

# RF Exposure Report

## (Part 0: SAR and PD Char Evaluation)

FCC ID : IHDT56AA5  
Equipment : Mobile Cellular Phone  
Brand Name : Motorola  
Model Name : XT2215-1  
Applicant : Motorola Mobility LLC  
222 W, Merchandise Mart Plaza, Chicago IL 60654 USA  
Standard : FCC 47 CFR Part 2 (2.1093)

We, Sporton International Inc. (Shenzhen), would like to declare that the tested sample has been evaluated in accordance with the test procedures and has been in compliance with the applicable technical standards.

The test results in this report apply exclusively to the tested model / sample. Without written approval of Sporton International Inc. (Shenzhen), the test report shall not be reproduced except in full.



Reviewed by: Hank Huang / Supervisor



Approved by: Johnny Chen / Manager



**Sporton International Inc. (Shenzhen)**

1/F, 2/F, Bldg 5, Shiling Industrial Zone, Xinwei Village, Xili, Nanshan, Shenzhen, 518055  
People's Republic of China



**Table of Contents**

**1. Introduction ..... 4**

**2. Product Description ..... 5**

**3. SAR Characterization..... 6**

    3.1 SAR design target and uncertainty..... 6

    3.2 SAR Char Table ..... 7

**4. Power Density Characterization ..... 8**

    4.1 PD Char Table..... 8

    4.2 Codebook for all beams ..... 9

    4.3 PD\_design\_target determination.....14

    4.4 Exposure positions for PD evaluation .....15

    4.5 Simulation and modeling validation.....16

    4.6 PD Char .....17

    4.7 Simulated input power limit for single beams .....17

    4.8 Simulated input power limit for beam pairs .....18

    4.9 Worst-case housing influence determination.....19

    4.10 PD Char .....26

    4.11 PD char generation .....26

    4.12 PD char Table.....27

**5. PD Test Setup.....32**

    5.1 PD Test – System Setup .....32

    5.2 Test Site Location.....32

    5.3 EUmmWave Probe / E-Field 5G Probe.....33

    5.4 Data Acquisition Electronics (DAE) .....34

    5.5 Scan configuration .....34

    5.6 System Verification Source .....34

    5.7 Power Density System Verification.....35

    5.8 System Verification Results.....35

**6. Uncertainty Assessment .....36**



### History of this test report

Report No.	Version	Description	Issued Date
FA1N0903-01A	01	Initial issue of report	Feb. 23, 2022



## 1. Introduction

The FCC RF exposure limit is defined based on time-averaged RF exposure. The product implements Qualcomm Smart Transmit feature which controls the instantaneous transmitting power for WWAN transmitter to ensure the product in compliance with FCC RF exposure limit over a defined time window, for SAR (transmit frequency  $\leq 6\text{GHz}$ ) and power density (transmit frequency  $> 6\text{GHz}$ ) to control and manage transmitting power in real time and to ensure at all times the time-averaged RF exposure is compliant to the regulation requirement. Cannot operate without SAR and PD characterization at the device level, beforehand.

This report describes the procedures for the SAR char and PD char generation, and the parameters obtained from SAR and PD characterization (referred to as SAR char and PD char, respectively) will be used as input for Smart Transmit. Both SAR char and PD char will be entered via the Embedded File System (EFS) to enable the Smart Transmit Feature.

Terminologies in this report

$P_{\text{limit}}$	The time-averaged RF power which corresponds to SAR_design_target.
$P_{\text{max}}$	Maximum target power level
SAR_design_target:	The design target for SAR compliance. It should be less than regulatory power density limit to account for all device design related uncertainties.
SAR char	$P_{\text{limit}}$ for all the technologies/bands for all applicable DSI
PD_design_target:	The design target for PD compliance. It should be less than regulatory power density 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 char	The table that contains input.power.limit fed to antenna port(s) for all supported beams.



## 2. Product Description

Product Feature & Specification	
Equipment Name	Mobile Cellular Phone
FCC ID	IHDT56AA5
Wireless Technology and Frequency Range	GSM850: 824 MHz ~ 849 MHz GSM1900: 1850 MHz ~ 1910 MHz WCDMA Band II: 1850 MHz ~ 1910 MHz WCDMA Band V: 824 MHz ~ 849 MHz LTE Band 2: 1850 MHz ~ 1910 MHz LTE Band 4: 1710 MHz ~ 1755 MHz LTE Band 5: 824 MHz ~ 849 MHz LTE Band 7: 2500 MHz ~ 2570 MHz LTE Band 12: 699 MHz ~ 716 MHz LTE Band 13: 777 MHz ~ 787 MHz LTE Band 48: 3550 MHz ~ 3700 MHz LTE Band 66: 1710 MHz ~ 1780 MHz 5G NR n2 : 1850 MHz ~ 1910 MHz 5G NR n5 : 824 MHz ~ 849 MHz 5G NR n66 : 1710 MHz ~ 1780 MHz 5G NR n77 : 3450 MHz ~ 3550 MHz, 3700 MHz ~ 3980 MHz 5G NR n78 : 3450 MHz ~ 3550 MHz, 3700 MHz ~ 3800 MHz 5G NR n260 : 37 GHz~40 GHz 5G NR n261 : 27.5 GHz~28.35 GHz WLAN 2.4GHz Band: 2400 MHz ~ 2483.5 MHz WLAN 5.2GHz Band: 5150 MHz ~ 5250 MHz WLAN 5.3GHz Band: 5250 MHz ~ 5350 MHz WLAN 5.5GHz Band: 5470 MHz ~ 5725 MHz WLAN 5.8GHz Band: 5725 MHz ~ 5825 MHz Bluetooth: 2402 MHz ~ 2480 MHz NFC : 13.56 MHz
Mode	GSM/GPRS/EGPRS RMC/AMR 12.2Kbps HSDPA HSUPA DC-HSDPA HSPA+(16QAM uplink is not supported) LTE: QPSK, 16QAM, 64QAM, 256QAM 5G NR : CP-OFDM / DFT-s-OFDM, PI/2 BPSK, QPSK, 16QAM, 64QAM, 256QAM WLAN 2.4GHz 802.11b/g/n HT20/HT40 WLAN 2.4GHz 802.11ac VHT20/VHT40 WLAN 5GHz 802.11a/n HT20/HT40 WLAN 5GHz 802.11ac VHT20/VHT40/VHT80 Bluetooth BR/EDR/LE NFC: ASK

### 3. SAR Characterization

SAR char must be generated to cover all radio configurations and usage scenarios that the wireless device supports for operating at 6 GHz or below. It will then be used as input for Smart Transmit to control and manage RF exposure for  $f < 6$  GHz.

#### 3.1 SAR design target and uncertainty

Exposure conditions	DSI	Trigger conditions
Head SAR	DSI2	Earpiece On
Body Worn Sensor on	DSI3	Sensor On + WiFi Off
Body Worn Sensor on / Hotspot	DSI3	Sensor On+ WiFi On
Body Worn & Extremity Sensor Off	DSI4	Sensor Off
Extremity	DSI6	Sensor On + WiFi Off
Extremity	DSI6	Sensor On + WiFi On

Exposure Condition	SAR design target (W/kg)	Standalone		Simultaneous	
		Bottom Ant	Top Ant	Bottom Ant	Top Ant
Body Worn	1g SAR	1.01	1.01	1.01	0.49
Hotspot	1g SAR			1.01	0.49
Head	1g SAR	1.01	1.01	1.01	0.70
Extremity	10g SAR	2.52	2.52	2.52	1.26

Note: Hotspot belongs to the simultaneous transmission mode.

	Uncertainty dB (k=2)
Sub6 radio TxAGC	1.0
Device to device variation	1.2
Total uncertainty	1.5

To account for total uncertainty, SAR\_design\_target should be determined as:

$$SAR_{design\_target} < SAR_{regulatory\_limit} \times 10^{\frac{-total\ uncertainty}{10}}$$

### 3.2 SAR Char Table

SAR char must be generated to cover all radio configurations and usage scenarios that the wireless device supports for operating at 6 GHz or below. It will then be used as input for Smart Transmit to control and manage RF exposure for  $f < 6$  GHz.

