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

For
PHONE

FCC ID: A4RG2YBB
Model Name: G2YBB

Report Number: 15107843-S5V1
Issue Date: 2024/05/09

Prepared for

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Prepared by

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Revision History

Rev.	Date	Revisions	Revised By
V1	2024/05/09	Initial Issue	--

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1. Attestation of Test Results

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<tr><td>Reference SAR Report</td><td colspan="3">15107843-S1</td></tr>
<tr><td rowspan="2">Exposure Category</td><td colspan="2">SAR Limits (W/Kg)</td><td rowspan="2">PD Limits
(W/m^2)</td></tr>
<tr><td>Peak Spatial Average
(1-g of tissue)</td><td>Extremities (hands, wrists, ankles, etc.)
(10-g of tissue)</td></tr>
<tr><td>General Population
(Uncontrolled Exposure)</td><td>1.6</td><td>4</td><td>10</td></tr>
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UL Verification Services Inc. tested the above equipment in accordance with the requirements set forth in the above standards. The test results show that the equipment tested is capable of demonstrating compliance with the requirements as documented in this report.
This report contains data provided by the customer which can impact the validity of results. UL Verification Services Inc. is only responsible for the validity of results after the integration of the data provided by the customer.
The results documented in this report apply only to the tested sample, under the conditions and modes of operation as described herein. It is the manufacturer's responsibility to assure that additional production units of this model are manufactured with identical electrical and mechanical components. All samples tested were in good operating condition throughout the entire test program. Measurement Uncertainties are published for informational purposes only and were not taken into account unless noted otherwise.
This document may not be altered or revised in any way unless done so by UL Verification Services Inc. and all revisions are duly noted in the revisions section. Any alteration of this document not carried out by UL Verification Services Inc. will constitute fraud and shall nullify the document. This report must not be used by the client to claim product certification, approval, or endorsement by A2LA, NIST, or any agency of the U.S. Government, or any agency of the U.S. government.

Approved & Released By:	Prepared By:
Dave Weaver Senior Staff Engineer UL Verification Services Inc.	Nathan Sousa Senior Laboratory Engineer UL Verification Services Inc.

2. Facilities and Accreditation

The test sites and measurement facilities used to collect data are located at:

47173 Benicia Street	47266 Benicia Street
SAR Labs A to H	SAR Labs 1 to 15

UL Verification Services Inc. is accredited by A2LA, Certificate Number 0751.05

The Test Lab Conformity Assessment Body Identifier (CABID)

Location	CABID	Company Number
47173 Benicia Street, Fremont, CA, 94538 UNITED STATES	US0104	2324A
47266 Benicia Street, Fremont, CA, 94538 UNITED STATES		

3. Introduction

The equipment under test (EUT) is a smart phone. It contains the Samsung modem supporting 2G/3G/4G WWAN technologies and mmW 5G NR bands. These WWAN modems enable Samsung's S.LSI TAS 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 Samsung S.LSI TAS to operate. Both *SAR Char* and *PD Char* will be loaded and stored in the EUT's software.

The EUT supports WLAN/BT radio(s) as well, but the WLAN/BT modem is not enabled with Samsung's S.LSI TAS feature.

4. SAR Characterization

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

4.1. 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 4-1.

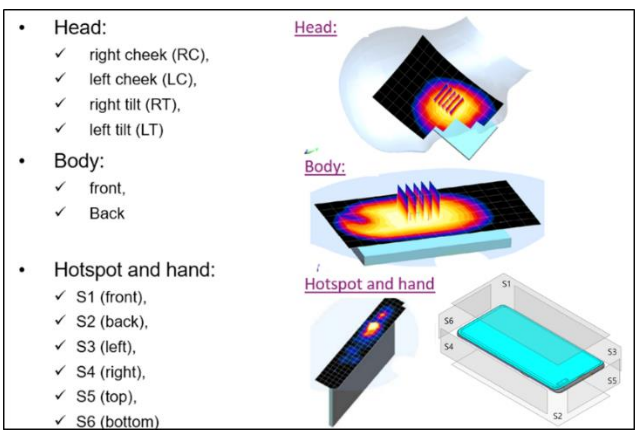

Figure 4-1: SAR evaluation for smartphone application

The *Device/Radio State Index* (D/RSI) used in Figure 3-2 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, 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}, $SAR_{extremity}$, $SAR_{hotspot}$}
- If the device can distinguish each of the above scenarios, then the worst-case SAR for each individual exposure scenario is given by corresponding SAR_{head}, SAR_{body}, $SAR_{extremity}$, and $SAR_{hotspot}$
- If the device can only distinguish a subset of the scenarios, then the worst-case SAR is given by:
  - Corresponding SAR for each exposure scenario that can be distinguished (D/RSI=yes)
  - Worst-case SAR among all other exposure scenario(s) that cannot be distinguished (D/RSI=no)

4.2. Usage Scenarios in SAR Evaluation

The EUT has a detection mechanism to distinguish Head, Body-worn, Hotspot, and Extremity exposure conditions, which is represented using *D/RSI 1 – 7*; within this report, D/RSIs will be referred to as Indices 1 – 6. These *Indices* states were used to determine the power limit for S.LSI TAS to operate; where the exposure scenario is managed as same Indices 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 S.LSI TAS to operate.

The corresponding usage scenarios supported by EUT are summarized in Table 4-1:

Table 4-1: Usage/Exposure Scenario

Scenario	INDICES State	Description	SAR Definition	Worst-case SAR
Head	Index 2 Index 3	▪ Device positioned next to head ▪ 1-g SAR evaluated in four positions (left/right cheek/tilt)	$SAR_{head} = max \{SAR_{LC}, SAR_{LT}, SAR_{RC}, SAR_{RT}\}$	SAR_{head}
Hotspot	Index 4	▪ Device transmits in Hotspot mode and assumed to be located next to human body ▪ 1-g SAR is evaluated for all six surfaces of the EUT (S1-S6 as shown in Figure 3-1) at 10 mm test separation distance relative to the flat phantom	$SAR_{hotspot} = max \{SAR_{s1}, SAR_{s2}, SAR_{s3}, SAR_{s4}, SAR_{s5}, SAR_{s6}\}$	$SAR_{hotspot}$
Extremity	Index 5	▪ Phablet extremity ▪ 10-g SAR is evaluated for all six surfaces of the EUT against the flat phantom with 0 mm test separation distance	$SAR_{extremity\ Index=5} = max \{SAR_{s1\ Index=5}, SAR_{s2\ Index=5}, SAR_{s3\ Index=5}, SAR_{s4\ Index=5}, SAR_{s5\ Index=5}, SAR_{s6\ Index=5}\}$	$SAR_{extremity}$
Body-worn	Index 5 Index 6	▪ Device state is body-worn ▪ 1-g SAR evaluated at the back and front of the EUT with 10 mm test separation distance relative to the flat phantom for body-worn exposure	$SAR_{body} = max\{SAR_{s1}, SAR_{s2}\}$	SAR_{body}

4.3. $SAR_{Design\ Target}$

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:

