# TEST REPORT

| KOSTEC Co., Ltd.<br>28(175-20, Annyeong-dong) 406-gil sejaro,<br>Hwaseong-si, Gyeonggi-do, Korea<br>Tel:031-222-4251, Fax:031-222-4252 | Report No.: KST-FCR-230009(1) | KOSTEC |
|---|---|---|

1. Applicant

   • Name : bitsensing Inc.

   • Address : 4,5F, 4, Godeung-ro, Sujeong-gu, Seongnam-si, Gyeonggi-do, South Korea

2. Test Item

   • Product Name: Mini-H

   • Model Name: MOD611

   • Brand: -

   • FCC ID: 2AVBK-MOD611

3. Manufacturer

   • Name : bitsensing Inc.

   • Address : 4,5F, 4, Godeung-ro, Sujeong-gu, Seongnam-si, Gyeonggi-do, South Korea

4. Date of Test : 2023. 10. 23. ~ 2023. 10. 24.

5. Test Method Used : FCC CFR 47, Part 15. Subpart C
   ANSI C 63.10-2013

6. Test Result : Compliance

7. Note: -

**Supplementary Information**

The device bearing the brand name and FCC ID specified above has been shown to comply with the applicable technical standards as indicated in the measurement report and was tested in accordance with measurement procedures specified in ANSI C 63.10-2013.

We attest to the accuracy of data and all measurements reported herein were performed by KOSTEC Co., Ltd. and were made under Chief Engineer's supervision. We assume full responsibility for the completeness of these measurements and vouch for the qualifications of all persons taking them.

The results shown in this test report refer only to the sample(s) tested unless otherwise stated.
This test report is not related to KOLAS accreditation.

| Affirmation | Tested by<br>Name : Choo, Kwang-Yeol (Signature) | Technical Manager<br>Name : Park, Gyeong-Hyeon (Signature) |
|---|---|---|

**2023. 11. 28.**

**KOSTEC Co., Ltd.**

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# 1. GENERAL INFORMATION

## 1.1 Test Facility

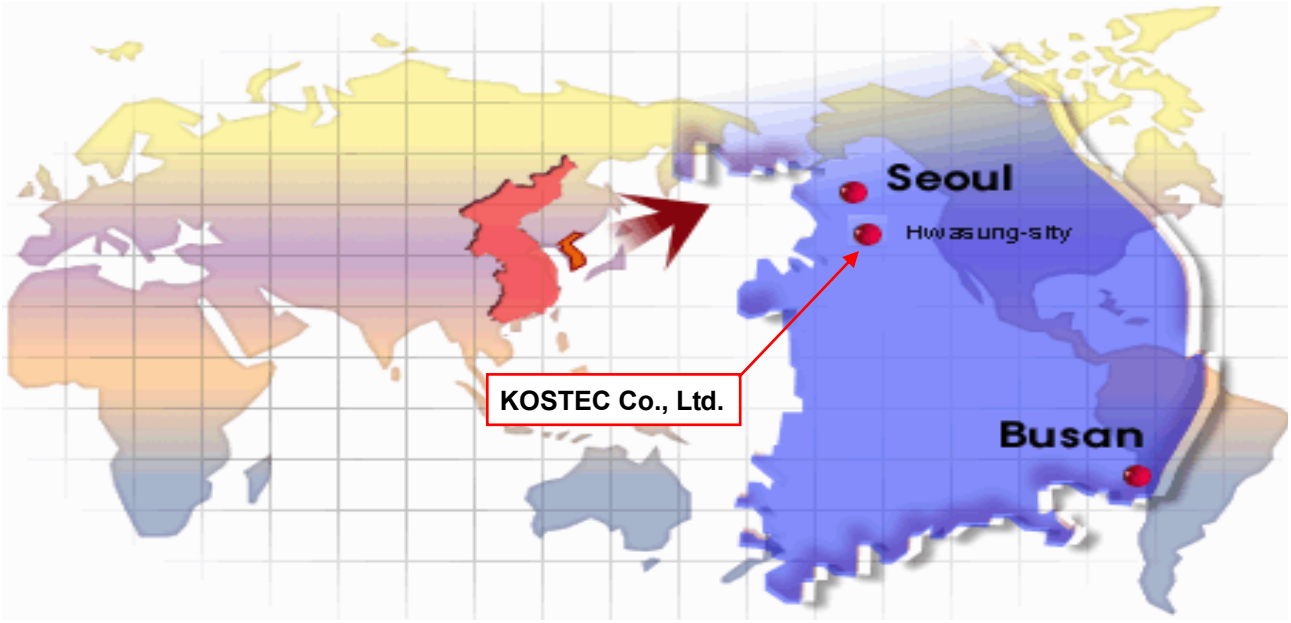
### Test laboratory and address

KOSTEC Co., Ltd.
28(175-20,Annyeong-dong)406-gil sejaro, Hwaseong-si Gyeonggi-do, Korea
Telephone Number: 82-31-222-4251
Facsimile Number: 82-31-222-4252

### Registration information

KOLAS No.: KT232
RRA (National Radio Research Agency): KR0041
FCC Designation No.: KR0041
IC Designation No.: KR0041
VCCI Membership No.: 2005

## 1.2 Location



## 1.3 Revision History of test report

| Rev. | Revisions | Effect page | Reviewed | Date |
|---|---|---|---|---|
| - | Initial issue | All | Gyeong Hyeon, Park | 2023. 10. 26. |
| 1 | Added FMCW desensitization factor | 16 | Gyeong Hyeon, Park | 2023. 11. 28. |

## 2. EQUIPMENT DESCRIPTION

The product specification described herein was declared by manufacturer. And refer to user's manual for the details.

| | |
|---|---|
| Equipment Name | Mini-H |
| Model No | MOD611 |
| Usage | 60GHz mmWave IoT radar sensor |
| Serial Number | Proto type |
| Modulation type | FMCW |
| Maximum output power(e.i.r.p) | 11.82 dBm |
| Operated Frequency | 57 GHz ~ 64 GHz |
| Channel Number | 1 |
| Operation temperature | -20 °C ~ 85 °C |
| Power Source | DC 5 V |
| Antenna Description | Patch Antenna(Fixed), gain : 5 dBi |
| Remark | 1. The device was operating at its maximum output power for all measurements.<br>2. The radiation measurements are performed in X, Y, Z axis positioning. Only the worst case (Y) is shown in the report.<br>3. The above DUT's information was declared by manufacturer. Please refer to the specifications or user manual for more detailed description.<br>4. Certificated Module(Single modular) is mounted in the EUT as following:<br>- Applicant: ESPRESSIF SYSTEMS (SHANGHAI) CO., LTD<br>- Contains FCC ID: 2AC7Z-ESP32WROVERE<br>- Model No.: ESP32-WROVER-E |
| FCC ID | 2AVBK-MOD611 |

# 3. SYSTEM CONFIGURATION FOR TEST

## 3.1 Characteristics of equipment

The Equipment Under Test (EUT) contains the following capabilities: This equipment is 60GHz mmWave IoT radar sensor. The detailed explanation is refer as user manual.

## 3.2 Used peripherals list

| Description | Model No. | Serial No. | Manufacture | Remark |
|---|---|---|---|---|
| AC/DC Adaptor | WL2017-1000USB | None | Shenzhen Songkang Investment Development co.,Ltd | For AC Conducted Emissions |

## 3.3 Product Modification

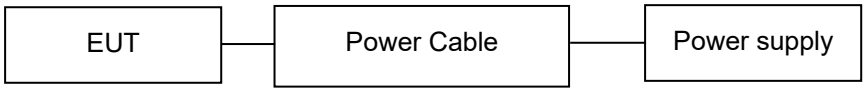
N/A

## 3.4 Operating Mode

The EUT was operated in the engineering mode to fix the TX frequency that was for the purpose of the measurements.

## 3.5 Test Setup of EUT

The measurements were taken in continuous transmit mode using the test mode. The cables were provided by the applicant.