**<P<sub>limit</sub> for supported technologies and bands (P<sub>limit</sub> in EFS file)>**

Band	Antenna	Head		Body Worn		Hotspot	Extremity		Sensor Off	P <sub>max</sub> *
		DSI2	DSI2_Sim TX	DSI3	DSI3_Sim TX	DSI3_Sim TX	DSI6	DSI6_Sim TX	DSI4	
GSM850(4 Tx slots)	1	35.3	35.3	24.0	24.0	24.0	28.8	28.8	26.0	26.0
GSM1900(3 Tx slots)	1	34.6	34.6	17.7	15.2	15.2	20.2	20.2	22.7	22.7
WCDMA V	1	30.0	30.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0
WCDMA II	1	33.2	33.2	16.5	15.0	15.0	19.5	19.5	23.0	23.0
LTE Band 12	1	32.1	32.1	25.2	25.2	25.2	23.0	23.0	23.0	23.0
LTE Band 12	2	24.5	21.5	25.6	22.5	22.5	23.0	23.0	23.0	23.0
LTE Band 13	1	31.4	31.4	25.2	25.2	25.2	23.0	23.0	23.0	23.0
LTE Band 13	2	22.5	21.0	25.2	21.5	21.5	23.0	23.0	23.0	23.0
LTE Band 5	1	30.4	30.4	23.0	23.0	23.0	24.3	24.3	23.0	23.0
LTE Band 5	2	22.0	20.5	23.0	20.5	20.5	25.1	24.3	23.0	23.0
LTE Band 66/4	1	31.0	31.0	17.0	15.5	15.5	21.0	21.0	23.0	23.0
LTE Band 66/4	2	23.0	20.5	23.0	20.0	20.0	23.0	19.5	23.0	23.0
LTE Band 2	1	33.0	33.0	16.5	15.5	15.5	20.0	20.0	23.0	23.0
LTE Band 2	2	21.0	19.5	21.0	18.0	18.0	23.0	20.0	23.0	23.0
LTE Band 7	1	38.4	38.4	15.5	14.0	14.0	18.5	18.5	23.0	23.0
LTE Band 48	4	22.4	20.5	17.5	14.5	14.5	17.5	14.5	21.0	21.0
FR1 N5	1	42.0	42.0	25.5	25.5	25.5	23.0	23.0	23.0	23.0
FR1 N5	2	24.5	21.5	26.3	22.0	22.0	23.0	23.0	23.0	23.0
FR1 N66	1	31.8	31.8	16.5	15.0	15.0	20.0	20.0	23.0	23.0
FR1 N66	2	24.8	22.0	25.6	21.5	21.5	23.0	23.0	23.0	23.0
FR1 N2	1	33.0	33.0	16.0	15.5	15.5	19.5	19.5	23.0	23.0
FR1 N2	2	22.0	20.5	21.5	19.0	19.0	22.0	19.0	23.0	23.0
FR1 N77 PC3/N78	4	21.5	20.0	14.0	11.0	11.0	16.5	13.5	23.0	23.0
FR1 N77 PC2	4	21.5	20.0	14.0	11.0	11.0	16.5	13.5	26.0	26.0
FR1 N77/N78 (SRS)	5	24.9	23.3	13.0	9.5	9.5	18.5	15.5	19.5	19.5
FR1 N77/N78 (SRS)	6	32.0	30.3	10.0	7.0	7.0	19.2	17.0	17.0	17.0
FR1 N77/N78 (SRS)	10	35.7	35.0	18.1	13.0	13.0	19.5	17.0	17.0	17.0

Note:

- 1) \*P<sub>max</sub> is used for RF tune up procedure. The maximum allowed output power is equal to P<sub>max</sub> + 1.0 dB uncertainty.
- 2) All P<sub>limit</sub> power levels entered in the Table correspond to average power levels after accounting for duty cycle in the case TDD modulation schemes (for e.g., GSM& LTE TDD & NR TDD).
- 3) The max allowed output power is the P<sub>limit</sub> + 1.0 dB device uncertainty, and if P<sub>limit</sub> is higher than P<sub>max</sub>, the device output power will be P<sub>max</sub> instead.
- 4) 5G NR n77/78 Ant 5/ Ant 6/ Ant 10 support SRS (Sounding Reference Signal) functionality.

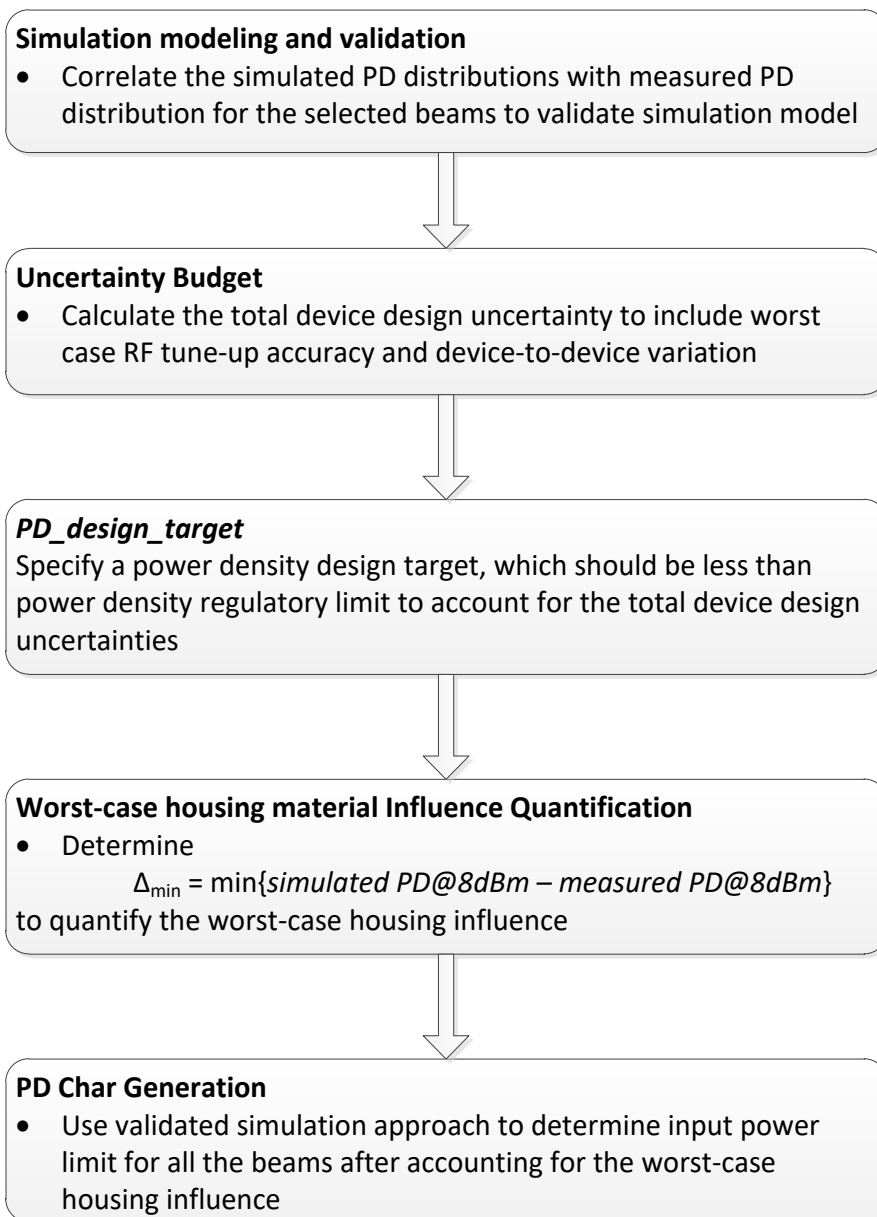
## 4. Power Density Characterization

The device with 5G mmW NR typically supports many beams and contains multiple mmW antenna arrays installed at different locations to achieve good coverage in the field. The power density (PD) measurement is a time-consuming test, and it is not practical to measure the power density for all the beams on all the surfaces of the device, thus a hybrid approach using electromagnetic (EM) simulation in combination with measurement is recommended for PD char generation

### 4.1 PD Char Table

The mmW device supports total N beams, where M out of N are single beams and the rest of (N-M) are beam pairs (where 2 single beams are excited at the same time).

The following figure outlines the PD char process.







**4.2 Codebook for all beams**

All the beams that the device supports are specified in the pre-defined codebook, and the codebook is device design specific and generated after evaluating radiation coverage from this particular device. In the field, a smartphone manages the beam selection and utilization based on this pre-defined codebook that is loaded and stored in the device.

Band	Beam ID 1	Beam ID 2	Antenna Module	Antenna Type	Feed No
n260	1		0	Patch	1
n260	3		0	Patch	1
n260	5		0	Patch	1
n260	7		0	Patch	1
n260	12		0	Patch	1
n260	13		0	Patch	2
n260	14		0	Patch	2
n260	15		0	Patch	2
n260	19		0	Patch	2
n260	20		0	Patch	2
n260	21		0	Patch	2
n260	27		0	Patch	4
n260	28		0	Patch	4
n260	29		0	Patch	4
n260	30		0	Patch	4
n260	31		0	Patch	4
n260	36		0	Patch	4
n260	37		0	Patch	4
n260	38		0	Patch	4
n260	39		0	Patch	4
n260		129	0	Patch	1
n260		131	0	Patch	1
n260		133	0	Patch	1
n260		135	0	Patch	1
n260		140	0	Patch	2
n260		141	0	Patch	2
n260		142	0	Patch	2
n260		143	0	Patch	2
n260		147	0	Patch	2
n260		148	0	Patch	2
n260		149	0	Patch	2
n260		155	0	Patch	4
n260		156	0	Patch	4
n260		157	0	Patch	4
n260		158	0	Patch	4
n260		159	0	Patch	4
n260		164	0	Patch	4
n260		165	0	Patch	4
n260		166	0	Patch	4
n260		167	0	Patch	4
n260	1	129	0	Patch	1x2
n260	3	131	0	Patch	1x2
n260	5	133	0	Patch	1x2
n260	7	135	0	Patch	1x2
n260	12	140	0	Patch	2x2
n260	13	141	0	Patch	2x2
n260	14	142	0	Patch	2x2
n260	15	143	0	Patch	2x2
n260	19	147	0	Patch	2x2
n260	20	148	0	Patch	2x2



n260	21	149	0	Patch	2x2
n260	27	155	0	Patch	4x2
n260	28	156	0	Patch	4x2
n260	29	157	0	Patch	4x2
n260	30	158	0	Patch	4x2
n260	31	159	0	Patch	4x2
n260	36	164	0	Patch	4x2
n260	37	165	0	Patch	4x2
n260	38	166	0	Patch	4x2
n260	39	167	0	Patch	4x2

