PART 0 Power Density Characterization Report

Test Report No. 14131461H-G

Customer	**Panasonic Corporation of North America**
Description of EUT	**Personal Computer**
Model Number of EUT	**FZ-40**
FCC ID	**ACJ9TGFZ40**
Issue Date	**May 9, 2022**
Remarks	**-**

Representative Test Engineer	**Approved By**
Hisayoshi Sato Engineer	Takayuki Shimada Leader

Report Cover Page - Form-ULID-003532 (DCS:13-EM-F0429) Issue# 20.0

ANNOUNCEMENT

- This test report shall not be reproduced in full or partial, without the written approval of UL Japan, Inc.
- The results in this report apply only to the sample tested.
- This sample tested is in compliance with the limits of the above regulation, if any.
- This test report covers PD technical requirements.
  It does not cover administrative issues such as Manual or non-PD test related Requirements. (if applicable)
- The all test items in this test report are conducted by UL Japan, Inc Ise EMC Lab.
- The information provided from the applicant for this report is identified.
- For test report(s) referred in this report, the latest version (including any revisions) is always referred.
- This test report is out of scope of any accreditation(s).

Contents

1 Introduction

This device uses Qualcomm® Smart Transmit feature and cannot operate without specific absorption ratio (SAR) and power density(PD) characterization at the device level, beforehand. The parameters obtained from SAR and PD characterization (char) is 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.

Part 0 report describes the results for the SAR char and PD char generation and evaluates them on the 5G milli wave (mmW) new radio (NR) enabled equipment under test (EUT).

This description is an overview for STx and test results may not include both sub6 (SAR) and mmW (PD).

2 Customer information

Company Name	Panasonic Corporation of North America
Address	Two Riverfront Plaza, 9th Floor Newark, NEW JERSEY, 07102-5940, USA
Telephone Number	+1-201-348-7760
Contact Person	Ben Botros

The information provided from the customer is as follows.
- Customer, Description of EUT, Model No. FCC ID on the cover and other relevant pages
- Operating / Test Mode(s) (Mode(s)) on all the relevant pages
- SECTION 2: Customer information
- SECTION 3: Equipment under test (EUT) other than the receipt date
- SECTION 8: PD device uncertainty, PD design target and *input.power.limit*

* The laboratory is exempted from liability of any test results affected from the above information in section 3.

3 Equipment under test (EUT)

3.1 Identification of EUT

Type	Personal Computer
Model Number	FZ-40
Serial number	1LTSA00160
Rating	AC 100 V to 240 V, 50 Hz / 60 Hz
Condition	Engineering prototype (Not for Sale: This sample is equivalent to mass-produced items.)
Modification	No Modification by the test lab.
Receipt Date	February 4, 2022
Test Date	February 28 to March 16, 2022

3.2 Product description

Model: FZ-40 (referred to as the EUT in this report) is a Personal Computer.

5G NR (FR2)	TDD	120 kHz	n258	Pi/2 BPSK (DFT-s-OFDM), QPSK (CP-OFDM/DFT-s-OFDM)
	TDD	120 kHz	n260	16QAM (CP-OFDM/DFT-s-OFDM),
	TDD	120 kHz	n261	64QAM (CP-OFDM/DFT-s-OFDM)
	-	-	-	
	-	-	-	MIMO Support: No
EN-DC(LTE-FR2 mmW) (NSA mode only)	Supported combination			*B48: not used in Canada(ISED)
	LTE Anchor Bands for NR band n258			LTE Band 2/5/7/12/66
	LTE Anchor Bands for NR band n260			LTE Band 2/5/12/13/14/48*/66
	LTE Anchor Bands for NR band n261			LTE Band 2/5/13/48*/66

Radio Module (Tested inside of Panasonic Personal Computer FZ-40)
Model : WW21A (FCC ID ACJ9TGWW21A / ISED certification number 216H-CFWW21A)

Wireless technologies	Dup.	Band		Mode
WCDMA	FDD		2	UMTS Rel. 99 (Data) HSDPA (Rel. 5)
	FDD		4	HSUPA (Rel. 6), HSPA+ (Rel. 7), DC-HSDPA (Rel. 8)
	FDD		5	
LTE	FDD		2	QPSK, 16QAM, 64AQM, 256QAM
	FDD		4	
	FDD		5	Downlink MIMO Support: Yes(2x2, 4x4)
*B42: not used in US (FCC)	FDD		7	Supported band : B2, B4, B7, B25, B38, B41, B42, B48, B66
	FDD		12	
*B48: not used in Canada(ISED)	FDD		13	Uplink MIMO Support: No
	FDD		14	Uplink transmission is limited to a single output stream.
	FDD		17	
	FDD		25	
	FDD		26	
	FDD(Rx only)		29	
	TDD		38	
	TDD		41	
	TDD		42	
	TDD(Rx only)		46	
	TDD		48	
	FDD		66	
	FDD		71	
LTE CA	Downlink			Uplink *B42: not used in US (FCC) / B48: not used in Canada(ISED)
	Maximum 7 carriers			Maximum 2 carriers Supported combination: <Inrta-band contiguous> 7C, 41C, 42C, 48C <Inter-band>2A-5A, 2A-12A, 2A-13A, 4A-5A, 4A-12A, 4A-13A, 5A-7A,5A-66A, 12A-66A, 13A-66A
5G NR (FR1)	FDD	15 kHz	n2	Pi/2 BPSK (DFT-s-OFDM),
	FDD	15 kHz	n5	QPSK (CP-OFDM/DFT-s-OFDM),
*n77, n78: not used in US (FCC)	TDD	15 kHz	n41	16QAM (CP-OFDM/DFT-s-OFDM),
	FDD	15 kHz	n66	64QAM (CP-OFDM/DFT-s-OFDM),
	FDD	15 kHz	n71	256QAM (CP-OFDM/DFT-s-OFDM)
	TDD	30 kHz	n77	Downlink MIMO Support: Yes(2x2, 4x4)
	TDD	30 kHz	n78	Supported band : n2, n41, n66, n77, n78
	-	-	-	Uplink MIMO Support: No
	-	-	-	Uplink transmission is limited to a single output stream.
EN-DC(LTE-FR1 Sub6) (NSA mode only)	Supported combination			*n77, n78: not used in US (FCC)
	LTE Anchor Bands for NR band n2			LTE Band 5/12/13
	LTE Anchor Bands for NR band n5			LTE Band 2/7/66
	LTE Anchor Bands for NR band n41			LTE Band 2/25/26/66
	LTE Anchor Bands for NR band n66			LTE Band 5/12/13/14/71
	LTE Anchor Bands for NR band n71			LTE Band 2/7/66
	LTE Anchor Bands for NR band n77*			LTE Band 41
	LTE Anchor Bands for NR band n78*			LTE Band 2/5/7/12/38/66