## 3.6 Used Test Equipment List

| No. | Instrument | Model | S/N | Manufacturer | Next Cal Date | Cal interval | used |
|---|---|---|---|---|---|---|---|
| 1 | T & H Chamber | PL-3J | 15003623 | ESPEC CORP | 2023.11.03 | 1 year | ☐ |
| 2 | T & H Chamber | SH-662 | 93000067 | ESPEC CORP | 2024.08.16 | 1 year | ☐ |
| 3 | T & H Chamber | SH-642 | 93011406 | ESPEC CORP | 2024.08.17 | 1 year | ☒ |
| 4 | Spectrum Analyzer | 8563EC | 3046A00527 | Agilent Technology | 2024.01.11 | 1 year | ☐ |
| 5 | Spectrum Analyzer | FSV30 | 104029 | Rohde & Schwarz | 2024.08.16 | 1 year | ☐ |
| 6 | Spectrum Analyzer | FSV30 | 20-353063 | Rohde & Schwarz | 2024.01.11 | 1 year | ☐ |
| 7 | Spectrum Analyzer | FSV40 | 101727 | Rohde & Schwarz | 2024.08.16 | 1 year | ☐ |
| 8 | Signal Analyzer | FSW43 | 101294 | Rohde & Schwarz | 2024.01.13 | 1 year | ☐ |
| 9 | Signal Analyzer | FSW85 | 101602 | Rohde & Schwarz | 2024.06.27 | 1 year | ☒ |
| 10 | EMI Test Receiver | ESCI7 | 100823 | Rohde & Schwarz | 2024.01.11 | 1 year | ☐ |
| 11 | EMI Test Receiver | ESPI | 100488 | Rohde & Schwarz | 2024.01.10 | 1 year | ☐ |
| 12 | EMI Test Receiver | ESI | 837514/004 | Rohde & Schwarz | 2024.08.16 | 1 year | ☒ |
| 13 | Vector Signal Analyzer | 89441A | 3416A02620 | Agilent Technology | 2024.01.13 | 1 year | ☐ |
| 14 | Network Analyzer | 8753ES | US39170869 | AGILENT | 2024.08.16 | 1 year | ☐ |
| 15 | EPM Series Power meter | E4418B | GB39512547 | Agilent Technology | 2024.01.12 | 1 year | ☐ |
| 16 | RF Power Sensor | E9300A | MY41496631 | Agilent Technology | 2024.01.12 | 1 year | ☐ |
| 17 | Microwave Frequency Counter | 5352B | 2908A00480 | Agilent Technology | 2024.01.11 | 1 year | ☐ |
| 18 | Audio Analyzer | 8903B | 3514A16919 | Agilent Technology | 2024.01.11 | 1 year | ☐ |
| 19 | Audio Telephone Analyzer | DD-5601CID | 520010281 | CREDIX | 2024.01.10 | 1 year | ☐ |
| 20 | Modulation Analyzer | 8901A | 3041A05716 | H.P | 2024.01.10 | 1 year | ☐ |
| 21 | Digital storage Oscilloscope | TDS3052 | B015962 | Tektronix | 2024.08.17 | 1 year | ☐ |
| 22 | ESG-D Series Signal Generator | E4436B | US39260458 | Agilent Technology | 2024.01.12 | 1 year | ☐ |
| 23 | Vector Signal Generator | SMBV100A | 257557 | Rohde & Schwarz | 2024.01.12 | 1 year | ☐ |
| 24 | GNSS Signal Generator | TC-2800A | 2800A000494 | TESCOM CO., LTD. | 2024.01.11 | 1 year | ☐ |
| 25 | Signal Generator | SMB100A | 179628 | Rohde & Schwarz | 2024.01.27 | 1 year | ☒ |
| 26 | Signal Generator | N5173B | MY57280148 | KEYSIGHT | 2024.05.31 | 1 year | ☒ |
| 27 | SLIDAC | None | 0207-4 | Myoung sung Ele. | 2024.01.10 | 1 year | ☐ |
| 28 | DC Power supply | DDPS-3K | U03-109 | Digitech Power | 2024.01.18 | 1 year | ☐ |
| 29 | DC Power supply | E3610A | KR24104505 | Agilent Technology | 2024.01.10 | 1 year | ☐ |
| 30 | DC Power supply | UP-3005T | 68 | Unicon Co.,Ltd | 2024.01.10 | 1 year | ☐ |
| 31 | DC Power Supply | SM 3400-D | 114701000117 | DELTA ELEKTRONIKA | 2024.01.10 | 1 year | ☐ |
| 32 | DC Power supply | 6632B | MY43004005 | Agilent Technology | 2024.01.11 | 1 year | ☐ |
| 33 | DC Power Supply | 6632B | MY43004137 | Agilent Technology | 2024.01.11 | 1 year | ☒ |
| 34 | Termination | 1433-3 | LM718 | WEINSCHEL | 2024.01.12 | 1 year | ☐ |
| 35 | Termination | 1432-3 | QR946 | AEROFLEX/WEINSCHEL | 2024.01.12 | 1 year | ☐ |
| 36 | Attenuator | 8498A | 3318A09485 | HP | 2024.01.11 | 1 year | ☐ |
| 37 | Step Attenuator | 8494B | 3308A32809 | HP | 2024.01.12 | 1 year | ☐ |
| 38 | RF Step Attenuator | RSP | 100091 | Rohde & Schwarz | 2024.01.13 | 1 year | ☐ |
| 39 | Attenuator | 18B50W-20F | 64671 | INMET | 2024.01.12 | 1 year | ☐ |
| 40 | Attenuator | 10 dB | 1 | Rohde & Schwarz | 2024.01.12 | 1 year | ☐ |
| 41 | Attenuator | 54A-10 | 74564 | WEINSCHEL | 2024.08.16 | 1 year | ☐ |
| 42 | Attenuator | 56-10 | 66920 | WEINSCHEL | 2024.01.12 | 1 year | ☐ |
| 43 | Attenuator | 48-40-33 | BL5992 | Weinschel Corp. | 2023.12.27 | 1 year | ☐ |
| 44 | Attenuator | SA18N100-20 | 001 | FAIRVIEW MICROWAVE | 2024.08.16 | 1 year | ☐ |
| 45 | Attenuator | SA26B-10 | 33464/2134 | FAIRVIEW MICROWAVE | 2024.08.18 | 1 year | ☐ |
| 46 | Attenuator | SA4018-10 | DC 2126 | FAIRVIEW MICROWAVE | 2024.08.18 | 1 year | ☐ |
| 47 | Power divider | 11636B | 51212 | HP | 2024.01.13 | 1 year | ☐ |
| 48 | 3Way Power divider | KPDSU3W | 00070365 | KMW | 2024.08.16 | 1 year | ☐ |
| 49 | 4Way Power divider | 70052651 | 173834 | KRYTAR | 2024.01.12 | 1 year | ☐ |
| 50 | 3Way Power divider | 1580 | SQ361 | WEINSCHEL | 2024.01.13 | 1 year | ☐ |
| 51 | OSP | OSP120 | 101577 | Rohde & Schwarz | 2024.01.13 | 1 year | ☐ |