Band	Beam ID 1	Beam ID 2	Antenna Module	Antenna Type	Feed No
n260	0		1	Patch	1
n260	2		1	Patch	1
n260	4		1	Patch	1
n260	6		1	Patch	1
n260	8		1	Patch	2
n260	9		1	Patch	2
n260	10		1	Patch	2
n260	11		1	Patch	2
n260	16		1	Patch	2
n260	17		1	Patch	2
n260	18		1	Patch	2
n260	22		1	Patch	4
n260	23		1	Patch	4
n260	24		1	Patch	4
n260	25		1	Patch	4
n260	26		1	Patch	4
n260	32		1	Patch	4
n260	33		1	Patch	4
n260	34		1	Patch	4
n260	35		1	Patch	4
n260		128	1	Patch	1
n260		130	1	Patch	1
n260		132	1	Patch	1
n260		134	1	Patch	1
n260		136	1	Patch	2
n260		137	1	Patch	2
n260		138	1	Patch	2
n260		139	1	Patch	2
n260		144	1	Patch	2
n260		145	1	Patch	2
n260		146	1	Patch	2
n260		150	1	Patch	4
n260		151	1	Patch	4
n260		152	1	Patch	4
n260		153	1	Patch	4
n260		154	1	Patch	4
n260		160	1	Patch	4
n260		161	1	Patch	4
n260		162	1	Patch	4
n260		163	1	Patch	4
n260	0	128	1	Patch	1x2
n260	2	130	1	Patch	1x2
n260	4	132	1	Patch	1x2
n260	6	134	1	Patch	1x2
n260	8	136	1	Patch	2x2



n260	9	137	1	Patch	2x2
n260	10	138	1	Patch	2x2
n260	11	139	1	Patch	2x2
n260	16	144	1	Patch	2x2
n260	17	145	1	Patch	2x2
n260	18	146	1	Patch	2x2
n260	22	150	1	Patch	4x2
n260	23	151	1	Patch	4x2
n260	24	152	1	Patch	4x2
n260	25	153	1	Patch	4x2
n260	26	154	1	Patch	4x2
n260	32	160	1	Patch	4x2
n260	33	161	1	Patch	4x2
n260	34	162	1	Patch	4x2
n260	35	163	1	Patch	4x2



Band	Beam ID 1	Beam ID 2	Antenna Module	Antenna Type	Feed No
n261	3		0	Patch	1
n261	4		0	Patch	1
n261	5		0	Patch	1
n261	9		0	Patch	2
n261	10		0	Patch	2
n261	11		0	Patch	2
n261	14		0	Patch	2
n261	15		0	Patch	2
n261	21		0	Patch	4
n261	22		0	Patch	4
n261	23		0	Patch	4
n261	24		0	Patch	4
n261	25		0	Patch	4
n261	30		0	Patch	4
n261	31		0	Patch	4
n261	32		0	Patch	4
n261	33		0	Patch	4
n261		131	0	Patch	1
n261		132	0	Patch	1
n261		133	0	Patch	1
n261		137	0	Patch	2
n261		138	0	Patch	2
n261		139	0	Patch	2
n261		142	0	Patch	2
n261		143	0	Patch	2
n261		149	0	Patch	4
n261		150	0	Patch	4
n261		151	0	Patch	4
n261		152	0	Patch	4
n261		153	0	Patch	4
n261		158	0	Patch	4
n261		159	0	Patch	4
n261		160	0	Patch	4
n261		161	0	Patch	4
n261	3	131	0	Patch	1x2
n261	4	132	0	Patch	1x2
n261	5	133	0	Patch	1x2
n261	9	137	0	Patch	2x2
n261	10	138	0	Patch	2x2
n261	11	139	0	Patch	2x2
n261	14	142	0	Patch	2x2
n261	15	143	0	Patch	2x2
n261	21	149	0	Patch	4x2
n261	22	150	0	Patch	4x2
n261	23	151	0	Patch	4x2
n261	24	152	0	Patch	4x2
n261	25	153	0	Patch	4x2
n261	30	158	0	Patch	4x2
n261	31	159	0	Patch	4x2
n261	32	160	0	Patch	4x2
n261	33	161	0	Patch	4x2



Band	Beam ID 1	Beam ID 2	Antenna Module	Antenna Type	Feed No
n261	0		1	Patch	1
n261	1		1	Patch	1
n261	2		1	Patch	1
n261	6		1	Patch	2
n261	7		1	Patch	2
n261	8		1	Patch	2
n261	12		1	Patch	2
n261	13		1	Patch	2
n261	16		1	Patch	4
n261	17		1	Patch	4
n261	18		1	Patch	4
n261	19		1	Patch	4
n261	20		1	Patch	4
n261	26		1	Patch	4
n261	27		1	Patch	4
n261	28		1	Patch	4
n261	29		1	Patch	4
n261		128	1	Patch	1
n261		129	1	Patch	1
n261		130	1	Patch	1
n261		134	1	Patch	2
n261		135	1	Patch	2
n261		136	1	Patch	2
n261		140	1	Patch	2
n261		141	1	Patch	2
n261		144	1	Patch	4
n261		145	1	Patch	4
n261		146	1	Patch	4
n261		147	1	Patch	4
n261		148	1	Patch	4
n261		154	1	Patch	4
n261		155	1	Patch	4
n261		156	1	Patch	4
n261		157	1	Patch	4
n261	0	128	1	Patch	1x2
n261	1	129	1	Patch	1x2
n261	2	130	1	Patch	1x2
n261	6	134	1	Patch	2x2
n261	7	135	1	Patch	2x2
n261	8	136	1	Patch	2x2
n261	12	140	1	Patch	2x2
n261	13	141	1	Patch	2x2
n261	16	144	1	Patch	4x2
n261	17	145	1	Patch	4x2
n261	18	146	1	Patch	4x2
n261	19	147	1	Patch	4x2
n261	20	148	1	Patch	4x2
n261	26	154	1	Patch	4x2
n261	27	155	1	Patch	4x2
n261	28	156	1	Patch	4x2
n261	29	157	1	Patch	4x2

**4.3 PD design target determination**

To account for total uncertainty, PD\_design\_target should meet the criteria:

$$PD\_design\_target < PD_{regulatory\_limit} \times 10^{\frac{-totaluncertainty}{10}}$$

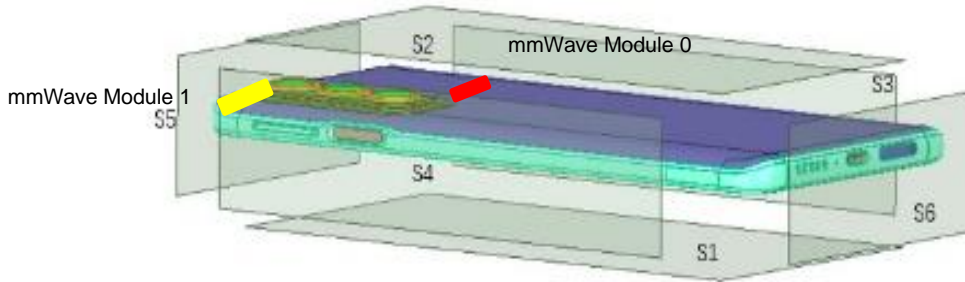
For this EUT, the PD design target and the uncertainty value are listed below

N260	PD design target	Antenna Module	W/m <sup>2</sup>
		Antenna Module 0/1	4.93

N261	PD design target	Antenna Module	W/m <sup>2</sup>
		Antenna Module 0/1	4.93

Item	Uncertainty dB (k=2)
Total uncertainty	2.1

**4.4 Exposure positions for PD evaluation**



Evaluation positions

Front view	Front	Back	Left side	Right side	Top side	Bottom side
	S1	S2	S3	S4	S5	S6
Module 0	V	V	V	V	V	-
Module 1	V	V	V	V	V	-

Remark:

1. Referring to the PD simulation report for the reason of selecting surfaces/edges.
2. The exposure positions selection is based on the all edges and surfaces of the device with a transmitting antenna located within 25 mm from that surface or edge.



**4.5 Simulation and modeling validation**

Power density simulations of all beams and surfaces were performed by the manufacturer. Details of these simulations and modeling validation can be found in the Power Density Simulation Report. Following Table includes a summary of the validation results to support worst-case housing influence quantification in power density characterization for this model With an input power of 6 dBm for n261 and n260 band, PD measurements are conducted for at least one single beam per antenna type and per antenna module (0,1) on worst-surface(s) . PD measurements are performed at mid channel of each mmW band and with CW modulation. PD value will be used to determine worst-case housing influence for conservative assessment

Band	Antenna Module	Beam ID 1	Beam ID 2	Frequency (GHz)	Exposure Surface	Test Separation (mm)	Modulation	Sporton Measured results Savg tot 4cm <sup>2</sup> (W/m <sup>2</sup> )	Simulated Pd (W/m <sup>2</sup> ), averaged over 4 cm <sup>2</sup>	Sim vs Meas (dB)
n260	Module 0	36		38.5	Back (S2)	2mm	CW	8.06	15.75	2.91
n260	Module 0		167	38.5	Back (S2)	2mm	CW	7.74	13.54	2.43
n260	Module 1	24		38.5	Top (S5)	2mm	CW	6.86	12.63	2.65
n260	Module 1		154	38.5	Top (S5)	2mm	CW	5.82	9.62	2.18
n260	Module 1	24		38.5	Back (S2)	2mm	CW	2.72	9.08	5.24
n260	Module 1		161	38.5	Back (S2)	2mm	CW	7.6	6.71	-0.54
n261	Module 0	32		27.925	Back (S2)	2mm	CW	8.49	14.81	2.42
n261	Module 0		159	27.925	Back (S2)	2mm	CW	10.5	13.61	1.13
n261	Module 1	28		27.925	Top (S5)	2mm	CW	7.01	12.14	2.39
n261	Module 1		146	27.925	Top (S5)	2mm	CW	6.02	11.25	2.72
n261	Module 1	28		27.925	Back (S2)	2mm	CW	4.23	7.44	2.45
n261	Module 1		146	27.925	Back (S2)	2mm	CW	4.35	6.9	2.00