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

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

Antenna	Technology	Mode	Pmax (Index 1)	Index 2	Head $SAR_{Design Target}$ (W/kg)	Head $SAR_{Design Limit}$ (W/kg)	Index 5	Body $SAR_{Design Target}$ (W/kg)	Extremity $SAR_{Design Target}$ (W/kg)	Body $SAR_{Design Limit}$ (W/kg)	Extremity $SAR_{Design Limit}$ (W/kg)	Index 4	Hotspot $SAR_{Design Target}$ (W/kg)	Hotspot $SAR_{Design Limit}$ (W/kg)	Total Uncertainty (dB)
ANT 1	GSM 850	GMSK 1 Slot	32.2	29.2	0.810	1.0	37.0	0.810	2.025	1.0	2.5	34.5	0.690	0.85	0.9
ANT 1	GSM 850	GPRS 1 Slot	32.2	29.2	0.810	1.0	37.0	0.810	2.025	1.0	2.5	34.5	0.690	0.85	0.9
ANT 1	GSM 850	GPRS 2 Slots	31.2	26.2	0.810	1.0	34.0	0.810	2.025	1.0	2.5	31.5	0.690	0.85	0.9
ANT 1	GSM 850	GPRS 3 Slots	30.2	24.4	0.810	1.0	32.2	0.810	2.025	1.0	2.5	29.7	0.690	0.85	0.9
ANT 1	GSM 850	GPRS 4 Slots	29.2	23.2	0.810	1.0	31.0	0.810	2.025	1.0	2.5	28.5	0.690	0.85	0.9
ANT 1	GSM 850	EGPRS 1 Slot	26.2	29.9	0.810	1.0	29.9	0.810	2.025	1.0	2.5	29.2	0.690	0.85	0.9
ANT 1	GSM 850	EGPRS 2 Slots	25.2	26.9	0.810	1.0	26.9	0.810	2.025	1.0	2.5	26.2	0.690	0.85	0.9
ANT 1	GSM 850	EGPRS 3 Slots	24.2	25.1	0.810	1.0	25.1	0.810	2.025	1.0	2.5	24.4	0.690	0.85	0.9
ANT 1	GSM 850	EGPRS 4 Slots	23.2	23.9	0.810	1.0	23.9	0.810	2.025	1.0	2.5	23.2	0.690	0.85	0.9
ANT 0	GSM 850	GMSK 1 Slot	32.5	34.0	0.790	1.0	33.0	0.790	1.975	1.0	2.5	32.2	0.680	0.86	1.0
ANT 0	GSM 850	GPRS 1 Slot	32.5	34.0	0.790	1.0	33.0	0.790	1.975	1.0	2.5	32.2	0.680	0.86	1.0
ANT 0	GSM 850	GPRS 2 Slots	31.5	31.0	0.790	1.0	30.0	0.790	1.975	1.0	2.5	29.3	0.680	0.86	1.0
ANT 0	GSM 850	GPRS 3 Slots	30.5	29.2	0.790	1.0	28.2	0.790	1.975	1.0	2.5	27.5	0.680	0.86	1.0
ANT 0	GSM 850	GPRS 4 Slots	29.5	28.0	0.790	1.0	27.0	0.790	1.975	1.0	2.5	26.3	0.680	0.86	1.0
ANT 0	GSM 850	EGPRS 1 Slot	26.5	30.2	0.790	1.0	30.2	0.790	1.975	1.0	2.5	26.5	0.680	0.86	1.0
ANT 0	GSM 850	EGPRS 2 Slots	25.5	27.2	0.790	1.0	27.2	0.790	1.975	1.0	2.5	25.5	0.680	0.86	1.0
ANT 0	GSM 850	EGPRS 3 Slots	24.5	25.4	0.790	1.0	25.4	0.790	1.975	1.0	2.5	24.5	0.680	0.86	1.0
ANT 0	GSM 850	EGPRS 4 Slots	23.5	24.2	0.790	1.0	24.2	0.790	1.975	1.0	2.5	23.5	0.680	0.86	1.0
ANT 0	GSM 1900	GMSK 1 Slot	28.2	46.8	0.810	1.0	27.7	0.810	2.025	1.0	2.5	24.7	0.690	0.85	0.9
ANT 0	GSM 1900	GPRS 1 Slot	28.2	46.8	0.810	1.0	27.7	0.810	2.025	1.0	2.5	24.7	0.690	0.85	0.9
ANT 0	GSM 1900	GPRS 2 Slots	27.2	43.8	0.810	1.0	24.7	0.810	2.025	1.0	2.5	21.7	0.690	0.85	0.9
ANT 0	GSM 1900	GPRS 3 Slots	26.7	42.0	0.810	1.0	22.9	0.810	2.025	1.0	2.5	19.9	0.690	0.85	0.9
ANT 0	GSM 1900	GPRS 4 Slots	25.7	40.8	0.810	1.0	21.7	0.810	2.025	1.0	2.5	18.7	0.690	0.85	0.9
ANT 0	GSM 1900	EGPRS 1 Slot	24.7	25.4	0.810	1.0	24.7	0.810	2.025	1.0	2.5	23.7	0.690	0.85	0.9
ANT 0	GSM 1900	EGPRS 2 Slots	23.7	24.4	0.810	1.0	23.7	0.810	2.025	1.0	2.5	21.7	0.690	0.85	0.9
ANT 0	GSM 1900	EGPRS 3 Slots	22.7	23.4	0.810	1.0	22.7	0.810	2.025	1.0	2.5	19.9	0.690	0.85	0.9
ANT 0	GSM 1900	EGPRS 4 Slots	21.7	22.4	0.810	1.0	21.7	0.810	2.025	1.0	2.5	18.7	0.690	0.85	0.9
ANT 2	GSM 1900	GMSK 1 Slot	29.0	31.8	0.790	1.0	28.8	0.790	1.975	1.0	2.5	27.6	0.680	0.86	1.0
ANT 2	GSM 1900	GPRS 1 Slot	29.0	31.8	0.790	1.0	28.8	0.790	1.975	1.0	2.5	27.6	0.680	0.86	1.0
ANT 2	GSM 1900	GPRS 2 Slots	28.0	28.8	0.790	1.0	25.8	0.790	1.975	1.0	2.5	25.1	0.680	0.86	1.0
ANT 2	GSM 1900	GPRS 3 Slots	27.5	27.0	0.790	1.0	24.0	0.790	1.975	1.0	2.5	23.3	0.680	0.86	1.0
ANT 2	GSM 1900	GPRS 4 Slots	26.5	25.8	0.790	1.0	22.8	0.790	1.975	1.0	2.5	22.1	0.680	0.86	1.0
ANT 2	GSM 1900	EGPRS 1 Slot	25.5	29.2	0.790	1.0	28.8	0.790	1.975	1.0	2.5	25.5	0.680	0.86	1.0
ANT 2	GSM 1900	EGPRS 2 Slots	24.5	26.2	0.790	1.0	25.8	0.790	1.975	1.0	2.5	24.5	0.680	0.86	1.0
ANT 2	GSM 1900	EGPRS 3 Slots	23.5	24.4	0.790	1.0	24.0	0.790	1.975	1.0	2.5	23.3	0.680	0.86	1.0
ANT 2	GSM 1900	EGPRS 4 Slots	22.5	23.2	0.790	1.0	22.8	0.790	1.975	1.0	2.5	22.1	0.680	0.86	1.0
ANT 0	W-CDMA B5	R99	24.3	28.8	0.760	1.0	26.2	0.760	1.900	1.0	2.5	25.5	0.640	0.84	1.2
ANT 0	W-CDMA B5	HSDPA	24.3	28.8	0.760	1.0	26.2	0.760	1.900	1.0	2.5	25.5	0.640	0.84	1.2
ANT 0	W-CDMA B5	HSUPA	24.3	28.8	0.760	1.0	26.2	0.760	1.900	1.0	2.5	25.5	0.640	0.84	1.2
ANT 0	W-CDMA B5	DC-HSDPA	24.3	28.8	0.760	1.0	26.2	0.760	1.900	1.0	2.5	25.5	0.640	0.84	1.2
ANT 1	W-CDMA B5	R99	24.0	22.1	0.780	1.0	27.4	0.780	1.950	1.0	2.5	26.7	0.660	0.85	1.1
ANT 1	W-CDMA B5	HSDPA	24.0	22.1	0.780	1.0	27.4	0.780	1.950	1.0	2.5	26.7	0.660	0.85	1.1
ANT 1	W-CDMA B5	HSUPA	24.0	22.1	0.780	1.0	27.4	0.780	1.950	1.0	2.5	26.7	0.660	0.85	1.1
ANT 1	W-CDMA B5	DC-HSDPA	24.0	22.1	0.780	1.0	27.4	0.780	1.950	1.0	2.5	26.7	0.660	0.85	1.1
ANT 0	W-CDMA B4	R99	23.2	33.2	0.780	1.0	18.8	0.780	1.950	1.0	2.5	17.5	0.660	0.85	1.1
ANT 0	W-CDMA B4	HSDPA	23.2	33.2	0.780	1.0	18.8	0.780	1.950	1.0	2.5	17.5	0.660	0.85	1.1
ANT 0	W-CDMA B4	HSUPA	23.2	33.2	0.780	1.0	18.8	0.780	1.950	1.0	2.5	17.5	0.660	0.85	1.1
ANT 0	W-CDMA B4	DC-HSDPA	23.2	33.2	0.780	1.0	18.8	0.780	1.950	1.0	2.5	17.5	0.660	0.85	1.1
ANT 2	W-CDMA B4	R99	24.0	32.0	0.760	1.0	20.8	0.760	1.900	1.0	2.5	20.1	0.640	0.84	1.2
ANT 2	W-CDMA B4	HSDPA	24.0	32.0	0.760	1.0	20.8	0.760	1.900	1.0	2.5	20.1	0.640	0.84	1.2
ANT 2	W-CDMA B4	HSUPA	24.0	32.0	0.760	1.0	20.8	0.760	1.900	1.0	2.5	20.1	0.640	0.84	1.2
ANT 2	W-CDMA B4	DC-HSDPA	24.0	32.0	0.760	1.0	20.8	0.760	1.900	1.0	2.5	20.1	0.640	0.84	1.2
ANT 0	W-CDMA B2	R99	23.2	34.7	0.780	1.0	18.9	0.780	1.950	1.0	2.5	17.2	0.660	0.85	1.1
ANT 0	W-CDMA B2	HSDPA	23.2	34.7	0.780	1.0	18.9	0.780	1.950	1.0	2.5	17.2	0.660	0.85	1.1
ANT 0	W-CDMA B2	HSUPA	23.2	34.7	0.780	1.0	18.9	0.780	1.950	1.0	2.5	17.2	0.660	0.85	1.1
ANT 0	W-CDMA B2	DC-HSDPA	23.2	34.7	0.780	1.0	18.9	0.780	1.950	1.0	2.5	17.2	0.660	0.85	1.1
ANT 2	W-CDMA B2	R99	24.0	23.3	0.760	1.0	20.8	0.760	1.900	1.0	2.5	20.1	0.640	0.84	1.2
ANT 2	W-CDMA B2	HSDPA	24.0	23.3	0.760	1.0	20.8	0.760	1.900	1.0	2.5	20.1	0.640	0.84	1.2
ANT 2	W-CDMA B2	HSUPA	24.0	23.3	0.760	1.0	20.8	0.760	1.900	1.0	2.5	20.1	0.640	0.84	1.2
ANT 2	W-CDMA B2	DC-HSDPA	24.0	23.3	0.760	1.0	20.8	0.760	1.900	1.0	2.5	20.1	0.640	0.84	1.2
ANT 0	LTE Band 71	PC3	24.3	29.8	0.830	1.0	27.5	0.830	2.075	1.0	2.5	26.3	0.710	0.85	0.8
ANT 1	LTE Band 71	PC3	24.0	23.3	0.850	1.0	29.3	0.850	2.125	1.0	2.5	28.6	0.720	0.85	0.7
ANT 0	LTE Band 12/17	PC3	24.3	28.9	0.830	1.0	27.5	0.830	2.075	1.0	2.5	25.0	0.710	0.85	0.8
ANT 1	LTE Band 12/17	PC3	24.0	22.4	0.850	1.0	28.6	0.850	2.125	1.0	2.5	26.9	0.720	0.85	0.7
ANT 0	LTE Band 13	PC3	24.3	27.6	0.830	1.0	26.1	0.830	2.075	1.0	2.5	25.4	0.710	0.85	0.8
ANT 1	LTE Band 13	PC3	24.0	22.0	0.850	1.0	26.6	0.850	2.125	1.0	2.5	25.9	0.720	0.85	0.7
ANT 0	LTE Band 14	PC3	24.3	27.3	0.830	1.0	26.5	0.830	2.075	1.0	2.5	25.8	0.710	0.85	0.8
ANT 1	LTE Band 14	PC3	24.0	22.2	0.850	1.0	27.1	0.850	2.125	1.0	2.5	26.4	0.720	0.85	0.7
ANT 0	LTE Band 26/5	PC3	24.3	28.9	0.830	1.0	27.7	0.830	2.075	1.0	2.5	27.0	0.710	0.85	0.8
ANT 1	LTE Band 26/5	PC3	24.0	22.5	0.850	1.0	27.4	0.850	2.125	1.0	2.5	26.7	0.720	0.85	0.7
ANT 0	LTE Band 66/4	PC3	23.2	32.2	0.830	1.0	19.2	0.830	2.075	1.0	2.5	17.8	0.710	0.85	0.8
ANT 1	LTE Band 66/4	PC3	24.0	18.3	0.810	1.0	27.2	0.810	2.025	1.0	2.5	23.3	0.690	0.85	0.9
ANT 2	LTE Band 66/4	PC3	24.0	26.1	0.810	1.0	22.7	0.810	2.025	1.0	2.5	22.0	0.690	0.85	0.9
ANT 5	LTE Band 66/4	PC3	24.0	14.7	0.890	1.0	19.9	0.890	2.225	1.0	2.5	18.6	0.760	0.85	0.5
ANT 0	LTE Band 25/2	PC3	23.2	35.7	0.830	1.0	18.8	0.830	2.075	1.0	2.5	17.0	0.710	0.85	0.8
ANT 1	LTE Band 25/2	PC3	24.0	15.1	0.810	1.0	20.6	0.810	2.025	1.0	2.5	19.9	0.690	0.85	0.9
ANT 2	LTE Band 25/2	PC3	24.0	23.6	0.810	1.0	22.8	0.810	2.025	1.0	2.5	22.1	0.690	0.85	0.9
ANT 5	LTE Band 25/2	PC3	24.0	15.8	0.890	1.0	21.2	0.890	2.225	1.0	2.5	19.7	0.760	0.85	0.5