| No. | Instrument | Model | S/N | Manufacturer | Next Cal Date | Cal interval | used |
|---|---|---|---|---|---|---|---|
| 52 | White noise audio filter | ST31EQ | 101902 | SoundTech | 2024.08.16 | 1 year | ☐ |
| 53 | Dual directional coupler | 778D | 17693 | HEWLETT PACKARD | 2024.01.11 | 1 year | ☐ |
| 54 | Dual directional coupler | 772D | 2839A00924 | HEWLETT PACKARD | 2024.01.11 | 1 year | ☐ |
| 55 | Band rejection filter | 3TNF-0006 | 26 | DOVER Tech | 2024.01.11 | 1 year | ☐ |
| 56 | Band rejection filter | 3TNF-0007 | 311 | DOVER Tech | 2024.01.11 | 1 year | ☐ |
| 57 | Band rejection filter | WTR-BRF2442-84NN | 09020001 | WAVE TECH Co.,LTD | 2024.01.11 | 1 year | ☐ |
| 58 | Band rejection filter | WRCJV12-5695-5725-5825-5855-50SS | 1 | Wainwright Instruments GmbH | 2024.01.11 | 1 year | ☐ |
| 59 | Band rejection filter | WRCJV12-5120-5150-5350-5380-40SS | 4 | Wainwright Instruments GmbH | 2024.01.11 | 1 year | ☐ |
| 60 | Band rejection filter | WRCGV10-2360-2400-2500-2540-50SS | 2 | Wainwright Instruments GmbH | 2024.01.11 | 1 year | ☐ |
| 61 | Band rejection filter | CTF-155M-S1 | 001 | RF One Electronics | 2024.08.16 | 1 year | ☐ |
| 62 | Band rejection filter | CTF-435M-S1 | 001 | RF One Electronics | 2024.08.16 | 1 year | ☐ |
| 63 | Band rejection filter | CTF-5890M-70MS1 | 1 | RF One Electronics | 2024.01.11 | 1 year | ☐ |
| 64 | Highpass Filter | WHJS1100-10EF | 1 | WAINWRIGHT | 2024.01.12 | 1 year | ☐ |
| 65 | Highpass Filter | WHJS3000-10EF | 1 | WAINWRIGHT | 2024.01.11 | 1 year | ☐ |
| 66 | Highpass Filter | WHNX6-5530-7000-26500-40CC | 2 | Wainwright Instruments GmbH | 2024.01.12 | 1 year | ☐ |
| 67 | Highpass Filter | WHNX6-2370-3000-26500-40CC | 4 | Wainwright Instruments GmbH | 2024.01.12 | 1 year | ☐ |
| 68 | WideBand Radio Communication Tester | CMW500 | 102276 | Rohde & Schwarz | 2024.01.10 | 1 year | ☐ |
| 69 | WideBand Radio Communication Tester | CMW500 | 117235 | Rohde & Schwarz | 2024.01.10 | 1 year | ☐ |
| 70 | WideBand Radio Communication Tester | MT8000A | 6261987920 | Anritsu | 2024.01.13 | 1 year | ☐ |
| 71 | WideBand Radio Communication Tester | MT8821C | 6262287695 | Anritsu | 2024.01.13 | 1 year | ☐ |
| 72 | Bluetooth Tester | TC-3000B | 3000B6A0166 | TESCOM CO., LTD. | 2024.01.10 | 1 year | ☐ |
| 73 | Loop Antenna | 6502 | 9203-0493 | EMCO | 2025.05.23 | 2 year | ☐ |
| 74 | Loop Antenna | FMZB1513 | #374 | Schwarzbeck | 2025.02.21 | 2 year | ☒ |
| 75 | BiconiLog Antenna(R) | 3142C | 35880 | ETS-LINDGREN | 2024.10.13 | 2 year | ☒ |
| 76 | Trilog-Broadband Antenna(R) | VULB 9168 | 9168-606 | SCHWARZBECK | 2024.11.30 | 2 year | ☐ |
| 77 | Biconical Antenna(T) | VUBA9117 | 9117-342 | Schwarz beck | 2024.01.24 | 2 year | ☐ |
| 78 | Horn Antenna | 3115 | 9605-4834 | EMCO | 2024.03.06 | 1 year | ☐ |
| 79 | Horn Antenna | QMS-00208 | 21909 | STEATITE ANTENNA | 2024.05.04 | 1 year | ☐ |
| 80 | Horn Antenna(R) | 3117 | 00135191 | ETS-LINDGREN | 2024.04.03 | 1 year | ☒ |
| 81 | Horn Antenna(T) | 3115 | 2996 | EMCO | 2024.01.12 | 1 year | ☐ |
| 82 | Horn Antenna(R) | BBHA 9170 | 9170-722 | SCHWARZBECK | 2024.01.12 | 1 year | ☒ |
| 83 | Horn Antenna(T) | BBHA 9170 | 743 | SCHWARZBECK | 2024.01.18 | 1 year | ☐ |
| 84 | AMPLIFIER(A_10) | TK-PA01S | 220109-L | TESTEK | 2024.01.11 | 1 year | ☐ |
| 85 | AMPLIFIER(C_3) | TK-PA01S | 200141-L | TESTEK | 2024.08.16 | 1 year | ☒ |
| 86 | PREAMPLIFIER(C_3) | 8449B | 3008A02577 | Agilent | 2024.01.10 | 1 year | ☒ |
| 87 | RF PRE AMPLIFIER | SCU08F2 | 100762 | Rohde & Schwarz | 2023.11.29 | 1 year | ☐ |
| 88 | AMPLIFIER | TK-PA18 | 150003 | TESTEK | 2024.01.10 | 1 year | ☒ |
| 89 | AMPLIFIER | TK-PA1840H | 160010-L | TESTEK | 2024.01.12 | 1 year | ☒ |
| 90 | Horn Antenna | M19RH | T01 | OML, Inc. | 2024.04.05 | 1 year | ☒ |
| 91 | Horn Antenna | M12RH | T02 | OML, Inc. | 2024.04.07 | 1 year | ☒ |
| 92 | Horn Antenna | M08RH | T03 | OML, Inc. | 2024.04.07 | 1 year | ☒ |
| 93 | Horn Antenna | M05RH | T04 | OML, Inc. | 2024.04.06 | 1 year | ☒ |
| 94 | Horn Antenna | M03RH | T05 | OML, Inc. | 2024.04.06 | 1 year | ☐ |
| 95 | Harmonic Mixer | M12HWD | 200529-1 | OML, Inc. | 2024.04.14 | 1 year | ☒ |
| 96 | Harmonic Mixer | M08HWD | 200529-1 | OML, Inc. | 2024.04.17 | 1 year | ☒ |
| 97 | Harmonic Mixer | M05HWD | 200529-1 | OML, Inc. | 2024.04.14 | 1 year | ☒ |
| 98 | Harmonic Mixer | M03HWD | 200529-1 | OML, Inc. | 2024.04.14 | 1 year | ☐ |
| 99 | Source Module | S19MS-A | 200529-1 | OML, Inc. | 2024.04.13 | 1 year | ☒ |
| 100 | Source Module | S12MS-A | 200529-1 | OML, Inc. | 2024.04.13 | 1 year | ☒ |
| 101 | Source Module | S08MS-A | 200529-1 | OML, Inc. | 2024.04.13 | 1 year | ☒ |
| 102 | Source Module | S05MS-A | 200529-1 | OML, Inc. | 2024.04.13 | 1 year | ☒ |
| 103 | Source Module | S03MS-A | 200529-1 | OML, Inc. | 2024.04.13 | 1 year | ☐ |

Note: The measuring equipment, which was utilized in performing the tests documented herein, has been calibrated in accordance with the manufacturer's recommendations for utilizing calibration equipment's, which is traceable to recognized national standards.
Especially, all antenna(Up to 40 GHz) for measurement is calibrated in accordance with the requirements of C 63.5.

## 3.7 Measurement uncertainty

The measurement uncertainties shown below were calculated in accordance with the requirements of ANSI C63.10-2013. All measurement uncertainty values are shown with a coverage factor of k = 2 to indicate a 95% level of confidence. The measurement uncertainty shown below meets or exceeds the UCISPR measurement uncertainty values specified in CISPR 16-4-2 and, thus, can be compared directly to specified limits to determine compliance.

| Parameter | Measurement uncertainty |
|---|---|
| Radiated Disturbance(Below 1 GHz) | 3.80 dB (CL: Approx 95 %, k=2) |
| Radiated Disturbance(1 GHz ~ 40 GHz) | 3.42 dB (CL: Approx 95 %, k=2) |
| Radiated Disturbance(Above 40 GHz) | 6.30 dB (CL: Approx 95 %, k=2) |

# 4. SUMMARY TEST RESULTS

| Description of Test | FCC Rule | Reference Clause | Used | Test Result |
|---|---|---|---|---|
| Bandwidth of Signal | 15.255(c) | Clause 5.1 | ☒ | Compliance |
| Duty cycle, Off Time Requirement | 15.255(c)(2)(iii)(A) | Clause 5.2 | ☒ | Compliance |
| Radiated Power | 15.255(c)(2)(iii)(A) | Clause 5.3 | ☒ | Compliance |
| Spurious Emissions | 15.255(d), 15.209 | Clause 5.4 | ☒ | Compliance |
| Frequency Stability | 15.255(f) | Clause 5.5 | ☒ | Compliance |
| Antenna Requirement | 15.203 | Clause 5.6 | ☒ | Compliance |
| AC Conducted emission | 15.207 | Clause 5.7 | ☒ | Compliance |
| Group Installation | 15.255(h) | - | ☐ | N/A)Note1) |

Compliance/pass : The EUT complies with the essential requirements in the standard.
Not Compliance : The EUT does not comply with the essential requirements in the standard.
N/A : The test was not applicable in the standard.
Note:
1) The test is not applicable since there are no external phase-locking inputs in this EUT

**Procedure Reference**
FCC CFR 47, Part 15. Subpart C
ANSI C 63.10-2013

# 5. MEASUREMENT RESULTS

## 5.1 Bandwidth of Signal

### 5.1.1 Standard Applicable [FCC §15.215(c)]

**FCC**

(c) Intentional radiators operating under the alternative provisions to the general emission limits, as contained in §§ 15.217 through 15.257 and in subpart E of this part, must be designed to ensure that the 20 dB bandwidth of the emission, or whatever bandwidth may otherwise be specified in the specific rule section under which the equipment operates, is contained within the frequency band designated in the rule section under which the equipment is operated. In the case of intentional radiators operating under the provisions of subpart E, the emission bandwidth may span across multiple contiguous frequency bands identified in that subpart. The requirement to contain the designated bandwidth of the emission within the specified frequency band includes the effects from frequency sweeping, frequency hopping and other modulation techniques that may be employed as well as the frequency stability of the transmitter over expected variations in temperature and supply voltage. If a frequency stability is not specified in the regulations, it is recommended that the fundamental emission be kept within at least the central 80% of the permitted band in order to minimize the possibility of out-of-band operation.

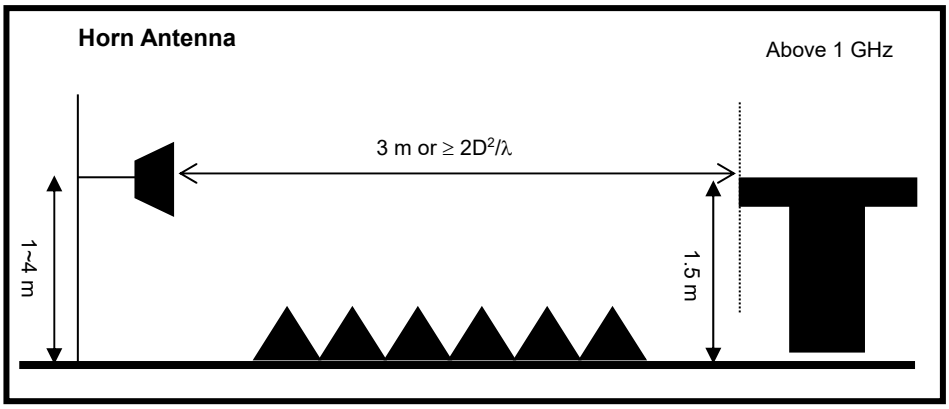
### 5.1.2 Test Environment conditions

• Ambient temperature : (21 ~ 22) ℃ • Relative Humidity : (51 ~ 53) % R.H.