Wireless module (Tested inside of Panasonic Personal Computer FZ-40)
Model : WL20B (FCC ID ACJ9TGWL20B / ISED certification number 216H-CFWL20B)

Wireless technologies	Dup.	Band		Mode
WLAN	TDD	2.4GHz	2412-2472 for US 2412-2462 for Canada	802.11b 802.11g 802.11n(20,40) 802.11ax(20,40)
	TDD	5GHz	5180-5240 5260-5320 5500-5720 5745-5825	802.11a 802.11n(20,40) 802.11ac(20,40.80.160) 802.11ax(20,40.80.160)
Bluetooth	TDD	2.4GHz	2402-2480	BR/EDR/LE

*This report is for mmW range

4 Location

UL Japan, Inc. Ise EMC Lab.
Shielded room for SAR testings
A2LA Certificate Number: 5107.02 / FCC Test Firm Registration Number: 884919
ISED SAR Lab Company Number: 2973C / CAB identifier: JP0002
4383-326 Asama-cho, Ise-shi, Mie-ken 516-0021 JAPAN
Telephone: +81-596-24-8999

5 References

Federal Communications Commission. (October 23, 2015). *447498 D01 General RF Exposure Guidance v06.*
International Electrotechnical Commission. (2018). *IEC TR 63170:2018* .
SPEAG. (August 2018). *5G Module V1.2 Application Note: 5G Compliance Testing.*

6 Time averaging for SAR and PD

The Qualcomm® Smart Transmit algorithm controls and manages the instantaneous Tx power to maintain the time-averaged Tx power (in turn, time-averaged RF exposure) is in compliance with regulatory limits.

7 Definitions, symbols, and abbreviations

7.1 Definitions

SAR_design_target : Target value to use STx and also this shall be less than regulatory SAR limit (i.e., 1g SAR limit for FCC) after accounting for all device design related uncertainties.

SAR_design_target_extremity : SAR_design_target for limbs

Tx_power_at_SAR_design_target : Transmit level that matches SAR_design_target

Δ min : housing material influence

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.

N beams : 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).

power density (PD) or S_{av} : Energy per unit time and unit area crossing a surface of area *A* characterized by the normal unit vector ˆ**n** and averaging time.

$$S_{av} = \frac{1}{AT} \int \int (\mathbf{E} \times \mathbf{H}) \cdot \hat{\boldsymbol{n}} \mathrm{d}A \mathrm{d}T$$

Specific Absorption Rate (SAR): : The time derivative (rate) of the incremental energy (dW) absorbed by (dissipated in) an incremental mass (dm) contained in a volume element (dV) of a given density (ρ), as shown in the following equation:

$$\mathrm{SAR} = \frac{d}{dt}\left(\frac{dW}{dm}\right) = \frac{d}{dt}\left(\frac{dW}{\rho dV}\right)$$

7.2 Symbols

Symbol	**Quantity**	**Unit**	**Dimensions**
E	Electric field	volt per meter	V / m
f	Frequency	hertz	Hz
H	Magnetic field	ampere per meter	A / m
λ	Wavelength	meter	m
S	Local power density	watt per square meter	W / m^2
PD or S_{av}	Spatial-average power density	watt per square meter	W / m^2 (mW / cm^2)
SAR	Specific Absorption Rate	watt per kilo gram	W / kg