Antenna	Technology	Mode	Pmax (Index 1)	Index 2	Head $SAR_{Design\ Target}$ (W/kg)	Head $SAR_{Design\ Limit}$ (W/kg)	Index 5	Body $SAR_{Design\ Target}$ (W/kg)	Extremity $SAR_{Design\ Target}$ (W/kg)	Body $SAR_{Design\ Limit}$ (W/kg)	Extremity $SAR_{Design\ Limit}$ (W/kg)	Index 4	Hotspot $SAR_{Design\ Target}$ (W/kg)	Hotspot $SAR_{Design\ Limit}$ (W/kg)	Total Uncertainty (dB)
ANT 0	LTE Band 30	PC3	22.2	31.9	0.780	1.0	20.5	0.780	1.950	1.0	2.5	17.8	0.660	0.85	1.1
ANT 2	LTE Band 30	PC3	23.0	26.8	0.810	1.0	22.9	0.810	2.025	1.0	2.5	22.2	0.690	0.85	0.9
ANT 0	LTE Band 7	PC3	23.8	34.0	0.810	1.0	20.6	0.810	2.025	1.0	2.5	17.1	0.690	0.85	0.9
ANT 2	LTE Band 7	PC3	24.2	22.3	0.810	1.0	20.9	0.810	2.025	1.0	2.5	20.2	0.690	0.85	0.9
ANT 0	LTE Band 41/38	PC3	25.8	34.4	0.810	1.0	23.4	0.810	2.025	1.0	2.5	20.0	0.690	0.85	0.9
ANT 0	LTE Band 41/38	PC2	29.6	36.0	0.810	1.0	25.0	0.810	2.025	1.0	2.5	21.6	0.690	0.85	0.9
ANT 2	LTE Band 41/38	PC3	26.2	25.3	0.810	1.0	25.6	0.810	2.025	1.0	2.5	23.5	0.690	0.85	0.9
ANT 2	LTE Band 41/38	PC2	29.2	26.9	0.810	1.0	27.2	0.810	2.025	1.0	2.5	25.1	0.690	0.85	0.9
ANT 6	LTE Band 48	PC3	23.3	33.2	0.780	1.0	24.5	0.780	1.950	1.0	2.5	23.8	0.660	0.85	1.1
ANT 7	LTE Band 48	PC3	23.5	35.8	0.650	1.0	24.4	0.650	1.625	1.0	2.5	23.7	0.550	0.85	1.9
ANT 0	NR n71	PC3	24.3	31.5	0.830	1.0	30.0	0.830	2.075	1.0	2.5	28.6	0.710	0.85	0.8
ANT 1	NR n71	PC3	24.0	26.3	0.850	1.0	35.4	0.850	2.125	1.0	2.5	28.8	0.720	0.85	0.7
ANT 0	NR n12	PC3	24.3	30.6	0.830	1.0	27.7	0.830	2.075	1.0	2.5	27.0	0.710	0.85	0.8
ANT 1	NR n12	PC3	24.0	22.7	0.850	1.0	34.3	0.850	2.125	1.0	2.5	27.6	0.720	0.85	0.7
ANT 0	NR n14	PC3	24.3	28.7	0.830	1.0	26.8	0.830	2.075	1.0	2.5	23.6	0.710	0.85	0.8
ANT 1	NR n14	PC3	24.0	23.0	0.850	1.0	32.0	0.850	2.125	1.0	2.5	23.3	0.720	0.85	0.7
ANT 0	NR n26/5	PC3	24.3	30.9	0.830	1.0	29.6	0.830	2.075	1.0	2.5	28.2	0.710	0.85	0.8
ANT 1	NR n26/5	PC3	24.0	22.3	0.850	1.0	28.9	0.850	2.125	1.0	2.5	28.2	0.720	0.85	0.7
ANT 0	NR n70	PC3	22.9	32.9	0.830	1.0	18.7	0.830	2.075	1.0	2.5	17.8	0.710	0.85	0.8
ANT 2	NR n70	PC3	23.7	28.6	0.810	1.0	21.6	0.810	2.025	1.0	2.5	20.9	0.690	0.85	0.9
ANT 0	NR n66	PC3	23.2	34.5	0.830	1.0	19.8	0.830	2.075	1.0	2.5	17.9	0.710	0.85	0.8
ANT 1	NR n66	PC3	24.0	19.0	0.810	1.0	25.7	0.810	2.025	1.0	2.5	23.3	0.690	0.85	0.9
ANT 2	NR n66	PC3	24.0	27.0	0.810	1.0	20.7	0.810	2.025	1.0	2.5	20.0	0.690	0.85	0.9
ANT 5	NR n66	PC3	24.0	16.8	0.890	1.0	21.6	0.890	2.225	1.0	2.5	20.9	0.760	0.85	0.5
ANT 0	NR n25/2	PC3	23.2	34.8	0.830	1.0	19.1	0.830	2.075	1.0	2.5	17.3	0.710	0.85	0.8
ANT 1	NR n25/2	PC3	24.0	14.6	0.810	1.0	20.9	0.810	2.025	1.0	2.5	20.2	0.690	0.85	0.9
ANT 2	NR n25/2	PC3	24.0	23.3	0.810	1.0	20.6	0.810	2.025	1.0	2.5	19.9	0.690	0.85	0.9
ANT 5	NR n25/2	PC3	24.0	17.0	0.890	1.0	21.6	0.890	2.225	1.0	2.5	20.9	0.760	0.85	0.5
ANT 0	NR n30	PC3	22.3	35.0	0.790	1.0	20.5	0.790	1.975	1.0	2.5	18.9	0.680	0.86	1.0
ANT 2	NR n30	PC3	23.0	26.0	0.810	1.0	20.6	0.810	2.025	1.0	2.5	19.9	0.690	0.85	0.9
ANT 0	NR n7	PC3	23.8	32.4	0.810	1.0	20.3	0.810	2.025	1.0	2.5	18.1	0.690	0.85	0.9
ANT 2	NR n7	PC3	24.2	21.6	0.810	1.0	19.0	0.810	2.025	1.0	2.5	18.3	0.690	0.85	0.9
ANT 0	NR n41/38	PC3	23.8	32.5	0.810	1.0	21.1	0.810	2.025	1.0	2.5	18.2	0.690	0.85	0.9
ANT 0	NR n41	PC2	28.0	35.5	0.810	1.0	24.1	0.810	2.025	1.0	2.5	21.2	0.690	0.85	0.9
ANT 0	NR n41	PC1P5	31.0	38.5	0.810	1.0	27.1	0.810	2.025	1.0	2.5	24.2	0.690	0.85	0.9
ANT 1	NR n41/38	PC3	24.1	16.4	0.810	1.0	25.1	0.810	2.025	1.0	2.5	23.1	0.690	0.85	0.9
ANT 1	NR n41	PC2	29.0	19.4	0.810	1.0	28.1	0.810	2.025	1.0	2.5	26.1	0.690	0.85	0.9
ANT 1	NR n41	PC1P5	32.0	22.4	0.810	1.0	31.1	0.810	2.025	1.0	2.5	29.1	0.690	0.85	0.9
ANT 2	NR n41/38	PC3	24.1	22.1	0.810	1.0	19.9	0.810	2.025	1.0	2.5	19.2	0.690	0.85	0.9
ANT 2	NR n41	PC2	29.0	25.1	0.810	1.0	22.9	0.810	2.025	1.0	2.5	22.2	0.690	0.85	0.9
ANT 2	NR n41	PC1P5	32.0	28.1	0.810	1.0	25.9	0.810	2.025	1.0	2.5	25.2	0.690	0.85	0.9
ANT 5	NR n41/38	PC3	24.1	18.1	0.890	1.0	29.6	0.890	2.225	1.0	2.5	23.8	0.760	0.85	0.5
ANT 5	NR n41	PC2	29.0	21.1	0.890	1.0	32.6	0.890	2.225	1.0	2.5	26.8	0.760	0.85	0.5
ANT 5	NR n41	PC1P5	31.0	24.1	0.710	1.0	35.6	0.710	1.775	1.0	2.5	29.8	0.600	0.85	1.5