### 5.1.3 Measurement Procedure

The test was performed according to ANSI C63.10, clause 9.3

### 5.1.4 Test setup



## 5.1.5 Measurement Result

| Center Freq. (GHz) | Measured -20 dBc Frequency | | 20 dB Bandwidth (MHz) | Lower Limit (GHz) | Upper Limit (GHz) | Result |
|---|---|---|---|---|---|---|
| | Lower Result (GHz) | Upper Result (GHz) | | | | |
| 60.8 | 57.963 | 63.627 | 5 660 | 57 | 64 | Compliance |

Occupied Bandwidth

## 5.2 Duty cycle, Off Time Requirement

### 5.2.1 Standard Applicable [FCC §15.255(c)(2)(iii)(A)]

**FCC**

(iii) 57.0–64.0 GHz:

(A) The peak EIRP shall not exceed 14 dBm, and the sum of continuous transmitter off-times of at least two milliseconds shall equal at least 25.5 milliseconds within any contiguous interval of 33 milliseconds, except as specific in paragraph (c)(2)(iii)(B) of this section;

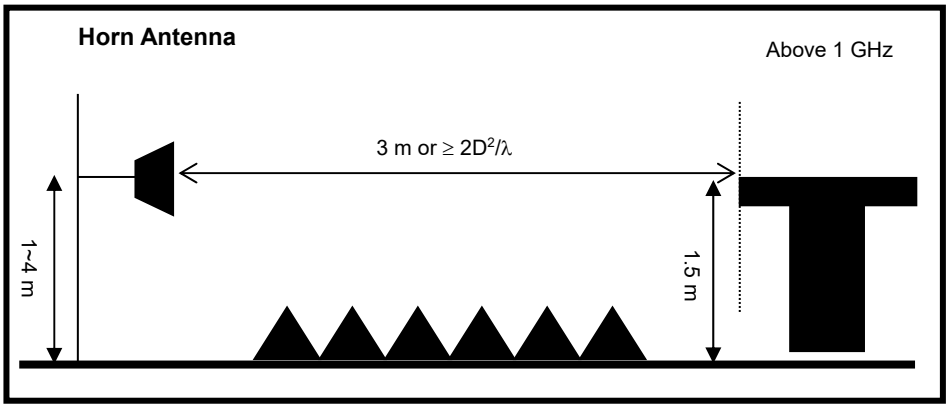
### 5.2.2 Test Environment conditions

• Ambient temperature : (21 ~ 22) ℃ • Relative Humidity : (51 ~ 53) % R.H.

### 5.2.3 Measurement Procedure

The test was performed according to ANSI C63.10, clause 9.5, 9.6, 9.7
The duty cycle was tested with the spectrum analyzer set to zero-span.

### 5.2.4 Test setup



## 5.2.5 Measurement Result

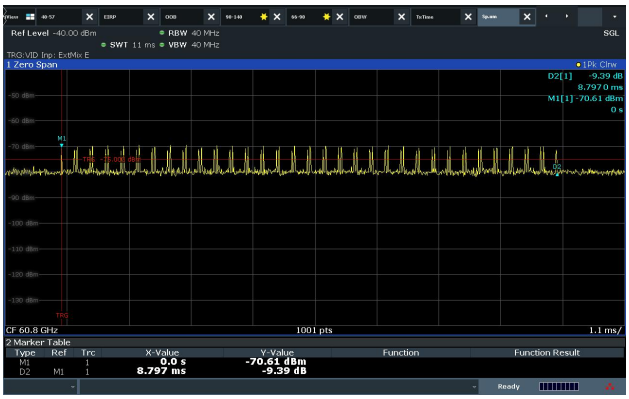
| TX On + TX OFF Time (ms) | TX On Time (ms) | TX Off Time (ms) | Duty Result (%) | Duty Factor (dB) |
|---|---|---|---|---|
| 99.00 | 8.76 | 90.24 | 8.85 | -10.53 |

| TX OFF Time Ratio (%) | Regulation Time (ms) | TX OFF Time within Regulation Time Limit (ms) | The ratio of TX OFF Time Limit (%) | Result |
|---|---|---|---|---|
| 91.15 | 33.00 | 25.50 | ≥77.27 | Compliance |

Calculating formula:
TX OFF Time = TX ON + TX OFF Time – TX ON Time
Duty = (TX ON Time / TX ON + TX OFF Time) * 100
Duty factor = 10 * log(TX ON + TX OFF Time / TX ON Time)
TX OFF Time Ratio = (TX OFF Time / TX ON + TX OFF Time) * 100

TX ON + TX OFF Time


TX ON Time



## 5.3 Radiated Power

### 5.3.1 Standard Applicable [FCC §15.255(c)(2)(iii)(A)]

**FCC**

(c)(2)(iii)(A) The peak EIRP shall not exceed 14 dBm, and the sum of continuous transmitter off-times of at least two milliseconds shall equal at least 25.5 milliseconds within any contiguous interval of 33 milliseconds, except as specific in paragraph (c)(2)(iii)(B) of this section;

(e) Limits on transmitter conducted output power.

(1) Except as specified in paragraph (e)(2) of this section, the peak transmitter conducted output power of devices other than field disturbance sensors/radars shall not exceed 500 mW. Depending on the gain of the antenna, it may be necessary to operate the intentional radiator using a lower peak transmitter output power in order to comply with the EIRP limits specified in paragraph (c) of this section.

### 5.3.2 Test Environment conditions

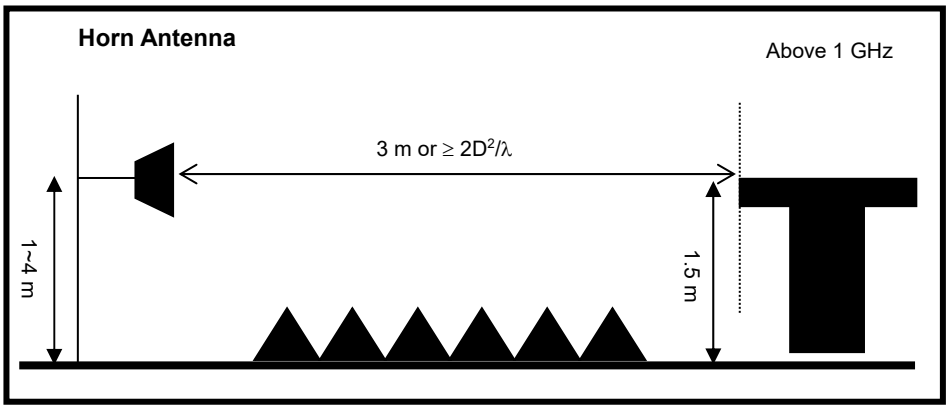
• Ambient temperature : (21 ~ 22) ℃ • Relative Humidity : (51 ~ 53) % R.H.

### 5.3.3 Measurement Procedure

Test Settings

1. Radiated power measurements are performed using the signal analyzer's swept mode measurement capability for signals with continuous operation.
2. RBW = 1~5% of the expected OBW, The analyzer limits maximum RBW at 40 MHz.
3. VBW ≥ 3 x RBW
4. Span as required, enough to observe the fundamental spike around 60.8 GHz
5. No. of sweep points ≥ 2 x span / RBW
6. Detector and Trace mode = Suitable for peak and average measurements respectively over 100 sweeps
7. The trace was allowed to stabilize

### 5.3.4 Test setup



## 5.3.5 Measurement Result

### Peak EIRP

| Freq. (GHz) | Reading (dBm) | Pol. (H/V) | Tested Distance (m) | Factor (dB) | FMCW desensitization factor(dB) | Meas. Result (dBm) | Limit (dBm) | Margin. (dB) | Result |
|---|---|---|---|---|---|---|---|---|---|
| 60.8 | -68.27 | H | 1 | 79.84 | 0.25 | 11.82 | 14 | 2.18 | Compliance |

**※Note**

Wavelength = Speed of light / Measurement frequency = 30 / 6 400 = 0.0047

$R_{(Far\ Field)}$ = (2 * (Max antenna length of EUT)$^2$) / Wavelength = (2 * (0.008 2)$^2$ / 0.004 7 = 0.028 7 m

Our measurement is performed at a minimum distance of 1 m > $R_{(Far\ field)}$

**Calculation of test results**

•Factor (dB): Mixer Loss(dB) + Cable Loss(dB) + FSPL(dB) - Antenna Gain(dBi)