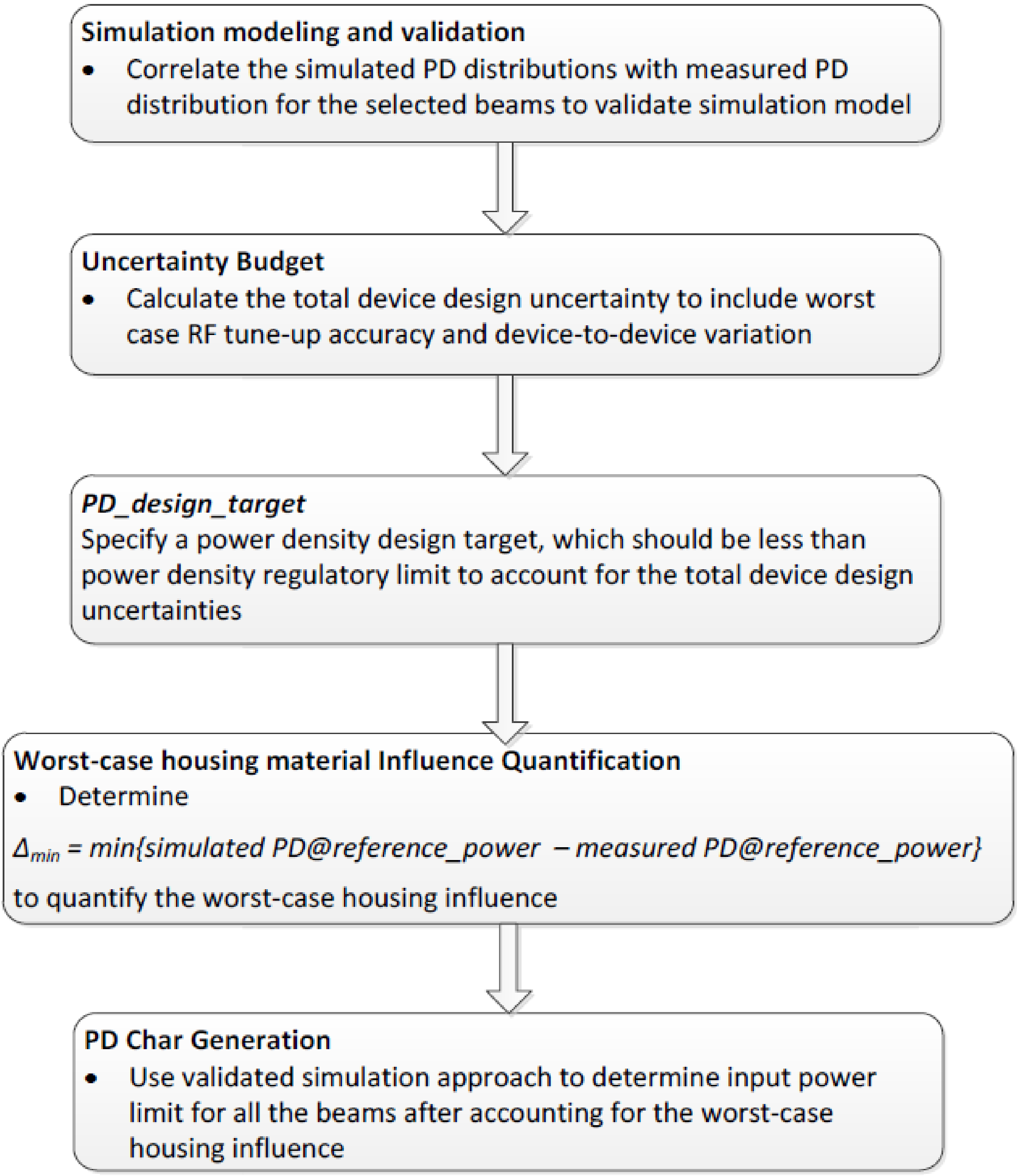
7.3 Abbreviations

DSI	: device state index
KDB	: knowledge data base from Federal communication committee (FCC)
BS or BSE	: base station or base station emulator
CW	: continuous wave
DUT	: device under test
NR	: new radio
PD	: power density
RF	: radio frequency
TER	: total exposure ratio
S_n	: surface number
S_{tot} or S_{total}	: total propagating power flux density into the phantom
S_n or S_{norm}	: surface normal propagating power flux density into the phantom or in normed vector space
Ant	: antenna
nG	: n generation (e.g. 3G, 4G and 5G)
☒	: applicable.
☐	: NOT applicable.

8 PD char generation

8.1 Outlines the PD char process

Figure 8-1 flow chart for power density characterization



8.2 Codebook

All the beams that the device supports are specified in the pre-defined codebook. The codebook is device design specific and generated after evaluating radiation coverage from this particular device.

This code book is provided by customer.

Table 8-1 codebook

Beam ID1	Beam ID2	mmwave#	# of Antenna port	Beam ID1	Beam ID2	mmwave#	# of Antenna port
0		0	1	24		0	4
1		0	1	25		0	4
2		1	1	26		1	4
3		1	1	27		1	4
4		2	1	28		1	4
5		2	1	29		1	4
6		0	2	30		1	4
7		0	2	31		2	4
8		0	2	32		2	4
9		1	2	33		2	4
10		1	2	34		2	4
11		1	2	35		2	4
12		2	2	36		0	4
13		2	2	37		0	4
14		2	2	38		0	4
15		0	2	39		0	4
16		0	2	40		1	4
17		1	2	41		1	4
18		1	2	42		1	4
19		2	2	43		1	4
20		2	2	44		2	4
21		0	4	45		2	4
22		0	4	46		2	4
23		0	4	47		2	4

Band n258 does not support ID 46,47

Beam ID1	Beam ID2	mmwave#	# of Antenna port	Beam ID1	Beam ID2	mmwave#	# of Antenna port
128		0	1	152		0	4
129		0	1	153		0	4
130		1	1	154		1	4
131		1	1	155		1	4
132		2	1	156		1	4
133		2	1	157		1	4
134		0	2	158		1	4
135		0	2	159		2	4
136		0	2	160		2	4
137		1	2	161		2	4
138		1	2	162		2	4
139		1	2	163		2	4
140		2	2	164		0	4
141		2	2	165		0	4
142		2	2	166		0	4
143		0	2	167		0	4
144		0	2	168		1	4
145		1	2	169		1	4
146		1	2	170		1	4
147		2	2	171		1	4
148		2	2	172		2	4
149		0	4	173		2	4
150		0	4	174		2	4
151		0	4	175		2	4

Band n258 does not support ID 174,175

Beam ID1	Beam ID2	mmwave#	# of Antenna port	Beam ID1	Beam ID2	mmwave#	# of Antenna port
0	128	0	1	24	152	0	4
1	129	0	1	25	153	0	4
2	130	1	1	26	154	1	4
3	131	1	1	27	155	1	4
4	132	2	1	28	156	1	4
5	133	2	1	29	157	1	4
6	134	0	2	30	158	1	4
7	135	0	2	31	159	2	4
8	136	0	2	32	160	2	4
9	137	1	2	33	161	2	4
10	138	1	2	34	162	2	4
11	139	1	2	35	163	2	4
12	140	2	2	36	164	0	4
13	141	2	2	37	165	0	4
14	142	2	2	38	166	0	4
15	143	0	2	39	167	0	4
16	144	0	2	40	168	1	4
17	145	1	2	41	169	1	4
18	146	1	2	42	170	1	4
19	147	2	2	43	171	1	4
20	148	2	2	44	172	2	4
21	149	0	4	45	173	2	4
22	150	0	4	46	174	2	4
23	151	0	4	47	175	2	4

Band n258 does not support ID 46 + 174,47 + 175

8.3 Simulation modeling and validation

8.3.1 Exposure scenarios in PD evaluation

For this EUT operating at frequencies > 6 GHz, PD is required to be assessed for all beams from all mmW antenna modules installed inside the device. Furthermore, this PD evaluation should be done at low, mid, and high channels for each supported mmW band in exposure scenario:

☒ **Human tissue at the device surface (*d0*)**: This assumption applies if the device does not have any detection scheme or if the device detects the object (or human tissue) is at *d0*. For this scenario, spatially-averaged PD (spatially averaged over the averaging area defined by regulatory agency, e.g., 4 cm^2 for FCC) is evaluated on worst surfaces of the.