## 4.6 PD Char

### 4.7 Simulated input power limit for single beams

Perform simulation at low, mid and high channel for each mmW band supported, with a given input power per active port, *sim.input.power.per.active.port* (6 dBm for this product):

1. Obtain  $PD_{surface}$  value (the worst PD among all identified surfaces of the device) at all three channels for all single beams (1~M) specified in *codebook\_sim*.
2. Adjust input power to determine a scaling factor at all three channels by:

$$s(i)_{low\_or\_mid\_high} = \frac{PD\ design\ target}{sim.PD_{surface}(i)}, i = 1, 2, \dots, M \quad (4)$$

3. Determine the worst-case scaling factor among low, mid and high channels:

$$s(i) = \min\{s_{low}(i), s_{mid}(i), s_{high}(i)\}, i = 1, 2, \dots, M \quad (5)$$

Note: This scaling factor applies to the input power at each antenna port

4. Determine the simulated input power limit, *sim.powerlimit*, for single beam *i* by:

$$sim.\ power_{limit}(i)dBm = 10 * \log(s(i)) + sim.input.power.per.active.port, i = 1, 2, \dots, M \quad (6)$$

#### 4.8 Simulated input power limit for beam pairs

The relative phase between single beams of a beam pair is swepted to find the worst case PD for beam-pairs operation, and PD simulation data has taken this into consideration for beam-pair operations take consideration of the variation relative phase was reported

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

For a given beam pair containing *beam\_a* and *beam\_b* with relative phase  $\phi$  and for a given channel, determine the worst-case  $\phi_{worstcase}$  which results in the highest total PD ( $\phi$ ) among all identified surfaces for this beam pair at this channel. When  $\phi_{worstcase}$  is determined for all three channels, obtain the scaling factor given by the below equation for low, mid and high channels:

$$S(i)_{low\_or\_mid\_high} = \frac{PD\ design\ target}{total.PD(\phi(i)_{worstcase})}, i = M+1, M+2, \dots N \quad (8)$$

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

$$s(i) = \min\{s_{low}(i), s_{mid}(i), s_{high}(i)\}, i = M+1, M+2, \dots N \quad (9)$$

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

$$sim.power_{limit}(i)dBm = 10 * \log(s(i)) + sim.input.power.per.active.port, i = M+1, M+2, \dots N \quad (10)$$

#### 4.9 Worst-case housing influence determination

Referring to the PD simulation report for PD simulation data for all beams . For non-metal material, the material property cannot be accurately characterized at mmW frequencies. The estimated material property for the device housing is used in the simulation model, which could impact 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.

Referring to the PD simulation report for PD simulation data for all beams, and the worst beams are selected to be tested Power density simulation for all

The mmW antenna modules are placed at different locations and only surrounding material/housing has impact on EM field propagation and in turn power density, and depending on the type of 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 DUT, the procedure to determine worst-case housing influence, denoted as  $\Delta_{min}$ :

1. Based on PD simulation, determine one or more worst-surface(s) that contains all the highest  $4\text{cm}^2$ -averaged PD for each of the beams, per antenna module and per antenna type in the mid channel of each band.
2. For identified worst surface(s) per antenna module and per antenna type group,
  - a. First determine  $\Delta_{min}$  based on identified worst surface(s) in Step 1, and then follow the procedures described in Section 4.6 to derive *input.power.limit* corresponding to *PD\_design\_target* for all the beams
  - b. Then prove all other surface(s) near-by the mmW module, i.e., surface(s) not selected in Step 1, is not required for housing material loss quantification (in other words, these nonevaluated surfaces have no influence on the determined *input.power.limit*) by:
    - i. Scale the simulated  $4\text{cm}^2$ -averaged PD values for all single beams to correspond to their *sim.power.limit*, and identify the worst-PD beam per each non-selected surface.
    - ii. Measure  $4\text{cm}^2$ -averaged PD at *input.power.limit* for the identified worst-PD beam at each non-selected surface
    - iii. Demonstrate all measured  $4\text{cm}^2$ -averaged PD values are below *PD\_design\_target*.
3. If any of the above surface(s) in Step (2.b.iii) have measured  $4\text{cm}^2$ -averaged PD  $\geq$  *PD\_design\_target*, then those surfaces must be included in the  $\Delta_{min}$  determination in Step (2.a), and follow the procedures in Section 4.6 to re-evaluate *input.power.limit* with these added surfaces.

Therefore, when comparing a simulated  $4\text{cm}^2$ -averaged PD and measured  $4\text{cm}^2$ -averaged PD for the above identified surfaces, the worst errors introduced when using the estimated material property in the simulation per module and per antenna type (worst out of both polarizations) is highlighted in bolded numbers in section 4.5. Thus, the worst-case housing influence, denoted as  $\Delta_{min}$  (= minimum of (sim.PD – meas.PD) for the same antenna type of each module), is determined as:



Band	Antenna	$\Delta_{min}(dB)$	
		AG0 Polarization	AG1 Polarization
n260	0	2.91	2.43
	1	2.65	-0.54
n261	0	2.42	1.13
	1	2.39	2.00

$\Delta_{min}$  represents the worst case where RF exposure is underestimated the most by simulation upon using the estimated material property for glass/plastics of the housing. For conservative assessment, the  $\Delta_{min}$  is used as the worst case correction and applied to each corresponding beam group to determine power limits in PD char for compliance. To ensure that condition described in Step (2.b.iii) is met, apply the correct input.power.limit to derive the PD simulated results for all beams, and select the worst beams (yellow highlighted in the PD table) for each of non-selected applicable surface(s). The PD test results for non-selected surfaces are less than PD\_design\_target, and meets condition in Step (2.b.iii), thus performing Step (3) is not needed

Simulated 4cm<sup>2</sup> PD values in the Power Density Simulation Report are scaled to input.power.limit and are listed in the tables below for all single beams for all identified surfaces, when assuming the simulation is performed with correct housing influence.

Determine the worst beam for each of non-selected surface(s), identified in the table below:

Non-Selected Surface(s) for module0, module1

Front view	Front	Back	Left side	Right side	Top side	Bottom side
	S1	S2	S3	S4	S5	S6
Module 0	V	-	V	V	V	-
Module 1	V	-	V	V	-	-

Then perform PD measurement for all determined worst-case beams, highlighted in orange in the tables below, on the corresponding surface. Measurement is performed in the mid channel of each band with CW modulation. The evaluation distance is at 2 mm.



**Simulated 4cm<sup>2</sup>-averaged PD at input.power.limit**  
 Determine the worst beam for each of non-selected surface(s)

<n260>

Beam ID 1	Beam ID 2	Antenna Module	n260 module0_Simulated 4cm <sup>2</sup> Averaged PD at input. Power. Limit					
			Surface 2mm_Mid channel					
			S1	S2	S3	S4	S5	S6
			front	back	left	right	top	bottom
1		0	0.26	4.81	0.17	0.14	0.08	0.01
3		0	0.18	4.81	0.21	0.05	0.07	0.02
5		0	0.21	4.82	0.26	0.06	0.05	0.03
7		0	0.21	4.76	0.65	0.05	0.07	0.03
12		0	0.27	4.81	0.68	0.07	0.06	0.03
13		0	0.20	4.82	0.40	0.06	0.09	0.04
14		0	0.20	4.82	0.18	0.15	0.09	0.03
15		0	0.24	4.82	0.31	0.03	0.11	0.03
19		0	0.17	4.81	0.33	0.11	0.07	0.03
20		0	0.27	4.82	0.52	0.01	0.12	0.05
21		0	0.19	4.82	0.57	0.10	0.06	0.02
27		0	0.31	4.73	0.76	0.07	0.11	0.06
28		0	0.25	4.74	0.35	0.19	0.18	0.06
29		0	0.31	4.82	0.34	0.02	0.23	0.07
30		0	0.27	4.82	0.74	0.17	0.10	0.03
31		0	0.22	4.82	0.22	0.07	0.17	0.07
36		0	0.24	4.82	0.62	0.16	0.09	0.03
37		0	0.26	4.82	0.19	0.03	0.23	0.08
38		0	0.34	4.81	0.75	0.06	0.15	0.08
39		0	0.22	4.81	0.61	0.29	0.09	0.03
	129	0	0.32	4.59	0.13	0.14	0.06	0.02
	131	0	0.46	4.53	0.30	0.02	0.13	0.02
	133	0	0.53	4.54	0.46	0.01	0.11	0.03
	135	0	0.44	4.35	0.63	0.02	0.08	0.02
	140	0	0.42	4.41	0.76	0.02	0.12	0.03
	141	0	0.76	4.51	0.16	0.01	0.24	0.05
	142	0	0.27	4.18	0.27	0.08	0.09	0.02
	143	0	0.28	4.32	0.25	0.09	0.09	0.02
	147	0	0.44	4.68	0.48	0.03	0.15	0.03
	148	0	0.74	4.56	0.59	0.01	0.21	0.05
	149	0	0.27	4.21	0.26	0.08	0.08	0.02
	155	0	0.30	4.30	0.97	0.06	0.13	0.03
	156	0	0.51	4.66	0.56	0.12	0.24	0.05
	157	0	0.80	4.44	0.61	0.09	0.34	0.07
	158	0	0.31	4.46	0.90	0.09	0.14	0.02
	159	0	0.50	4.36	0.50	0.12	0.22	0.05
	164	0	0.34	4.39	0.87	0.09	0.15	0.02
	165	0	0.75	4.66	0.08	0.04	0.34	0.09
	166	0	0.43	4.10	1.40	0.06	0.21	0.05
	167	0	0.41	4.19	0.74	0.08	0.17	0.02



