# RADIO TEST REPORT

## Test Report No. : 13525959H-C-R1

| | | |
|---|---|---|
| **Applicant** | : | **SHIMANO INC.** |
| **Type of EUT** | : | **Rear Derailleur** |
| **Model Number of EUT** | : | **3GK1** |
| **FCC ID** | : | **WY7-3GK1** |
| **Test regulation** | : | **FCC Part 15 Subpart C: 2020** |
| **Test Result** | : | **Complied (Refer to SECTION 3.2)** |

1. This test report shall not be reproduced in full or partial, without the written approval of UL Japan, Inc.
2. The results in this report apply only to the sample tested.
3. This sample tested is in compliance with the limits of the above regulation.
4. The test results in this test report are traceable to the national or international standards.
5. This test report must not be used by the customer to claim product certification, approval, or endorsement by the A2LA accreditation body.
6. This test report covers Radio technical requirements.
   It does not cover administrative issues such as Manual or non-Radio test related Requirements. (if applicable)
7. The all test items in this test report are conducted by UL Japan, Inc. Ise EMC Lab.
8. The opinions and the interpretations to the result of the description in this report are outside scopes where UL Japan has been accredited.
9. The information provided from the customer for this report is identified in Section 1.
10. This report is a revised version of 13525959H-C. 13525959H-C is replaced with this report.

**Date of test:** October 12 to 18, 2020

**Representative test engineer:**
T. Nakagawa
Tomohisa Nakagawa
Engineer
Consumer Technology Division

**Approved by:**
Takayuki. S
Takayuki Shimada
Leader
Consumer Technology Division

CERTIFICATE 5107.02

☐ The testing in which "Non-accreditation" is displayed is outside the accreditation scopes in UL Japan.
☒ There is no testing item of "Non-accreditation".

**UL Japan, Inc.**
**Ise EMC Lab.**
4383-326 Asama-cho, Ise-shi, Mie-ken 516-0021 JAPAN
Telephone : +81 596 24 8999
Facsimile : +81 596 24 8124

# REVISION HISTORY

## Original Test Report No.: 13525959H-C

| Revision | Test report No. | Date | Page revised | Contents |
|---|---|---|---|---|
| - (Original) | 13525959H-C | November 24, 2020 | - | - |
| 1 | 13525959H-C-R1 | January 18, 2021 | P11 | Corrected No.1 cable (RF Cable) on the list of cable used;<br>Unshielded → Shielded |

# Reference: Abbreviations (Including words undescribed in this report)

| | |
|---|---|
| A2LA | The American Association for Laboratory Accreditation |
| AC | Alternating Current |
| AFH | Adaptive Frequency Hopping |
| AM | Amplitude Modulation |
| Amp, AMP | Amplifier |
| ANSI | American National Standards Institute |
| Ant, ANT | Antenna |
| AP | Access Point |
| ASK | Amplitude Shift Keying |
| Atten., ATT | Attenuator |
| AV | Average |
| BPSK | Binary Phase-Shift Keying |
| BR | Bluetooth Basic Rate |
| BT | Bluetooth |
| BT LE | Bluetooth Low Energy |
| BW | BandWidth |
| Cal Int | Calibration Interval |
| CCK | Complementary Code Keying |
| Ch., CH | Channel |
| CISPR | Comite International Special des Perturbations Radioelectriques |
| CW | Continuous Wave |
| DBPSK | Differential BPSK |
| DC | Direct Current |
| D-factor | Distance factor |
| DFS | Dynamic Frequency Selection |
| DQPSK | Differential QPSK |
| DSSS | Direct Sequence Spread Spectrum |
| EDR | Enhanced Data Rate |
| EIRP, e.i.r.p. | Equivalent Isotropically Radiated Power |
| EMC | ElectroMagnetic Compatibility |
| EMI | ElectroMagnetic Interference |
| EN | European Norm |
| ERP, e.r.p. | Effective Radiated Power |
| EU | European Union |
| EUT | Equipment Under Test |
| Fac. | Factor |
| FCC | Federal Communications Commission |
| FHSS | Frequency Hopping Spread Spectrum |
| FM | Frequency Modulation |
| Freq. | Frequency |
| FSK | Frequency Shift Keying |
| GFSK | Gaussian Frequency-Shift Keying |
| GNSS | Global Navigation Satellite System |
| GPS | Global Positioning System |
| Hori. | Horizontal |
| ICES | Interference-Causing Equipment Standard |
| IEC | International Electrotechnical Commission |
| IEEE | Institute of Electrical and Electronics Engineers |
| IF | Intermediate Frequency |
| ILAC | International Laboratory Accreditation Conference |
| ISED | Innovation, Science and Economic Development Canada |
| ISO | International Organization for Standardization |
| JAB | Japan Accreditation Board |
| LAN | Local Area Network |
| LIMS | Laboratory Information Management System |
| MCS | Modulation and Coding Scheme |
| MRA | Mutual Recognition Arrangement |
| N/A | Not Applicable |
| NIST | National Institute of Standards and Technology |
| NS | No signal detect. |
| NSA | Normalized Site Attenuation |
| NVLAP | National Voluntary Laboratory Accreditation Program |
| OBW | Occupied Band Width |
| OFDM | Orthogonal Frequency Division Multiplexing |
| P/M | Power meter |
| PCB | Printed Circuit Board |
| PER | Packet Error Rate |
| PHY | Physical Layer |
| PK | Peak |
| PN | Pseudo random Noise |
| PRBS | Pseudo-Random Bit Sequence |
| PSD | Power Spectral Density |
| QAM | Quadrature Amplitude Modulation |
| QP | Quasi-Peak |
| QPSK | Quadri-Phase Shift Keying |
| RBW | Resolution Band Width |
| RDS | Radio Data System |
| RE | Radio Equipment |
| RF | Radio Frequency |
| RMS | Root Mean Square |
| RSS | Radio Standards Specifications |
| Rx | Receiving |
| SA, S/A | Spectrum Analyzer |
| SG | Signal Generator |
| SVSWR | Site-Voltage Standing Wave Ratio |
| TR | Test Receiver |
| Tx | Transmitting |
| VBW | Video BandWidth |
| Vert. | Vertical |
| WLAN | Wireless LAN |

