Testing Laboratory 3787

RADIO TEST REPORT

FCC ID	:	2AEIM-1616631
Equipment	:	Vehicle Millimeter-wave Radar Sensor
Brand Name	:	Tesla
Model Name	:	1616631
Applicant	:	Tesla, Inc. 3500 Deer Creek Road Palo Alto, California US 94304 United States Of America
Manufacturer	:	Tesla, Inc. 3500 Deer Creek Road Palo Alto, California US 94304 United States Of America
Standard	:	47 CFR FCC Part 15.255

The product was received on May 05, 2022, and testing was started from May 26, 2022 and completed on Jun. 17, 2022. We, Sporton International Inc. Hsinchu Laboratory, would like to declare that the tested sample has been evaluated in accordance with the procedures given in ANSI C63.10-2013 47 CFR FCC Part 15.255 and shown 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. Hsinchu Laboratory, the test report shall not be reproduced except in full.

Approved by: Sam Chen

Sporton International Inc. Hsinchu Laboratory
No.8, Ln. 724, Bo'ai St., Zhubei City, Hsinchu County 302010, Taiwan (R.O.C.)

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History of this test report

Report No.	Version	Description	Issued Date
FR141246-01	01	Initial issue of report	Aug. 11, 2022

Summary of Test Result

Report Clause	Ref Std. Clause	Test Items	Result (PASS/FAIL)	Remark
-	15.207	AC Power Conducted Emissions	N/A	Note
3.1	15.255(e)	Occupied Bandwidth	PASS	-
3.2	15.255(c)	EIRP Power	PASS	-
3.3	15.255(c)	Peak Conducted Power	PASS	-
3.4	15.255(d)	Transmitter Spurious Emissions	PASS	-
3.5	15.255(f)	Frequency Stability	PASS	-
3.6	15.255(a),(h)	Operation Restriction and Group Installation	PASS	-
Note: The EUT was DC-powered (Vehicle battery); it's not necessary to apply to AC Power Port Conducted Emission.				

Declaration of Conformity:
1. The test results with all measurement uncertainty excluded are presented in accordance with the regulation limits or requirements declared by manufacturers. It's means measurement values may risk exceeding the limit of regulation standards, if measurement uncertainty is include in test results. 2. The measurement uncertainty please refer to report "Measurement Uncertainty".
Comments and Explanations:
The declared of product specification for EUT presented in the report are provided by the manufacturer, and the manufacturer takes all the responsibilities for the accuracy of product specification.

Reviewed by: Sam Chen

Report Producer: Jessie Wei

1 General Description

1.1 Information

1.1.1 RF General Information

RF General Information			
Frequency Range (GHz)	**Operating Frequency Range (GHz)**	**Test Frequency (GHz)**	**Modulation**
57-71 GHz	60-64 GHz	62.04	FMCW
		60.00 / 62.00 / 64.00	Sweeping-stop mode

Note: The test firmware two modes were made available, sweeping mode and Sweeping-stop mode. Sweeping mode is FM-CW signal sweeping in the operating band. Sweeping-stop mode is one carrier signal operating at fixed frequency.

1.1.2 Antenna Information

Ant.	Brand	Model Name	Antenna Type	Connector	Gain (dBi)
1	Tesla	1616631	Array Antenna	N/A	9.2

Note: The above information was declared by manufacturer.

1.1.3 Power Levels

Worst Power Levels	
Applicable power levels	☐ Conducted ☒ EIRP
Frequency (GHz)	Highest (P_{high}):
	Peak Power (dBm)
60.00	11.77
62.00	12.11
64.00	11.42

1.1.4 Operating Conditions

Operating Conditions				
☐ -20 °C to +50 °C				
☐ 0 °C to +40 °C				
☒ Other: -40 °C to +85 °C				
EUT Power Type	From DC power			
Test Software Version	ICR Certification GUI V1.0			
Supply Voltage	☐ AC	State AC voltage		V
Supply Voltage	☒ DC	State DC voltage	9~18	V

1.1.5 Equipment Use Condition

Equipment Use Condition
☐ Fixed field disturbance sensors at 61-61.5GHz
☒ Except fixed field disturbance sensors at 61-61.5GHz
☐ Except fixed field disturbance sensors

1.1.6 Duty Cycle

Duty Cycle (%)	Duty Cycle Factor (dB)
7.27	11.38

1.2 Applicable Standards

According to the specifications of the manufacturer, the EUT must comply with the requirements of the following standards:

- 47 CFR FCC Part 15.255
- ANSI C63.10-2013 Section 9. “Procedures for testing millimeter-wave systems”

The following reference test guidance is not within the scope of accreditation of TAF.

- FCC KDB 414788 D01 v01r01

FCC Waiver Documents:

- FCC DA-21-407A1
- DA-20-898A1_Rcd
- FCC Waiver Request 07.31.2020

1.3 Testing Location

Testing Location Information	
Test Lab.：Sporton International Inc. Hsinchu Laboratory	
Hsinchu (TAF: 3787)	ADD: No.8, Ln. 724, Bo’ai St., Zhubei City, Hsinchu County 302010, Taiwan (R.O.C.) TEL: 886-3-656-9065 FAX: 886-3-656-9085 Test site Designation No. TW3787 with FCC. Conformity Assessment Body Identifier (CABID) TW3787 with ISED.

Test Condition	Test Site No.	Test Engineer	Test Environment (°C / %)	Test Date
RF Radiated	TH03-CB	Eddie Weng	21.2~23.2 / 58~61	May 30, 2022
Radiated below 1GHz	10CH01-CB	Joe Chu	22~23 / 57~58	Jun. 17, 2022
Radiated above 1GHz	03CH04-CB	Eddie Weng	24.2~24.7 / 63~66	May 26, 2022~ Jun. 03, 2022

2 Test Configuration of Equipment under Test

2.1 Parameters of Test Software Setting

Channel Plan (GHz)	60.00	62.00	64.00
Software Setting	6	6	4

2.2 Conformance Tests and Related Test Frequencies

Test Item	Test Frequencies (GHz)
Occupied Bandwidth	62.04
EIRP Power & EIRP PSD	60.00 / 62.00 / 64.00
Peak Conducted Power	60.00 / 62.00 / 64.00
Transmitter Spurious Emissions (below 1 GHz)	60.00 / 62.00 / 64.00
Transmitter Spurious Emissions (1 GHz-40 GHz)	60.00 / 62.00 / 64.00
Transmitter Spurious Emissions (above 40 GHz)	60.00 / 62.00 / 64.00
Frequency Stability	62.04

Tests Item	Transmitter Spurious Emissions
Operating Mode < 1GHz	Normal Link
1	EUT in X axis
2	EUT in Z axis
3	EUT in Y axis
For operating mode 2 is the worst case and it was record in this test report.	
Operating Mode > 1GHz	CTX
The EUT was performed at X axis, Y axis and Z axis position, and the worst case was found at X axis. So the measurement will follow this same test configuration.	
1	EUT in X axis_60.00 GHz
2	EUT in X axis_62.00 GHz
3	EUT in X axis_64.00 GHz

2.3 EUT Operation during Test

During the test, executed the test program to control the EUT continuously transmit RF signal.

2.4 Accessories

N/A

2.5 Support Equipment

Support Equipment				
No.	**Equipment**	**Brand Name**	**Model Name**	**FCC ID**
A	Power Supply	Advanced	LPS-305	N/A

2.6 Far Field Boundary Calculations

The far-field boundary is given as:

far field = (2 * L^2) /**λ**

where:

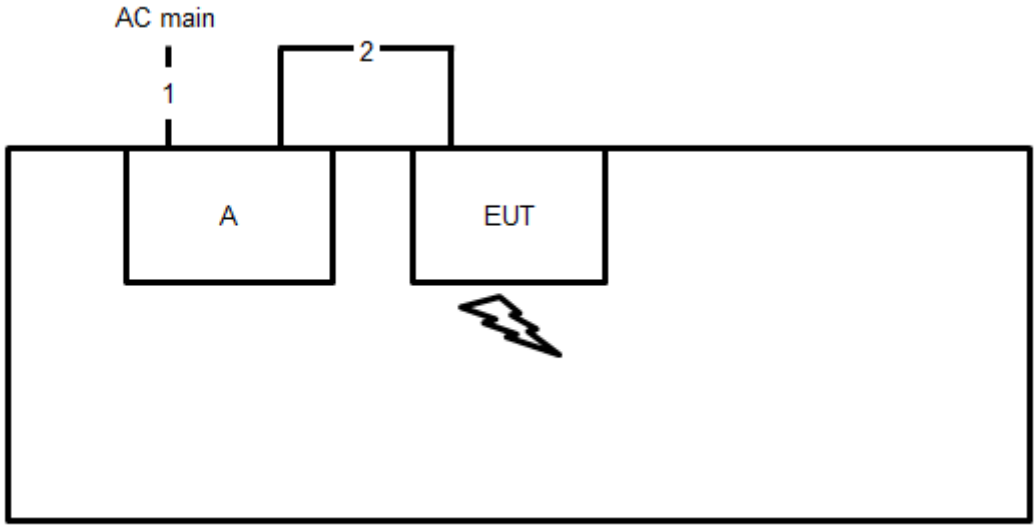
L = Largest Antenna Dimension, including the reflector, in meters

λ= wavelength in meters

Far Field (m)				
Frequency (GHz)	**L (m)**	**Lambda (m)**	**d(Far Field) (m)**	**d(Far Field) (cm)**
60.00	0.047	0.0050000	0.884	88.36
62.00	0.047	0.0048387	0.913	91.31
64.00	0.047	0.0046875	0.943	94.25

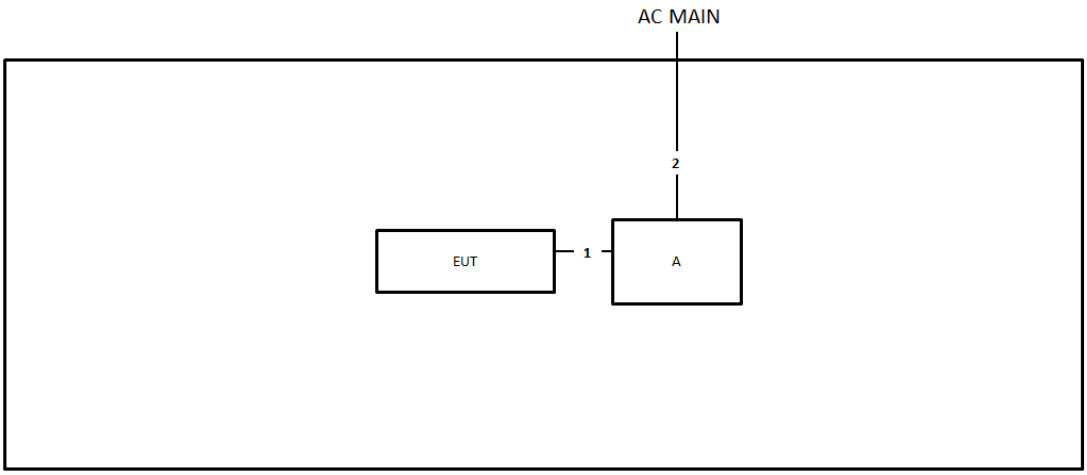
2.7 Test Setup Diagram

Test Setup Diagram - Transmitter Spurious Emissions below 1 GHz



Item	Connection	Shielded	Length
1	Power cable	No	1.8m
2	Power cable	No	1.5m

Test Setup Diagram - Transmitter Spurious Emissions above 1 GHz



Item	Connection	Shielded	Length
1	Power cable	No	1.5m
2	Power cable	No	1.5m

3 Transmitter Test Result

3.1 Occupied Bandwidth

3.1.1 Limit of Occupied Bandwidth

6dBc Bandwidth (see Note 1)	None
99% Occupied Bandwidth (see Note 2)	None

NOTE 1: The 6dBc bandwidth is the frequency bandwidth of the signal power at the -6 dBc points when measured with a 100 kHz resolution bandwidth. These measurements shall also be performed at normal test conditions.

NOTE 2: The 99% occupied bandwidth is the frequency bandwidth of the signal power at the 99% channel power of occupied bandwidth when resolution bandwidth should be approximately 1 % to 5 % of the occupied bandwidth (OBW). These measurements shall also be performed at normal test conditions.