<n260>

Beam ID 1	Beam ID 2	Antenna Module	n260 module1_Simulated 4cm^2 Averaged PD at input. Power. Limit					
			Surface 2mm_Mid channel					
			S1	S2	S3	S4	S5	S6
			front	back	left	right	top	bottom
0		1	2.17	2.92	0.06	2.00	4.58	0.00
2		1	1.59	3.14	0.07	0.69	4.60	0.00
4		1	1.44	3.42	0.06	0.37	4.61	0.00
6		1	1.63	3.17	0.10	0.26	4.56	0.00
8		1	1.22	3.20	0.08	0.90	4.61	0.00
9		1	2.11	3.17	0.07	1.20	4.60	0.00
10		1	1.67	3.52	0.14	0.27	4.60	0.01
11		1	1.58	3.16	0.03	1.94	4.60	0.00
16		1	1.31	3.24	0.07	0.56	4.60	0.00
17		1	1.90	3.35	0.05	0.25	4.60	0.01
18		1	1.26	3.43	0.12	0.50	4.60	0.01
22		1	1.61	3.45	0.15	1.44	4.61	0.00
23		1	1.71	3.08	0.02	2.08	4.57	0.00
24		1	2.06	3.30	0.05	0.27	4.60	0.01
25		1	1.60	3.55	0.18	0.98	4.39	0.00
26		1	1.56	3.37	0.08	1.94	4.60	0.00
32		1	1.55	3.28	0.06	2.04	4.60	0.00
33		1	2.06	3.27	0.07	0.90	4.60	0.00
34		1	1.97	3.36	0.08	0.71	4.60	0.01
35		1	1.62	3.59	0.15	1.41	4.58	0.00
	128	1	1.96	2.90	0.05	1.90	4.40	0.00
	130	1	2.57	2.68	0.10	0.21	3.99	0.00
	132	1	2.94	3.08	0.13	0.13	4.37	0.00
	134	1	2.48	2.59	0.08	0.08	3.91	0.00
	136	1	1.90	2.39	0.13	1.20	3.70	0.01
	137	1	2.83	2.95	0.03	0.11	4.05	0.00
	138	1	2.76	2.78	0.17	0.14	4.03	0.01
	139	1	2.14	2.65	0.04	1.10	4.14	0.01
	144	1	1.94	2.50	0.06	1.19	3.92	0.01
	145	1	3.06	2.94	0.09	0.12	3.92	0.01
	146	1	1.98	2.53	0.05	1.17	3.97	0.01
	150	1	2.27	2.61	0.19	1.02	3.88	0.00
	151	1	2.60	2.75	0.01	0.87	3.87	0.01
	152	1	2.84	2.55	0.06	0.73	3.67	0.01
	153	1	2.12	2.73	0.36	1.02	4.04	0.00
	154	1	2.53	2.86	0.07	1.12	4.34	0.00
	160	1	2.40	2.75	0.09	1.12	4.07	0.00
	161	1	2.73	2.93	0.01	0.48	3.85	0.01
	162	1	2.62	2.79	0.44	0.88	4.07	0.01
	163	1	2.29	2.77	0.19	1.08	4.27	0.00



<n261>

Beam ID 1	Beam ID 2	Antenna Module	n261 module0_Simulated 4cm^2 Averaged PD at input. Power. Limit					
			Surface 2mm_Mid channel					
			S1	S2	S3	S4	S5	S6
			front	back	left	right	top	bottom
3		0	0.33	4.72	0.22	0.13	0.09	0.00
4		0	0.22	4.37	0.16	0.09	0.08	0.01
5		0	0.22	4.53	0.47	0.03	0.08	0.01
9		0	0.23	4.64	0.31	0.18	0.08	0.01
10		0	0.32	4.27	0.06	0.05	0.16	0.02
11		0	0.22	4.61	0.28	0.18	0.08	0.01
14		0	0.22	4.55	0.24	0.17	0.09	0.02
15		0	0.26	4.63	0.30	0.16	0.10	0.01
21		0	0.33	4.69	0.77	0.33	0.13	0.01
22		0	0.27	4.49	0.70	0.03	0.19	0.04
23		0	0.23	4.38	0.03	0.02	0.25	0.04
24		0	0.30	4.54	0.12	0.13	0.18	0.02
25		0	0.34	4.72	1.04	0.36	0.12	0.01
30		0	0.35	4.72	1.19	0.20	0.13	0.01
31		0	0.24	4.47	0.17	0.04	0.23	0.04
32		0	0.27	4.44	0.09	0.04	0.23	0.03
33		0	0.32	4.67	0.53	0.28	0.14	0.01
	131	0	0.22	4.18	0.20	0.05	0.07	0.01
	132	0	0.13	4.79	0.16	0.08	0.07	0.01
	133	0	0.15	4.81	0.43	0.05	0.08	0.02
	137	0	0.23	4.52	0.36	0.13	0.10	0.02
	138	0	0.16	4.53	0.08	0.01	0.13	0.03
	139	0	0.21	4.81	0.77	0.13	0.09	0.01
	142	0	0.23	4.52	0.20	0.10	0.11	0.02
	143	0	0.24	4.52	0.36	0.11	0.11	0.02
	149	0	0.37	4.49	1.18	0.28	0.14	0.01
	150	0	0.19	4.73	0.57	0.01	0.21	0.04
	151	0	0.16	4.67	0.05	0.00	0.24	0.05
	152	0	0.31	4.52	0.24	0.12	0.18	0.03
	153	0	0.32	4.61	1.09	0.35	0.10	0.01
	158	0	0.31	4.64	0.98	0.25	0.14	0.01
	159	0	0.15	4.71	0.11	0.02	0.22	0.04
	160	0	0.20	4.67	0.09	0.03	0.22	0.04
	161	0	0.34	4.53	1.04	0.30	0.13	0.01



<n261>

Beam ID 1	Beam ID 2	Antenna Module	n261 module1_Simulated 4cm^2 Averaged PD at input. Power. Limit					
			Surface 2mm_Mid channel					
			S1	S2	S3	S4	S5	S6
			front	back	left	right	top	bottom
0		1	2.40	2.64	0.07	1.74	4.60	0.00
1		1	2.28	2.48	0.05	0.65	4.30	0.00
2		1	2.14	2.56	0.06	0.21	4.43	0.00
6		1	2.00	2.69	0.12	2.05	4.53	0.00
7		1	2.50	2.42	0.02	0.49	4.10	0.01
8		1	2.07	2.69	0.11	2.01	4.48	0.00
12		1	2.32	2.63	0.09	1.69	4.35	0.00
13		1	2.26	2.57	0.09	1.66	4.47	0.01
16		1	2.43	3.17	0.19	2.45	4.65	0.01
17		1	2.48	2.59	0.05	0.37	4.36	0.01
18		1	2.48	2.66	0.00	0.16	4.30	0.01
19		1	2.52	2.64	0.02	1.18	4.42	0.01
20		1	2.43	3.24	0.23	2.68	4.66	0.01
26		1	2.58	2.52	0.17	1.07	4.52	0.01
27		1	2.46	2.69	0.02	0.26	4.38	0.01
28		1	2.55	2.66	0.02	0.60	4.35	0.01
29		1	2.43	2.93	0.11	1.91	4.58	0.00
	128	1	2.01	2.60	0.07	0.92	4.05	0.00
	129	1	2.15	2.64	0.04	0.69	4.66	0.00
	130	1	2.28	2.57	0.04	0.25	4.70	0.00
	134	1	2.04	2.47	0.14	0.76	4.71	0.00
	135	1	2.31	2.86	0.02	0.35	4.39	0.00
	136	1	1.96	2.50	0.12	1.68	4.39	0.00
	140	1	2.09	2.61	0.04	0.97	4.36	0.00
	141	1	2.30	2.62	0.13	1.47	4.40	0.00
	144	1	2.67	2.91	0.30	2.33	4.35	0.01
	145	1	2.42	2.81	0.02	0.14	4.59	0.00
	146	1	2.39	2.78	0.01	0.10	4.53	0.00
	147	1	2.48	2.74	0.04	1.26	4.46	0.00
	148	1	2.67	3.02	0.30	2.99	4.49	0.01
	154	1	2.30	2.70	0.20	2.10	4.52	0.01
	155	1	2.42	2.82	0.02	0.17	4.62	0.00
	156	1	2.49	2.84	0.02	0.35	4.57	0.00
	157	1	2.58	2.82	0.26	2.16	4.37	0.01





4cm<sup>2</sup>-averaged PD for the selected beams on non-selected surfaces for  $\Delta_{min}$  determination