Antenna	Technology	Mode	Pmax (Index 1)	Index 2	Head $SAR_{Design\ Target}$ (W/kg)	Head $SAR_{Design\ Limit}$ (W/kg)	Index 5	Body $SAR_{Design\ Target}$ (W/kg)	Extremity $SAR_{Design\ Target}$ (W/kg)	Body $SAR_{Design\ Limit}$ (W/kg)	Extremity $SAR_{Design\ Limit}$ (W/kg)	Index 4	Hotspot $SAR_{Design\ Target}$ (W/kg)	Hotspot $SAR_{Design\ Limit}$ (W/kg)	Total Uncertainty (dB)
ANT 1	NR n48	PC3	21.3	16.4	0.780	1.0	23.5	0.780	1.950	1.0	2.5	22.8	0.660	0.85	1.1
ANT 5	NR n48	PC3	22.5	16.6	0.810	1.0	25.8	0.810	2.025	1.0	2.5	21.5	0.690	0.85	0.9
ANT 6	NR n48	PC3	21.3	27.3	0.780	1.0	18.9	0.780	1.950	1.0	2.5	18.2	0.660	0.85	1.1
ANT 7	NR n48	PC3	21.5	31.0	0.650	1.0	18.4	0.650	1.625	1.0	2.5	17.7	0.550	0.85	1.9
ANT 1	NR n77/78 (Block A)	PC3	24.0	14.9	0.780	1.0	22.4	0.780	1.950	1.0	2.5	19.9	0.660	0.85	1.1
ANT 1	NR n77/78 (Block A)	PC2	28.0	17.9	0.780	1.0	25.4	0.780	1.950	1.0	2.5	22.9	0.660	0.85	1.1
ANT 1	NR n77/78 (Block A)	PC1P5	31.0	20.9	0.780	1.0	28.4	0.780	1.950	1.0	2.5	25.9	0.660	0.85	1.1
ANT 1	NR n77/78 (Block B)	PC3	24.0	14.9	0.780	1.0	22.4	0.780	1.950	1.0	2.5	19.9	0.660	0.85	1.1
ANT 1	NR n77/78 (Block B)	PC2	28.0	17.9	0.780	1.0	25.4	0.780	1.950	1.0	2.5	22.9	0.660	0.85	1.1
ANT 1	NR n77/78 (Block B)	PC1P5	31.0	20.9	0.780	1.0	28.4	0.780	1.950	1.0	2.5	25.9	0.660	0.85	1.1
ANT 1	NR n77/78 (Block C)	PC3	24.0	14.9	0.780	1.0	22.4	0.780	1.950	1.0	2.5	19.9	0.660	0.85	1.1
ANT 1	NR n77/78 (Block C)	PC2	28.0	17.9	0.780	1.0	25.4	0.780	1.950	1.0	2.5	22.9	0.660	0.85	1.1
ANT 1	NR n77/78 (Block C)	PC1P5	31.0	20.9	0.780	1.0	28.4	0.780	1.950	1.0	2.5	25.9	0.660	0.85	1.1
ANT 5	NR n77/78 (Block A)	PC3	24.0	16.6	0.810	1.0	22.6	0.810	2.025	1.0	2.5	21.9	0.690	0.85	0.9
ANT 5	NR n77/78 (Block A)	PC2	27.0	19.6	0.650	1.0	25.6	0.650	1.625	1.0	2.5	24.9	0.550	0.85	1.9
ANT 5	NR n77/78 (Block A)	PC1P5	31.0	22.6	0.810	1.0	28.6	0.810	2.025	1.0	2.5	27.9	0.690	0.85	0.9
ANT 5	NR n77/78 (Block B)	PC3	24.0	16.6	0.810	1.0	22.6	0.810	2.025	1.0	2.5	21.9	0.690	0.85	0.9
ANT 5	NR n77/78 (Block B)	PC2	27.0	19.6	0.650	1.0	25.6	0.650	1.625	1.0	2.5	24.9	0.550	0.85	1.9
ANT 5	NR n77/78 (Block B)	PC1P5	31.0	22.6	0.810	1.0	28.6	0.810	2.025	1.0	2.5	27.9	0.690	0.85	0.9
ANT 5	NR n77/78 (Block C)	PC3	24.0	16.6	0.810	1.0	22.6	0.810	2.025	1.0	2.5	21.9	0.690	0.85	0.9
ANT 5	NR n77/78 (Block C)	PC2	27.0	19.6	0.650	1.0	25.6	0.650	1.625	1.0	2.5	24.9	0.550	0.85	1.9
ANT 5	NR n77/78 (Block C)	PC1P5	31.0	22.6	0.810	1.0	28.6	0.810	2.025	1.0	2.5	27.9	0.690	0.85	0.9
ANT 6	NR n77/78 (Block A)	PC3	24.0	23.3	0.780	1.0	18.5	0.780	1.950	1.0	2.5	17.8	0.660	0.85	1.1
ANT 6	NR n77/78 (Block A)	PC2	29.0	26.3	0.780	1.0	21.5	0.780	1.950	1.0	2.5	20.8	0.660	0.85	1.1
ANT 6	NR n77/78 (Block A)	PC1P5	32.0	29.3	0.780	1.0	24.5	0.780	1.950	1.0	2.5	23.8	0.660	0.85	1.1
ANT 6	NR n77/78 (Block B)	PC3	24.0	23.3	0.780	1.0	18.5	0.780	1.950	1.0	2.5	17.8	0.660	0.85	1.1
ANT 6	NR n77/78 (Block B)	PC2	29.0	26.3	0.780	1.0	21.5	0.780	1.950	1.0	2.5	20.8	0.660	0.85	1.1
ANT 6	NR n77/78 (Block B)	PC1P5	32.0	29.3	0.780	1.0	24.5	0.780	1.950	1.0	2.5	23.8	0.660	0.85	1.1
ANT 6	NR n77/78 (Block C)	PC3	24.0	23.3	0.780	1.0	18.5	0.780	1.950	1.0	2.5	17.8	0.660	0.85	1.1
ANT 6	NR n77/78 (Block C)	PC2	29.0	26.3	0.780	1.0	21.5	0.780	1.950	1.0	2.5	20.8	0.660	0.85	1.1
ANT 6	NR n77/78 (Block C)	PC1P5	32.0	29.3	0.780	1.0	24.5	0.780	1.950	1.0	2.5	23.8	0.660	0.85	1.1
ANT 7	NR n77/78 (Block A)	PC3	22.8	28.4	0.650	1.0	18.1	0.650	1.625	1.0	2.5	17.4	0.550	0.85	1.9
ANT 7	NR n77/78 (Block A)	PC2	28.0	31.4	0.710	1.0	21.1	0.710	1.775	1.0	2.5	20.4	0.600	0.85	1.5
ANT 7	NR n77/78 (Block A)	PC1P5	30.8	34.4	0.680	1.0	24.1	0.680	1.700	1.0	2.5	23.4	0.570	0.84	1.7
ANT 7	NR n77/78 (Block B)	PC3	22.8	28.4	0.650	1.0	18.1	0.650	1.625	1.0	2.5	17.4	0.550	0.85	1.9
ANT 7	NR n77/78 (Block B)	PC2	28.0	31.4	0.710	1.0	21.1	0.710	1.775	1.0	2.5	20.4	0.600	0.85	1.5
ANT 7	NR n77/78 (Block B)	PC1P5	30.8	34.4	0.680	1.0	24.1	0.680	1.700	1.0	2.5	23.4	0.570	0.84	1.7
ANT 7	NR n77/78 (Block C)	PC3	22.8	28.4	0.650	1.0	18.1	0.650	1.625	1.0	2.5	17.4	0.550	0.85	1.9
ANT 7	NR n77/78 (Block C)	PC2	28.0	31.4	0.710	1.0	21.1	0.710	1.775	1.0	2.5	20.4	0.600	0.85	1.5
ANT 7	NR n77/78 (Block C)	PC1P5	30.8	34.4	0.680	1.0	24.1	0.680	1.700	1.0	2.5	23.4	0.570	0.84	1.7
ANT 1	NTN S-Band	N/A	22.5	N/A	N/A	N/A	22.0	0.790	1.975	1.0	2.5	N/A	N/A	N/A	1.0
ANT 5	NTN L-Band	N/A	23.6	N/A	N/A	N/A	24.6	0.790	1.975	1.0	2.5	N/A	N/A	N/A	1.0

4.4. SAR Characterization

Referring to the initial FCC submission, the worst-case *reported* SAR for each antenna/technology/band/Indices is summarized in Table 4-2:

Table 4-2: Worst-case *reported* SAR

Tech/Band	Antenna				Worst-case SAR (W/kg)				Nominal (dBm) + Uncertainty (dBm)			
	Head	Body-worn	Hotspot	Extremity	Head	Body-worn	Hotspot	Extremity	Head	Body-worn	Hotspot	Extremity
	Index 2	Index 5	Index 4	Index 5	Index 2	Index 5	Index 4	Index 5	Index 2	Index 5	Index 4	Index 5
GSM 850 4 slots	ANT 1	ANT 1	ANT 1	N/A	0.560	0.665	0.566	N/A	24.10	30.10	29.40	N/A
GSM 1900 4 slots	ANT 2	ANT 0	ANT 0	N/A	0.519	0.750	0.393	N/A	26.80	22.60	19.60	N/A
W-CDMA B2	ANT 2	ANT 0	ANT 0	N/A	0.717	0.812	0.635	N/A	24.50	20.00	18.30	N/A
W-CDMA B4	ANT 2	ANT 0	ANT 0	N/A	0.157	0.678	0.714	N/A	25.20	19.90	18.60	N/A
W-CDMA B5	ANT 1	ANT 0	ANT 0	N/A	0.731	0.651	0.651	N/A	23.20	25.50	25.50	N/A
LTE Band 7	ANT 2	ANT 0	ANT 0	ANT 0	0.732	0.984	0.768	2.367	23.20	21.50	18.00	21.50
LTE Band 12/17	ANT 1	ANT 0	ANT 0	N/A	0.791	0.484	0.633	N/A	23.10	25.10	25.10	N/A
LTE Band 13	ANT 1	ANT 0	ANT 0	N/A	0.720	0.630	0.630	N/A	22.70	25.10	25.10	N/A
LTE Band 14	ANT 1	ANT 0	ANT 0	N/A	0.652	0.538	0.538	N/A	22.90	25.10	25.10	N/A
LTE Band 25/2	ANT 1	ANT 0	ANT 2	N/A	0.770	0.939	0.846	N/A	16.00	20.00	23.00	N/A
LTE Band 26/5	ANT 1	ANT 1	ANT 1	N/A	0.872	0.462	0.462	N/A	23.20	24.70	24.70	N/A
LTE Band 30	ANT 2	ANT 0	ANT 2	ANT 0	0.418	0.903	0.794	2.469	23.60	21.60	23.10	21.60
LTE Band 41	ANT 2	ANT 0	ANT 0	ANT 0	0.809	0.827	0.793	2.044	25.10	24.30	20.90	24.30
LTE Band 41 (PC2)	ANT 0	N/A	N/A	N/A	0.065	N/A	N/A	N/A	26.90	N/A	N/A	N/A
LTE Band 48	ANT 6	ANT 7	ANT 7	N/A	0.065	0.484	0.484	N/A	22.40	23.40	23.40	N/A
LTE Band 66/4	ANT 1	ANT 0	ANT 0	N/A	0.635	0.937	0.791	N/A	19.20	20.00	18.60	N/A
LTE Band 71	ANT 1	ANT 0	ANT 0	N/A	0.783	0.481	0.535	N/A	24.00	25.10	25.10	N/A
NTN S-Band	N/A	ANT 1	N/A	ANT 1	N/A	0.986	N/A	2.335	N/A	23.00	N/A	23.00
NTN L-Band	N/A	ANT 5	N/A	ANT 5	N/A	0.495	N/A	1.899	N/A	24.60	N/A	24.60
NR n7	ANT 2	ANT 0	ANT 0	ANT 0	0.558	0.842	0.759	1.422	22.50	21.20	19.00	21.20
NR n12	ANT 1	ANT 0	ANT 0	N/A	0.797	0.454	0.454	N/A	23.40	25.10	25.10	N/A
NR n14	ANT 1	ANT 0	ANT 0	N/A	0.735	0.571	0.486	N/A	23.70	25.10	24.40	N/A
NR n25/2	ANT 2	ANT 0	ANT 0	N/A	0.489	0.848	0.603	N/A	24.20	19.90	18.10	N/A
NR n26/5	ANT 1	ANT 1	ANT 1	N/A	0.765	0.323	0.323	N/A	23.00	24.70	24.70	N/A
NR n30	ANT 2	ANT 0	ANT 2	N/A	0.689	0.810	0.821	N/A	23.90	21.50	20.80	N/A
NR n41	ANT 2	ANT 0	ANT 0	ANT 0	0.734	0.815	0.792	0.778	23.00	22.00	19.10	22.00
NR n48	ANT 5	ANT 1	ANT 1	N/A	0.517	0.599	0.599	N/A	17.50	22.40	22.40	N/A
NR n66	ANT 1	ANT 0	ANT 0	N/A	0.720	0.962	0.697	N/A	19.90	20.60	18.70	N/A
NR n70	ANT 2	ANT 0	ANT 0	N/A	0.375	0.669	0.709	N/A	24.60	19.50	18.60	N/A
NR n71	ANT 1	ANT 0	ANT 0	N/A	0.595	0.265	0.313	N/A	24.70	25.10	25.10	N/A
NR n77 (Block A) PC3	ANT 1	ANT 1	ANT 1	ANT 1	0.549	0.671	0.778	1.775	16.00	23.50	21.00	23.50
NR n77 (Block B) PC3	ANT 1	ANT 1	ANT 6	N/A	0.613	0.680	0.504	N/A	16.00	23.50	18.90	N/A
NR n77 (Block C) PC3	ANT 1	ANT 1	ANT 6	N/A	0.598	0.386	0.297	N/A	16.00	23.50	18.90	N/A