3.1.2 Measuring Instruments

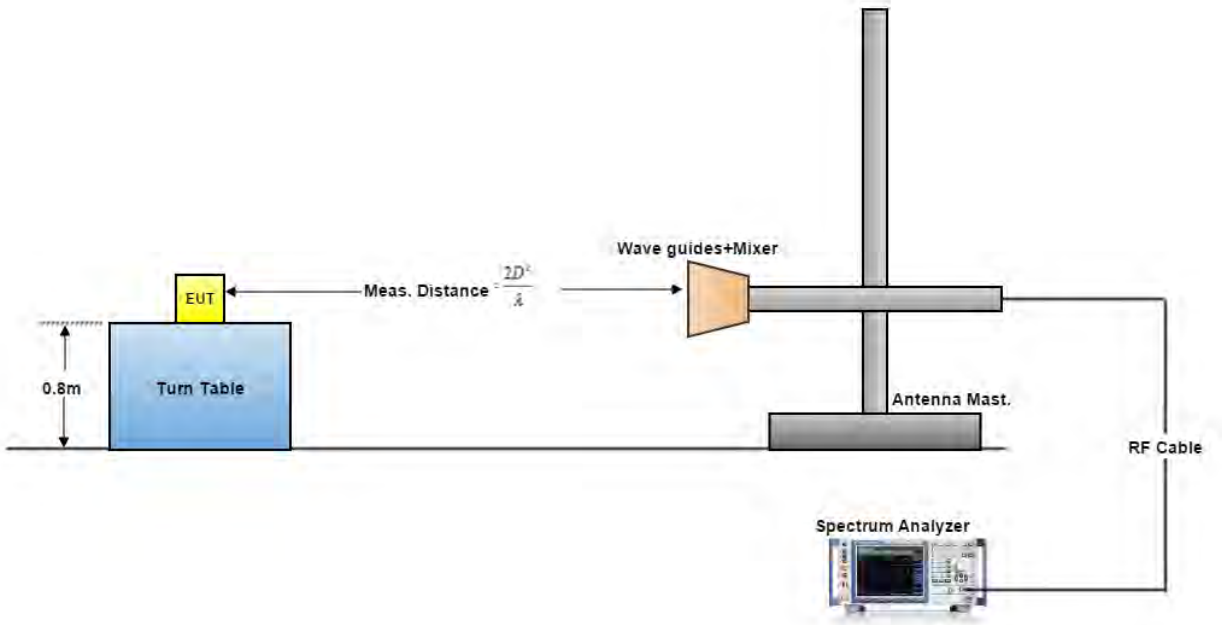
Refer a measuring instruments list in this test report.

3.1.3 Test Procedures

Method of measurement: Refer as ANSI C63.10-2013, clauses 6.9.2.

3.1.4 Test Setup

Occupied Channel Bandwidth



3.1.5 Test Result of Occupied Bandwidth

Test Conditions	see ANSI C63.10, clause 5.11
Test Setup	see ANSI C63.10, clause 6.9.2
NOTE: If equipment having different transmit operating modes (see test report clause 1.1.2), the measurements are uninfluenced by different transmit operating modes, may not need to be repeated for all the operating modes. Similar, if the equipment supports different modulations and/or data rates, the measurements described in ANSI C63.10, clause 5.11 may not need to be repeated for all these modulations and data rates. Simple comparison of engineering test across all operating modes, modulations and data rates may need to be performed to define the worse case combination to be used for the conformance testing. Refer as ANSI C63.10, clause 15, observe and record with plotted graphs or photographs the worst-case (i.e., widest) occupied bandwidth produced by these different modulation sources.	

Test Results			
Test Freq. (GHz)	**6 dBc Bandwidth (MHz)**	**99% Occupied Bandwidth (MHz)**	**Limit (MHz)**
62.04	3251.70	3239.92	N/A

3.1.5.1 Bandwidth Plots

Test Frequency: 62.04 GHz
6 dBc Bandwidth & Occupied Bandwidth

3.2 EIRP Power & EIRP PSD

3.2.1 Limit of EIRP Power & EIRP PSD

EIRP Power Limit		
Use Condition	**EIRP Average Power**	**EIRP Peak Power**
Fixed field disturbance sensors at within the frequency band 61-61.5GHz	40 dBm	43 dBm
Fixed field disturbance sensors at outside of the band 61-61.5GHz	10 dBm	13 dBm
Except fixed field disturbance sensors at 61-61.5GHz	N/A	10 dBm
Except outdoor fixed Point to Point	40 dBm	43 dBm
Outdoor fixed Point to Point	82 dBm	85 dBm
FCC Waiver	N/A	13 dBm
Note: For fixed point-to-point transmitters located outdoors, the average power of any emission shall not exceed 82 dBm, and shall be reduced by 2 dB for every dB that the antenna gain is less than 51 dBi. The peak power of any emission shall not exceed 85 dBm, and shall be reduced by 2 dB for every dB that the antenna gain is less than 51 dBi.		

NOTE: For the applicable limit, see 15.255 (c).

3.2.2 Measuring Instruments

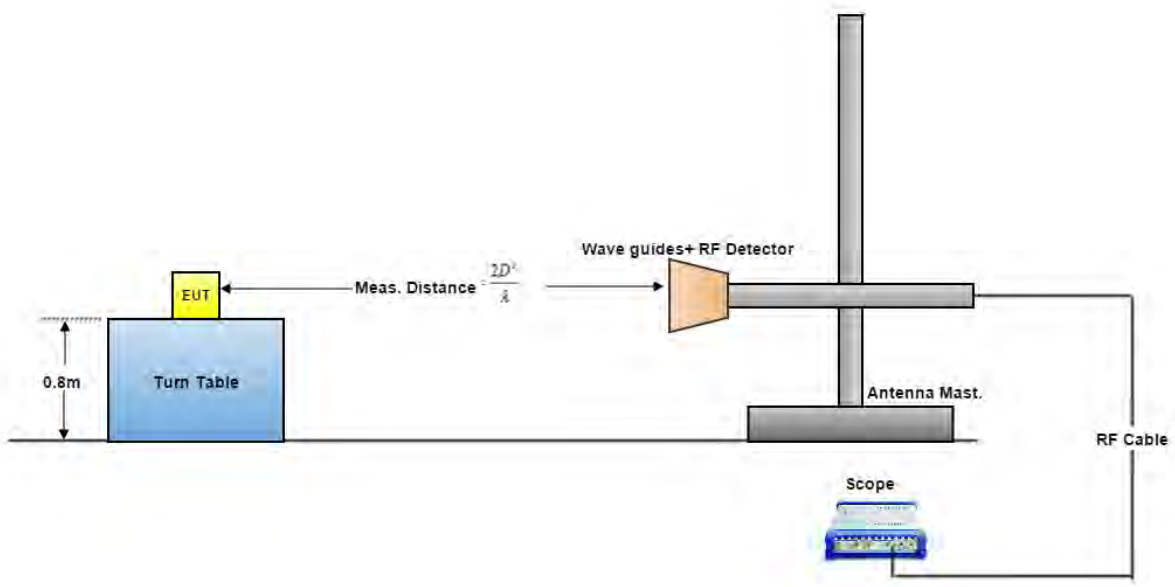
Refer a measuring instruments list in this test report.

3.2.3 Test Procedures

Method of measurement: Refer as ANSI C63.10-2013 clause 9.3 & 9.5.

3.2.4 Test Setup

EIPR Power & EIRP PSD



3.2.5 Test Result of EIRP Power & EIRP PSD

Test Conditions	see ANSI C63.10, clause 5.11 & clause 9
Test Setup	see ANSI C63.10, clause 9.11

NOTE: If the equipment supports different modulations and/or data rates, the measurements described in ANSI C63.10, clause 5.11 may not need to be repeated for all these modulations and data rates. Simple comparison of engineering test across all operating modes, modulations and data rates may need to be performed to define the worst case combination to be used for the conformance testing.

3.2.5.1 Test Result of EIRP Power & EIRP PSD

Freq. (GHz)	Rx Gain (dBi)	DSO Peak (mV)	P-Peak (dBm)	E-Meas-Peak (dBuV/m)	Test Distance (m)	EIRP-Peak (dBm)	EIRP-Peak Limit (dBm)	Test Result
60.00	23.6	29.37	-32.65	116.57	1.00	11.77	13	Pass
62.00	23.6	29.69	-32.60	116.91	1.00	12.11	13	Pass
64.00	23.6	24.52	-33.56	116.22	1.00	11.42	13	Pass

The measured power level is converted to EIRP using the Friis equation:

For radiated emissions, calculate the field strength (E) in dBμV/meter.

$E = 126.8 – 20\log(\lambda) + P – G$

where:

E : is the field strength of the emission at the measurement distance, in dBμV/m

P : is the power measured at the output of the test antenna, in dBm

λ: is the wavelength of the emission under investigation [300/fMHz], in m

G : is the gain of the test antenna, in dBi For radiated emissions, calculate the EIRP (dBm). If the measurement was performed in the far field, calculate the EIRP.

EIRP = E-meas +20log(d-meas)-104.7

where:

EIRP : is the equivalent isotopically radiated power, in dBm

E-meas. : is the field strength of the emission at the measurement distance, in dBμV/m

d-meas. : is the measurement distance, in m

NOTE 1: For the applicable limit, see 15.255 (c)

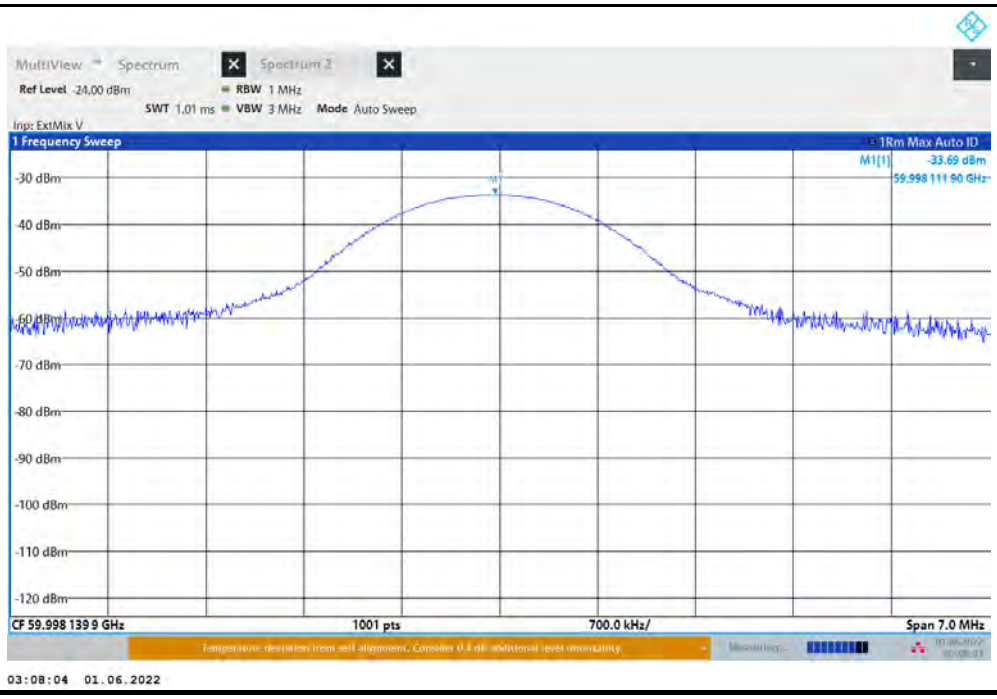
NOTE 2: The comparison method which replaces EUT with a signal generator is used to find the correct conversion factor between “DSO(mV)” & “Power Measured(dBm)”.