Band	Antenna Module	Beam ID 1	Beam ID 2	Frequency (GHz)	Exposure Surface	Input Power limit	Test Separation (mm)	Modulation	Sporton Measured results Savg inc 4cm <sup>2</sup> (W/m <sup>2</sup> )	Sporton Measured results Savg tot 4cm <sup>2</sup> (W/m <sup>2</sup> )	Epeak [V/m]	Hpeak [A/m]
n260	Module 0		157	38.5	Front (S1)	4.09	2mm	CW	0.031	0.035	6.6	0.023
n260	Module 0		166	38.5	Left (S3)	3.64	2mm	CW	0.618	0.66	23.8	0.064
n260	Module 0	39		38.5	Right (S4)	3.51	2mm	CW	0.297	0.311	13.3	0.039
n260	Module 0		157	38.5	Top (S5)	4.09	2mm	CW	0.105	0.11	9.73	0.027
n260	Module 1		145	38.5	Front (S1)	4.91	2mm	CW	0.419	0.476	32	0.086
n260	Module 1		162	38.5	Left (S3)	3.79	2mm	CW	0.041	0.045	6.51	0.02
n260	Module 1	23		38.5	Right (S4)	4.65	2mm	CW	0.948	1.05	29.2	0.077
n261	Module 0		149	27.925	Front (S1)	3.11	2mm	CW	0.077	0.095	8.41	0.031
n261	Module 0	30		27.925	Left (S3)	4.47	2mm	CW	0.656	0.702	23.1	0.062
n261	Module 0	25		27.925	Right (S4)	5.27	2mm	CW	0.207	0.219	16.9	0.053
n261	Module 0	23		27.925	Top (S5)	2.72	2mm	CW	0.104	0.117	10	0.027
n261	Module 1		148	27.925	Front (S1)	6.1	2mm	CW	0.673	0.742	28.5	0.083
n261	Module 1		148	27.925	Left (S3)	6.1	2mm	CW	0.278	0.298	12.6	0.039
n261	Module 1		148	27.925	Right (S4)	6.1	2mm	CW	1.35	1.54	32.2	0.095

Measure power density for the beams identified by “Qualcomm MG script” on their corresponding worst surfaces printed from the script.

Band	Antenna Module	Beam ID 1	Beam ID 2	Frequency (GHz)	Exposure Surface	Input Power limit	Test Separation (mm)	Modulation	Sporton Measured results Savg inc 4cm <sup>2</sup> (W/m <sup>2</sup> )	Sporton Measured results Savg tot 4cm <sup>2</sup> (W/m <sup>2</sup> )	Epeak [V/m]	Hpeak [A/m]
n260	Module 0		166	38.5	S2(Back)	3.64	2mm	CW	2.98	3.51	82.5	0.233
n260	Module 1		134	38.5	S5(Top)	9.27	2mm	CW	1.88	2.57	69.1	0.183
n261	Module 0	32		27.925	S2(Back)	2.56	2mm	CW	3.55	4.16	80.3	0.229
n261	Module 1		154	27.925	S5(Top)	5.62	2mm	CW	3.8	5.34	92.3	0.224

**4.10 PD Char**

This section describes the PD char generation that complies with the *PD\_design\_target* and is in compliance with the regulatory power density limit.

**4.11 PD char generation**

Ideally, if there is no uncertainty associated with hardware as described in Section 4.4, after accounting for the housing influence ( $\Delta_{min}$ ), *input.power.limit(i)*, for beam *i* can be obtained:

$$input.power.limit(i) = 6 dBm + 10 * \log(s(i)) + \Delta_{min}, i \in all\ beams \quad (11)$$

If simulation overestimates the housing influence, then  $\Delta_{min}$  (= minimum {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 loss, then  $\Delta_{min}$  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.

In reality, the hardware design has uncertainty which must be properly considered in equation (11). In Section 4.7, the TxAGC uncertainty at reference power level (6dBm in report) is embedded in the process of  $\Delta_{min}$  determination and should be removed to avoid double counting this uncertainty.

If -TxAGC uncertainty at reference power level <  $\Delta_{min}$  < TxAGC uncertainty at reference power level,

$$Input.power.limit(i) = sim.power_{limit}(i), i = 1,2,...,N \quad (12)$$

else if  $\Delta_{min}$  < -TxAGC uncertainty at reference power level,

$$Input.power.limit(i) = sim.power_{limit}(i) + (\Delta_{min} + TxAGC\ uncertainty), i = 1,2,...,N \quad (13)$$

else if  $\Delta_{min}$  > TxAGC uncertainty at reference power level,

$$Input.power.limit(i) = sim.power_{limit}(i) + (\Delta_{min} - TxAGC\ uncertainty), i = 1,2,...,N \quad (14)$$

1) The input power limit is derived and listed in the table below

AG0 Polarization				
Band	Antenna Module	$\Delta_{min}$ (dB)	TxAGC uncertainty (dB)	Input.power.limit (dBm)
n260	0	2.91	0.63	sim. power limit(i) + 2.28
	1	2.65	0.63	sim. power limit(i) + 2.02
n261	0	2.42	0.63	sim. power limit(i) + 1.79
	1	2.39	0.63	sim. power limit(i) + 1.76

AG1 Polarization				
Band	Antenna Module	$\Delta_{min}$ (dB)	TxAGC uncertainty (dB)	Input.power.limit (dBm)
n260	0	2.43	0.63	sim. power limit(i) + 1.80
	1	-0.54	0.63	sim. power limit(i)
n261	0	1.13	0.63	sim. power limit(i) + 0.50
	1	2.00	0.63	sim. power limit(i) + 1.37



4.12 PD char Table

Combining the information in previous sections, PD char is derived and listed below

Band	Beam ID 1	Beam ID 2	Antenna Module	Antenna Type	Feed No	Input power limit(dBm)
n260	1		0	Patch	1	9.69
n260	3		0	Patch	1	8.56
n260	5		0	Patch	1	7.58
n260	7		0	Patch	1	8.94
n260	12		0	Patch	1	5.17
n260	13		0	Patch	2	5.57
n260	14		0	Patch	2	5.95
n260	15		0	Patch	2	6.43
n260	19		0	Patch	2	5.03
n260	20		0	Patch	2	5.59
n260	21		0	Patch	2	5.15
n260	27		0	Patch	4	3.41
n260	28		0	Patch	4	3.99
n260	29		0	Patch	4	3.47
n260	30		0	Patch	4	3.21
n260	31		0	Patch	4	3.46
n260	36		0	Patch	4	3.14
n260	37		0	Patch	4	3.25
n260	38		0	Patch	4	3.64
n260	39		0	Patch	4	3.51
n260		129	0	Patch	1	7.34
n260		131	0	Patch	1	7.64
n260		133	0	Patch	1	8.83
n260		135	0	Patch	1	10.09
n260		140	0	Patch	2	6.13
n260		141	0	Patch	2	5.53
n260		142	0	Patch	2	4.19
n260		143	0	Patch	2	4.16
n260		147	0	Patch	2	5.12
n260		148	0	Patch	2	7.03
n260		149	0	Patch	2	4.11
n260		155	0	Patch	4	3.00
n260		156	0	Patch	4	3.44
n260		157	0	Patch	4	4.09
n260		158	0	Patch	4	3.19
n260		159	0	Patch	4	3.27
n260		164	0	Patch	4	3.08
n260		165	0	Patch	4	3.55
n260		166	0	Patch	4	3.64
n260		167	0	Patch	4	2.71
n260	1	129	0	Patch	1x2	4.99
n260	3	131	0	Patch	1x2	4.55
n260	5	133	0	Patch	1x2	4.78
n260	7	135	0	Patch	1x2	6.00
n260	12	140	0	Patch	2x2	2.20
n260	13	141	0	Patch	2x2	2.05
n260	14	142	0	Patch	2x2	1.76
n260	15	143	0	Patch	2x2	1.89
n260	19	147	0	Patch	2x2	1.60
n260	20	148	0	Patch	2x2	2.68
n260	21	149	0	Patch	2x2	2.44
n260	27	155	0	Patch	4x2	-0.31
n260	28	156	0	Patch	4x2	0.09



n260	29	157	0	Patch	4x2	0.00
n260	30	158	0	Patch	4x2	-0.34
n260	31	159	0	Patch	4x2	-0.11
n260	36	164	0	Patch	4x2	-0.30
n260	37	165	0	Patch	4x2	-0.18
n260	38	166	0	Patch	4x2	-0.26
n260	39	167	0	Patch	4x2	-0.32

Band	Beam ID 1	Beam ID 2	Antenna Module	Antenna Type	Feed No	Input power limit(dBm)
n260	0		1	Patch	1	10.81
n260	2		1	Patch	1	9.24
n260	4		1	Patch	1	8.26
n260	6		1	Patch	1	9.68
n260	8		1	Patch	2	5.76
n260	9		1	Patch	2	7.60
n260	10		1	Patch	2	6.17
n260	11		1	Patch	2	7.25
n260	16		1	Patch	2	6.03
n260	17		1	Patch	2	6.21
n260	18		1	Patch	2	6.03
n260	22		1	Patch	4	3.89
n260	23		1	Patch	4	4.65
n260	24		1	Patch	4	3.63
n260	25		1	Patch	4	3.96
n260	26		1	Patch	4	4.31
n260	32		1	Patch	4	4.36
n260	33		1	Patch	4	4.52
n260	34		1	Patch	4	4.04
n260	35		1	Patch	4	4.31
n260		128	1	Patch	1	6.88
n260		130	1	Patch	1	6.76
n260		132	1	Patch	1	8.53
n260		134	1	Patch	1	9.27
n260		136	1	Patch	2	3.92
n260		137	1	Patch	2	5.79
n260		138	1	Patch	2	6.29
n260		139	1	Patch	2	3.78
n260		144	1	Patch	2	3.60
n260		145	1	Patch	2	4.91
n260		146	1	Patch	2	3.61
n260		150	1	Patch	4	2.32
n260		151	1	Patch	4	2.25
n260		152	1	Patch	4	2.78
n260		153	1	Patch	4	2.98
n260		154	1	Patch	4	2.54
n260		160	1	Patch	4	2.37
n260		161	1	Patch	4	2.40
n260		162	1	Patch	4	3.79
n260		163	1	Patch	4	2.51
n260	0	128	1	Patch	1x2	4.41
n260	2	130	1	Patch	1x2	3.67
n260	4	132	1	Patch	1x2	3.92
n260	6	134	1	Patch	1x2	5.22
n260	8	136	1	Patch	2x2	0.88
n260	9	137	1	Patch	2x2	2.72
n260	10	138	1	Patch	2x2	1.67



n260	11	139	1	Patch	2x2	0.98
n260	16	144	1	Patch	2x2	1.61
n260	17	145	1	Patch	2x2	1.32
n260	18	146	1	Patch	2x2	1.61
n260	22	150	1	Patch	4x2	-1.21
n260	23	151	1	Patch	4x2	-0.87
n260	24	152	1	Patch	4x2	-0.98
n260	25	153	1	Patch	4x2	-0.96
n260	26	154	1	Patch	4x2	-0.99
n260	32	160	1	Patch	4x2	-1.18
n260	33	161	1	Patch	4x2	-0.65
n260	34	162	1	Patch	4x2	-0.72
n260	35	163	1	Patch	4x2	-0.98