Using the reported SAR listed in Table 4-2, 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/Indices as:

1. For Indices= 5, P_{limit} is calculated based on 10-g SAR extremity evaluation at 0 mm spacing.
2. For Indices= 2, P_{limit} is calculated based on 1-g SAR head exposure evaluation.
3. For Indices = 4, P_{limit} is calculated based on Hotspot 1-g SAR evaluation at 10 mm spacing.
4. For Indices = 5, the worst-case SAR exposure is determined as maximum normalized SAR among body-worn SAR (normalized, i.e., Body-worn SAR divided by the FCC 1-g SAR limit) and extremity SAR measured at 0 mm (normalized, i.e., Extremity SAR divided by the FCC 10-g SAR limit). Therefore, the P_{limit} for Indices = 5 case is calculated and given by:

$$P_{limit} = \min\{\, \mathrm{P}_{limit} \text{ corresponding to body worn 1gSAR evaluation at 10 mm spacing,} \\ P_{limit} \text{ corresponding to 10-g SAR extremity evaluation at 0 mm spacing,} \\ P_{max} \text{maximum RF tuneup power for the case that the SAR test is excluded}\}$$

The SAR Char is listed in Table 4-3.

Table 4-3: SAR Characterization

Exposure Scenario		Duty Cycle	Head		Body-worn		Hotspot		Extremity		P_{max} (dBm)	
Spatial-average			1-g		1-g		1-g		10-g			
Test Distance			0 mm		10 mm		10 mm		0 mm			
Power Mode (DSI)			Index 2		Index 5		Index 4		Index 5			
Antenna	Tech/Band		P_{limit} (dBm)	P_{limit} (dBm)	P_{limit} (dBm)	P_{limit} (dBm)	P_{limit} (dBm)	P_{limit} (dBm)	P_{limit} (dBm)	P_{limit} (dBm)		
			Burst Average	Frame Average	Burst Average	Frame Average	Burst Average	Frame Average	Burst Average	Frame Average	Burst Average	Frame Average
ANT 0	GSM 850 GPRS 4 Slots	50.0%	28.00	24.99	27.00	23.99	26.30	23.29	27.00	23.99	29.50	26.49
	GSM 1900 GPRS 4 Slots	50.0%	40.80	37.79	21.70	18.69	18.70	15.69	21.70	18.69	25.70	22.69
	W-CDMA B2	100.0%	34.70	34.70	18.90	18.90	17.20	17.20	18.90	18.90	23.20	23.20
	W-CDMA B4	100.0%	33.20	33.20	18.80	18.80	17.50	17.50	18.80	18.80	23.20	23.20
	W-CDMA B5	100.0%	28.80	28.80	26.20	26.20	25.50	25.50	26.20	26.20	24.30	24.30
	LTE Band 7	100.0%	34.00	34.00	20.60	20.60	17.10	17.10	20.60	20.60	23.80	23.80
	LTE Band 12/17	100.0%	28.90	28.90	27.50	27.50	25.00	25.00	27.50	27.50	24.30	24.30
	LTE Band 13	100.0%	27.60	27.60	26.10	26.10	25.40	25.40	26.10	26.10	24.30	24.30
	LTE Band 14	100.0%	27.30	27.30	26.50	26.50	25.80	25.80	26.50	26.50	24.30	24.30
	LTE Band 25/2	100.0%	35.70	35.70	18.80	18.80	17.00	17.00	18.80	18.80	23.20	23.20
	LTE Band 26/5	100.0%	28.90	28.90	27.70	27.70	27.00	27.00	27.70	27.70	24.30	24.30
	LTE Band 30	100.0%	31.90	31.90	20.50	20.50	17.80	17.80	20.50	20.50	22.20	22.20
	LTE Band 41/38	63.3%	34.40	32.41	23.40	21.41	20.00	18.01	23.40	21.41	25.80	23.81
	LTE Band 41 (PC2)	43.3%	36.00	32.36	25.00	21.36	21.60	17.96	25.00	21.36	29.60	25.96
	LTE Band 66/4	100.0%	32.20	32.20	19.20	19.20	17.80	17.80	19.20	19.20	23.20	23.20
	LTE Band 71	100.0%	29.80	29.80	27.50	27.50	26.30	26.30	27.50	27.50	24.30	24.30
	NR n7	100.0%	32.40	32.40	20.30	20.30	18.10	18.10	20.30	20.30	23.80	23.80
	NR n12	100.0%	30.60	30.60	27.70	27.70	27.00	27.00	27.70	27.70	24.30	24.30
	NR n14	100.0%	28.70	28.70	26.80	26.80	23.60	23.60	26.80	26.80	24.30	24.30
	NR n25/2	100.0%	34.80	34.80	19.10	19.10	17.30	17.30	19.10	19.10	23.20	23.20
	NR n26/5	100.0%	30.90	30.90	29.60	29.60	28.20	28.20	29.60	29.60	24.30	24.30
	NR n30	100.0%	35.00	35.00	20.50	20.50	18.90	18.90	20.50	20.50	22.30	22.30
	NR n66	100.0%	34.50	34.50	19.80	19.80	17.90	17.90	19.80	19.80	23.20	23.20
	NR n70	100.0%	32.90	32.90	18.70	18.70	17.80	17.80	18.70	18.70	22.90	22.90
	NR n71	100.0%	31.50	31.50	30.00	30.00	28.60	28.60	30.00	30.00	24.30	24.30
ANT 1	GSM 850 GPRS 4 Slots	50.0%	23.20	20.19	31.00	27.99	28.50	25.49	31.00	27.99	29.20	26.19
	W-CDMA B5	100.0%	22.10	22.10	27.40	27.40	26.70	26.70	27.40	27.40	24.00	24.00
	LTE Band 12/17	100.0%	22.40	22.40	28.60	28.60	26.90	26.90	28.60	28.60	24.00	24.00
	LTE Band 13	100.0%	22.00	22.00	26.60	26.60	25.90	25.90	26.60	26.60	24.00	24.00
	LTE Band 14	100.0%	22.20	22.20	27.10	27.10	26.40	26.40	27.10	27.10	24.00	24.00
	LTE Band 25/2	100.0%	15.10	15.10	20.60	20.60	19.90	19.90	20.60	20.60	24.00	24.00
	LTE Band 26/5	100.0%	22.50	22.50	27.40	27.40	26.70	26.70	27.40	27.40	24.00	24.00
	LTE Band 66/4	100.0%	18.30	18.30	27.20	27.20	23.30	23.30	27.20	27.20	24.00	24.00
	LTE Band 71	100.0%	23.30	23.30	29.30	29.30	28.60	28.60	29.30	29.30	24.00	24.00
	NTN S-Band	100.0%	N/A	N/A	22.00	22.00	N/A	N/A	22.00	22.00	22.50	22.50
	NR n12	100.0%	22.70	22.70	34.30	34.30	27.60	27.60	34.30	34.30	24.00	24.00
	NR n14	100.0%	23.00	23.00	32.00	32.00	23.30	23.30	32.00	32.00	24.00	24.00
	NR n25/2	100.0%	14.60	14.60	20.90	20.90	20.20	20.20	20.90	20.90	24.00	24.00
	NR n26/5	100.0%	22.30	22.30	28.90	28.90	28.20	28.20	28.90	28.90	24.00	24.00
	NR n41/38	100.0%	16.40	16.40	25.10	25.10	23.10	23.10	25.10	25.10	24.10	24.10
	NR n48	100.0%	16.40	16.40	23.50	23.50	22.80	22.80	23.50	23.50	21.30	21.30
	NR n66	100.0%	19.00	19.00	25.70	25.70	23.30	23.30	25.70	25.70	24.00	24.00
	NR n71	100.0%	26.30	26.30	35.40	35.40	28.80	28.80	35.40	35.40	24.00	24.00
	NR n77/78 (Block A)	100.0%	14.90	14.90	22.40	22.40	19.90	19.90	22.40	22.40	24.00	24.00
	NR n77/78 (Block B)	100.0%	14.90	14.90	22.40	22.40	19.90	19.90	22.40	22.40	24.00	24.00
	NR n77/78 (Block C)	100.0%	14.90	14.90	22.40	22.40	19.90	19.90	22.40	22.40	24.00	24.00