•Meas Result (dBm): Reading(dBm) + Factor(dB)

**FSPL measurement**

•FSPL = TxPower - RxPower;

•RxPower = S.A Measured Level - Rx Ant Gain + Mixer Conversion Loss + Cable Loss;

•TxPower = OML Source Output + Tx Ant Gain;

These calculation results are same as results which were calculated with formulas described in the section 9 of ANSI C63.10-2013

**FMCW desensitization factor**

The derivation of the FMCW desensitization factor is given in Keysight Application Note 5952-1039 Appendix B.

$$\alpha = \frac{1}{\sqrt[4]{1+\left(\frac{2\ln(2)}{\pi}\right)^2\left(\frac{F_s}{T_s B^2}\right)^2}}$$

and

FMCW desensitization factor = 20 Log(α)

Where

$F_S$ = FMCW Sweep Width or Chirp Width

$T_S$ = FMCW Sweep Time(Declared by manufacturer)

B = 3-dB bandwidth of Gaussian RBW Filter

| FMCW Sweep Width (MHz) | FMCW Sweep Time (us) | 3-dB bandwidth of Gaussian RBW Filter(MHz) | FMCW desensitization factor(dB) |
|---|---|---|---|
| 5 660 | 8 145 | 40 | 0.25 |

Peak EIRP

## 5.4 Spurious emissions

### 5.4.1 Standard Applicable [FCC §15.255(d), 15.209]

**FCC**

(d) Limits on spurious emissions.

(1) The power density of any emissions outside the 57–71 GHz band shall consist solely of spurious emissions.

(2)Click to open paragraph tools Radiated emissions below 40 GHz shall not exceed the general limits in § 15.209.

| Frequency (MHz) | Field strength (microvolts/meter) | Measurement distance (meters) |
|---|---|---|
| 0.009-0.490 | 2400/F(kHz) | 300 |
| 0.490-1.705 | 24000/F(kHz) | 30 |
| 1.705-30.0 | 30 | 30 |
| 30-88 | 100 | 3 |
| 88-216 | 150 | 3 |
| 216-960 | 200 | 3 |
| Above 960 | 500 | 3 |

(3) Between 40 GHz and 200 GHz, the level of these emissions shall not exceed 90 pW/cm2 at a distance of 3 meters.

(4) The levels of the spurious emissions shall not exceed the level of the fundamental emission.

### 5.4.2 Test Environment conditions

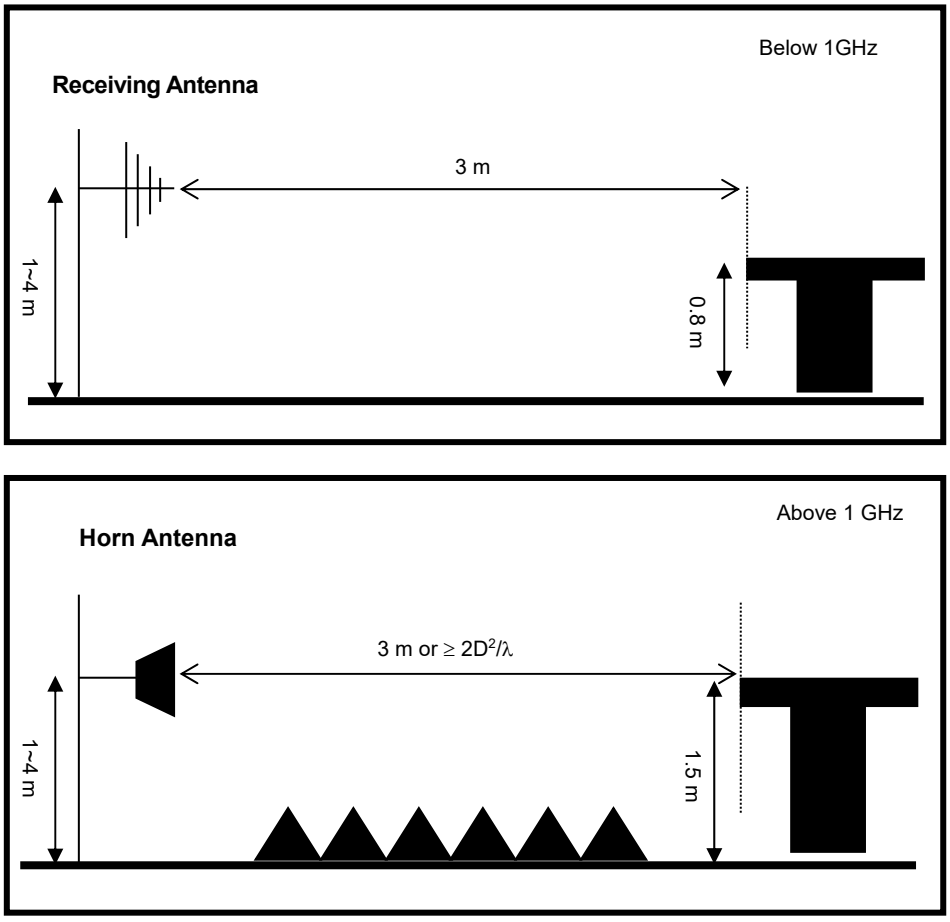
• Ambient temperature : (21 ~ 22) ℃ • Relative Humidity : (51 ~ 53) % R.H.

### 5.4.3 Measurement Procedure

The measurements procedure of the Spurious RF Radiated emissions is as following describe method.

1. The EUT is placed on a turntable, which is 1.5 m above ground plane.
2. The turntable shall be rotated for 360 degrees to determine the position of maximum emission level.
3. Maximum procedure was performed on the six highest emissions to ensure EUT compliance.
4. And also, each emission was to be maximized by changing the polarization of receiving antenna both horizontal and vertical.
5. Repeat above procedures until the measurements for all frequencies are complete.

5.4.4 Test setup




All measurements were taken at a distance greater than the calculated far field as below

*Wavelength = Speed of light / Measurement frequency = 30 / 6 400 = 0.0047*

*(2 * (Max antenna length of EUT)$^2$) / Wavelength = (2 * (0.008 2)$^2$ / 0.004 7 = 0.028 7 m*

## 5.4.5 Measurement Result

▣ Below 1 GHz

| Freq. (MHz) | Reading (dBμV/m) | Antenna | | | CL (dB) | AMP (dB) | Meas Result (dBμV/m) | Limit (dBμV/m ) | Mgn (dB) | Result |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Height (m) | Pol. (H/V) | Fctr. (dB/m) | | | | | | |
| 35.51 | 28.02 | 1.0 | V | 20.20 | 0.77 | 52.03 | 28.02 | 40.00 | 11.98 | Compliance |
| 80.24 | 27.13 | 1.0 | V | 11.93 | 1.06 | 51.78 | 27.13 | 40.00 | 12.87 | Compliance |
| 118.10 | 25.67 | 1.0 | V | 12.76 | 1.51 | 51.63 | 25.67 | 43.50 | 17.83 | Compliance |
| 141.77 | 15.34 | 1.5 | H | 13.85 | 1.71 | 51.54 | 15.34 | 43.50 | 28.16 | Compliance |
| 163.16 | 30.92 | 1.0 | V | 15.05 | 1.86 | 51.50 | 30.92 | 43.50 | 12.58 | Compliance |
| 165.47 | 21.09 | 1.5 | H | 15.14 | 1.87 | 51.49 | 21.09 | 43.50 | 22.41 | Compliance |

Freq.(㎒) : Measurement frequency, Reading(dBμV/m) : includes values for Antenna factor, Cable loss, and Amp gain, Antenna (Height, Pol, Fctr) : Antenna Height, Polarization and Factor, Cbl(dB) : Cable loss, Pre AMP(dB) : Preamplifier gain(dB), Meas Result (dBμV/m ) :Reading(dBμV/m)+ Antenna factor.(dB/m )+ CL(dB) - Pre AMP(dB)
Limit(dBμV/m): Limit value specified with FCC Rule, Mgn(dB) : FCC Limit (dBμV/m) − Meas Result(dBμV/m)

- The transmitter radiated spectrum was investigated from 9 kHz to 1 GHz.
- The spurious signals detected do not depend on the operating mode.

▣ 1 GHz – 40 GHz

| Freq. (GHz) | Reading (dBμV/m) | | Antenna | | | CL (dB) | AMP (dB) | Meas Result (dBμV/m) | | Limit (dBμV/m ) | | Mgn. (dB) | | Result |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PK | PK | Height (m) | Pol. (H/V) | Fctr. (dB/m) | | | PK | AV | PK | AV | PK | AV | |
| No critical peaks found | | | | | | | | | | | | | | |

**※Note**
- Above 1 GHz is measured average and peak detector mode on Spectrum analyzer in accordance with FCC Rule15.35
- Limit: 54 dBμV/m(Average), 74 dBμV /m(Peak), Attenuated more than 20 dB below the permissible value.
- It is not recorded on the report that the reading of emissions are attenuated more than 20 dB below the permissible limits or the field strength is too small to measured.
- The transmitter radiated spectrum was investigated from 1 GHz to 40 GHz.

