.13	9.06
	26	7.22	7.82	8.34		26	6.89	7.34	7.61		26	8.47	8.42	8.09
	27	5.39	6.13	5.62		27	4.52	5.82	3.68		27	5.60	4.97	4.86
	28	4.96	5.64	5.13		28	3.83	4.48	2.23		28	5.02	4.53	4.32
	29	4.24	4.71	4.79		29	5.60	5.24	5.08		29	4.40	3.69	3.47
	30	9.48	7.84	7.25		30	6.72	6.08	6.66		30	6.06	7.06	7.66
	31	9.16	7.72	8.03		31	5.52	5.32	5.51		31	8.64	8.93	8.59
	32	10.02	9.25	9.57		32	6.46	6.42	5.50		32	8.32	8.87	8.41
	33	15.12	18.63	22.72		33	11.51	16.33	17.05		33	23.04	24.13	22.20
	34	17.60	21.95	19.19		34	12.97	14.60	16.53		34	22.70	22.48	23.10
	35	16.72	22.31	22.94		35	12.37	13.66	14.27		35	21.71	20.67	20.91
	36	20.11	21.00	23.43		36	14.00	15.35	17.00		36	18.69	18.27	17.44
	37	14.87	16.92	22.84		37	12.13	14.69	14.62		37	22.65	24.16	22.64
	38	17.55	16.83	18.37		38	11.94	12.40	11.05		38	18.4	18.88	19
	39	16.00	18.69	16.08		39	13.13	11.71	11.05		39	15.65	16.19	16.69
	40	17.16	16.28	15.08		40	15.38	15.50	13.18		40	17.62	18.37	16.64
	41	18.82	17.46	18.54		41	16.79	15.62	16.10		41	17.86	18.65	18.68
	42	21.85	22.92	22.63		42	12.44	12.99	13.92		42	22.50	22.37	20.00
	43	15.49	17.63	21.35		43	12.63	14.85	16.54		43	23.25	24.28	22.98
	44	17.57	24.21	21.10		44	12.69	14.59	15.53		44	22.14	21.38	22.25
	45	18.75	21.80	24.04		45	12.12	13.68	15.89		45	19.82	18.53	18.37
	46	17.95	21.35	23.95		46	13.77	15.61	15.61		46	21.38	22.50	20.27
	47	17.59	19.68	16.67		47	12.83	11.21	11.10		47	17.22	16.53	16.48
	48	15.95	16.47	15.62		48	13.41	13.45	11.20		48	17.06	18.07	17.61
	49	18.05	17.05	16.59		49	13.79	15.06	12.56		49	17.25	17.30	16.39
	50	20.70	20.71	21.09		50	18.30	16.05	16.68		50	20.50	20.78	19.07

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	128	4.44	3.88	4.36	N/A	128	3.80	2.85	2.85	N/A	128	4.36	4.55	4.65
	129	1.61	2.84	2.41		129	1.96	1.79	1.83		129	2.41	2.51	2.78
	130	4.26	5.18	4.54		130	3.31	3.42	3.35		130	4.54	5.16	5.15
	131	3.41	4.76	3.99		131	3.27	3.42	3.11		131	3.99	3.94	3.83
	132	4.07	3.71	3.53		132	2.68	2.58	1.89		132	3.53	3.52	3.56
	133	4.14	3.56	4.53		133	3.75	2.76	2.73		133	4.53	4.46	4.20
	134	3.35	4.21	4.21		134	3.43	3.43	3.67		134	4.21	4.12	4.74
	135	2.75	4.85	3.90		135	3.30	2.29	2.32		135	3.90	3.83	3.61
	136	4.07	4.27	4.01		136	3.94	4.15	3.53		136	4.01	4.06	2.99
	137	2.35	3.38	4.53		137	2.94	3.45	2.59		137	4.53	4.47	3.62
	138	2.66	2.82	3.12		138	3.19	2.61	3.00		138	3.12	3.11	2.97