Exposure Scenario		Duty Cycle	Head		Body-worn		Hotspot		Extremity		P_{max} (dBm)	
Spatial-average			1-g		1-g		1-g		10-g			
Test Distance			0 mm		10 mm		10 mm		0 mm			
Power Mode (DSI)			Index 2		Index 5		Index 4		Index 5			
Antenna	Tech/Band		P_{limit} (dBm)	P_{limit} (dBm)	P_{limit} (dBm)	P_{limit} (dBm)	P_{limit} (dBm)	P_{limit} (dBm)	P_{limit} (dBm)	P_{limit} (dBm)		
			Burst Average	Frame Average	Burst Average	Frame Average	Burst Average	Frame Average	Burst Average	Frame Average	Burst Average	Frame Average
ANT 2	GSM 1900 GPRS 4 Slots	50.0%	25.80	22.79	22.80	19.79	22.10	19.09	22.80	19.79	26.50	23.49
	W-CDMA B2	100.0%	23.30	23.30	20.80	20.80	20.10	20.10	20.80	20.80	24.00	24.00
	W-CDMA B4	100.0%	32.00	32.00	20.80	20.80	20.10	20.10	20.80	20.80	24.00	24.00
	LTE Band 7	100.0%	22.30	22.30	20.90	20.90	20.20	20.20	20.90	20.90	24.20	24.20
	LTE Band 25/2	100.0%	23.60	23.60	22.80	22.80	22.10	22.10	22.80	22.80	24.00	24.00
	LTE Band 30	100.0%	26.80	26.80	22.90	22.90	22.20	22.20	22.90	22.90	23.00	23.00
	LTE Band 41/38	63.3%	25.30	23.31	25.60	23.61	23.50	21.51	25.60	23.61	26.20	24.21
	LTE Band 66/4	100.0%	26.10	26.10	22.70	22.70	22.00	22.00	22.70	22.70	24.00	24.00
	NR n7	100.0%	21.60	21.60	19.00	19.00	18.30	18.30	19.00	19.00	24.20	24.20
	NR n25/2	100.0%	23.30	23.30	20.60	20.60	19.90	19.90	20.60	20.60	24.00	24.00
	NR n30	100.0%	26.00	26.00	20.60	20.60	19.90	19.90	20.60	20.60	23.00	23.00
	NR n41	100.0%	22.10	22.10	19.90	19.90	19.20	19.20	19.90	19.90	24.10	24.10
	NR n66	100.0%	27.00	27.00	20.70	20.70	20.00	20.00	20.70	20.70	24.00	24.00
	NR n70	100.0%	28.60	28.60	21.60	21.60	20.90	20.90	21.60	21.60	23.70	23.70
ANT 5	LTE Band 25/2	100.0%	15.80	15.80	21.20	21.20	19.70	19.70	21.20	21.20	24.00	24.00
	LTE Band 66/4	100.0%	14.70	14.70	19.90	19.90	18.60	18.60	19.90	19.90	24.00	24.00
	NTN L-Band	100.0%	N/A	N/A	24.60	24.60	N/A	N/A	24.60	24.60	23.60	23.60
	NR n25/2	100.0%	17.00	17.00	21.60	21.60	20.90	20.90	21.60	21.60	24.00	24.00
	NR n41	100.0%	18.10	18.10	29.60	29.60	23.80	23.80	29.60	29.60	24.10	24.10
	NR n48	100.0%	16.60	16.60	25.80	25.80	21.50	21.50	25.80	25.80	22.50	22.50
	NR n66	100.0%	16.80	16.80	21.60	21.60	20.90	20.90	21.60	21.60	24.00	24.00
	NR n77/78 (Block A)	100.0%	16.60	16.60	22.60	22.60	21.90	21.90	22.60	22.60	24.00	24.00
	NR n77/78 (Block B)	100.0%	16.60	16.60	22.60	22.60	21.90	21.90	22.60	22.60	24.00	24.00
	NR n77/78 (Block C)	100.0%	16.60	16.60	22.60	22.60	21.90	21.90	22.60	22.60	24.00	24.00
ANT 6	LTE Band 48	63.3%	33.20	31.21	24.50	22.51	23.80	21.81	24.50	22.51	23.30	21.31
	NR n48	100.0%	27.30	27.30	18.90	18.90	18.20	18.20	18.90	18.90	21.30	21.30
	NR n77/78 (Block A)	100.0%	23.30	23.30	18.50	18.50	17.80	17.80	18.50	18.50	24.00	24.00
	NR n77/78 (Block B)	100.0%	23.30	23.30	18.50	18.50	17.80	17.80	18.50	18.50	24.00	24.00
	NR n77/78 (Block C)	100.0%	23.30	23.30	18.50	18.50	17.80	17.80	18.50	18.50	24.00	24.00
ANT 7	LTE Band 48	63.3%	35.80	33.81	24.40	22.41	23.70	21.71	24.40	22.41	23.50	21.51
	NR n48	100.0%	31.00	31.00	18.40	18.40	17.70	17.70	18.40	18.40	21.50	21.50
	NR n77/78 (Block A)	100.0%	28.40	28.40	18.10	18.10	17.40	17.40	18.10	18.10	22.80	22.80
	NR n77/78 (Block B)	100.0%	28.40	28.40	18.10	18.10	17.40	17.40	18.10	18.10	22.80	22.80
	NR n77/78 (Block C)	100.0%	28.40	28.40	18.10	18.10	17.40	17.40	18.10	18.10	22.80	22.80

5. Power Density Characterization

The EUT's 5G mmW NR contains mmW antenna module(s) as shown in Figure 5-1; there is a total of 32 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.

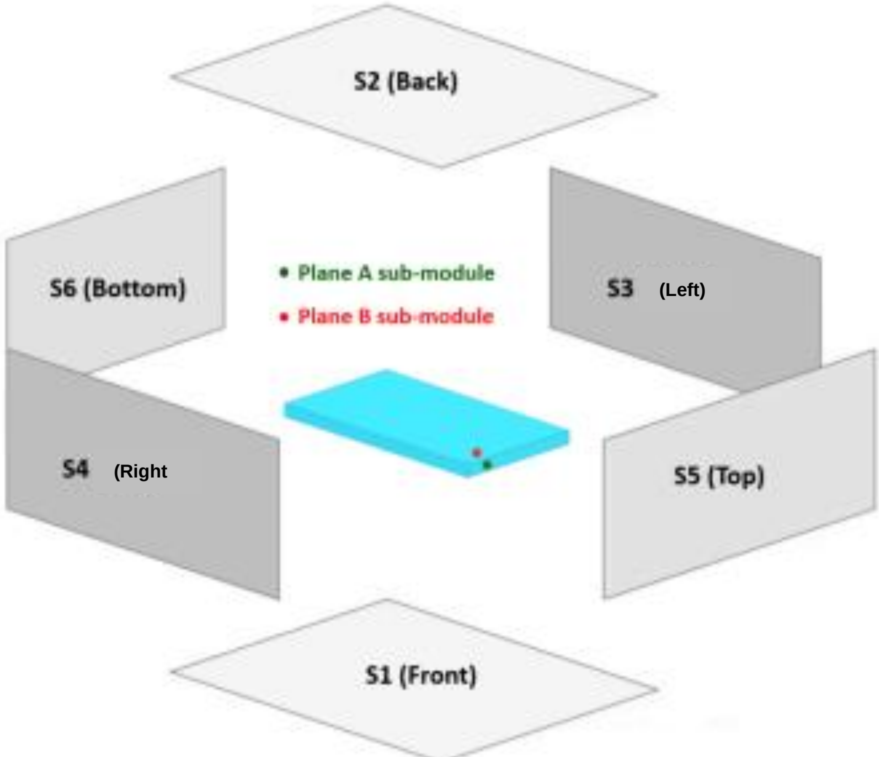

Figure 5-1: EUT with mmW antenna modules

5.1. 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=right, S4=left, S5=top,* and *S6=bottom* as shown in Figure 5-2) and the worst-case PD is determined by taking the maximum PD among all the evaluated surfaces for each beam/band.

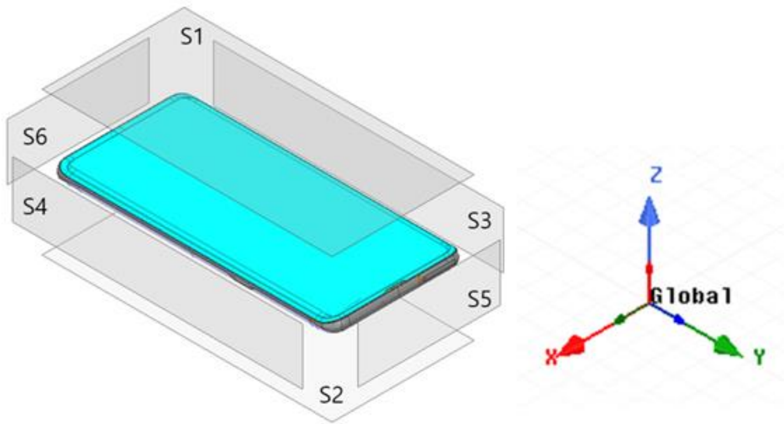

Figure 5-2: EUT surface definition

5.2. PD Characterization Overview

Parameters used in PD Characterization:

- The EUT supports a total of 21 beams per band, where 14 beams are single beams (SISO) and 7 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.
- ***P_{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 P_{limit} fed to antenna port(s) for all supported beams.

Figure 5-3 outlines the PD Char process.

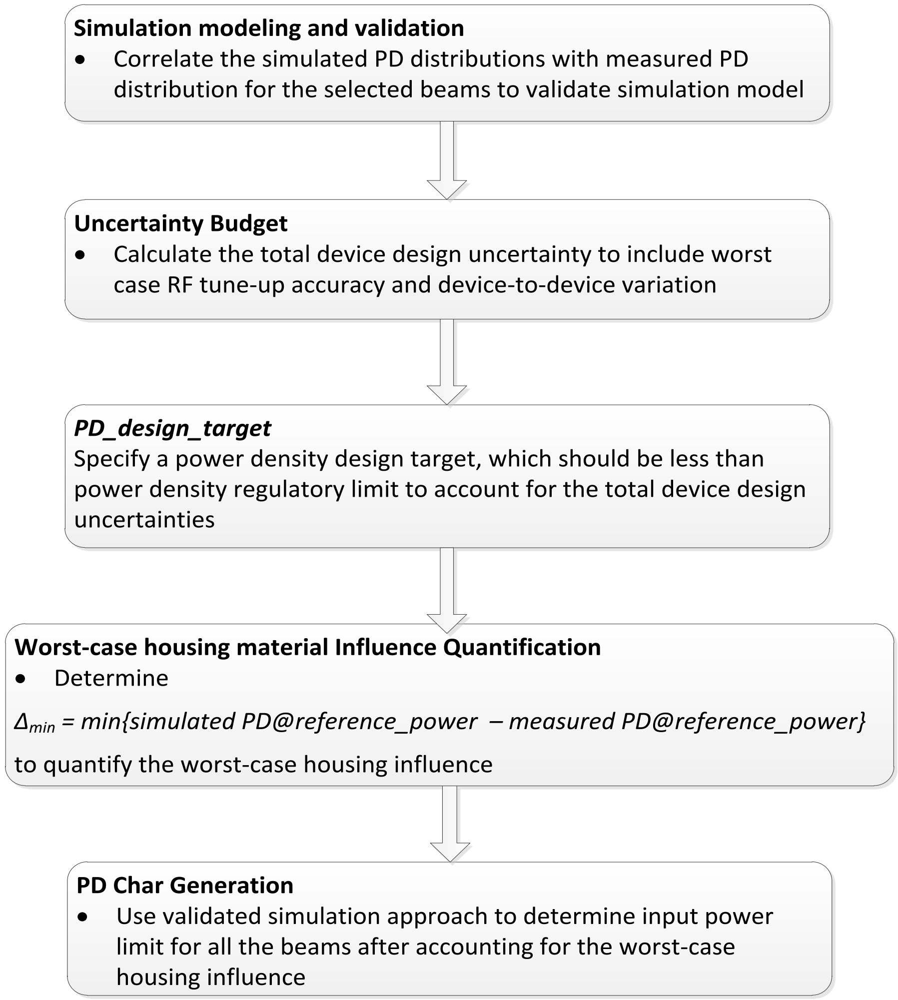

Figure 5-3 High level flow chart for power density characterization

5.3. 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 5-1 shows all the beams and their relevant information.