Band	Beam ID 1	Beam ID 2	Antenna Module	Antenna Type	Feed No	Input power limit(dBm)
n261	3		0	Patch	1	10.48
n261	4		0	Patch	1	8.26
n261	5		0	Patch	1	8.34
n261	9		0	Patch	2	6.43
n261	10		0	Patch	2	6.41
n261	11		0	Patch	2	6.65
n261	14		0	Patch	2	6.74
n261	15		0	Patch	2	6.22
n261	21		0	Patch	4	4.48
n261	22		0	Patch	4	3.23
n261	23		0	Patch	4	2.72
n261	24		0	Patch	4	2.71
n261	25		0	Patch	4	5.27
n261	30		0	Patch	4	4.47
n261	31		0	Patch	4	2.93
n261	32		0	Patch	4	2.56
n261	33		0	Patch	4	3.81
n261		131	0	Patch	1	7.83
n261		132	0	Patch	1	7.07
n261		133	0	Patch	1	8.64
n261		137	0	Patch	2	4.69
n261		138	0	Patch	2	4.62
n261		139	0	Patch	2	5.84
n261		142	0	Patch	2	4.50
n261		143	0	Patch	2	4.69
n261		149	0	Patch	4	3.11
n261		150	0	Patch	4	2.10
n261		151	0	Patch	4	1.90
n261		152	0	Patch	4	2.34
n261		153	0	Patch	4	3.65
n261		158	0	Patch	4	3.52
n261		159	0	Patch	4	1.89
n261		160	0	Patch	4	2.11
n261		161	0	Patch	4	3.07
n261	3	131	0	Patch	1x2	4.68
n261	4	132	0	Patch	1x2	3.79
n261	5	133	0	Patch	1x2	4.44
n261	9	137	0	Patch	2x2	1.36
n261	10	138	0	Patch	2x2	1.56
n261	11	139	0	Patch	2x2	3.01
n261	14	142	0	Patch	2x2	1.59
n261	15	143	0	Patch	2x2	1.20
n261	21	149	0	Patch	4x2	-1.25
n261	22	150	0	Patch	4x2	-1.42
n261	23	151	0	Patch	4x2	-1.56
n261	24	152	0	Patch	4x2	-1.65
n261	25	153	0	Patch	4x2	-0.69
n261	30	158	0	Patch	4x2	-0.92
n261	31	159	0	Patch	4x2	-1.44
n261	32	160	0	Patch	4x2	-1.59
n261	33	161	0	Patch	4x2	-1.49



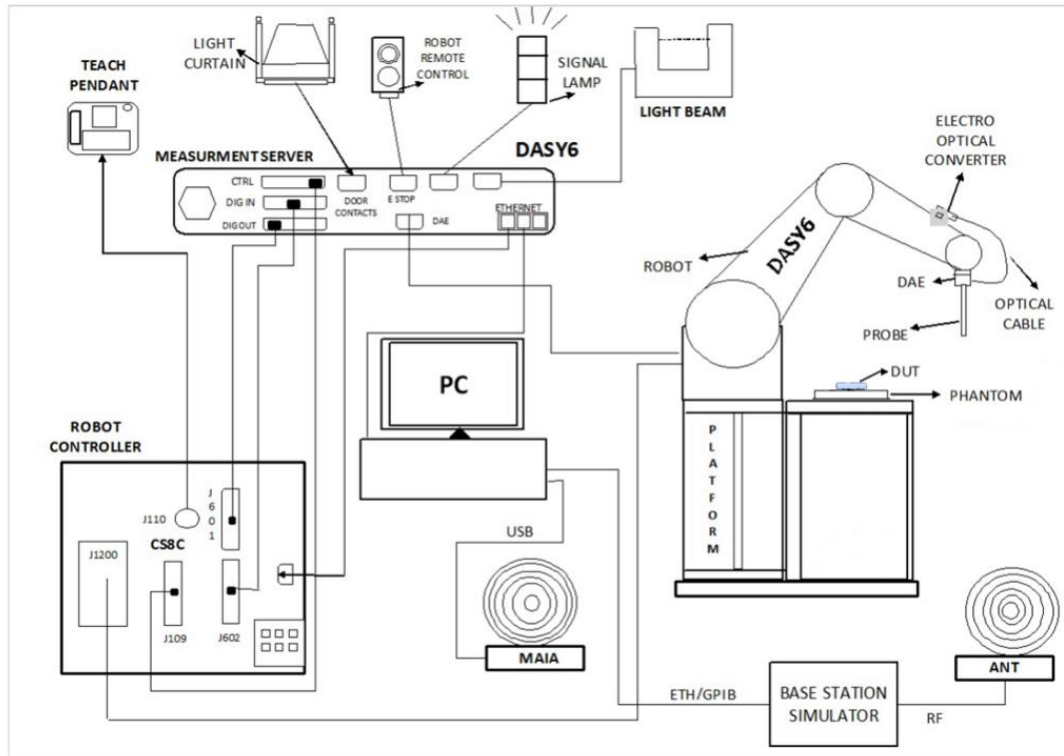
Band	Beam ID 1	Beam ID 2	Antenna Module	Antenna Type	Feed No	Input power limit(dBm)
n261	0		1	Patch	1	11.60
n261	1		1	Patch	1	9.64
n261	2		1	Patch	1	9.31
n261	6		1	Patch	2	8.09
n261	7		1	Patch	2	7.38
n261	8		1	Patch	2	8.24
n261	12		1	Patch	2	8.28
n261	13		1	Patch	2	7.56
n261	16		1	Patch	4	5.70
n261	17		1	Patch	4	4.03
n261	18		1	Patch	4	3.49
n261	19		1	Patch	4	3.47
n261	20		1	Patch	4	6.24
n261	26		1	Patch	4	5.08
n261	27		1	Patch	4	3.72
n261	28		1	Patch	4	3.30
n261	29		1	Patch	4	4.60
n261		128	1	Patch	1	9.94
n261		129	1	Patch	1	9.11
n261		130	1	Patch	1	10.61
n261		134	1	Patch	2	8.37
n261		135	1	Patch	2	6.20
n261		136	1	Patch	2	7.19
n261		140	1	Patch	2	6.65
n261		141	1	Patch	2	7.02
n261		144	1	Patch	4	5.30
n261		145	1	Patch	4	3.87
n261		146	1	Patch	4	3.42
n261		147	1	Patch	4	3.98
n261		148	1	Patch	4	6.10
n261		154	1	Patch	4	5.62
n261		155	1	Patch	4	3.56
n261		156	1	Patch	4	3.68
n261		157	1	Patch	4	5.04
n261	0	128	1	Patch	1x2	6.75
n261	1	129	1	Patch	1x2	5.95
n261	2	130	1	Patch	1x2	6.45
n261	6	134	1	Patch	2x2	5.14
n261	7	135	1	Patch	2x2	3.26
n261	8	136	1	Patch	2x2	4.14
n261	12	140	1	Patch	2x2	3.93
n261	13	141	1	Patch	2x2	3.46
n261	16	144	1	Patch	4x2	1.02
n261	17	145	1	Patch	4x2	0.32
n261	18	146	1	Patch	4x2	0.09
n261	19	147	1	Patch	4x2	0.09
n261	20	148	1	Patch	4x2	1.39
n261	26	154	1	Patch	4x2	0.95
n261	27	155	1	Patch	4x2	0.21
n261	28	156	1	Patch	4x2	0.08
n261	29	157	1	Patch	4x2	0.53

## 5. PD Test Setup

### 5.1 PD Test – System Setup

The system to be used for the near field power density measurement

- SPEAG DASY6 system
  - SPEAG cDASY6 5G module software
  - EUmmWVx probe
- 5G Phantom cover



### 5.2 Test Site Location

Sporton International Inc. (Shenzhen) is accredited to ISO/IEC 17025:2017 by American Association for Laboratory Accreditation with Certificate Number 5145.01.