Freq. (GHz)	Rx Gain (dBi)	Measurement Distance (m)	Read Worse Frequency (GHz)	Read Level (dBm/MHz)	EIRP PSD (dBm/MHz)	Limit (dBm/MHz)
60.00	23.6	1.00	59.99	-33.69	10.71	13
62.00	23.6	1.00	61.99	-33.67	11.02	13
64.00	23.6	1.00	63.99	-34.49	10.47	13

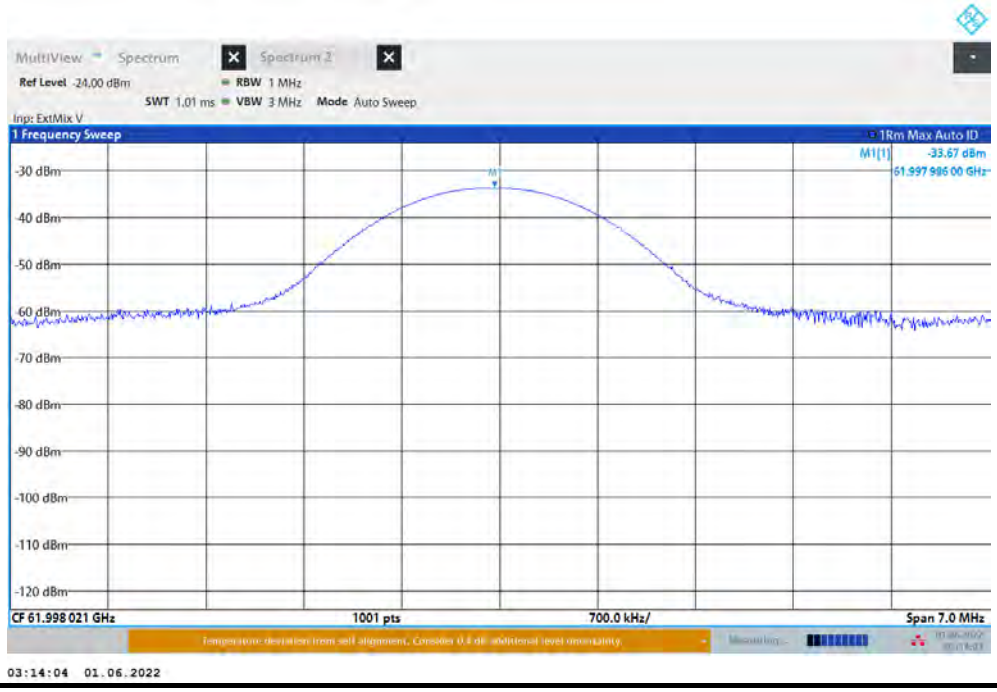
Note: EIRP PSD = Meas. Level - RX Antenna Gain + 20*log(4*Pi(3.14159)*D/(300/(Frequency*1000)))

3.2.5.2 EIRP PSD Plots

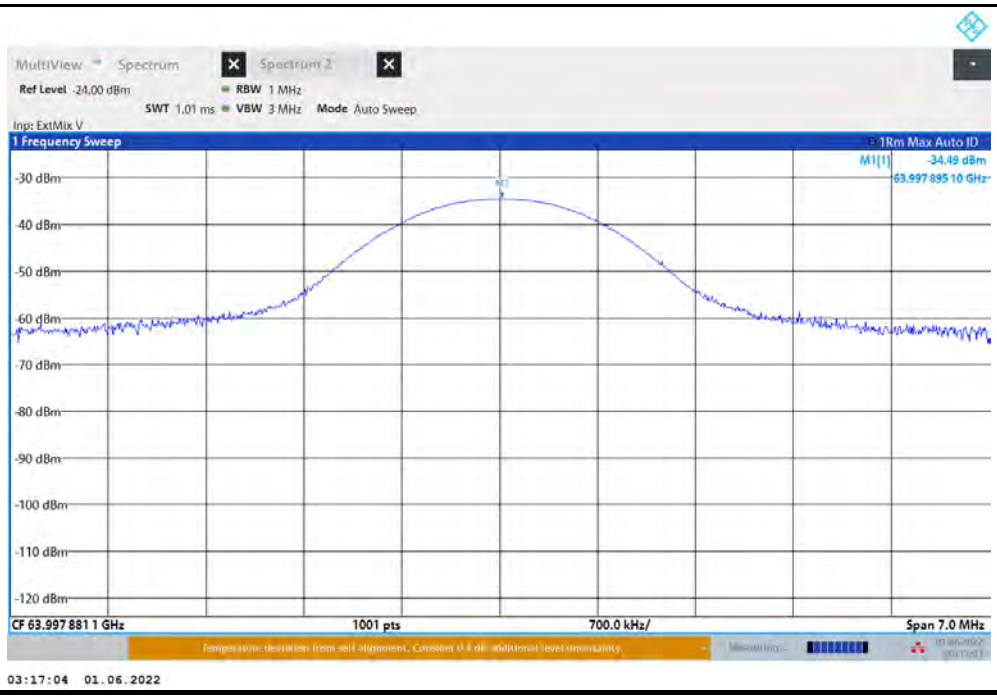
Test Frequency: 60.00 GHz



Test Frequency: 62.00 GHz



Test Frequency: 64.00 GHz



3.3 Peak Conducted Power

3.3.1 Limit of Peak Conducted Power

Peak Conducted Power Limit			
Use Condition	**6dBc Bandwidth**	**Occupied Bandwidth**	**Peak Conducted Power (note 1)**
Fixed field disturbance sensors at within the frequency band 61-61.5GHz	> 100MHz	≤500MHz	500mW
	≤ 100MHz		500mW x (BW/100) (see note 2)
Fixed field disturbance sensors at outside of the band 61-61.5GHz and within 57 -71 GHz	> 100MHz	N/A	500mW
	≤ 100MHz		500mW x (BW/100) (see note 2)
Except fixed field disturbance sensors at 61-61.5GHz	N/A	> 500MHz	-10 dBm
Except outdoor fixed Point to Point,	> 100MHz	N/A	500mW
Outdoor fixed Point to Point	≤ 100MHz	N/A	500mW x (BW/100) (see note 2)
NOTE 1: For the applicable limit, see FCC 15.255(c) NOTE 2: BW= 6dB bandwidth (measured at RBW 100kHz)			

3.3.2 Measuring Instruments

Refer a measuring instruments list in this test report.

3.3.3 Test Procedures

Method of measurement: Refer as ANSI C63.10-2013, clause 9.5

3.3.4 Test Result of Peak Conducted Power

Test Conditions	see ANSI C63.10, clause 5.11 & clause 9
Test Setup	see ANSI C63.10, clause 9.11
NOTE: If the equipment supports different modulations and/or data rates, the measurements described in ANSI C63.10, clause 5.11 may not need to be repeated for all these modulations and data rates. Simple comparison of engineering test across all operating modes, modulations and data rates may need to be performed to define the worst case combination to be used for the conformance testing.	

3.3.4.1 Peak Conducted Power

Test Results					
Test Freq. (GHz)	**EIRP-Peak (dBm)**	**Max. Ant. Gain (dBi)**	**Peak Power (dBm)** (note1)	**P-Cond Limit (dBm)**	**Test Result**
60.00	11.77	9.20	2.57	10	Pass
62.00	12.11	9.20	2.91	10	Pass
64.00	11.42	9.20	2.22	10	Pass

NOTE 1: Because EUT used for the integral antenna without temporary RF connector provided. Therefore peak conducted power is equal to EIRP power subtract the antenna gain.

NOTE 2: For radiated emission measurements, calculate conducted transmitter output power P(cond)(dBm)

P(cond) = EIRP - G(dBi)

where:

G(dBi) is gain of EUT antenna.

3.4 Transmitter Spurious Emissions

3.4.1 Limit of Transmitter Spurious Emissions

Frequency Range	Limit
Radiated emissions below 40 GHz	15.209
Radiated emissions above 40 GHz – 200GHz	90 pW/cm^2 @ 3 m (Equivalent EIRP 102 μW, -9.91dBm)
NOTE 1: For the applicable limit, see 15.255(d)	
NOTE 2: Spurious emissions shall not exceed the level of the fundamental emission.	