▣ 40 GHz – 200 GHz

| Freq. (GHz) | Reading (dBm) | Pol. (H/V) | Factor (dB) | Tested Distance (m) | Meas. Result (dBm) | Limit (dBm) | Limit (pW/cm$^2$) | Margin. (dB) | Result |
|---|---|---|---|---|---|---|---|---|---|
| 41.946 | -55.68 | H | 45.49 | 0.5 | -10.19 | 5.67 | 90 | 15.86 | Compliance |
| 63.827 | -94.03 | H | 83.97 | 0.5 | -10.06 | 5.67 | 90 | 15.73 | Compliance |
| 64.425 | -96.39 | H | 83.24 | 0.5 | -13.15 | 5.67 | 90 | 18.82 | Compliance |
| 101.484 | -92.49 | H | 68.39 | 0.5 | -24.10 | 5.67 | 90 | 29.77 | Compliance |
| 140.841 | -93.65 | H | 83.52 | 0.1 | -10.13 | 19.65 | 90 | 29.78 | Compliance |

**※Note**

**Calculation of test results**

•Factor (dB): Mixer Loss(dB) + Cable Loss(dB) + FSPL(dB) - Antenna Gain(dBi)

•Meas Result (dBm): Reading(dBm) + Factor(dB)

**FSPL measurement**

•FSPL = TxPower - RxPower;

•RxPower = S.A Measured Level - Rx Ant Gain + Mixer Conversion Loss + Cable Loss;

•TxPower = OML Source Output + Tx Ant Gain;

**FCC Limit**

•Between 40 GHz and 200 GHz, the level of these emissions shall not exceed 90 pW/cm2 at a distance of 3 meters.

Notes:

90 pW/cm$^2$ = 1 pW = $10^{-9}$ mW; 90 * $10^{-9}$ mW = 9 * $10^{-8}$ mW

1 mW/cm$^2$ = 155.76 dBuV/m

9 * $10^{-8}$ mW/cm$^2$ = 85.31 dBuV/m @ 3 m

= -9.89 dBm @ 3 m

= -0.35 dBm @ 1 m

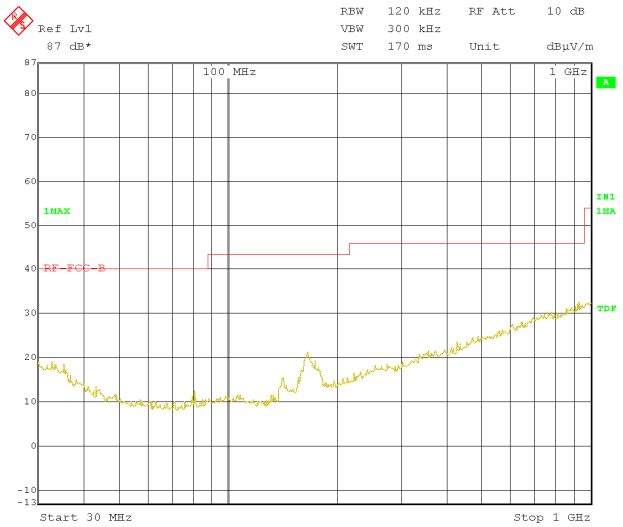
= 5.67 dBm @ 0.5 m

= 19.65 dBm @ 0.1 m

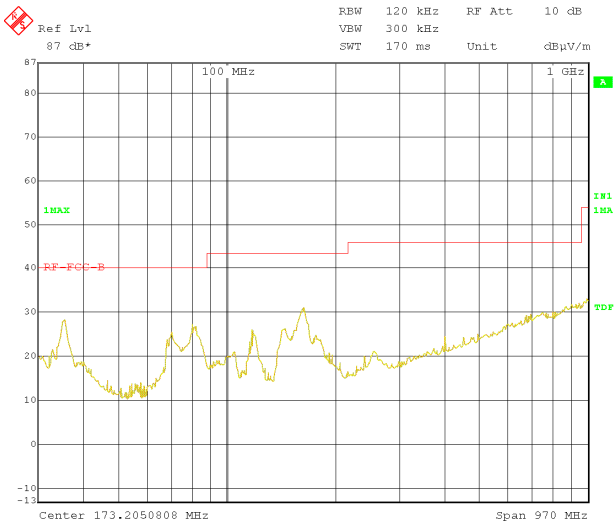
5.4.6 Plots
*The worst case only.

▪ Below 1 GHz

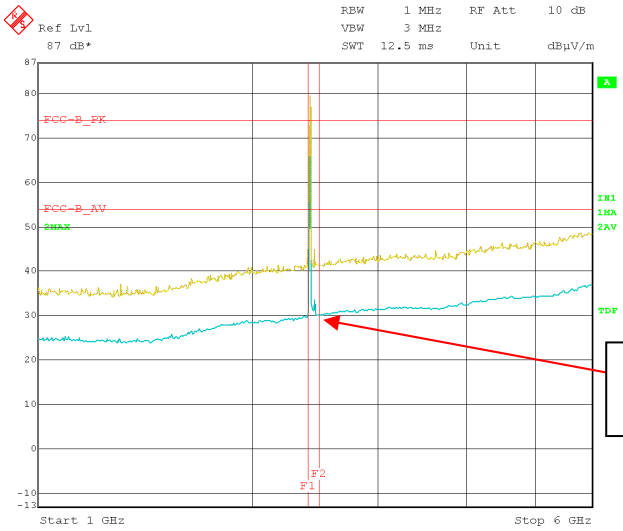
Horizontal




Vertical

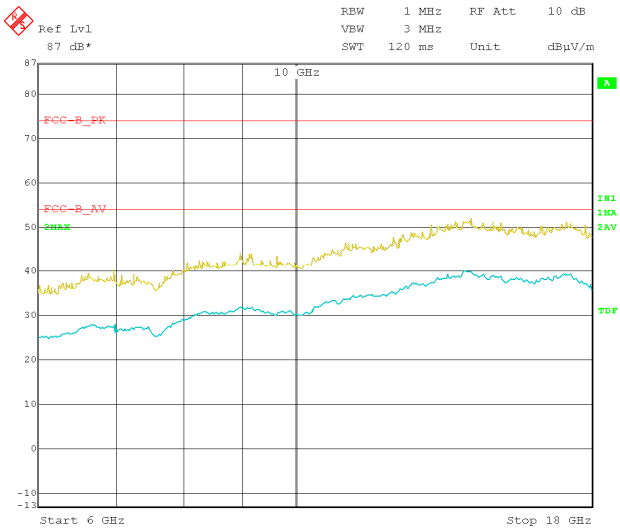



▪ 1 GHz ~ 6 GHz

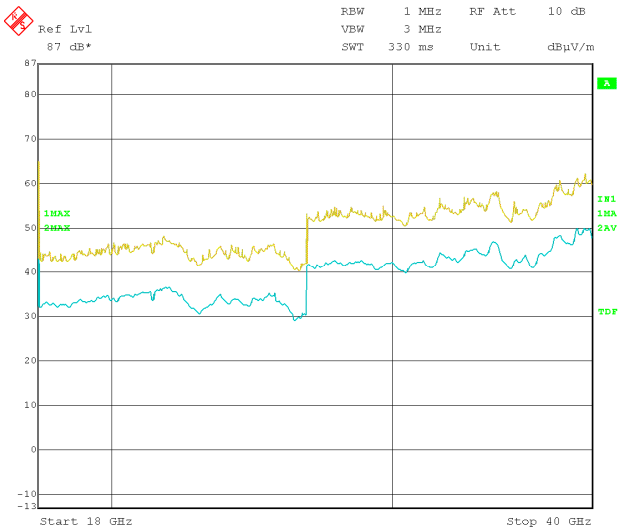



The signal within this band originates from the approved frequency range of the certified DTS module; therefore, it is excluded from spurious emission.