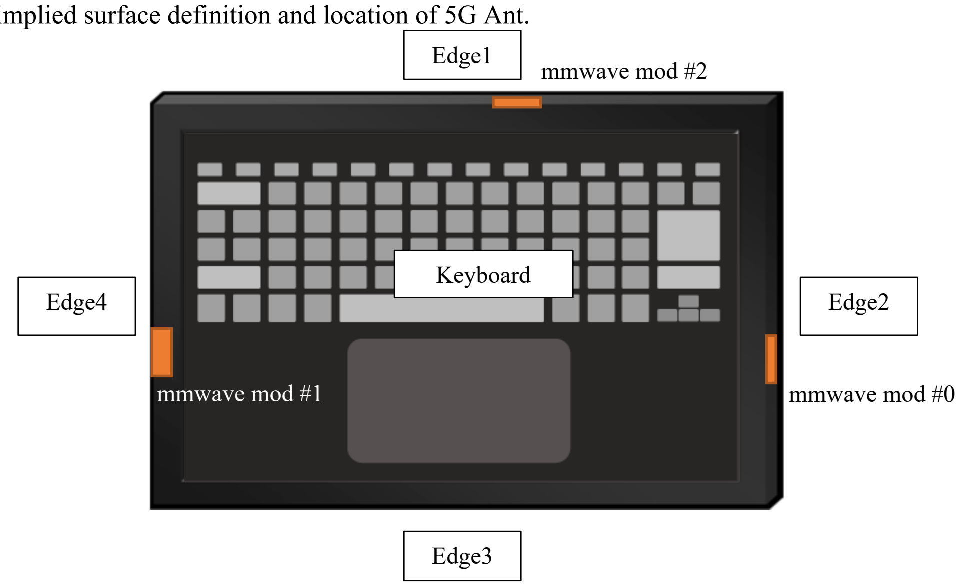
$PD_{surface(worst\ case)}$ = module installed surface at each mmwave module #

☐ **Object (human tissue) is detected at a certain distance away "*d*" from the smartphone**: The worst case spatially-averaged PD is determined by taking maximum among the spatially-averaged PD from detectable region and from all undetectable regions

Table 8-2 PD evaluation surface for PD char

mmwave#	Keyboard S1	Bottom S2	Edeg1 S3	Edge2 S4	Edge3 S5	Edge4 S6
0	☐	☐	☐	☒	☐	☐
1	☒	☐	☐	☐	☐	☐
2	☐	☐	☒	☐	☐	☐

Figure 8-2 Simplied surface definition and location of 5G Ant.



8.3.2 Modeling for simulation

PD simulation is conducted by the manufacturer. Details are shown manufacture's report(s).

8.3.3 Modeling validation

To validate modeling and simulation:

1. Select one beam (i.e., antenna array configuration) per antenna type and per antenna module.
2. For a given input power, perform both PD simulation and PD measurement to obtain the simulated PD distributions and measured PD distribution based on measurement procedure of Speag.
3. Validate modeling and simulation by correlating the simulated PD distribution and measured PD distribution for all configurations selected in Step 1.
4. The modeling validation is performed through correlating the simulated PD distribution to measured PD distribution.
5. These discrepancies in PD magnitude will be used to determine the worst-case housing influence (due to non-metal material property uncertainty). The worst-case housing influence will be accounted for in PD Char generation for conservative RF exposure assessment.

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.

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 next table.

PD measurements are conducted at middle channel for each band and transmission is CW with 6 dBm.
Delta is used for worst case housing influence for conservative assessment.

Table 8-3 Beams and surface selection for PD correlation, measurement results and delta(sim. – meas. in dB unit).

Band	Module #	Freq. Ch	MHz	Beam ID	Pol.	input.power.limit [dBm]	Mode	EUT surface	Day	sPD Sim. W/m^2	sPD Meas. W/m^2	delta min [dB]	worst delta min [dB]
n258	0	L-Mid.	24400.02	37	Vert.	6.0	CW	Edge 2	2022/02/22	12.25	13.60	-0.45	-0.60
n258	0	H-Mid.	24799.98	165	Hori.	6.0	CW	Edge 2	2022/02/22	11.76	13.50	-0.60	
n258	1	L-Mid.	24400.02	29	Vert.	6.0	CW	Front	2022/02/18	11.96	13.50	-0.53	-0.53
n258	1	L-Mid.	24400.02	157	Hori.	6.0	CW	Front	2022/02/21	11.73	12.20	-0.17	
n258	2	L-Mid.	24400.02	32	Vert.	6.0	CW	Edge 1	2022/02/24	11.29	12.60	-0.47	-0.47
n258	2	L-Mid.	24400.02	170	Hori.	6.0	CW	Edge 1	2022/02/24	12.06	12.20	-0.05	

Band	Module #	Freq. Ch	MHz	Beam ID	Pol.	input.power.limit [dBm]	Mode	EUT surface	Day	sPD Sim. W/m^2	sPD Meas. W/m^2	delta min [dB]	worst delta min [dB]
n261	0	Mid.	27923.5	38	Vert.	6.0	CW	Edge 2	2022/02/22	9.99	13.70	-1.37	-1.37
n261	0	Mid.	27923.5	150	Hori.	6.0	CW	Edge 2	2022/02/22	10.12	13.00	-1.09	
n261	1	Mid.	27923.5	29	Vert.	6.0	CW	Front	2022/02/21	10.60	14.40	-1.33	-1.58
n261	1	Mid.	27923.5	157	Hori.	6.0	CW	Front	2022/02/25	10.91	15.70	-1.58	
n261	2	Mid.	27923.5	33	Vert.	6.0	CW	Edge 1	2022/02/24	10.57	13.40	-1.03	-1.27
n261	2	Mid.	27923.5	174	Hori.	6.0	CW	Edge 1	2022/02/24	10.38	13.90	-1.27	

Band	Module #	Freq. Ch	MHz	Beam ID	Pol.	input.power.limit [dBm]	Mode	EUT surface	Day	sPD Sim. W/m^2	sPD Meas. W/m^2	delta min [dB]	worst delta min [dB]
n260	0	Mid.	38498.88	25	Vert.	6.0	CW	Edge 2	2022/02/22	10.53	11.40	-0.35	-0.35
n260	0	Mid.	38498.88	153	Hori.	6.0	CW	Edge 2	2022/02/22	10.26	9.81	0.20	
n260	1	Mid.	38498.88	30	Vert.	6.0	CW	Front	2022/02/22	10.25	12.80	-0.97	-0.97
n260	1	Mid.	38498.88	155	Hori.	6.0	CW	Front	2022/02/22	9.23	10.50	-0.56	
n260	2	Mid.	38498.88	31	Vert.	6.0	CW	Edge 1	2022/02/24	11.00	13.70	-0.95	-0.95
n260	2	Mid.	38498.88	173	Hori.	6.0	CW	Edge 1	2022/02/25	9.38	8.72	0.32	

8.4 PD device uncertainty

Table 8-4 PD uncertain budget

Item	
PD radio TxAGC	0.5
Total uncertainty	2.1

k=2

8.5 PD design target

To account for the total design related uncertainty, *PD_design_target* needs to be:

$$PD\_design\_target\ [\mathrm{W} / \mathrm{m}^2] < PDregulatory\_limit\ [\mathrm{W} / \mathrm{m}^2] \times 10^{\frac{-PD\ total\ uncertainty}{10}}$$

the *PD_design_target* for the EUT is determined as: < 6.16 W / m^2

mmwave module #	*PD_design_target* [W / m^2]
0, 1, 2	6.0

8.6 Worst case housing determination

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.