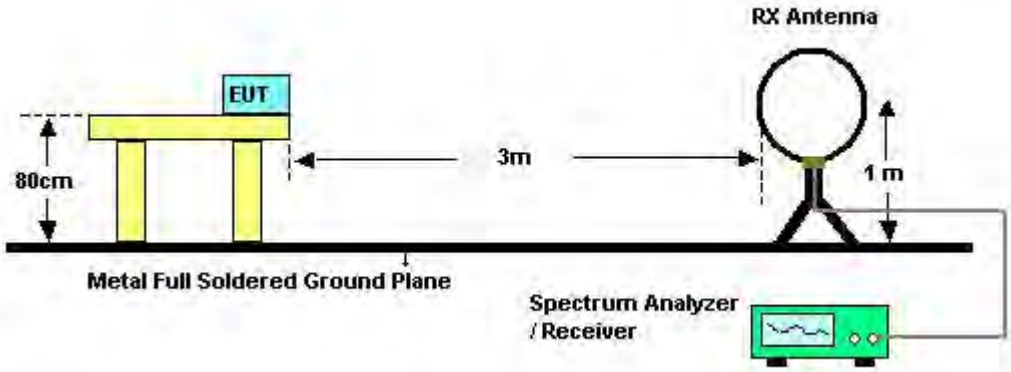
3.4.2 Test Procedures

Method of measurement: Refer as ANSI C63.10-2013, clause 9.12

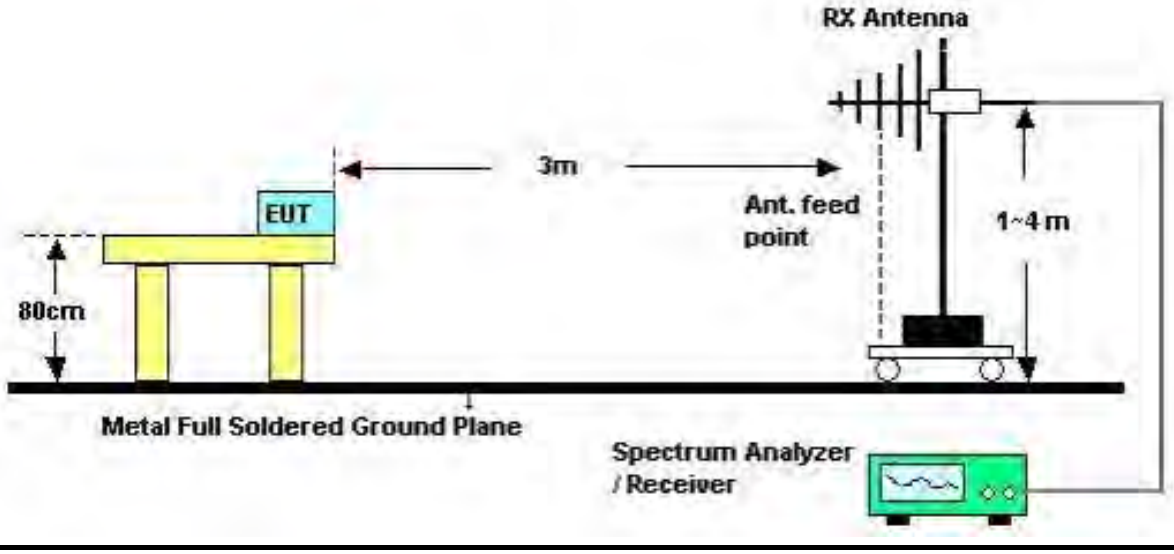
3.4.3 Test Setup

Transmitter Spurious Emissions

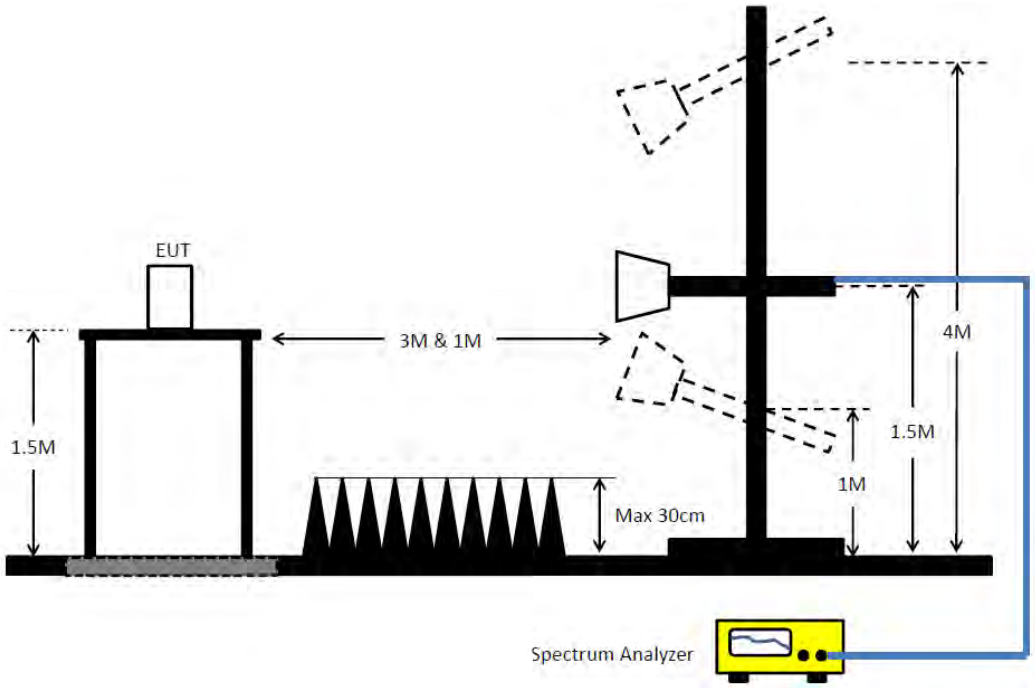
9kHz ~30MHz



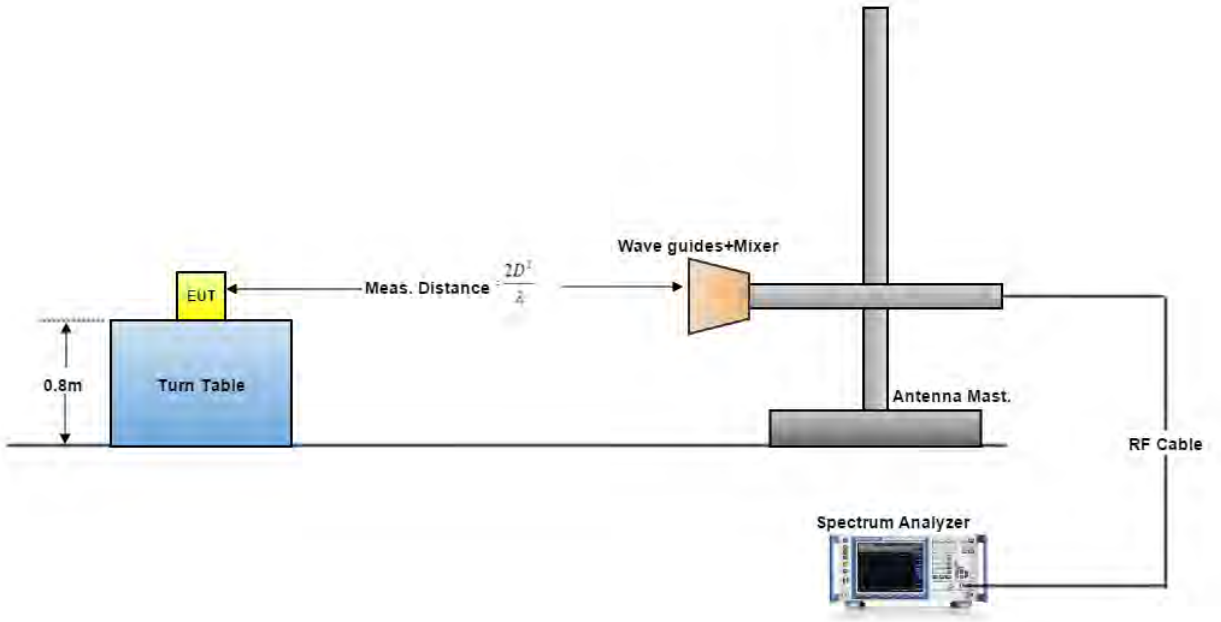
30MHz~1GHz



1GHz ~40GHz



Above 40GHz



A measuring distance of at 3 m shall be used for measurements at frequencies up to 15 GHz. For frequencies above 15 GHz, any suitable measuring distance may be used. The measurement distance is chosen up to far field distance, depending on the test system noise floor for detecting spurious emission signals. Then above 15 GHz shall be extrapolated to the specified distance using an extrapolation factor of 20 dB/decade from spec. distance (3 m) to measurement distance. Distance extrapolation factor = 20 log (spec. distance [3 m] / measurement distance [N m]) (dB) .The measurements described in ANSI C63.10, clause 7.8.6. If the emission cannot be detected at 1 m, reduce the RBW to increase system sensitivity. Note the value. If the emission still cannot be detected, move the horn closer to the EUT, noting the distance at which a measurement is made.

3.4.4 Measurement Results Calculation

The measured Level is calculated using:

For below 40GHz

Corrected Reading: Antenna factor (AF) + Cable loss (CL) + Read level (Raw) - Preamp factor (PA)(if applicable) = Level.

For above 40GHz

EIRP = Meas. Level - RX Antenna Gain + 20*log(4*Pi(3.14159)*D/(300/(Frequency*1000)))

3.4.5 Test Result of Transmitter Spurious Emissions

Test Conditions	see ANSI C63.10, clause 5.11 & clause 9
Test Setup	see ANSI C63.10, clause 9.12 、9.13
NOTE: If equipment having different channel plan and nominal channel bandwidth modes (see test report clause 1.1.1), the measurements are uninfluenced by different channel plan and nominal channel bandwidth modes, may not need to be repeated for all modes.	

3.4.5.1 Test Result of Transmitter Spurious Emissions (Below 30MHz)

There is a comparison data of both open-field test site and alternative test site - semi-Anechoic chamber according to KDB414788 Radiated Test Site, and the result came out very similar.

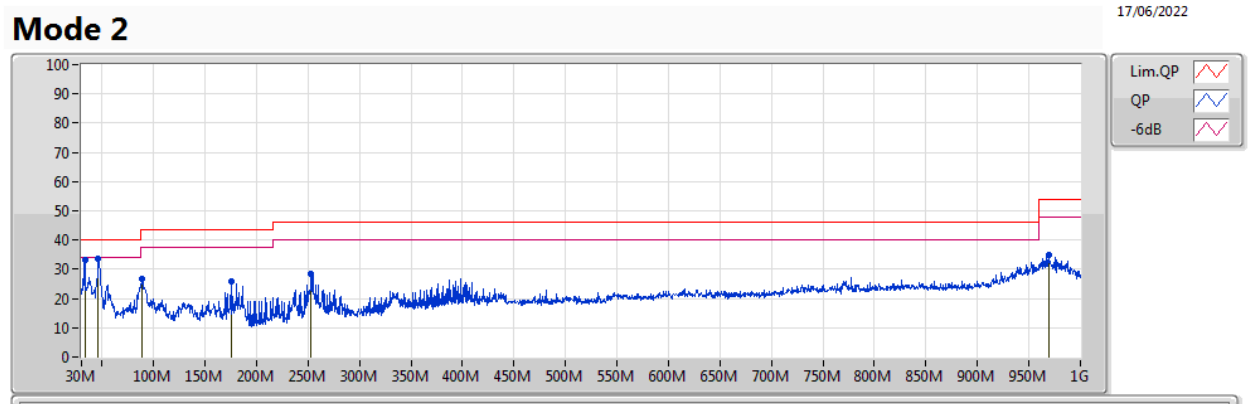
All amplitude of spurious emissions that are attenuated by more than 20 dB below the permissible value has no need to be reported.

The radiated emissions were investigated from 9 kHz or the lowest frequency generated within the device, up to the 10 harmonic or 40 GHz, whichever is appropriate.

3.4.5.2 Test Result of Transmitter Spurious Emissions

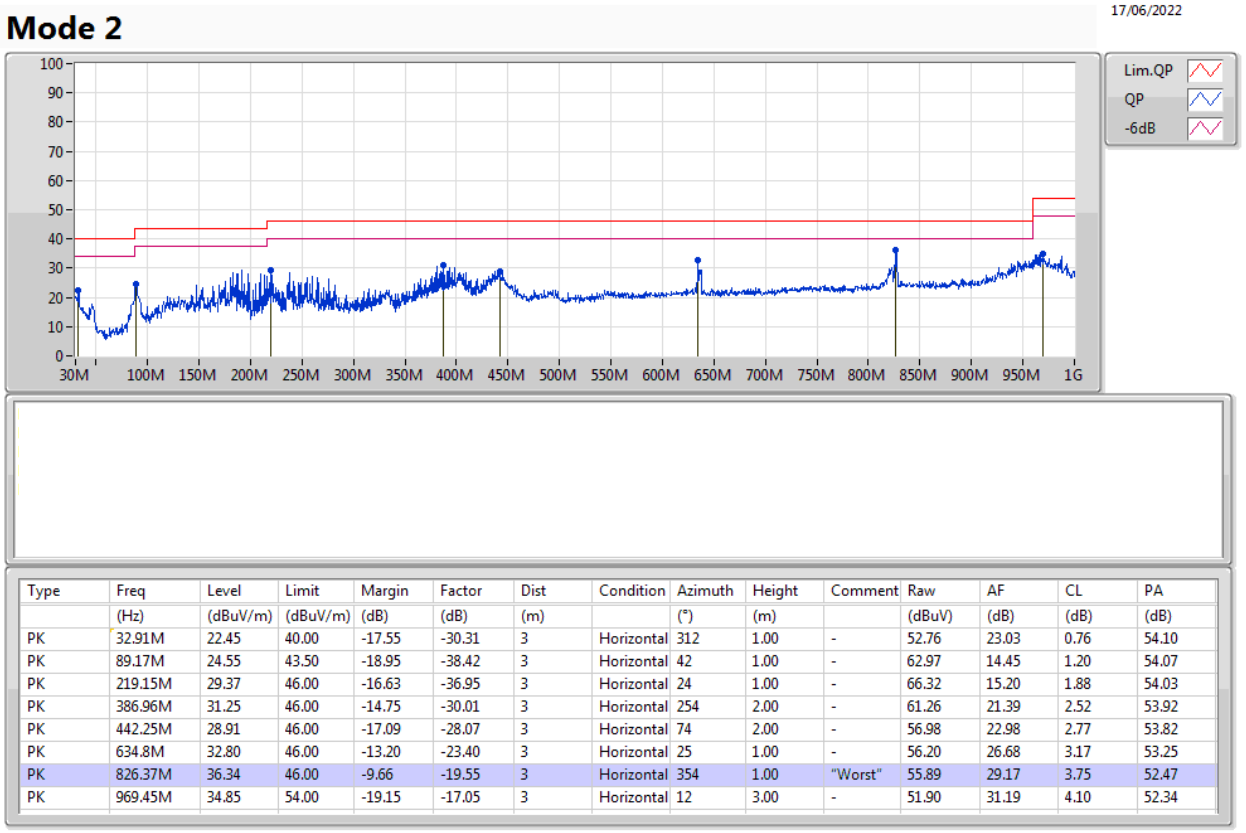
Test Range	30 MHz – 1000 MHz	Test Distance	3 m
Test Configuration	Normal Link	Test Mode	Mode 2

Vertical



Type	Freq	Level	Limit	Margin	Factor	Dist	Condition	Azimuth	Height	Comment	Raw	AF	CL	PA
	(Hz)	(dBuV/m)	(dBuV/m)	(dB)	(dB)	(m)		(°)	(m)		(dBuV)	(dB)	(dB)	(dB)
PK	33.4M	33.28	40.00	-6.72	-30.49	3	Vertical	21	1.00	-	63.77	22.84	0.77	54.10
PK	46.49M	33.79	40.00	-6.21	-36.98	3	Vertical	352	1.00	"Worst"	70.77	16.27	0.83	54.08
PK	88.69M	26.62	43.50	-16.88	-38.53	3	Vertical	35	2.00	-	65.15	14.35	1.20	54.08
PK	175.02M	25.93	43.50	-17.57	-37.03	3	Vertical	145	3.00	-	62.96	15.35	1.68	54.06
PK	252.62M	28.57	46.00	-17.43	-33.33	3	Vertical	282	3.00	-	61.90	18.76	2.01	54.10
PK	969.45M	34.95	54.00	-19.05	-17.05	3	Vertical	14	2.00	-	52.00	31.19	4.10	52.34