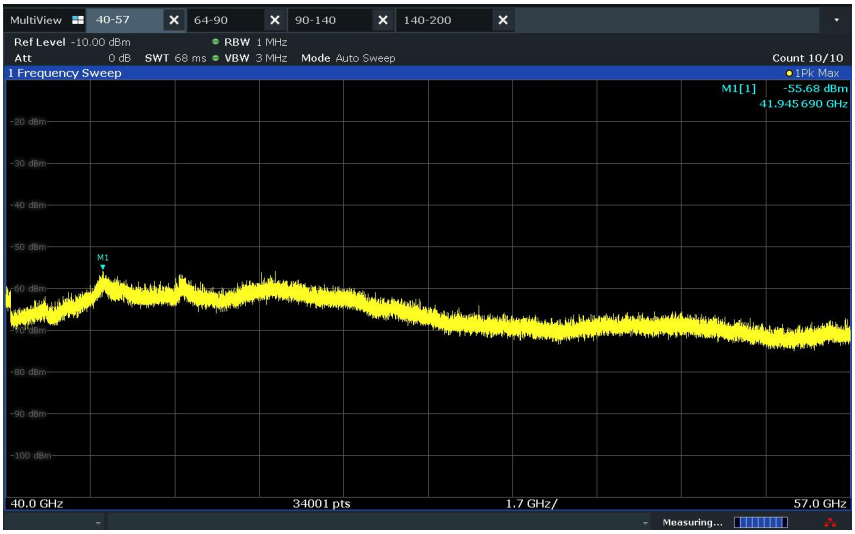
▪ 6 GHz ~ 18 GHz



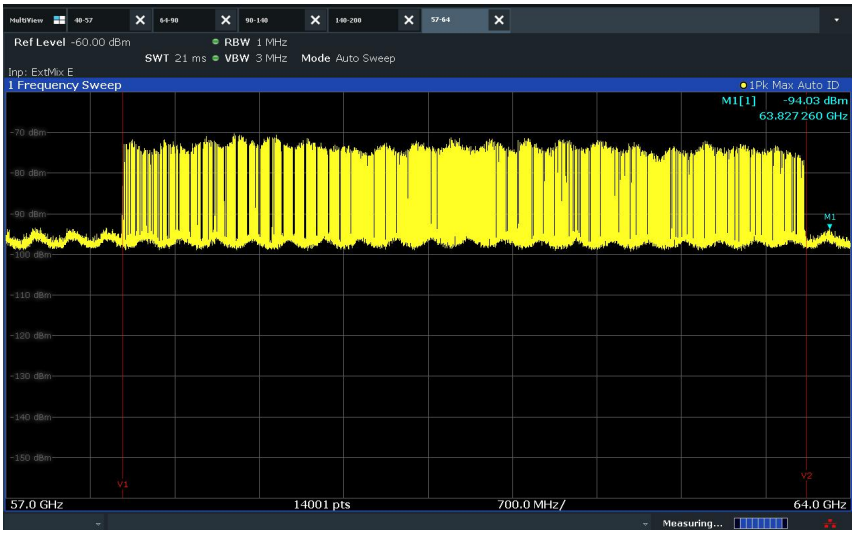
- 18 GHz ~ 40 GHz



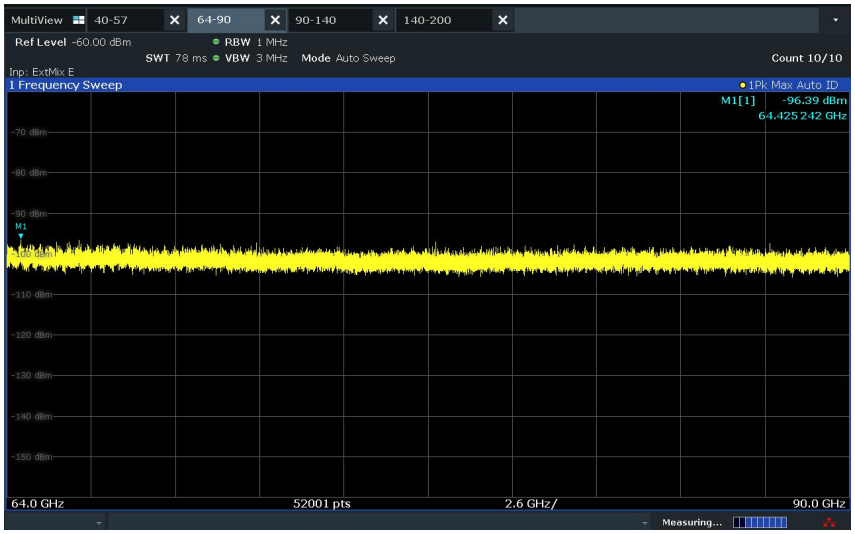

- 40 GHz ~ 57 GHz



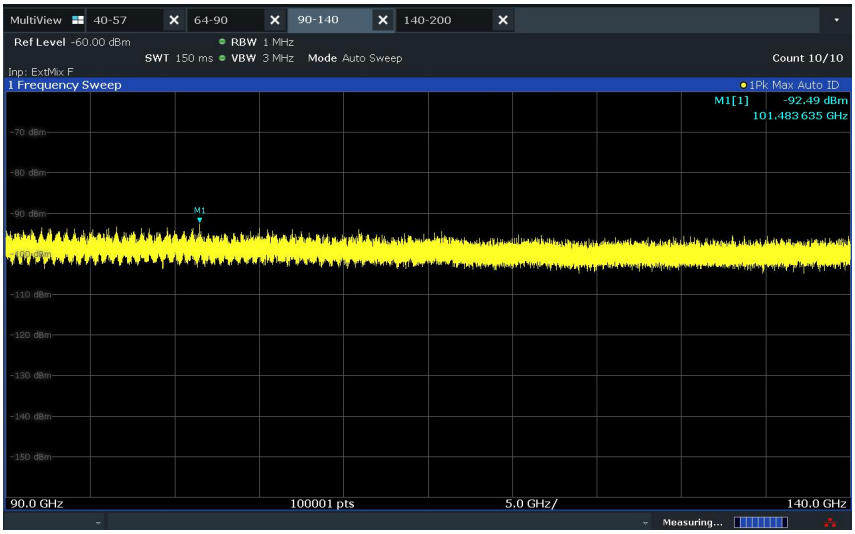

- 57 GHz ~ 64 GHz(Allowed frequency band)



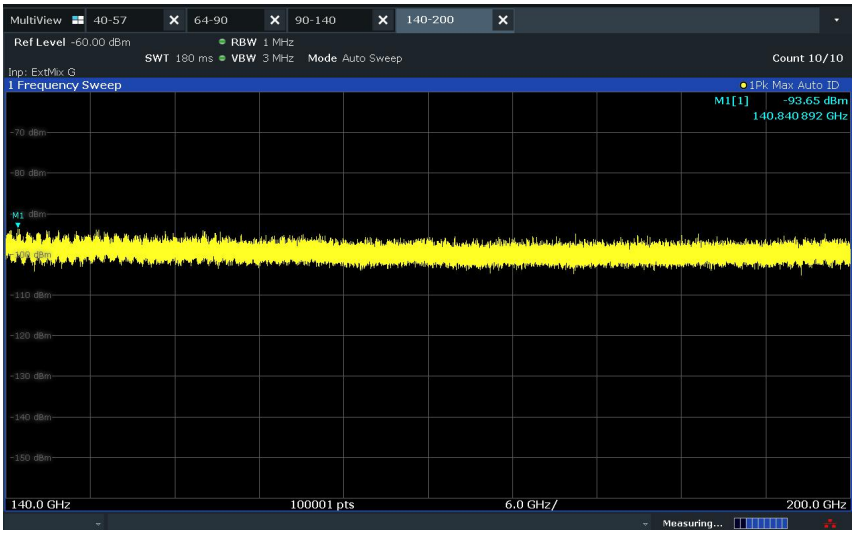
- 64 GHz ~ 90 GHz




- 90 GHz ~ 140 GHz




- 140 GHz ~ 200 GHz



## 5.5 Frequency Stability

### 5.5.1 Standard Applicable [FCC §15.255(f)]

**FCC**

(f) Frequency stability. Fundamental emissions must be contained within the frequency bands specified in this section during all conditions of operation. Equipment is presumed to operate over the temperature range −20 to + 50 degrees Celsius with an input voltage variation of 85% to 115% of rated input voltage, unless justification is presented to demonstrate otherwise.

### 5.5.2 Test Environment conditions

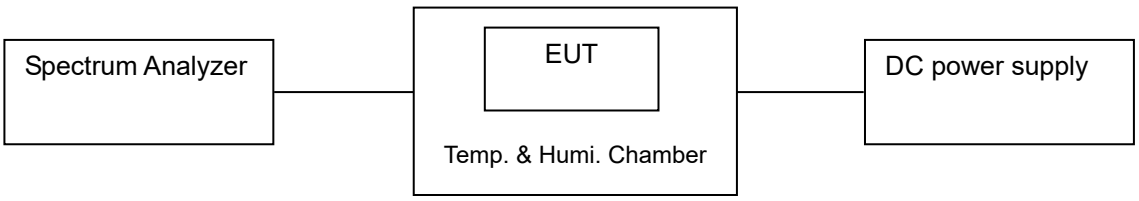
• Ambient temperature : (20 ~ 21) ℃ • Relative Humidity : (53 ~ 55) % R.H.

### 5.5.3 Measurement Procedure

The spectrum analyzer is set to the as follows :

• Set the RBW: 1 % to 3 % of the 99 % bandwidth.
• Set the VBW: ≥ 3 x RBW.
• Detector = Peak.
• Sweep time = auto couple.
• Trace mode = max hold.
• Allow trace to fully stabilize.
• The frequency drift was investigated for every 10 ℃ increment until the unit is stabilized then recorded the reading in tabular format with the temperature range of -20 ℃ to 85 ℃. (Manufacturer declaration)
• Voltage supplied to EUT is 12 V reference temperature was done at 20 ℃.
• The voltage was varied by ±15 % of nominal.