The PD evaluation needs to be performed for all the beams listed in Table 5-1.

Table 5-1: EUT Codebook

n258				
Polarity	Beam ID 1	Beam ID 2	Module/ Plane	# of Elements
H	0	0	A-Plane	4
	1	1	A-Plane	4
	2	2	A-Plane	4
	3	3	A-Plane	4
	4	4	A-Plane	4
	5	5	A-Plane	4
	6	6	A-Plane	4
V	0	0	A-Plane	4
	1	1	A-Plane	4
	2	2	A-Plane	4
	3	3	A-Plane	4
	4	4	A-Plane	4
	5	5	A-Plane	4
	6	6	A-Plane	4
H+V	0	0	A-Plane	8
	1	1	A-Plane	8
	2	2	A-Plane	8
	3	3	A-Plane	8
	4	4	A-Plane	8
	5	5	A-Plane	8
	6	6	A-Plane	8
H	0	0	B-Plane	4
	1	1	B-Plane	4
	2	2	B-Plane	4
	3	3	B-Plane	4
	4	4	B-Plane	4
	5	5	B-Plane	4
	6	6	B-Plane	4
V	0	0	B-Plane	4
	1	1	B-Plane	4
	2	2	B-Plane	4
	3	3	B-Plane	4
	4	4	B-Plane	4
	5	5	B-Plane	4
	6	6	B-Plane	4
H+V	0	0	B-Plane	8
	1	1	B-Plane	8
	2	2	B-Plane	8
	3	3	B-Plane	8
	4	4	B-Plane	8
	5	5	B-Plane	8
	6	6	B-Plane	8

n260				
Polarity	Beam ID 1	Beam ID 2	Module/ Plane	# of Elements
H	0	0	A-Plane	4
	1	1	A-Plane	4
	2	2	A-Plane	4
	3	3	A-Plane	4
	4	4	A-Plane	4
	5	5	A-Plane	4
	6	6	A-Plane	4
V	0	0	A-Plane	4
	1	1	A-Plane	4
	2	2	A-Plane	4
	3	3	A-Plane	4
	4	4	A-Plane	4
	5	5	A-Plane	4
	6	6	A-Plane	4
H+V	0	0	A-Plane	8
	1	1	A-Plane	8
	2	2	A-Plane	8
	3	3	A-Plane	8
	4	4	A-Plane	8
	5	5	A-Plane	8
	6	6	A-Plane	8
H	0	0	B-Plane	4
	1	1	B-Plane	4
	2	2	B-Plane	4
	3	3	B-Plane	4
	4	4	B-Plane	4
	5	5	B-Plane	4
	6	6	B-Plane	4
V	0	0	B-Plane	4
	1	1	B-Plane	4
	2	2	B-Plane	4
	3	3	B-Plane	4
	4	4	B-Plane	4
	5	5	B-Plane	4
	6	6	B-Plane	4
H+V	0	0	B-Plane	8
	1	1	B-Plane	8
	2	2	B-Plane	8
	3	3	B-Plane	8
	4	4	B-Plane	8
	5	5	B-Plane	8
	6	6	B-Plane	8

n261				
Polarity	Beam ID 1	Beam ID 2	Module/ Plane	# of Elements
H	0	0	A-Plane	4
	1	1	A-Plane	4
	2	2	A-Plane	4
	3	3	A-Plane	4
	4	4	A-Plane	4
	5	5	A-Plane	4
	6	6	A-Plane	4
V	0	0	A-Plane	4
	1	1	A-Plane	4
	2	2	A-Plane	4
	3	3	A-Plane	4
	4	4	A-Plane	4
	5	5	A-Plane	4
	6	6	A-Plane	4
H+V	0	0	A-Plane	8
	1	1	A-Plane	8
	2	2	A-Plane	8
	3	3	A-Plane	8
	4	4	A-Plane	8
	5	5	A-Plane	8
	6	6	A-Plane	8
H	0	0	B-Plane	4
	1	1	B-Plane	4
	2	2	B-Plane	4
	3	3	B-Plane	4
	4	4	B-Plane	4
	5	5	B-Plane	4
	6	6	B-Plane	4
V	0	0	B-Plane	4
	1	1	B-Plane	4
	2	2	B-Plane	4
	3	3	B-Plane	4
	4	4	B-Plane	4
	5	5	B-Plane	4
	6	6	B-Plane	4
H+V	0	0	B-Plane	8
	1	1	B-Plane	8
	2	2	B-Plane	8
	3	3	B-Plane	8
	4	4	B-Plane	8
	5	5	B-Plane	8
	6	6	B-Plane	8

5.4. Simulation and modeling validation

5.4.1. Modeling for Simulation

Device modeling is described in the operational description.

5.4.2. 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.

   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 5-1.

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 as well as the surfaces that are adjacent to the antenna array as they could potentially have strong radiating energy when considering the orientation of antenna array and type of antenna array (i.e., patch array or dipole 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.

The modeling validation is performed through correlating the simulated point PD distribution to measured point PD distribution.

The difference in 4cm^2-avg PD is not used for the purpose of validity of the modeling because the housing material property (for non-metal material) used in the simulation is an approximation (note the accurate material properties are not available at mmW frequencies). This discrepancies in PD magnitude will be used to determine the worst-case housing influence (due to non-metal material property uncertainty) in §5.6. The worst-case housing influence will be accounted for in PD Characterization generation for conservative RF exposure assessment, see §5.7 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 5-2.

Table 5-2: Beams and surfaces selection for PD correlation

Band	Module/ Plane	Pol	Beam ID 1	Beam ID 2	Surface
n258	A-Plane	H	N/A	0	S5 (Top)
		V	0	N/A	S5 (Top)
		H+V	4	4	S5 (Top)
	B-Plane	H	N/A	5	S2 (Back)
		V	2	N/A	S2 (Back)
		H+V	6	6	S2 (Back)
n260	A-Plane	H	N/A	1	S5 (Top)
		V	4	N/A	S5 (Top)
		H+V	6	6	S5 (Top)
	B-Plane	H	N/A	1	S2 (Back)
		V	4	N/A	S2 (Back)
		H+V	3	3	S2 (Back)
n261	A-Plane	H	N/A	5	S5 (Top)
		V	1	N/A	S5 (Top)
		H+V	0	0	S5 (Top)
	B-Plane	H	N/A	4	S2 (Back)
		V	2	N/A	S2 (Back)
		H+V	5	5	S2 (Back)

With an input power of 17.0 dBm for n258, n260, and n261, PD measurement and PD simulation are conducted for all beams and surfaces listed in Table 5-2. 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 5-3 lists the measured 4cm^2-averaged PD and simulated 4cm^2-averaged PD for all selected beams and surfaces for n258, n260, and n261. The discrepancy between simulated and measured PD value will be used to determine worst-case housing influence for conservative assessment (see Section 4.6).

Table 5-3: Measured and simulated 4cm² averaged PD for selected beams with 17 dBm input power

Band	Module/ Plane	Polarity	Beam ID 1	Beam ID 2	Surface	$4cm^2$ avg. PD (W/m^2)		Delta[1]
						Meas.	Sim	
n258	A-Plane	H	N/A	0	S5 (Top)	7.83	10.93	**1.45**
		V	0	N/A	S5 (Top)	17.40	13.86	**-0.99**
		H+V	4	4	S5 (Top)	20.70	23.11	**0.48**
	B-Plane	H	N/A	5	S2 (Back)	6.60	6.85	**0.16**
		V	2	N/A	S2 (Back)	5.55	5.78	**0.18**
		H+V	6	6	S2 (Back)	11.90	15.57	**1.17**
n260	A-Plane	H	N/A	1	S5 (Top)	11.50	10.42	**-0.43**
		V	4	N/A	S5 (Top)	14.90	11.44	**-1.15**
		H+V	6	6	S5 (Top)	17.80	21.90	**0.90**
	B-Plane	H	N/A	1	S2 (Back)	10.30	5.90	**-2.42**
		V	4	N/A	S2 (Back)	8.10	6.05	**-1.27**
		H+V	3	3	S2 (Back)	18.10	13.41	**-1.30**
n261	A-Plane	H	N/A	5	S5 (Top)	5.81	10.66	**2.64**
		V	1	N/A	S5 (Top)	6.21	11.48	**2.67**
		H+V	0	0	S5 (Top)	12.00	21.47	**2.53**
	B-Plane	H	N/A	4	S2 (Back)	3.54	6.79	**2.83**
		V	2	N/A	S2 (Back)	4.79	6.46	**1.30**
		H+V	5	5	S2 (Back)	7.62	16.35	**3.32**

[1]Delta = Sim - Meas (dB)

5.4.3. Simulation for power density

The model is validated in §5.4.3, 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 4-2, 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 and the type of antenna array, the surface planes identified for PD evaluation to determine the worst-case PD are selected and listed in Table 5-4.

Table 5-4: PD evaluation plane

Module/ Plane	Front	Back	Left	Right	Top	Bottom
	S1	S2	S3	S4	S5	S6
A-Plane	Yes	Yes	Yes	No	Yes	No
B-Plane	Yes	Yes	Yes	No	Yes	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 §5.4.2, 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 Appendix C to show that the PD hotspots are captured in this analysis.

5.5. $PD_{Design\ Target}$

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

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

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)
2.30	4.42	7.5

5.6. 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.