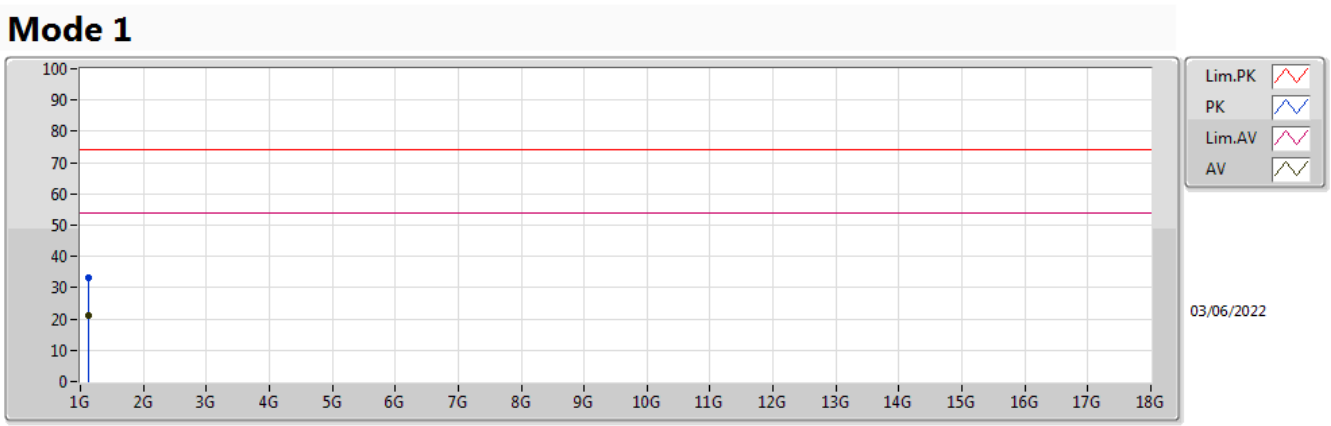
Horizontal



Type	Freq	Level	Limit	Margin	Factor	Dist	Condition	Azimuth	Height	Comment	Raw	AF	CL	PA
	(Hz)	(dBuV/m)	(dBuV/m)	(dB)	(dB)	(m)		(°)	(m)		(dBuV)	(dB)	(dB)	(dB)
PK	32.91M	22.45	40.00	-17.55	-30.31	3	Horizontal	312	1.00	-	52.76	23.03	0.76	54.10
PK	89.17M	24.55	43.50	-18.95	-38.42	3	Horizontal	42	1.00	-	62.97	14.45	1.20	54.07
PK	219.15M	29.37	46.00	-16.63	-36.95	3	Horizontal	24	1.00	-	66.32	15.20	1.88	54.03
PK	386.96M	31.25	46.00	-14.75	-30.01	3	Horizontal	254	2.00	-	61.26	21.39	2.52	53.92
PK	442.25M	28.91	46.00	-17.09	-28.07	3	Horizontal	74	2.00	-	56.98	22.98	2.77	53.82
PK	634.8M	32.80	46.00	-13.20	-23.40	3	Horizontal	25	1.00	-	56.20	26.68	3.17	53.25
PK	826.37M	36.34	46.00	-9.66	-19.55	3	Horizontal	354	1.00	"Worst"	55.89	29.17	3.75	52.47
PK	969.45M	34.85	54.00	-19.15	-17.05	3	Horizontal	12	3.00	-	51.90	31.19	4.10	52.34

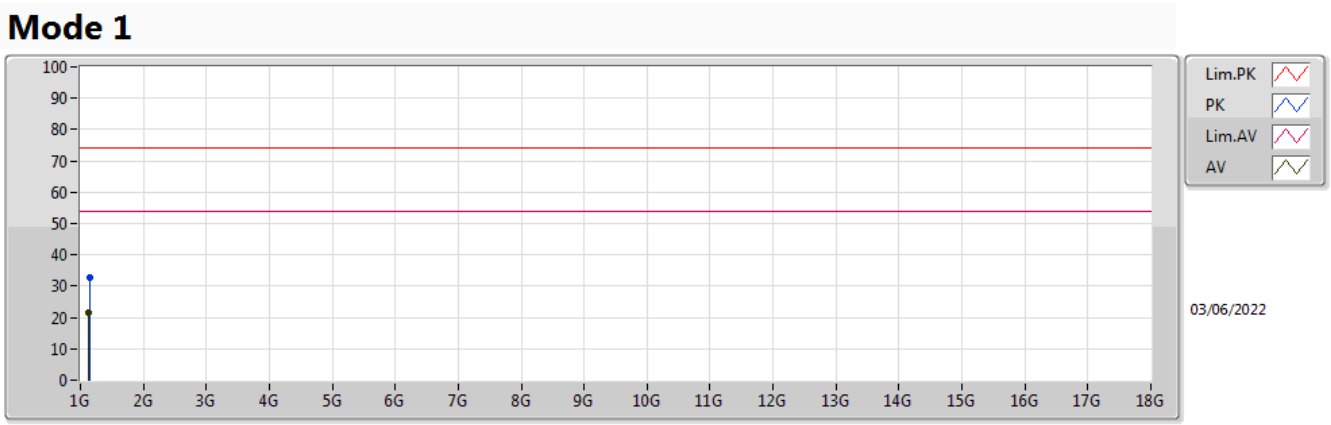
Test Range	1 GHz – 18 GHz	Test Distance	3 m
Test Configuration	CTX	Test Mode	Mode 1

Vertical



Type	Freq	Level	Limit	Margin	Factor	Dist	Condition	Azimuth	Height	Comment	Raw	AF	CL	PA
	(Hz)	(dBuV/m)	(dBuV/m)	(dB)	(dB/m)	(m)		(°)	(m)		(dBuV/m)	(dB/m)	(dB)	(dB)
PK	1.13616G	33.22	74.00	-40.78	-9.06	3	Vertical	342	1.63	-	42.28	25.13	3.10	37.29
AV	1.13596G	21.23	54.00	-32.77	-9.06	3	Vertical	342	1.63	"Worst"	30.29	25.13	3.10	37.29

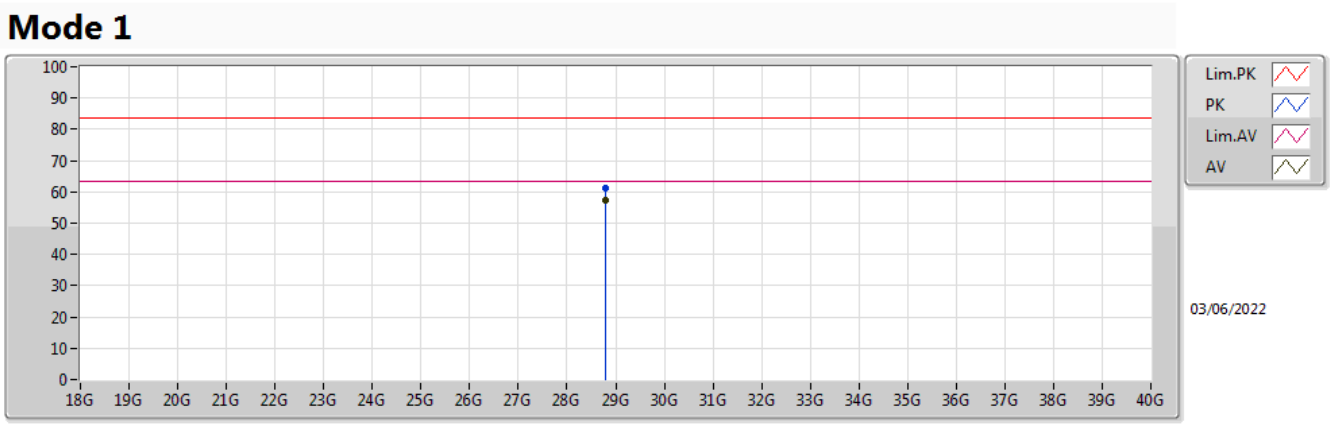
Horizontal



Type	Freq	Level	Limit	Margin	Factor	Dist	Condition	Azimuth	Height	Comment	Raw	AF	CL	PA
	(Hz)	(dBuV/m)	(dBuV/m)	(dB)	(dB/m)	(m)		(°)	(m)		(dBuV/m)	(dB/m)	(dB)	(dB)
PK	1.14132G	32.92	74.00	-41.08	-8.98	3	Horizontal	198	1.46	-	41.90	25.20	3.11	37.29
AV	1.13592G	21.41	54.00	-32.59	-9.06	3	Horizontal	198	1.46	"Worst"	30.47	25.13	3.10	37.29

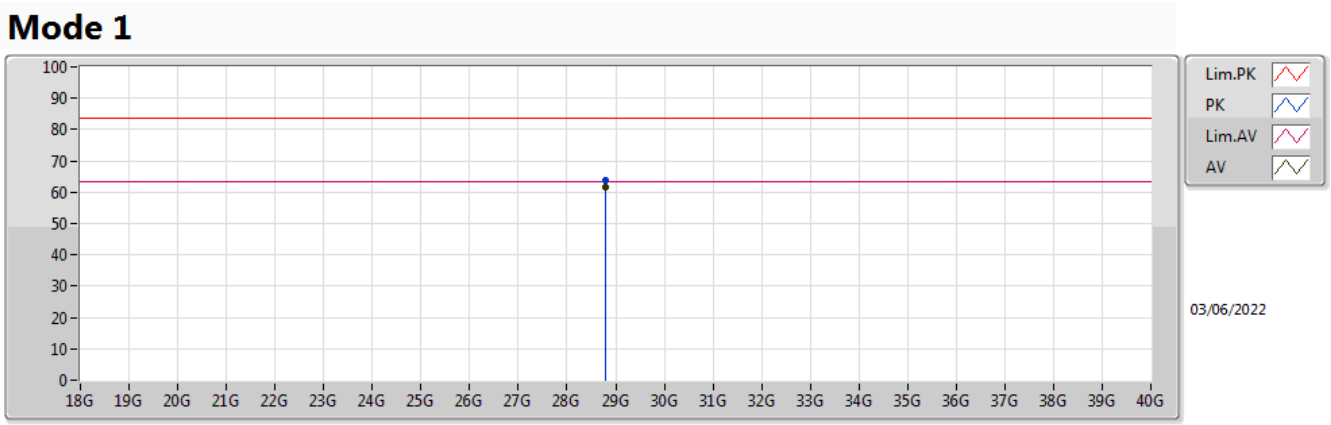
Test Range	18 GHz – 40 GHz	Test Distance	1 m
Test Configuration	CTX	Test Mode	Mode 1

Vertical



Type	Freq	Level	Limit	Margin	Factor	Dist	Condition	Azimuth	Height	Comment	Raw	AF	CL	PA
	(Hz)	(dBuV/m)	(dBuV/m)	(dB)	(dB/m)	(m)		(°)	(m)		(dBuV/m)	(dB/m)	(dB)	(dB)
PK	28.79909G	61.24	83.54	-22.30	12.78	1	Vertical	26	1.52	-	48.46	39.82	18.80	45.84
AV	28.79907G	57.20	63.54	-6.34	12.78	1	Vertical	24	1.52	"Worst"	44.42	39.82	18.80	45.84

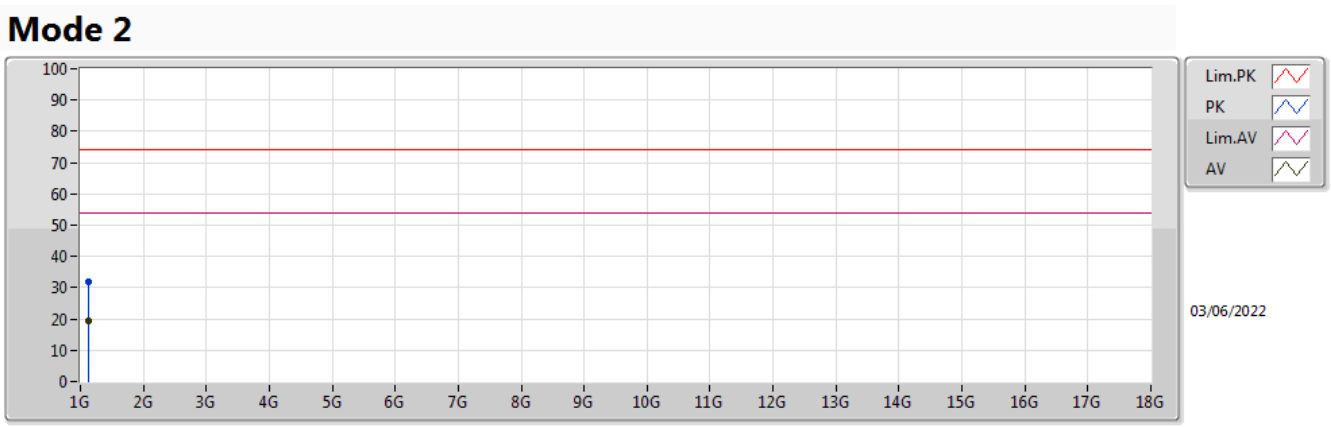
Horizontal



Type	Freq	Level	Limit	Margin	Factor	Dist	Condition	Azimuth	Height	Comment	Raw	AF	CL	PA
	(Hz)	(dBuV/m)	(dBuV/m)	(dB)	(dB/m)	(m)		(°)	(m)		(dBuV/m)	(dB/m)	(dB)	(dB)
PK	28.79906G	63.82	83.54	-19.72	12.78	1	Horizontal	285	1.56	-	51.04	39.82	18.80	45.84
AV	28.79906G	61.84	63.54	-1.70	12.78	1	Horizontal	285	1.56	"Worst"	49.06	39.82	18.80	45.84