	139	2.99	3.54	1.52		139	3.28	3.99	3.30		139	1.52	3.39	3.64
	140	6.89	8.62	7.85		140	7.60	6.58	5.90		140	7.70	7.06	6.64
	141	8.70	8.21	9.62		141	7.13	5.91	5.86		141	9.22	8.65	8.36
	142	6.95	7.21	6.82		142	7.24	7.14	7.37		142	9.01	9.50	9.86
	143	7.32	7.87	6.88		143	6.94	7.93	7.78		143	7.85	8.75	9.02
	144	6.80	7.75	6.77		144	6.07	5.38	5.29		144	6.54	6.18	6.44
	145	6.57	7.68	7.01		145	3.63	3.56	2.22		145	6.94	6.85	6.92
	146	5.54	6.64	6.36		146	2.77	3.18	2.92		146	6.21	6.46	6.58
	147	4.58	5.37	5.19		147	6.51	5.72	5.39		147	5.36	6.13	6.28
	148	4.89	6.99	6.96		148	5.29	3.64	3.45		148	7.87	9.05	8.87
	149	9.95	8.68	7.83		149	6.29	4.66	4.45		149	7.75	9.03	8.96
	150	7.23	9.28	10.26		150	7.40	5.41	5.75		150	9.62	9.89	9.49
	151	5.25	9.35	9.01		151	6.88	6.90	6.96		151	10.09	9.81	9.18
	152	6.72	8.67	7.72		152	7.32	6.78	6.37		152	6.72	6.95	5.64
	153	6.28	7.95	7.40		153	7.40	6.54	6.79		153	9.70	9.5	9.43
	154	6.61	8.82	7.93		154	6.74	6.18	6.17		154	6.75	6.7	5.74
	155	6.83	7.84	6.93		155	5.64	5.07	3.84		155	7.05	6.84	6.96
	156	6.08	7.24	6.73		156	2.97	3.11	1.97		156	6.84	6.81	6.86
	157	4.85	5.86	5.71		157	4.18	4.10	4.19		157	5.19	5.98	6.16
	158	9.43	7.68	7.78		158	6.54	6.95	6.76		158	5.33	8.15	7.94
	159	8.99	9.52	9.34		159	5.31	4.68	3.62		159	8.18	9.19	9.1
	160	6.55	8.82	10.09		160	7.41	6.19	6.50		160	10.86	11.23	11.07
	161	14.69	18.01	22.37		161	16.35	15.78	13.57		161	22.70	21.76	17.5
	162	19.47	21.31	21.96		162	17.47	14.51	13.52		162	21.96	20.79	17.85
	163	22.49	22.77	22.31		163	17.17	14.23	14.17		163	22.01	21.75	20.58
	164	22.81	21.64	22.61		164	16.04	15.31	14.38		164	21.21	22.41	20.27
	165	19.94	19.35	19.05		165	14.55	16.51	15.61		165	22.48	23.69	22.37
	166	14.69	20.10	18.46		166	13.08	12.98	12.29		166	18.05	21.28	19.56
	167	15.97	18.69	13.59		167	12.28	11.73	11.28		167	14.06	16.56	14.95
	168	14.17	19.40	15.70		168	15.53	14.63	11.72		168	12.91	14.96	13.98
	169	13.41	20.04	15.79		169	16.82	13.56	11.35		169	19.89	20.43	18.81
	170	14.05	23.54	22.87		170	12.86	13.61	13.16		170	24.69	26.18	25.21
	171	17.00	20.16	23.48		171	17.06	15.69	12.73		171	22.31	21.37	17.42
	172	21.93	22.84	20.87		172	15.84	13.49	13.99		172	21.14	20.49	19.09
	173	21.88	21.63	20.97		173	16.68	14.46	14.42		173	22.13	22.46	20.73
	174	22.67	21.43	22.37		174	16.34	16.03	16.09		174	22.58	23.61	21.26
	175	17.91	20.77	15.32		175	12.17	12.04	11.88		175	17.12	20.02	17.9