Since the mmW antenna modules are placed at different location as shown in Figure 8-2, only surrounding material/housing has impact on EM field propagation and in turn 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 DUT, the procedure to determine worst-case housing influence, denoted as Δmin:

1. Based on PD simulation, determine one or more worst-surface(s) that contains all the highest 4 cm2-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 Δmin based on identified worst surface(s) in *input.power.limit*
   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 non-evaluated surfaces have no influence on the determined *input.power.limit*) by:
   i. Scale the simulated 4 cm2-averaged PD values for all single beams to correspond to their *sim.powerlimit*, and identify the worst-PD beam per each non-selected surface.
   ii. Measure 4 cm2-averaged PD at *input.power.limit* for the identified worst-PD beam at each non-selected surface
   iii. Demonstrate all measured 4 cm2-averaged PD values are below *PD_design_target*.
3. If any of the above surface(s) in Step (2.b.iii) have measured 4 cm2-averaged PD ≥ *PD_design_target,* then those surfaces must be included in the Δmin determination in Step (2.a), and follow the PD measurement procedures to re-evaluate input.power.limit with these added surfaces.

Δmin 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 Δmin is used as the worst-case factor and applied to all the beams in the corresponding beam group to determine input power limits in PD char for compliance

Results are shown at Table 8-3

Table 8-5 non worst surface result

Band	Module #.	Freq. Ch	MHz	Beam ID		input.power.limit [dBm]	Mode	EUT surface	Day	S_{total} W/m^2	S_{norm} W/m^2	drift [dB]
n258	0	L-Mid.	24400.02	24	Vert.	3.1	CW	Back(Bottom)	2022/03/02	0.16	0.14	0.03
n258	0	L-Mid.	24400.02	152	Hori.	3.0	CW	Front(Side-B)	2022/03/16	2.22	1.72	0.06
n258	1	H-Mid.	24799.98	168	Hori.	3.3	CW	Back(Bottom)	2022/03/02	0.01	0.01	n/a
n258	1	L-Mid.	24400.02	29	Vert.	2.9	CW	Edge 4(Side-B)	2022/03/11	1.89	1.73	-0.18
n258	2	H-Mid.	24799.98	32	Vert.	3.2	CW	Back(Bottom)	2022/03/02	0.69	0.59	0.09
n258	2	H-Mid.	24799.98	162	Hori.	4.2	CW	Front(Side-B)	2022/03/16	1.23	1.02	-0.20

Band	Module #.	Freq. Ch	MHz	Beam ID		input.power.limit [dBm]	Mode	EUT surface	Day	S_{total} W/m^2	S_{norm} W/m^2	drift [dB]
n261	0	Mid.	27923.5	23	Vert.	2.7	CW	Back(Bottom)	2022/03/04	1.96	1.73	0.11
n261	0	Mid.	27923.5	135	Hori.	6.2	CW	Front(Side-B)	2022/03/11	3.30	2.70	0.19
n261	1	Mid.	27923.5	155	Hori.	3.7	CW	Back(Bottom)	2022/03/04	0.03	0.02	n/a
n261	1	Mid.	27923.5	40	Vert.	3.9	CW	Edge 4(Side-B)	2022/03/11	1.78	1.48	-0.05
n261	2	Mid.	27923.5	46	Vert.	2.7	CW	Back(Bottom)	2022/03/04	0.56	0.48	-0.14
n261	2	Mid.	27923.5	12	Vert.	5.6	CW	Front(Side-B)	2022/03/14	1.16	1.10	0.06

Band	Module #.	Freq. Ch	MHz	Beam ID		input.power.limit [dBm]	Mode	EUT surface	Day	S_{total} W/m^2	S_{norm} W/m^2	drift [dB]
n260	0	Mid.	38498.88	149	Hori.	3.9	CW	Back(Bottom)	2022/03/04	0.51	0.48	-0.02
n260	0	Mid.	38498.88	37	Vert.	3.8	CW	Front(Side-B)	2022/03/16	2.93	2.56	-0.03
n260	1	Mid.	38498.88	156	Hori.	4.1	CW	Back(Bottom)	2022/03/04	0.03	0.02	0.04
n260	1	Mid.	38498.88	3	Vert.	9.1	CW	Edge 4(Side-B)	2022/03/11	0.86	0.75	0.08
n260	2	Mid.	38498.88	174	Hori.	4.0	CW	Back(Bottom)	2022/03/04	0.93	0.74	-0.16
n260	2	Mid.	38498.88	44	Vert.	3.0	CW	Front(Side-B)	2022/03/14	1.47	1.38	-0.02

* n/a: Power drift could not be measured due to the too low level.

Confirmed all measured 4 cm2-averaged PD values are below PD_design_target.

8.7 PD char generation

This section describes the PD Char generation that complies with the PD_design_target determined in Section 6.4 and is in compliance with the regulatory power density limit.

8.7.1 Scaling factor for single beam

1. Obtain PDsurface value (the worst PD among all identified surfaces of the device), i.e., $sim.PDsurface$, at all three channels for all single beams (1~M) specified in codebook_sim.

2. Calculate scaling factors at all three channels by:

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

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

$$S(i) = \min\left\{S_{Low}(i), S_{mid}(i), S_{high}(i)\right\}, i = 1,2,\dots M$$

And *S(i)* is applied to the input power at each antenna port.