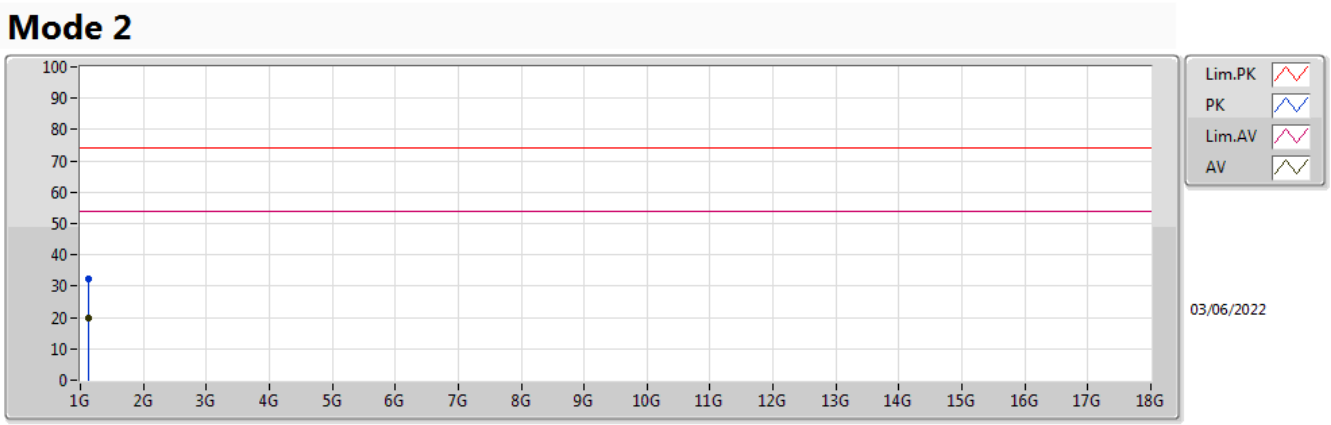
Test Range	1 GHz – 18 GHz	Test Distance	3 m
Test Configuration	CTX	Test Mode	Mode 2

Vertical



Type	Freq	Level	Limit	Margin	Factor	Dist	Condition	Azimuth	Height	Comment	Raw	AF	CL	PA
	(Hz)	(dBuV/m)	(dBuV/m)	(dB)	(dB/m)	(m)		(°)	(m)		(dBuV/m)	(dB/m)	(dB)	(dB)
PK	1.1289G	32.09	74.00	-41.91	-10.71	3	Vertical	334	1.52	-	42.80	23.95	2.63	37.29
AV	1.13592G	19.52	54.00	-34.48	-10.62	3	Vertical	334	1.52	"Worst"	30.14	24.03	2.64	37.29

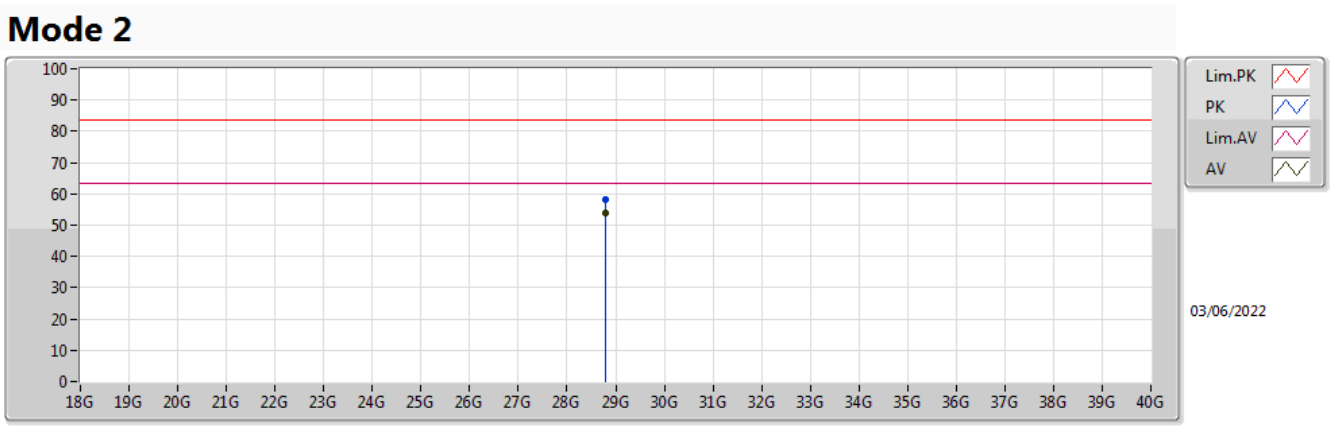
Horizontal



Type	Freq	Level	Limit	Margin	Factor	Dist	Condition	Azimuth	Height	Comment	Raw	AF	CL	PA
	(Hz)	(dBuV/m)	(dBuV/m)	(dB)	(dB/m)	(m)		(°)	(m)		(dBuV/m)	(dB/m)	(dB)	(dB)
PK	1.13584G	32.39	74.00	-41.61	-10.62	3	Horizontal	312	1.50	-	43.01	24.03	2.64	37.29
AV	1.1261G	19.90	54.00	-34.10	-10.75	3	Horizontal	312	1.50	"Worst"	30.65	23.91	2.63	37.29

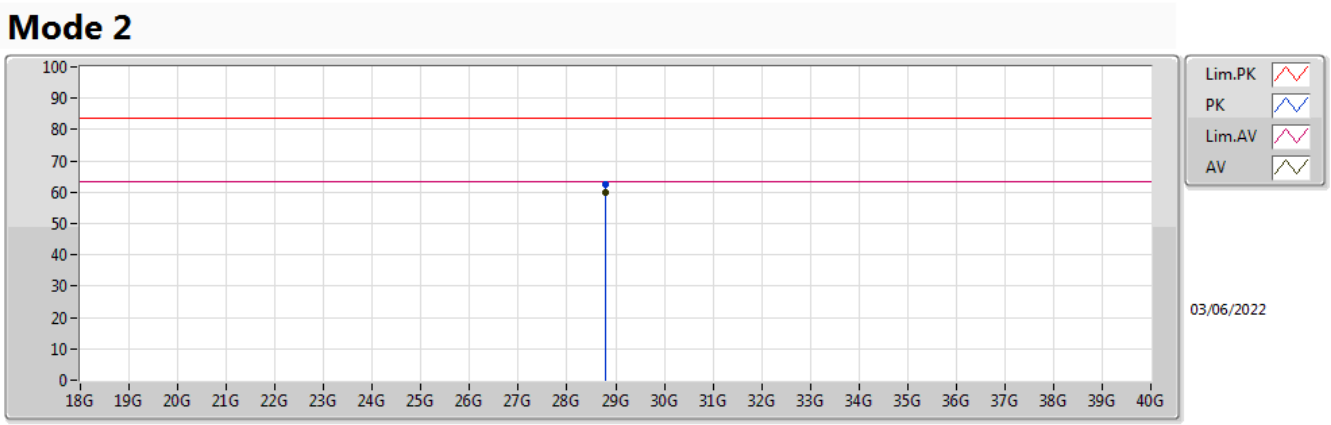
Test Range	18 GHz – 40 GHz	Test Distance	1 m
Test Configuration	CTX	Test Mode	Mode 2

Vertical



Type	Freq	Level	Limit	Margin	Factor	Dist	Condition	Azimuth	Height	Comment	Raw	AF	CL	PA
	(Hz)	(dBuV/m)	(dBuV/m)	(dB)	(dB/m)	(m)		(°)	(m)		(dBuV/m)	(dB/m)	(dB)	(dB)
PK	28.79918G	58.36	83.54	-25.18	12.78	1	Vertical	31	1.60	-	45.58	39.82	18.80	45.84
AV	28.79908G	53.83	63.54	-9.71	12.78	1	Vertical	31	1.60	"Worst"	41.05	39.82	18.80	45.84

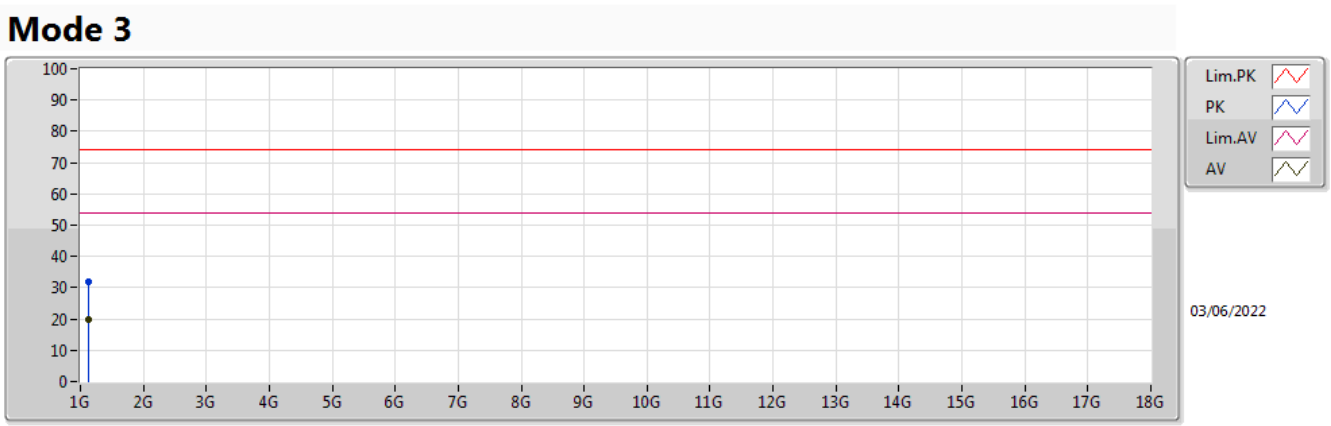
Horizontal



Type	Freq	Level	Limit	Margin	Factor	Dist	Condition	Azimuth	Height	Comment	Raw	AF	CL	PA
	(Hz)	(dBuV/m)	(dBuV/m)	(dB)	(dB/m)	(m)		(°)	(m)		(dBuV/m)	(dB/m)	(dB)	(dB)
AV	28.79907G	59.85	63.54	-3.69	12.78	1	Horizontal	286	1.56	"Worst"	47.07	39.82	18.80	45.84
PK	28.79913G	62.34	83.54	-21.20	12.78	1	Horizontal	286	1.56	-	49.56	39.82	18.80	45.84

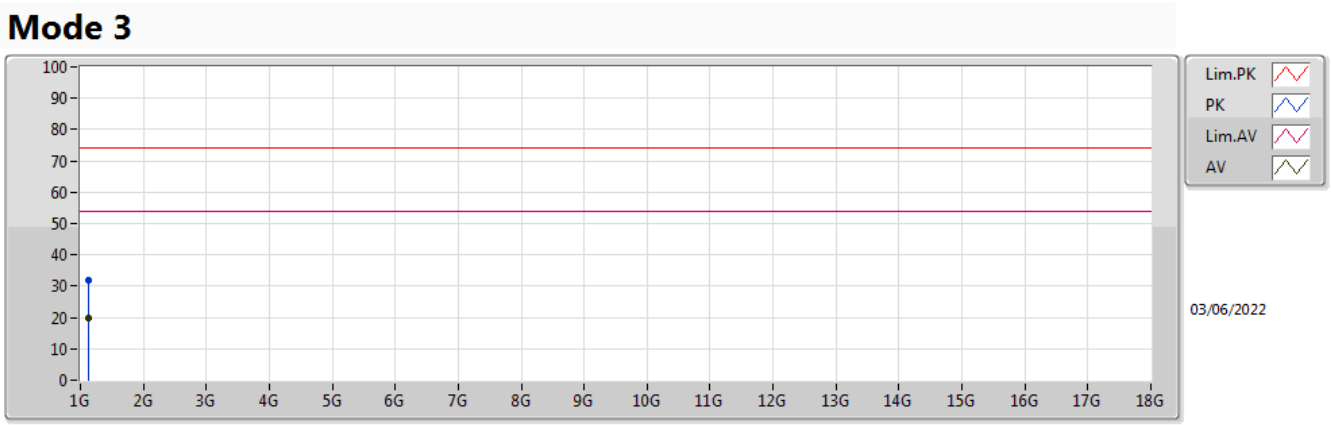
Test Range	1 GHz – 18 GHz	Test Distance	3 m
Test Configuration	CTX	Test Mode	Mode 3