### 5.5.4 Test setup



## 5.5.5 Measurement Result

| Temp(℃) | Power Supply | Frequency Range(GHz) | | | Limit(GHz) | Result |
|---|---|---|---|---|---|---|
| 85 | DC 5 (Vnom) | 58.018 51 | ~ | 63.602 19 | 57 ~ 64 | Compliance |
| 80 | | 58.014 36 | ~ | 63.598 37 | | Compliance |
| 70 | | 58.009 51 | ~ | 63.594 16 | | Compliance |
| 60 | | 58.004 85 | ~ | 63.590 04 | | Compliance |
| 50 | | 58.001 07 | ~ | 63.586 72 | | Compliance |
| 40 | | 57.996 56 | ~ | 63.583 26 | | Compliance |
| 30 | | 57.992 80 | ~ | 63.578 50 | | Compliance |
| 20(Ref.) | | 57.987 98 | ~ | 63.574 97 | | Compliance |
| 10 | | 57.984 38 | ~ | 63.571 81 | | Compliance |
| 0 | | 57.979 43 | ~ | 63.568 56 | | Compliance |
| -10 | | 57.975 71 | ~ | 63.563 82 | | Compliance |
| -20 | | 57.970 75 | ~ | 63.558 94 | | Compliance |
| Nom Temperature | DC 4.25 (Vmin) | 57.987 96 | ~ | 63.574 98 | | Compliance |
| Nom Temperature | DC 5.75 (Vmax) | 57.987 97 | ~ | 63.574 97 | | Compliance |

- Reference only

## 5.6 Antenna requirement

### 5.6.1 Standard applicable [FCC §15.203]

For intentional device, according to §15.203, an intentional radiator shall be designed to ensure that no antenna other than furnished by responsible party shall be used with the device.

The use of a permanently attached antenna or of an antenna that user a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this section.

The manufacturer may design the unit so that broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited.

### 5.6.2 Antenna details

| Frequency Band | Antenna Type | Gain [dBi] | Results |
|---|---|---|---|
| 57~64 | Patch Antenna(Fixed) | 5 dBi(Max.) | Compliance |

※ The antennas of this E.U.T permanently attached

## 5.7 AC Power Conducted emissions

### 5.7.1 Standard Applicable [FCC §15.207(a)]

For intentional radiator that is designed to be connected to the public utility(AC)power line, the radio frequency. Voltage that is conducted back onto the AC power line on any frequencies hopping mode within the band 150 kHz to 30 MHz shall not exceed the limits in the following table, as measured using a 50 μH/50 ohms line Impedance stabilization network(LISN). Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the boundary between the frequency ranges.

§15.207 limits for AC line conducted emissions;

| Frequency of Emission(㎒) | Conducted Limit (dBμV) | |
|---|---|---|
| | Quasi-peak | Average |
| 0.15 ~ 0.5 | 66 to 56 * | 56 to 46 * |
| 0.5 ~ 5 | 56 | 46 |
| 5 ~ 30 | 60 | 50 |

* Decreases with the logarithm of the frequency

### 5.7.2 Test Environment conditions

• Ambient temperature : (21 ~ 22) ℃ • Relative Humidity : (51 ~ 53) % R.H.

### 5.7.3 Measurement Procedure

EUT was placed on a non- metallic table height of 0.8 m above the reference ground plane. Cables connected to EUT were fixed to cause maximum emission. Test was made with the antenna positioned in both the horizontal and vertical planes of polarization. The measurement antenna was varied in height above the conducting ground plane to obtain the Maximum signal strength.

### 5.7.4 Used equipment

| Equipment | Model No. | Serial No. | Manufacturer | Next cal date | Cal interval | Used |
|---|---|---|---|---|---|---|
| Test receiver | ESCS30 | 100111 | Rohde & Schwarz | 2024. 01. 10. | 1 year | ☒ |
| Pulse Limiter | ESH3-Z2 | 100097 | Rohde & Schwarz | 2024. 01. 10. | 1 year | ☒ |
| LISN | ESH2-Z5 | 100044 | R&S | 2024. 01. 10. | 1 year | ☐ |
| | ESH3-Z5 | 100147 | R&S | 2024. 01. 10. | 1 year | ☒ |

*Test Program: " ESXS-K1 V2.2"

Measurement uncertainty

The measurement uncertainties shown below were calculated in accordance with the requirements of ANSI C63.10-2013. All measurement uncertainty values are shown with a coverage factor of k = 2 to indicate a 95% level of confidence. The measurement uncertainty shown below meets or exceeds the UCISPR measurement uncertainty values specified in CISPR 16-4-2 and, thus, can be compared directly to specified limits to determine compliance.

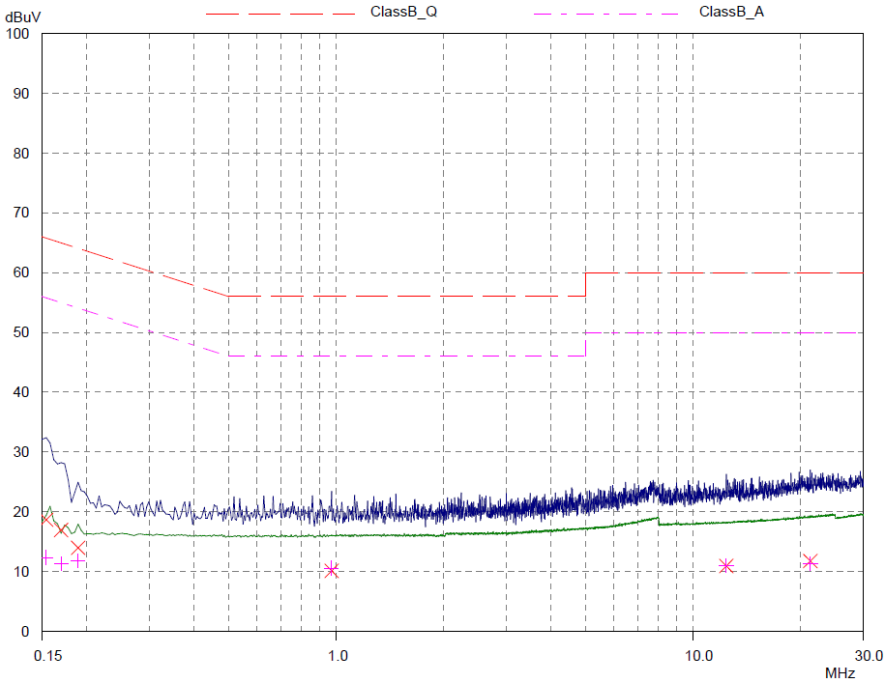
0.009 kHz ~ 30 MHz(L) : 3.94 dB(CL: Approx 95 %, *k*=2)
0.009 kHz ~ 30 MHz(N) : 3.32 dB(CL: Approx 95 %, *k*=2)

## 5.7.5 Measurement Result

| Freq. | Factor [dB] | | POL | QP | | | CISPR AV | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Limit | Reading | Result | Limit | Reading | Result |
| [㎒] | LISN | CABLE +P/L | | [dB㎶] | [dB㎶] | [dB㎶] | [dB㎶] | [dB㎶] | [dB㎶] |
| 0.154 | 0.29 | 9.89 | L | 65.79 | 18.65 | 18.94 | 55.79 | 12.01 | 12.30 |
| 0.170 | 0.28 | 9.89 | L | 64.98 | 16.95 | 17.23 | 54.98 | 10.89 | 11.17 |
| 0.189 | 0.27 | 9.90 | L | 64.08 | 13.96 | 14.23 | 54.08 | 11.51 | 11.78 |
| 0.970 | 0.27 | 9.96 | L | 56.00 | 10.13 | 10.40 | 46.00 | 10.16 | 10.43 |
| 12.396 | 0.99 | 10.28 | L | 60.00 | 10.93 | 11.92 | 50.00 | 10.54 | 11.53 |
| 21.291 | 1.12 | 10.43 | L | 60.00 | 11.77 | 12.89 | 50.00 | 11.02 | 12.14 |
| 0.158 | 0.25 | 9.89 | N | 65.58 | 19.79 | 20.04 | 55.58 | 12.95 | 13.20 |
| 0.170 | 0.25 | 9.89 | N | 64.98 | 16.95 | 17.20 | 54.98 | 11.01 | 11.26 |
| 0.189 | 0.24 | 9.90 | N | 64.08 | 13.98 | 14.22 | 54.08 | 11.35 | 11.59 |
| 3.322 | 0.40 | 10.05 | N | 56.00 | 10.25 | 10.65 | 46.00 | 10.29 | 10.69 |
| 29.017 | 0.78 | 10.55 | N | 60.00 | 11.94 | 12.72 | 50.00 | 11.09 | 11.87 |

* LISN: LISN insertion Loss, Cable: Cable Loss, P/L:pulse limiter factor
* L: Line. Live, N: Line. Neutral
* Reading: test receiver reading value (with cable loss & pulse limiter factor)
* Result = LISN + Reading

Line. Live




Line. Neutral