8.7.2 Scaling factor for beam pairs

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

For 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:

$$total\ PD(\varphi) = \frac{1}{2}\sqrt{Re\ \{PDx(\varphi)\}^2 + Re\ \{PDy(\varphi)\}^2 + Re\ \{PDz(\varphi)\}^2}$$
$$= \frac{1}{2}\left\{\left(\overrightarrow{Ea} + \overrightarrow{Ebe^{-J\omega\varphi}}\right) \times \left(\overrightarrow{Ha} + \overrightarrow{Hbe^{-J\omega\varphi}}\right)\right\}$$

where, PDx(φ), PDy(φ) and PDz(φ) are the three components of the $total\ PD$ (φ); Ea and Ha are the extracted E-fields and H-fields of beam_a, while Eb and Hb are the extracted E-fields and H-fields of beam_b.

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

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

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

$$S(i) = \min\ \{S_{Low}(i), S_{mid}(i), S_{high}(i)\}, i = M+1, M+2, \dots. N$$

8.7.3 Input power limit

Input power limit, $input.power.limit(i)$, for beam i can be obtained:

$$input.power.limit(i)=sim.powerlimit(i)+ \Delta min, i=1,2,\ldots,N$$

If simulation overestimates the housing influence, then Δmin (= 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.

If simulation overestimates the housing influence, then Δmin (= 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.

In reality, the hardware design has uncertainty which must be properly considered.6.5 , the TxAGC uncertainty is embedded in the process of Δmin determination. Since TxAGC uncertainty is already accounted for in PD_design_target, it needs to be removed to avoid double counting this uncertainty.

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

$$input.\ power.\ limit(i) = P_{\mathrm{ref}} + 10 * \log(s(i)) \text{ , } i = 1,2,\ldots\mathrm{M} \text{ (1)}$$

else if Δ_{min} < -TxAGC uncertainty,

$$input.\ power.\ limit(i) = P_{\mathrm{ref}} + 10 * \log(s(i)) + (\Delta_{min} + \text{TxAGC uncertainty, } i = 1, 2,\ldots\mathrm{M} \text{ (2)}$$

else if Δ_{min} > TxAGC uncertainty,

$$input.\ power.\ limit(i) = P_{\mathrm{ref}} + 10 * \log(s(i)) + (\Delta_{min} - \text{TxAGC uncertainty), } i = 1, 2,\ldots\mathrm{M} \text{ (3)}$$

Following above logic, the *input.power.limit* for this EUT can be calculated using Equations (1), (2) and (3).

Appendix 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 $\varnothing$, for beam pair consisting of *beam_a* and *beam_b*, the combined E and H, $\{Ex_{\_pair\_i}, Ey_{\_pair\_i}, Ez_{\_pair\_i}\}$ and $\{Hx_{\_pair\_i}, Hy_{\_pair\_i}, Hz_{\_pair\_i}\}$, can be expressed as:

$$Ex(\varphi)_{\_pair\_i} = Ex_{\_a} + Ex_{\_b} \times e^{-j\omega\varphi}$$

$$Ey(\varphi)_{\_pair\_i} = Ey_{\_a} + Ey_{\_b} \times e^{-j\omega\varphi}$$

$$Ez(\varphi)_{\_pair\_i} = Ez_{\_a} + Ez_{\_b} \times e^{-j\omega\varphi}$$

$$Hx(\varphi)_{\_pair\_i} = Hx_{\_a} + Hx_{\_b} \times e^{-j\omega\varphi}$$

$$Hy(\varphi)_{\_pair\_i} = Hy_{\_a} + Hy_{\_b} \times e^{-j\omega\varphi}$$

$$Hz(\varphi)_{\_pair\_i} = Hz_{\_a} + Hz_{\_b} \times e^{-j\omega\varphi}$$

The combined PD can then be calculated:

$$PDx(\varphi)_{pair\_i} = Ey(\varphi)_{\_pair\_i} \times Hz(\varphi)_{pair\_i}{*} - Ez(\varphi)_{\_pair\_i} \times Hy(\varphi)_{\_pair\_i}$$

$$PDy(\varphi)_{\_pair\_i} = Ez(\varphi)_{\_pair\_i} \times Hx(\varphi)_{\_pair\_i}{*} - Ex(\varphi)_{\_pair\_i} \times Hz(\varphi)_{\_pair\_i}$$

$$PDz(\varphi)_{\_pair\_i} = Ex(\varphi)_{\_pair\_i} \times Hy(\varphi)_{\_pair\_i}{*} - Ey(\varphi)_{\_pair\_i} \times Hx(\varphi)_{\_pair\_i}$$

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

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

Appendix B Input Power Limit

B.1 n258 input.power.limit

Beam ID1	Beam ID2	mmwave#	# of Antenna port	input power limit
0		0	1	8.0
1		0	1	10.3
2		1	1	8.2
3		1	1	10.2
4		2	1	8.4
5		2	1	10.6
6		0	2	5.4
7		0	2	5.3
8		0	2	6.0
9		1	2	5.2
10		1	2	5.4
11		1	2	6.0
12		2	2	6.1
13		2	2	5.5
14		2	2	6.2
15		0	2	5.3
16		0	2	5.8
17		1	2	5.2
18		1	2	5.7
19		2	2	5.8
20		2	2	5.5
21		0	4	2.9
22		0	4	3.1
23		0	4	3.0
24		0	4	3.1
25		1	4	4.4
26		1	4	3.1
27		1	4	3.0
28		1	4	3.0
29		1	4	2.9
30		2	4	3.5
31		2	4	3.4
32		2	4	3.2
33		2	4	3.5
34		2	4	5.3
35		0	4	2.9
36		0	4	2.9
37		0	4	2.8
38		1	4	3.2
39		1	4	3.1
40		1	4	3.1
41		1	4	3.0
42		2	4	3.3
43		2	4	3.3
44		2	4	3.4
45		2	4	3.8
128		0	1	8.0
129		0	1	10.2
130		1	1	8.7
131		1	1	9.6
132		2	1	8.7
133		2	1	10.0
134		0	2	6.6
135		0	2	6.2
136		0	2	5.6
137		1	2	6.1
138		1	2	6.1
139		1	2	5.7
140		2	2	6.2
141		2	2	6.1
142		2	2	6.4
143		0	2	6.0
144		0	2	6.3
145		1	2	5.9
146		1	2	6.4