Vertical



Type	Freq	Level	Limit	Margin	Factor	Dist	Condition	Azimuth	Height	Comment	Raw	AF	CL	PA
	(Hz)	(dBuV/m)	(dBuV/m)	(dB)	(dB/m)	(m)		(°)	(m)		(dBuV/m)	(dB/m)	(dB)	(dB)
PK	1.13588G	31.73	74.00	-42.27	-10.62	3	Vertical	224	1.50	-	42.35	24.03	2.64	37.29
AV	1.13591G	19.92	54.00	-34.08	-10.62	3	Vertical	224	1.50	"Worst"	30.54	24.03	2.64	37.29

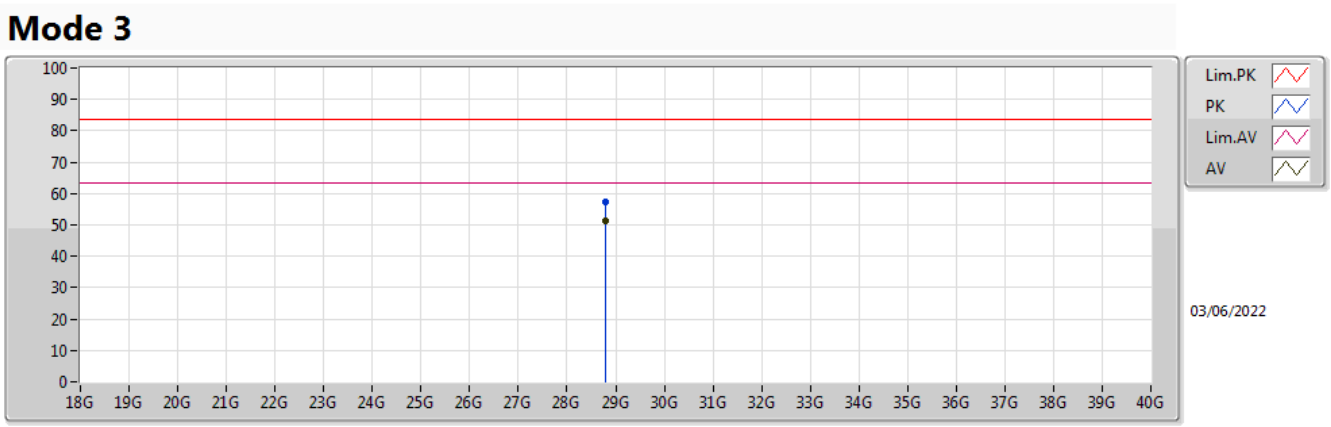
Horizontal



Type	Freq	Level	Limit	Margin	Factor	Dist	Condition	Azimuth	Height	Comment	Raw	AF	CL	PA
	(Hz)	(dBuV/m)	(dBuV/m)	(dB)	(dB/m)	(m)		(°)	(m)		(dBuV/m)	(dB/m)	(dB)	(dB)
PK	1.13516G	31.93	74.00	-42.07	-10.63	3	Horizontal	197	1.50	-	42.56	24.02	2.64	37.29
AV	1.13603G	19.74	54.00	-34.26	-10.62	3	Horizontal	197	1.50	"Worst"	30.36	24.03	2.64	37.29

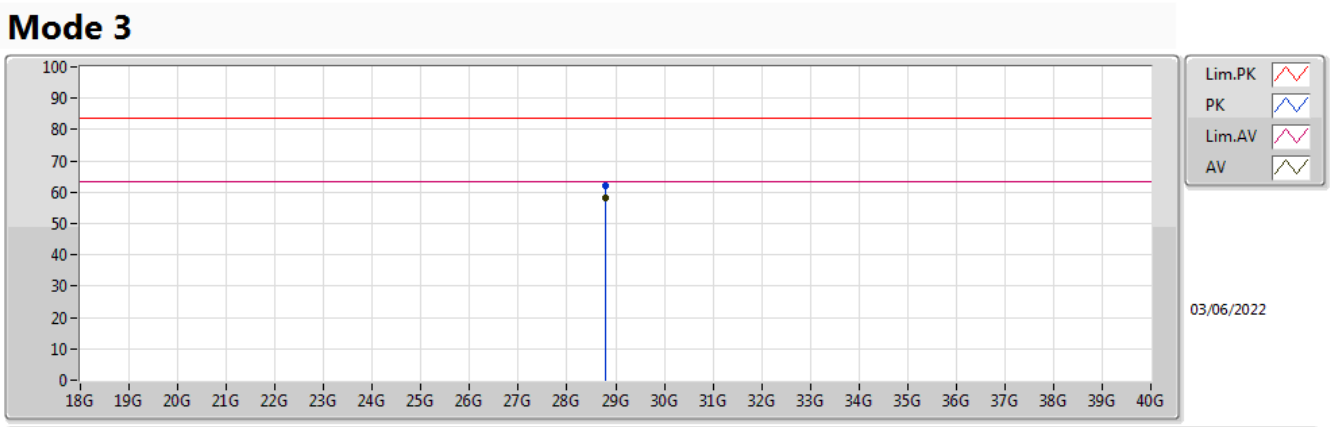
Test Range	18 GHz – 40 GHz	Test Distance	1 m
Test Configuration	CTX	Test Mode	Mode 1

Vertical



Type	Freq	Level	Limit	Margin	Factor	Dist	Condition	Azimuth	Height	Comment	Raw	AF	CL	PA
	(Hz)	(dBuV/m)	(dBuV/m)	(dB)	(dB/m)	(m)		(°)	(m)		(dBuV/m)	(dB/m)	(dB)	(dB)
PK	28.79904G	57.48	83.54	-26.06	12.78	1	Vertical	27	1.60	-	44.70	39.82	18.80	45.84
AV	28.79903G	51.27	63.54	-12.27	12.78	1	Vertical	27	1.60	"Worst"	38.49	39.82	18.80	45.84

Horizontal



Type	Freq	Level	Limit	Margin	Factor	Dist	Condition	Azimuth	Height	Comment	Raw	AF	CL	PA
	(Hz)	(dBuV/m)	(dBuV/m)	(dB)	(dB/m)	(m)		(°)	(m)		(dBuV/m)	(dB/m)	(dB)	(dB)
PK	28.79898G	62.05	83.54	-21.49	12.78	1	Horizontal	285	1.55	-	49.27	39.82	18.80	45.84
AV	28.79905G	58.14	63.54	-5.40	12.78	1	Horizontal	285	1.55	"Worst"	45.36	39.82	18.80	45.84

Test Range	40GHz – 200GHz			
Test Frequency (GHz)	**Rx Antenna Gain (dBi)**	**Measurement Distance (m)**	**Read Worse Frequency (GHz)**	**Read Level (dBm)**
60.00	23.6	1.00	53.48	-91.69
EIRP (dBm)	**Specification Distance (m)**	**Power Density (pW/cm^2)**	**Limit (pW/cm^2)**	**Test Result**
-48.28	3	0.0131	90	PASS

Test Range	40GHz – 200GHz			
Test Frequency (GHz)	**Rx Antenna Gain (dBi)**	**Measurement Distance (m)**	**Read Worse Frequency (GHz)**	**Read Level (dBm)**
62.00	23.6	1.00	55.06	-91.13
EIRP (dBm)	**Specification Distance (m)**	**Power Density (pW/cm^2)**	**Limit (pW/cm^2)**	**Test Result**
-47.47	3	0.0158	90	PASS

Test Range	40GHz – 200GHz			
Test Frequency (GHz)	**Rx Antenna Gain (dBi)**	**Measurement Distance (m)**	**Read Worse Frequency (GHz)**	**Read Level (dBm)**
64.00	23.6	1.00	73.69	-94.8
EIRP (dBm)	**Specification Distance (m)**	**Power Density (pW/cm^2)**	**Limit (pW/cm^2)**	**Test Result**
-48.61	3	0.0122	90	PASS

Note:
EIRP = Prx – Grx + Free Space Path Loss = Prx – Grx + 20Log(4πd/ λ)2
Which
Prx = Read Level.
Grx = Rx Antenna Gain.
A distance factor is offset and the formula is 20LOG(D1/D2)
Which
D1 = Specification Distance
D2 = Measurement Distance

3.5 Frequency Stability

3.5.1 Limit of Frequency Stability

Frequency Stability	Limit
Refer as 15.255(f) and ANSI C63.10-2013, clause 9.14	within the frequency bands
Note: These measurements shall also be performed at normal and extreme test conditions.	

3.5.2 Measuring Instruments

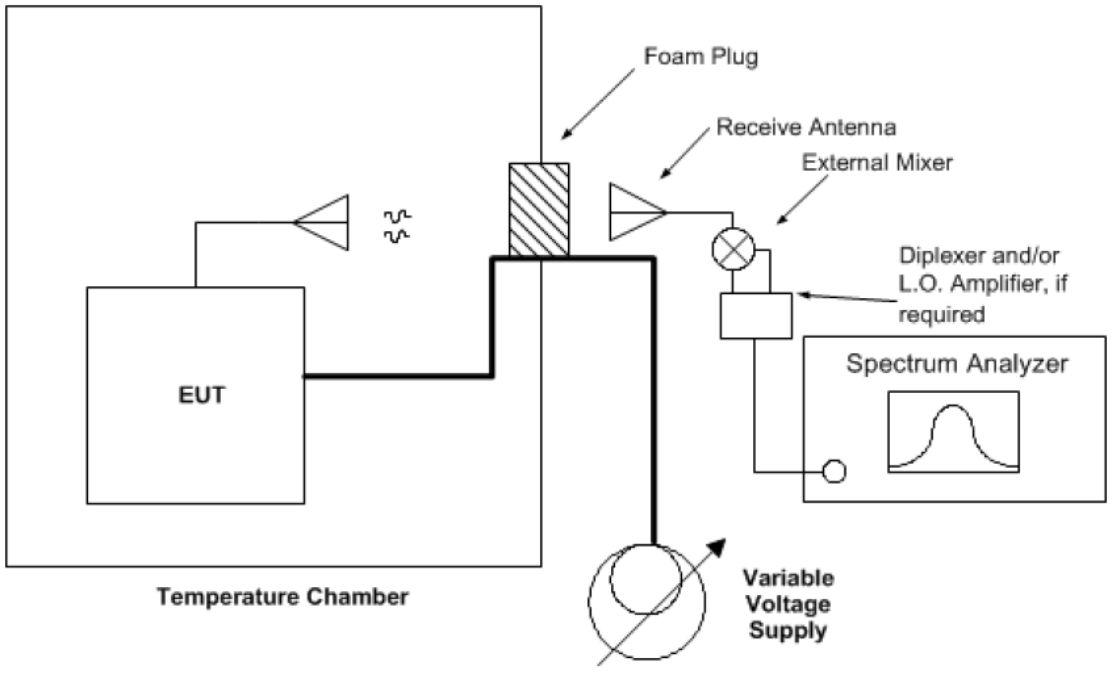
Refer a measuring instruments list in this test report.

3.5.3 Test Procedures

Method of measurement: Refer as ANSI C63.10-2013, clauses 9.14.

3.5.4 Test Setup

Frequency Stability



3.5.5 Test Result of Frequency Stability

Test Conditions	see ANSI C63.10, clause 5.11 & clause 9
Test Setup	see ANSI C63.10, clause 9.14
NOTE: If equipment having different channel plan and nominal channel bandwidth modes (see test report clause 1.1.1), the measurements are uninfluenced by different channel plan and nominal channel bandwidth modes, may not need to be repeated for all modes.	