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 5-5. Thus, the worst-case housing influence, denoted as $\Delta_{min} = \mathrm{Sim.PD} - \mathrm{Meas.PD}$, is determined as:

Table 5-5: Δ_{min} for n258, n260, and n261

Band	Module/ Plane	Polarity	Δ_{min} (dB)
n258	A-Plane	H	**1.45**
		V	**-0.99**
		H+V	**0.48**
	B-Plane	H	**0.16**
		V	**0.18**
		H+V	**1.17**
n260	A-Plane	H	**-0.43**
		V	**-1.15**
		H+V	**0.90**
	B-Plane	H	**-2.42**
		V	**-1.27**
		H+V	**-1.30**
n261	A-Plane	H	**2.64**
		V	**2.67**
		H+V	**2.53**
	B-Plane	H	**2.83**
		V	**1.30**
		H+V	**3.32**

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 P_{limits} in PD char for compliance (see §5.7.3 for details).

5.7. PD Characterization

This section describes the PD Characterization generation that complies with the $PD_{Design\ Target}$ determined in §5.5 and complies the regulatory power density limit.

5.7.1. Scaling Factor for Single Beams

To determine the P_{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 5-1.

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:

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

4. Determine the simulated P_{limit}, $sim.power_{limit}$, for single beam i by:

$$sim.power_{limit}\ dBm = 10 * log_{10}\big(s(i)\big) + sim.input.power.at.active.port, i \in single\ beams$$

5.7.2. Scaling Factor for Beam Pairs

The relative phase between beam pair is not controlled in the modem's design 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*:

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

The simulated P_{limit}, $sim.power_{limit}$, for beam pair i can be determined by:

$$sim.power_{limit}\ dBm = 10 * log_{10}\big(s(i)\big) + sim.input.power.at.active.port, i \in beam\ pairs$$

5.7.3. P_{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 P_{limit}, denoted as $P_{limit}\ (i)$, for beam *i* can be obtained after accounting for the housing influence (Δ_{min}) determined in Table 5-5 of §5.6, given by:

$$P_{limit}\ (i) = sim.power_{limit}(i) + \ \Delta_{min},\ i \in all\ beams \quad (7)$$

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 5-5) 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 §5.6, the TxAGC uncertainty is embedded in the process of Δ_{min} determination. Since TxAGC uncertainty is already accounted for in $PD_{Design\ Target}$ (see §5.5), it needs to be removed to avoid double counting this uncertainty.

Thus, Equation 7 is modified to:

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

$$input.power.limit(i) = sim.power_{limit}(i),\ i \in all\ beams \quad (8)$$

else if Δ_{min} < -TxAGC uncertainty,

$$input.power.limit(i) = sim.power_{limit}(i) + \ (\Delta_{min} + \text{TxAGC uncertainty at reference power level}), i \in all\ beams \quad (9)$$

else if Δ_{min} > TxAGC uncertainty,

$$input.power.limit(i) = sim.power_{limit}(i) + (\Delta_{min} - \text{TxAGC uncertainty at reference power level}), i \in all\ beams \quad (10)$$

Following the logic above, the P_{limit} for this EUT can be calculated using Equations (8), (9) and (10), i.e.,

Table 5-6: P_{limit} calculation

Band	Module/Plane	Polarity	Δ_{min} (dB)	*Input.power.limit(i)* Equation	*Input.power.limit(i)* (dBm)
n258	A-Plane	H	**1.45**	sim.power_limit(i) + 0.45	13.36
		V	**-0.99**	sim.power_limit(i)	12.03
		H+V	**0.48**	sim.power_limit(i)	9.81
	B-Plane	H	**0.16**	sim.power_limit(i)	13.02
		V	**0.18**	sim.power_limit(i)	13.50
		H+V	**1.17**	sim.power_limit(i) + 0.17	9.94
n260	A-Plane	H	**-0.43**	sim.power_limit(i)	13.11
		V	**-1.15**	sim.power_limit(i) + -0.15	12.72
		H+V	**0.90**	sim.power_limit(i)	9.67
	B-Plane	H	**-2.42**	sim.power_limit(i) + -1.42	12.44
		V	**-1.27**	sim.power_limit(i) + -0.27	13.23
		H+V	**-1.30**	sim.power_limit(i) + -0.3	10.04
n261	A-Plane	H	**2.64**	sim.power_limit(i) + 1.64	14.79
		V	**2.67**	sim.power_limit(i) + 1.67	14.46
		H+V	**2.53**	sim.power_limit(i) + 1.53	11.51
	B-Plane	H	**2.83**	sim.power_limit(i) + 1.83	15.19
		V	**1.30**	sim.power_limit(i) + 0.3	13.82
		H+V	**3.32**	sim.power_limit(i) + 2.32	12.33

Thus, the EUT PD Char for n258, n260, and n261 is as shown in Table 5-7.

Table 5-7: PD Characterization

Module/ Plane	Polarity	Beam ID 1	Beam ID 2	n258 Input Power Limit (dBm)	n260 Input Power Limit (dBm)	n261 Input Power Limit (dBm)
A-Plane	H	N/A	0	9.81	9.67	11.51
		N/A	1			
		N/A	2			
		N/A	3			
		N/A	4			
		N/A	5			
		N/A	6			
	V	0	N/A			
		1	N/A			
		2	N/A			
		3	N/A			
		4	N/A			
		5	N/A			
		6	N/A			
	H+V	0	0			
		1	1			
		2	2			
		3	3			
		4	4			
		5	5			
		6	6			
B-Plane	H	N/A	0	9.94	10.04	12.33
		N/A	1			
		N/A	2			
		N/A	3			
		N/A	4			
		N/A	5			
		N/A	6			
	V	0	N/A			
		1	N/A			
		2	N/A			
		3	N/A			
		4	N/A			
		5	N/A			
		6	N/A			
	H+V	0	0			
		1	1			
		2	2			
		3	3			
		4	4			
		5	5			
		6	6			

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 P_{limits}

Table B-1 lists P_{limits} per channel per band for all the beams that EUT supports.

Table B-1: Simulated P_{limit} for n258, n260, and n261

Module/ Plane	Polarity	Beam ID 1	Beam ID 2	n258			n260			n261		
				Low	Mid	High	Low	Mid	High	Low	Mid	High
A-Plane	H	N/A	0	14.73	13.02	13.07	13.86	13.96	13.70	13.28	13.24	13.25
		N/A	1	13.70	13.00	13.65	13.23	13.27	13.22	13.45	13.28	13.15
		N/A	2	13.63	13.48	13.66	14.12	14.64	14.70	13.81	13.57	13.21
		N/A	3	13.90	13.92	13.56	15.76	15.42	14.97	14.14	13.94	13.70
		N/A	4	13.93	13.01	13.08	13.92	14.43	14.28	14.18	13.78	13.64
		N/A	5	14.79	13.05	13.56	13.95	13.64	13.45	13.45	13.17	13.23
		N/A	6	14.98	13.76	13.58	14.41	13.48	13.11	14.48	14.36	14.28
	V	0	N/A	15.12	12.57	12.47	14.05	14.34	14.12	12.79	12.95	13.07
		1	N/A	15.03	13.49	13.89	13.59	13.62	13.63	12.81	12.85	12.86
		2	N/A	14.07	12.79	13.24	13.84	14.08	14.13	13.33	13.23	13.21
		3	N/A	14.30	13.92	13.67	14.10	14.06	13.56	13.70	13.43	13.26
		4	N/A	13.78	12.78	12.89	13.11	12.87	12.95	13.96	13.80	13.64
		5	N/A	14.83	13.67	14.11	13.91	13.67	13.34	14.35	14.12	13.60
		6	N/A	16.04	13.39	13.62	13.79	13.10	13.18	15.80	15.74	14.84
	H+V	0	0	11.85	9.96	9.86	10.82	11.12	10.81	9.99	10.13	10.29
		1	1	10.31	9.95	10.44	9.67	10.33	10.00	10.06	10.14	10.07
		2	2	9.94	10.04	10.29	10.55	10.52	10.58	10.69	10.39	10.30
		3	3	10.12	10.87	10.57	10.98	11.43	11.02	10.49	10.23	10.13
		4	4	10.20	9.81	10.00	10.31	10.32	10.03	10.61	10.32	10.14
		5	5	11.12	10.10	10.90	10.46	10.26	10.20	10.65	10.24	9.98
		6	6	12.71	10.62	10.65	10.16	10.05	9.89	11.82	11.62	11.36
B-Plane	H	N/A	0	15.10	14.22	14.47	15.64	15.14	14.29	13.62	13.60	13.62
		N/A	1	14.87	14.54	13.97	15.17	14.20	14.26	13.64	13.67	13.72
		N/A	2	13.43	15.26	13.67	15.30	14.02	13.86	13.65	13.36	13.38
		N/A	3	15.70	14.52	14.63	15.35	14.64	14.34	13.56	13.50	13.46
		N/A	4	13.61	14.26	13.68	15.13	14.16	14.18	13.40	13.58	13.65
		N/A	5	14.96	14.10	13.72	15.59	14.93	14.55	14.07	14.30	14.36
		N/A	6	14.84	13.89	13.50	16.10	15.62	14.67	14.33	14.62	14.58
	V	0	N/A	14.91	15.07	14.01	14.88	14.20	13.65	13.78	13.69	13.90
		1	N/A	15.31	14.27	13.24	14.91	14.23	13.61	13.78	13.69	13.90
		2	N/A	15.17	13.95	12.63	14.92	14.18	13.89	13.64	13.56	13.52
		3	N/A	14.98	13.99	13.80	14.93	14.43	13.95	14.15	13.97	13.68
		4	N/A	14.40	14.14	13.29	14.55	13.54	13.50	13.87	13.86	13.89
		5	N/A	14.60	13.93	13.26	15.13	13.78	13.76	13.70	13.90	13.83
		6	N/A	14.41	14.20	13.43	16.12	14.76	14.18	13.82	14.17	14.38
	H+V	0	0	11.97	11.24	10.18	11.80	11.54	10.72	10.52	10.36	10.46
		1	1	11.37	11.11	10.08	11.51	10.90	10.71	10.29	10.36	10.33
		2	2	11.06	10.82	9.77	11.71	10.97	10.52	10.20	10.01	10.10
		3	3	11.88	10.95	10.59	11.28	10.61	10.38	10.60	10.37	10.20
		4	4	10.20	11.04	9.97	11.38	10.44	10.34	10.25	10.31	10.36
		5	5	11.33	10.63	10.11	11.61	10.98	10.82	10.14	10.22	10.36
		6	6	10.71	10.01	10.17	12.49	11.89	11.01	10.46	10.58	10.75

END OF REPORT