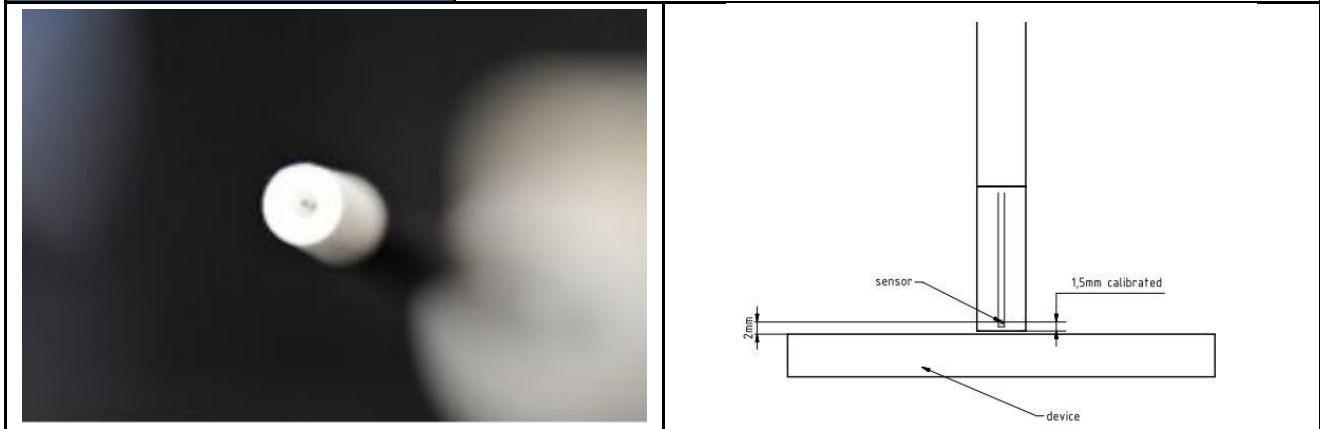
Testing Laboratory			
Test Firm	Sporton International Inc. (Shenzhen)		
Test Site Location	1/F, 2/F, Bldg 5, Shiling Industrial Zone, Xinwei Village, Xili, Nanshan, Shenzhen, 518055 People's Republic of China TEL: +86-755-86379589 FAX: +86-755-86379595		
Test Site No.	Sporton Site No.	FCC Designation No.	FCC Test Firm Registration No.
	SAR02-SZ	CN1256	421272



**5.3 EUmmWave Probe / E-Field 5G Probe**

The probe design allows measurements at distances as small as 2 mm from the sensors to the surface of the device under test (DUT). The typical sensor to probe tip distance is 1.5 mm.

<b>Frequency</b>	750 MHz – 110 GHz
<b>Probe Overall Length</b>	320 mm
<b>Probe Body Diameter</b>	8.0 mm
<b>Tip Length</b>	23.0 mm
<b>Tip Diameter</b>	8.0 mm
<b>Probe's two dipoles length</b>	0.9 mm – Diode loaded
<b>Dynamic Range</b>	< 20 V/m - 10000 V/m with PRE-10 (min < 50 V/m - 3000 V/m)
<b>Position Precision</b>	< 0.2 mm
<b>Distance between diode sensors and probe's tip</b>	1.5 mm
<b>Minimum Mechanical separation between probe tip and a Surface</b>	0.5 mm
<b>Applications</b>	E-field measurements of 5G devices and other mm-wave transmitters operating above 10GHz in < 2 mm distance from device (free-space) Power density, H-field and far-field analysis using total field reconstruction.
<b>Compatibility</b>	cDASY6 + 5G-Module SW1.0 and higher



**5.4 Data Acquisition Electronics (DAE)**

The data acquisition electronics (DAE) consists of a highly sensitive electrometer-grade preamplifier with auto-zeroing, a channel and gain-switching multiplexer, a fast 16 bit AD-converter and a command decoder and control logic unit. Transmission to the measurement server is accomplished through an optical downlink for data and status information as well as an optical uplink for commands and the clock.

The input impedance of the DAE is 200 MOhm; the inputs are symmetrical and floating. Common mode rejection is above 80 dB.



**5.5 Scan configuration**

Fine-resolution scans on 2 different planes are performed to reconstruct the E- and H-fields as well as the power density; the z-distance between the 2 planes is set to  $\lambda/4$ .

The (x, y) grid step is also set  $\lambda/4$ , the grid extent is set to sufficiently large to identify the field pattern and the peak.

**5.6 System Verification Source**

The System Verification sources at 30 GHz and above comprise horn-antennas and very stable signal generators.

<b>Model</b>	Ka-band horn antenna
<b>Calibrated frequency:</b>	30 GHz at 5.55mm from the case surface
<b>Frequency accuracy</b>	$\pm 100$ MHz
<b>E-field polarization</b>	linear
<b>Harmonics</b>	-20 dBc
<b>Total radiated power</b>	14 dBm
<b>Power stability</b>	0.05 dB
<b>Power consumption</b>	5 W
<b>Size</b>	100 x 100 x 100 mm
<b>Weight</b>	1 kg

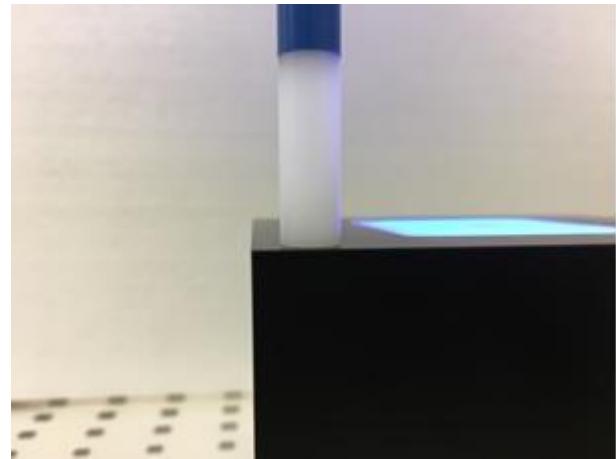
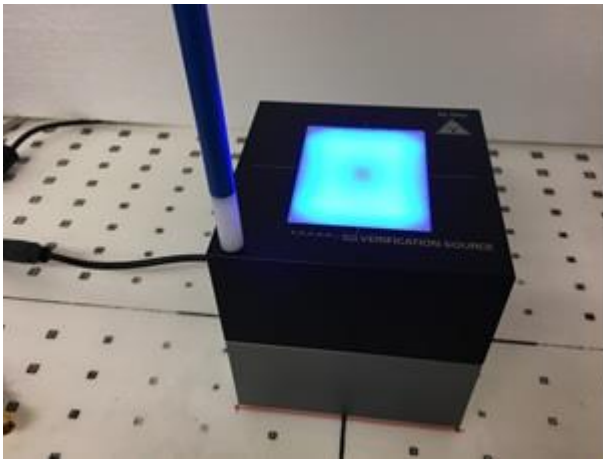


### 5.7 Power Density System Verification

The system performance check verifies that the system operates within its specifications. The EUT is replaced by a calibrated source, the same spatial resolution, measurement region and the test separation used in the calibration was applied to system check. Through visual inspection into the measured power density distribution, both spatially (shape) and numerically (level) have no noticeable difference. The measured results should be within 0.66 dB of the calibrated targets.

Frequency [GHz]	Grid step	Grid extent X/Y [mm]	Measurement points
10	0.25 ( $\frac{\lambda}{4}$ )	120/120	16 × 16
30	0.25 ( $\frac{\lambda}{4}$ )	60/60	24 × 24
60	0.25 ( $\frac{\lambda}{4}$ )	32.5/32.5	26 × 26
90	0.25 ( $\frac{\lambda}{4}$ )	30/30	36 × 36

Settings for measurement of verification sources



Verification Setup photo

### 5.8 System Verification Results

System Verification								
Frequency (GHz)	5G Verification Source	Probe S/N	DAE S/N	Distance (mm)	Measured 4 cm <sup>2</sup> (W/m <sup>2</sup> )	Targeted 4 cm <sup>2</sup> (W/m <sup>2</sup> )	Deviation (dB)	Date
30GHz	30GHz_1034	9432	1664	5.55	34.8	36.8	-0.24	2022/1/15
30GHz	30GHz_1034	9432	1664	5.55	34.1	36.8	-0.33	2022/1/24



## 6. Uncertainty Assessment

The budget is valid for evaluation distances  $> \lambda/2\pi$ . For specific tests and configurations, the Uncertainty could be considerably smaller.

Preliminary Module mmWave Uncertainty Budget Evaluation Distances to the Antennas $> \lambda / 2\pi$						
Error Description	Uncertainty Value ( $\pm$ dB)	Probability	Divisor	(Ci)	Standard Uncertainty ( $\pm$ dB)	(Vi) Veff
<b>Measurement System</b>						
Probe Calibration	0.49	N	1	1	0.49	$\infty$
Hemispherical Isotropy	0.50	R	1.732	1	0.29	$\infty$
Linearity	0.20	R	1.732	0	0.00	$\infty$
System Detection Limits	0.04	R	1.732	1	0.02	$\infty$
Modulation Response	0.40	R	1.732	1	0.23	$\infty$
Readout Electronics	0.03	N	1	1	0.03	$\infty$
Response Time	0.00	R	1.732	1	0.00	$\infty$
Integration Time	0.00	R	1.732	1	0.00	$\infty$
RF Ambient Noise	0.04	R	1.732	1	0.02	$\infty$
RF Ambient Reflections	0.21	R	1.732	1	0.12	$\infty$
Probe Positioner	0.04	R	1.732	1	0.02	$\infty$
Probe Positioning	0.30	R	1.732	1	0.17	$\infty$
S <sub>avg</sub> Reconstruction	0.60	R	1.732	1	0.35	$\infty$
<b>Test Sample Related</b>						
Power Drift	0.10	R	1.732	1	0.06	$\infty$
Input Power	0.27	N	1	0	0.00	$\infty$
Combined Std. Uncertainty					0.74 dB	$\infty$
Coverage Factor for 95 %					K=2	
Expanded STD Uncertainty					1.48 dB	