147		2	2	6.5
148		2	2	6.0
149		0	4	3.2
150		0	4	3.5
151		0	4	3.3
152		0	4	3.0
153		1	4	3.4
154		1	4	3.1
155		1	4	3.3
156		1	4	3.1
157		1	4	3.0
158		2	4	5.0
159		2	4	3.3
160		2	4	3.5
161		2	4	3.5
162		2	4	4.2
163		0	4	3.1
164		0	4	3.2
165		0	4	3.0
166		1	4	3.2
167		1	4	3.2
168		1	4	3.3
169		1	4	3.1
170		2	4	2.9
171		2	4	3.3
172		2	4	3.3
173		2	4	3.7
0	128	0	1	4.8
1	129	0	1	9.0
2	130	1	1	5.7
3	131	1	1	8.5
4	132	2	1	6.0
5	133	2	1	9.2
6	134	0	2	3.4
7	135	0	2	2.6
8	136	0	2	4.0
9	137	1	2	2.2
10	138	1	2	2.8
11	139	1	2	3.9
12	140	2	2	3.8
13	141	2	2	2.6
14	142	2	2	3.6
15	143	0	2	2.8
16	144	0	2	2.9
17	145	1	2	2.8
18	146	1	2	2.9
19	147	2	2	3.3
20	148	2	2	3.1
21	149	0	4	0.3
22	150	0	4	1.1
23	151	0	4	0.3
24	152	0	4	0.1
25	153	1	4	0.4
26	154	1	4	0.4
27	155	1	4	0.5
28	156	1	4	0.1
29	157	1	4	0.2
30	158	2	4	1.6
31	159	2	4	0.6
32	160	2	4	1.0
33	161	2	4	1.2
34	162	2	4	3.0
35	163	0	4	0.2
36	164	0	4	0.4
37	165	0	4	0.0
38	166	1	4	0.5
39	167	1	4	0.6
40	168	1	4	0.3
41	169	1	4	0.1
42	170	2	4	0.2
43	171	2	4	0.7

44	172	2	4	0.8
45	173	2	4	1.5

B.2 n261 input.power.limit

Beam ID1	Beam ID2	mmwave#	# of Antenna port	input power limit
0		0	1	7.9
1		0	1	8.3
2		1	1	7.7
3		1	1	8.9
4		2	1	8.2
5		2	1	8.1
6		0	2	5.9
7		0	2	5.3
8		0	2	5.5
9		1	2	5.5
10		1	2	5.3
11		1	2	6.3
12		2	2	5.6
13		2	2	5.6
14		2	2	5.5
15		0	2	5.3
16		0	2	5.7
17		1	2	5.5
18		1	2	4.9
19		2	2	5.4
20		2	2	6.0
21		0	4	4.5
22		0	4	3.3
23		0	4	2.7
24		0	4	2.8
25		0	4	3.8
26		1	4	3.7
27		1	4	3.5
28		1	4	2.5
29		1	4	2.2
30		1	4	4.2
31		2	4	5.0
32		2	4	3.1
33		2	4	2.7
34		2	4	3.2
35		2	4	4.1
36		0	4	4.2
37		0	4	2.7
38		0	4	2.7
39		0	4	3.5
40		1	4	3.9
41		1	4	2.9
42		1	4	2.3
43		1	4	3.3
44		2	4	4.7
45		2	4	2.7
46		2	4	2.7
47		2	4	3.7
128		0	1	8.4
129		0	1	8.0
130		1	1	7.8
131		1	1	8.5
132		2	1	8.5
133		2	1	8.1
134		0	2	5.7
135		0	2	6.2
136		0	2	5.6
137		1	2	6.2
138		1	2	5.8
139		1	2	5.8
140		2	2	6.2
141		2	2	6.1
142		2	2	5.4
143		0	2	6.0

144		0	2	6.5
145		1	2	5.5
146		1	2	5.3
147		2	2	5.8
148		2	2	5.9
149		0	4	3.8
150		0	4	2.7
151		0	4	2.9
152		0	4	3.2
153		0	4	4.8
154		1	4	4.4
155		1	4	3.7
156		1	4	2.3
157		1	4	2.3
158		1	4	4.3
159		2	4	4.6
160		2	4	2.9
161		2	4	2.8
162		2	4	2.9
163		2	4	4.2
164		0	4	2.9
165		0	4	2.8
166		0	4	2.8
167		0	4	4.5
168		1	4	5.4
169		1	4	3.3
170		1	4	2.5
171		1	4	2.8
172		2	4	4.0
173		2	4	2.9
174		2	4	2.8
175		2	4	4.0
0	128	0	1	5.9
1	129	0	1	4.3
2	130	1	1	3.9
3	131	1	1	6.1
4	132	2	1	6.0
5	133	2	1	4.4
6	134	0	2	3.3
7	135	0	2	2.6
8	136	0	2	3.3
9	137	1	2	3.7
10	138	1	2	2.3
11	139	1	2	3.5
12	140	2	2	2.9
13	141	2	2	2.8
14	142	2	2	2.9
15	143	0	2	3.2
16	144	0	2	3.4
17	145	1	2	2.9
18	146	1	2	1.6
19	147	2	2	3.4
20	148	2	2	3.0
21	149	0	4	1.5
22	150	0	4	0.1
23	151	0	4	-0.1
24	152	0	4	0.0
25	153	0	4	1.4
26	154	1	4	0.9
27	155	1	4	0.9
28	156	1	4	-0.7
29	157	1	4	-0.7
30	158	1	4	0.6
31	159	2	4	2.8
32	160	2	4	0.0
33	161	2	4	-0.3
34	162	2	4	-0.1
35	163	2	4	1.2
36	164	0	4	0.2
37	165	0	4	-0.2
38	166	0	4	-0.1

39	167	0	4	0.9
40	168	1	4	1.9
41	169	1	4	0.0
42	170	1	4	-0.5
43	171	1	4	-0.1
44	172	2	4	1.2
45	173	2	4	-0.2
46	174	2	4	-0.3
47	175	2	4	0.7