3.5.5.1 Frequency Stability with Respect to Ambient Temperature

Frequency Stability with Respect to Ambient Temperature			
Test Results			
Test Temp.erature (°C)	**Measured Frequency (MHz)**	**Delta Frequency (kHz)**	**Limit (±kHz)**
-40	62040.211	220	Within band
-30	62040.205	214	Within band
-20	62039.341	-650	Within band
-10	62039.599	-392	Within band
0	62039.678	-313	Within band
10	62039.897	-94	Within band
20	62039.991	Reference	Within band
30	62039.871	-120	Within band
40	62039.796	-195	Within band
50	62039.651	-340	Within band
60	62040.598	607	Within band
70	62040.433	442	Within band
85	62040.378	387	Within band
NOTE: The manufacturer’s specified temperature range of -40 to 85°C.			

3.5.5.2 Frequency Stability When Varying Supply Voltage

Frequency Stability When Varying Supply Voltage			
Test Results			
Test Voltage: (Vdc)	Measured Frequency (MHz)	Delta Frequency (kHz)	Limit (±kHz)
13.6	62039.858	-133	Within band
16	62039.991	Reference	Within band
18.4	62039.871	-120	Within band

3.6 Operation Restriction and Group Installation

3.6.1 Limit of Operation Restriction and Group Installation

Item	Limit
Operation Restriction	Operation is not permitted for the following products: ♦ Equipment used on aircraft or satellites. (Refer as 15.255 (a)) ♦ Field disturbance sensors, including vehicle radar systems, unless the field disturbance sensors are employed for fixed operation. (Refer as 15.255 (a))
Group Installation	Operation is not permitted for the following products: ♦ External phase-locking (Refer as 15.255 (h))

3.6.2 Result of Operation Restriction

Manufacturer declares that EUT will not been used on aircraft or satellites. Then user manual will include a statement to caution EUT is not permitted for used on aircraft or satellites.

3.6.3 Result of Group Installation

The frequency, amplitude and phase of the transmit signal are set within the EUT. There are no external phase-locking inputs or any other means of combining two or more units together to realize a beam-forming array.

4 Test Equipment and Calibration Data

Instrument	Brand	Model No.	Serial No.	Characteristics	Calibration Date	Calibration Due Date	Remark
10m Semi Anechoic Chamber NSA	TDK	SAC-10M	10CH01-CB	30MHz~1GHz 10m,3m	Jan. 27, 2022	Jan. 26, 2023	Radiation (10CH01-CB)
Amplifier	Agilent	8447D	2944A10783	9kHz ~ 1.3GHz	Mar. 11, 2022	Mar. 10, 2023	Radiation (10CH01-CB)
Amplifier	Agilent	8447D	2944A10784	9kHz ~ 1.3GHz	Mar. 11, 2022	Mar. 10, 2023	Radiation (10CH01-CB)
Low Cable	Woken	SUCOFLEX 104	low cable-01	25MHz ~ 1GHz	Oct. 19, 2021	Oct. 18, 2022	Radiation (10CH01-CB)
Low Cable	Woken	SUCOFLEX 104	low cable-02	25MHz ~ 1GHz	Oct. 19, 2021	Oct. 18, 2022	Radiation (10CH01-CB)
EMI Test Receiver	Rohde&Schwarz	ESCI	100186	9kHz ~ 3GHz	Jul. 12, 2021	Jul. 11, 2022	Radiation (10CH01-CB)
Spectrum Analyzer	Rohde&Schwarz	FSV30	101026	9kHz ~ 30GHz	Apr. 22, 2022	Apr. 21, 2023	Radiation (10CH01-CB)
Bilog Antenna with 6dB Attenuator	Chase & EMCI	CBL6111A &N-6-06	1543 &AT-N0609	30MHz ~ 1GHz	Jul. 01, 2021	Jun. 30, 2022	Radiation (10CH01-CB)
Amplifier	EM	EM101	060703	10MHz ~ 1GHz	Oct. 20, 2021	Oct. 19, 2022	Radiation (10CH01-CB)
Low Cable	TITAN	T318E	low cable-03	30MHz ~ 1GHz	Jun. 17, 2022	Jun. 16, 2023	Radiation (10CH01-CB)
Loop Antenna	Teseq	HLA 6120	24155	9kHz - 30 MHz	May 14, 2022	May 13, 2023	Radiation (10CH01-CB)
Software	SPORTON	SENSE	V5.10	-	N.C.R.	N.C.R.	Radiation (10CH01-CB)
3m Semi Anechoic Chamber VSWR	TDK	SAC-3M	03CH04-CB	1GHz ~18GHz 3m	Feb. 24, 2022	Feb. 23, 2023	Radiation (03CH04-CB)
Horn Antenna	ETS‧Lindgren	3115	00143147	750MHz~18GHz	Oct. 25, 2021	Oct. 24, 2022	Radiation (03CH04-CB)
Horn Antenna	Schwarzbeck	BBHA 9170	BBHA9170252	15GHz ~ 40GHz	Aug. 05, 2021	Aug. 04, 2022	Radiation (03CH04-CB)
Pre-Amplifier	Agilent	83017A	MY53270063	0.5GHz ~ 26.5GHz	Jul. 12, 2021	Jul. 11, 2022	Radiation (03CH04-CB)
Pre-Amplifier	MITEQ	TTA1840-35-HG	1864479	18GHz ~ 40GHz	Jul. 13, 2021	Jul. 12, 2022	Radiation (03CH04-CB)
Spectrum Analyzer	R&S	FSP40	100142	9kHz~40GHz	Mar. 28, 2022	Mar. 27, 2023	Radiation (03CH04-CB)
RF Cable-high	Woken	RG402	High Cable-21	1GHz - 18GHz	Oct. 04, 2021	Oct. 03, 2022	Radiation (03CH04-CB)
RF Cable-high	Woken	RG402	High Cable-21+67	1GHz - 18GHz	Oct. 04, 2021	Oct. 03, 2022	Radiation (03CH04-CB)
High Cable	Woken	WCA0929M	40G#5+7	1GHz ~ 40 GHz	Dec. 14, 2021	Dec. 13, 2022	Radiation (03CH04-CB)

Instrument	Brand	Model No.	Serial No.	Characteristics	Calibration Date	Calibration Due Date	Remark
High Cable	Woken	WCA0929M	40G#5	1GHz ~ 40 GHz	Dec. 08, 2021	Dec. 07, 2022	Radiation (03CH04-CB)
High Cable	Woken	WCA0929M	40G#7	1GHz ~ 40 GHz	Dec. 14, 2021	Dec. 13, 2022	Radiation (03CH04-CB)
Test Software	SPORTON	SENSE	V5.10	-	N.C.R.	N.C.R.	Radiation (03CH04-CB)
Mixer	OML	M19HWA	U91113-1	40 ~ 60 GHz	Mar. 10, 2022	Mar. 09, 2023	Radiation (03CH04-CB)
*Mixer	OML	M15HWA	V91113-1	50 ~ 75 GHz	Nov. 13, 2020	Nov. 12, 2022	Radiation (03CH04-CB)
*Mixer	OML	M12HWA	E91113-1	60 ~ 90 GHz	Nov. 14, 2020	Nov. 13, 2022	Radiation (03CH04-CB)
Mixer	OML	M08HWA	F91113-1	90 ~ 140 GHz	Mar. 10, 2022	Mar. 09, 2023	Radiation (03CH04-CB)
Mixer	OML	M05HW/A	G91113-1	140 ~ 220 GHz	Mar. 10, 2022	Mar. 09, 2023	Radiation (03CH04-CB)
Detector	Millitech	DET-15-RPFW0	#A18185(074)	50 ~ 75 GHz	Apr. 23, 2022	Apr. 22, 2023	Radiation (03CH04-CB)
PC Oscilloscope	PICO TECH	6402C	CX372/002	N/A	Jul. 08, 2021	Jul. 07, 2022	Radiation (03CH04-CB)
Standard Horn Antenna	Custom Microwave	M19RH	U91113-A	40 ~ 60 GHz	N.C.R	N.C.R	Radiation (03CH04-CB)
Standard Horn Antenna	Custom Microwave	M15RH	V91113-A	50 ~ 75 GHz	N.C.R	N.C.R	Radiation (03CH04-CB)
Standard Horn Antenna	Custom Microwave	M12RH	E91113-A	60 ~ 90 GHz	N.C.R	N.C.R	Radiation (03CH04-CB)
Standard Horn Antenna	Custom Microwave	M08RH	F91113-A	90 ~ 140 GHz	N.C.R	N.C.R	Radiation (03CH04-CB)
Standard Horn Antenna	Custom Microwave	M05RH	G91113-A	140 ~ 220 GHz	N.C.R	N.C.R	Radiation (03CH04-CB)
Spectrum analyzer	R&S	FSV40	101028	9kHz~40GHz	Jan. 07, 2022	Jan. 06, 2023	Radiation (TH03-CB)
Temp. and Humidity Chamber	Gaint Force	GTH-408-40-CP-AR	MAA1410-011	-40~100 degree	Sep. 09, 2021	Sep. 08, 2022	Radiation (TH03-CB)
RF Cable-high	Woken	RG402	High Cable-11	1 GHz –18 GHz	Oct. 04, 2021	Oct. 03, 2022	Radiation (TH03-CB)
RF Cable-high	Woken	RG402	High Cable-12	1 GHz –18 GHz	Oct. 04, 2021	Oct. 03, 2022	Radiation (TH03-CB)
RF Cable-high	Woken	RG402	High Cable-13	1 GHz –18 GHz	Oct. 04, 2021	Oct. 03, 2022	Radiation (TH03-CB)
RF Cable-high	Woken	RG402	High Cable-14	1 GHz –18 GHz	Oct. 04, 2021	Oct. 03, 2022	Radiation (TH03-CB)
RF Cable-high	Woken	RG402	High Cable-15	1 GHz –18 GHz	Oct. 04, 2021	Oct. 03, 2022	Radiation (TH03-CB)
RF Cable-high	Woken	RG402	SWI-03-P1	1 GHz –26.5 GHz	Dec. 13, 2021	Dec. 12, 2022	Radiation (TH03-CB)
RF Cable-high	Woken	RG402	SWI-03-P2	1 GHz –26.5 GHz	Dec. 13, 2021	Dec. 12, 2022	Radiation (TH03-CB)

Instrument	Brand	Model No.	Serial No.	Characteristics	Calibration Date	Calibration Due Date	Remark
RF Cable-high	Woken	RG402	SWI-03-P3	1 GHz –26.5 GHz	Dec. 13, 2021	Dec. 12, 2022	Radiation (TH03-CB)
RF Cable-high	Woken	RG402	SWI-03-P4	1 GHz –26.5 GHz	Dec. 13, 2021	Dec. 12, 2022	Radiation (TH03-CB)
RF Cable-high	Woken	RG402	SWI-03-P5	1 GHz –26.5 GHz	Dec. 13, 2021	Dec. 12, 2022	Radiation (TH03-CB)

Note: Calibration Interval of instruments listed above is one year.
"*" Calibration Interval of instruments listed above is two years.
N.C.R. means Non-Calibration required.

5 Measurement Uncertainty

For test date before Jun. 01, 2022

Test Items	Uncertainty	Remark
Radiated Emission (9kHz ~ 30MHz)	4.2 dB	Confidence levels of 95%
Radiated Emission (30MHz ~ 1,000MHz)	5.5 dB	Confidence levels of 95%
Radiated Emission (1GHz ~ 18GHz)	4.7 dB	Confidence levels of 95%
Radiated Emission (18GHz ~ 40GHz)	4.2 dB	Confidence levels of 95%
Radiated Emission (40GHz ~ 60GHz)	4.3 dB	Confidence levels of 95%
Radiated Emission (60GHz ~ 90GHz)	4.5 dB	Confidence levels of 95%
Radiated Emission (90GHz ~ 200GHz)	5.3 dB	Confidence levels of 95%
Temperature	1.1°C	Confidence levels of 95%

For test date after May 31, 2022

Test Items	Uncertainty	Remark
Radiated Emission (9kHz ~ 30MHz)	3.4 dB	Confidence levels of 95%
Radiated Emission (30MHz ~ 1,000MHz)	5.6 dB	Confidence levels of 95%
Radiated Emission (1GHz ~ 18GHz)	5.2 dB	Confidence levels of 95%
Radiated Emission (18GHz ~ 40GHz)	4.7 dB	Confidence levels of 95%
Radiated Emission (40GHz ~ 60GHz)	3.0 dB	Confidence levels of 95%
Radiated Emission (60GHz ~ 90GHz)	3.2 dB	Confidence levels of 95%
Radiated Emission (90GHz ~ 200GHz)	4.3 dB	Confidence levels of 95%
Temperature	1.2°C	Confidence levels of 95%