	176	13.59	18.96	14.61		176	10.84	9.75	8.37		176	12.26	14.84	13.91
	177	14.17	19.75	16.30		177	17.20	15.50	13.69		177	16.04	17.08	15.81
	178	12.74	20.73	17.28		178	14.80	12.12	12.67		178	23.32	24.04	22.75

n258			n260			n261		
Paired ID (Beam Pair)	Beam ID	Worst Case Sim Beam Pair	Paired ID (Beam Pair)	Beam ID	Worst Case Sim Beam Pair	Paired ID (Beam Pair)	Beam ID	Worst Case Sim Beam Pair
128	0	9.03	128	0	6.89	128	0	9.03
129	1	8.76	129	1	4.65	129	1	7.12
130	2	12.10	130	2	8.73	130	2	11.76
131	3	10.55	131	3	7.26	131	3	10.55
132	4	8.83	132	4	6.20	132	4	7.69
133	5	10.77	133	5	7.15	133	5	8.82
134	6	10.07	134	6	8.22	134	6	10.07
135	7	10.00	135	7	6.08	135	7	10.00
136	8	8.08	136	8	8.41	136	8	8.81
137	9	9.98	137	9	7.31	137	9	8.50
138	10	9.40	138	10	8.64	138	10	7.54
139	11	8.54	139	11	8.51	139	11	9.11
140	12	20.12	140	12	14.52	140	12	22.80
141	13	23.57	141	13	15.32	141	13	23.93
142	14	18.49	142	14	12.65	142	14	23.54
143	15	18.38	143	15	16.15	143	15	17.50
144	16	18.15	144	16	12.22	144	16	14.79
145	17	17.00	145	17	9.99	145	17	15.46
146	18	14.87	146	18	8.22	146	18	14.00
147	19	15.75	147	19	12.97	147	19	12.96
148	20	16.18	148	20	14.94	148	20	16.47
149	21	16.49	149	21	11.90	149	21	17.97
150	22	17.21	150	22	14.36	150	22	18.76
151	23	16.85	151	23	11.96	151	23	20.13
152	24	16.27	152	24	13.97	152	24	18.15
153	25	21.17	153	25	15.76	153	25	23.99
154	26	22.66	154	26	14.02	154	26	17.75
155	27	17.94	155	27	12.19	155	27	15.75
156	28	16.04	156	28	8.58	156	28	14.62
157	29	14.93	157	29	11.08	157	29	13.45
158	30	23.93	158	30	11.18	158	30	17.53
159	31	23.14	159	31	12.14	159	31	19.27
160	32	19.34	160	32	15.91	160	32	20.99
161	33	53.21	161	33	37.22	161	33	63.09
162	34	50.91	162	34	33.19	162	34	52.41
163	35	53.90	163	35	32.25	163	35	51.30
164	36	55.05	164	36	35.84	164	36	49.31
165	37	58.44	165	37	35.15	165	37	55.13
166	38	44.01	166	38	29.72	166	38	41.42
167	39	48.67	167	39	31.28	167	39	36.91
168	40	47.22	168	40	37.48	168	40	38.48
169	41	49.54	169	41	37.38	169	41	44.03
170	42	63.06	170	42	32.63	170	42	55.34
171	43	54.44	171	43	33.80	171	43	57.61
172	44	51.09	172	44	33.35	172	44	50.63
173	45	52.11	173	45	32.53	173	45	48.67
174	46	61.58	174	46	39.73	174	46	55.18
175	47	52.12	175	47	30.89	175	47	39.82
176	48	45.86	176	48	29.80	176	48	37.76
177	49	48.58	177	49	34.97	177	49	38.56
178	50	55.16	178	50	37.55	178	50	51.5