B.3 n260 input.power.limit

Beam ID1	Beam ID2	mmwave#	# of Antenna port	input power limit
0		0	1	9.4
1		0	1	8.4
2		1	1	7.8
3		1	1	9.1
4		2	1	7.6
5		2	1	8.1
6		0	2	5.3
7		0	2	6.1
8		0	2	5.7
9		1	2	5.0
10		1	2	5.9
11		1	2	5.6
12		2	2	4.6
13		2	2	5.4
14		2	2	5.3
15		0	2	5.4
16		0	2	6.0
17		1	2	5.9
18		1	2	5.8
19		2	2	6.0
20		2	2	5.6
21		0	4	3.7
22		0	4	3.7
23		0	4	4.1
24		0	4	3.6
25		0	4	3.5
26		1	4	3.6
27		1	4	3.3
28		1	4	3.7
29		1	4	3.5
30		1	4	3.1
31		2	4	2.9
32		2	4	3.3
33		2	4	3.8
34		2	4	3.1
35		2	4	3.1
36		0	4	3.6
37		0	4	3.8
38		0	4	3.7
39		0	4	3.6
40		1	4	3.3
41		1	4	3.4
42		1	4	3.8
43		1	4	3.3
44		2	4	3.0
45		2	4	3.4
46		2	4	3.8
47		2	4	3.1
128		0	1	10.1
129		0	1	8.6
130		1	1	8.4
131		1	1	8.6
132		2	1	8.7
133		2	1	8.3
134		0	2	6.5
135		0	2	6.9
136		0	2	6.6

137		1	2	6.1
138		1	2	6.7
139		1	2	5.4
140		2	2	5.4
141		2	2	5.9
142		2	2	6.2
143		0	2	6.8
144		0	2	5.7
145		1	2	6.5
146		1	2	6.5
147		2	2	5.5
148		2	2	6.6
149		0	4	3.9
150		0	4	3.8
151		0	4	4.2
152		0	4	4.1
153		0	4	3.7
154		1	4	3.4
155		1	4	3.7
156		1	4	4.1
157		1	4	3.8
158		1	4	3.2
159		2	4	3.8
160		2	4	3.6
161		2	4	4.1
162		2	4	3.8
163		2	4	3.6
164		0	4	3.6
165		0	4	4.1
166		0	4	4.3
167		0	4	3.7
168		1	4	3.8
169		1	4	3.8
170		1	4	4.1
171		1	4	3.4
172		2	4	3.6
173		2	4	3.6
174		2	4	4.0
175		2	4	3.7
0	128	0	1	6.6
1	129	0	1	5.5
2	130	1	1	5.2
3	131	1	1	5.7
4	132	2	1	4.8
5	133	2	1	5.3
6	134	0	2	2.7
7	135	0	2	3.6
8	136	0	2	3.3
9	137	1	2	2.7
10	138	1	2	3.3
11	139	1	2	3.5
12	140	2	2	2.2
13	141	2	2	2.6
14	142	2	2	2.4
15	143	0	2	3.2
16	144	0	2	3.0
17	145	1	2	2.9
18	146	1	2	3.4
19	147	2	2	2.9
20	148	2	2	3.2
21	149	0	4	0.6
22	150	0	4	1.1
23	151	0	4	1.1
24	152	0	4	0.8
25	153	0	4	1.0
26	154	1	4	0.7
27	155	1	4	0.6
28	156	1	4	1.2
29	157	1	4	0.6
30	158	1	4	0.0
31	159	2	4	0.1

32	160	2	4	0.0
33	161	2	4	1.6
34	162	2	4	0.7
35	163	2	4	0.3
36	164	0	4	0.5
37	165	0	4	0.9
38	166	0	4	0.9
39	167	0	4	0.9
40	168	1	4	0.6
41	169	1	4	0.7
42	170	1	4	1.0
43	171	1	4	0.4
44	172	2	4	0.2
45	173	2	4	0.4
46	174	2	4	1.2
47	175	2	4	0.6

Appendix C Measurement uncertainty

C.1 PD measurement uncertainty

Error Description		Uncert. value (dB)	Probab. Distri.	Div.	(c_i)	Std. Unc. (± dB)	(v_i) v_{eff}
Uncertainty terms dependent on the measurement system							
Calibration	±	0.49	N	1	1	0.49	∞
Probe correction	±	0.00	R	√3	1	0.00	∞
Frequency response (BW <= 1 GHz)	±	0.20	R	√3	1	0.12	∞
Sensor cross coupling	±	0.00	R	√3	1	0.00	∞
Isotropy	±	0.50	R	√3	1	0.29	∞
Linearity	±	0.20	R	√3	1	0.12	∞
Probe scattering	±	0.00	R	√3	1	0.00	∞
Probe positioning o set	±	0.30	R	√3	1	0.17	∞
Probe positioning repeatability	±	0.04	R	√3	1	0.02	∞
Sensor mechanical o set	±	0.00	R	√3	1	0.00	∞
Probe spatial resolution	±	0.00	R	√3	1	0.00	∞
Field impedance dependance	±	0.00	R	√3	1	0.00	∞
Amplitude and phase drift	±	0.00	R	√3	1	0.00	∞
Amplitude and phase noise	±	0.04	R	√3	1	0.02	∞
Measurement area truncation	±	0.00	R	√3	1	0.00	∞
Data acquisition	±	0.03	N	1	1	0.03	∞
Sampling	±	0.00	R	√3	1	0.00	∞
Field reconstruction	±	0.95	R	√3	1	0.55	∞
Forward transformation	±	0.00	R	√3	1	0.00	∞
Power density scaling		-	R	√3	1	-	∞
Spatial averaging		0.10	R	√3	1	0.06	∞
System detection limit	±	0.04	R	√3	1	0.02	∞
Uncertainty terms dependent on the DUT and environmental factors							
Probe coupling with DUT	±	0.00	R	√3	1	0.00	∞
Modulation response	±	0.40	R	√3	1	0.23	∞
Integration time	±	0.00	R	√3	1	0.00	∞
Response time	±	0.00	R	√3	1	0.00	∞
Device holder influence	±	0.10	R	√3	1	0.06	∞
DUT alignment	±	0.00	R	√3	1	0.00	∞
RF ambient conditions	±	0.04	R	√3	1	0.02	∞
Ambient reflections	±	0.04	R	√3	1	0.02	∞
Immunity / secondary reception	±	0.00	R	√3	1	0.00	∞
Drift of the DUT	±	0.21	R	√3	1	0.12	∞
Combined Std. Uncertainty						0.87	∞
Expanded STD Uncertainty (k = 2)						1.74	

Appendix D Revision History

Original Test Report No.: 14131461H-G

Revision	Test Report No.	Date	Page Revised Contents
- (Original)	14131461H-G	May 9, 2022	-

End of Report