**CONTENTS** **PAGE**

# SECTION 1: Customer information

| | | |
|---|---|---|
| Company Name | : | SHIMANO INC. |
| Address | : | 3-77 Oimatsu-cho, Sakai-ku, Sakai City, Osaka 590-8577, Japan |
| Telephone Number | : | +81-72-223-7019 |
| Facsimile Number | : | +81-72-223-3266 |
| Contact Person | : | Toshihiko Takahashi |

The information provided from the customer is as follows;
- Applicant, Type of EUT, Model Number of EUT, FCC ID on the cover and other relevant pages
- Operating/Test Mode(s) (Mode(s)) on all the relevant pages
- SECTION 1: Customer information
- SECTION 2: Equipment under test (EUT) other than the Receipt Date
- SECTION 4: Operation of EUT during testing

* The laboratory is exempted from liability of any test results affected from the above information in SECTION 2 and 4.

# SECTION 2: Equipment under test (EUT)

## 2.1 Identification of EUT

| | | |
|---|---|---|
| Type | : | Rear Derailleur |
| Model Number | : | 3GK1 |
| Serial Number | : | Refer to SECTION 4.2 |
| Rating | : | DC 7.4 V (Battery) |
| Receipt Date | : | October 7, 2020 |
| Country of Mass-production | : | Japan |
| Condition | : | Production prototype<br>(Not for Sale: This sample is equivalent to mass-produced items.) |
| Modification | : | No Modification by the test lab. |

## 2.2 Product Description

Model: 3GK1 (referred to as the EUT in this report) is a Rear Derailleur.

**General Specification**

| | | |
|---|---|---|
| Operating Temperature | : | -10 deg. C to +50 deg. C |

**Radio Specification**

**SHIMANO ORIGINAL**

| | | |
|---|---|---|
| Radio Type | : | Transceiver |
| Frequency of Operation | : | 2478 MHz |
| Modulation | : | GFSK |
| Antenna type | : | Monopole Antenna |
| Antenna Gain | : | -3.7 dBi |
| Maximum Clock frequency | : | 24 MHz |

**Bluetooth Low Energy**

| | | |
|---|---|---|
| Equipment Type | : | Transceiver |
| Frequency of Operation | : | 2402 MHz - 2480 MHz |
| Type of Modulation | : | GFSK |
| Antenna Type | : | Monopole Antenna |
| Antenna Gain | : | -3.7 dBi |
| Maximum Clock frequency | : | 32 MHz |

**ANT+**

| | | |
|---|---|---|
| Equipment Type | : | Transceiver |
| Frequency of Operation | : | 2402 MHz - 2480 MHz |
| Type of Modulation | : | GFSK |
| Antenna Type | : | Monopole Antenna |
| Antenna Gain | : | -3.7 dBi |
| Maximum Clock frequency | : | 32 MHz |

* The test is not applicable to Bluetooth Low Energy and ANT+ parts since the already approved module (FCC ID: WY7-SWAN3) is mounted on the EUT.

# SECTION 3: Test specification, procedures & results

## 3.1 Test Specification

Test Specification : FCC Part 15 Subpart C
FCC Part 15 final revised on October 13, 2020

Title : FCC 47 CFR Part 15 Radio Frequency Device Subpart C Intentional Radiators
Section 15.207 Conducted limits
Section 15.247 Operation within the bands 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz

* The revision does not affect the test result conducted before its effective date.
* Also the EUT complies with FCC Part 15 Subpart B.

## 3.2 Procedures and results

| Item | Test Procedure | Specification | Worst margin | Results | Remarks |
|---|---|---|---|---|---|
| Conducted Emission | **FCC:** ANSI C63.10-2013 6. Standard test methods | **FCC:** Section 15.207 | - | N/A | *1) |
| | **ISED:** RSS-Gen 8.8 | **ISED:** RSS-Gen 8.8 | | | |
| 6dB Bandwidth | **FCC:** KDB 558074 D01 15.247 Meas Guidance v05r02 | **FCC:** Section 15.247(a)(2) | See data. | Complied a) | Conducted |
| | **ISED:** - | **ISED:** RSS-247 5.2(a) | | | |
| Maximum Peak Output Power | **FCC:** KDB 558074 D01 15.247 Meas Guidance v05r02 | **FCC:** Section 15.247(b)(3) | | Complied b) | Conducted |
| | **ISED:** RSS-Gen 6.12 | **ISED:** RSS-247 5.4(d) | | | |
| Power Density | **FCC:** KDB 558074 D01 15.247 Meas Guidance v05r02 | **FCC:** Section 15.247(e) | | Complied c) | Conducted |
| | **ISED:** - | **ISED:** RSS-247 5.2(b) | | | |
| Spurious Emission Restricted Band Edges | **FCC:** KDB 558074 D01 15.247 Meas Guidance v05r02 | **FCC:** Section15.247(d) | 6.1 dB 15416.330 MHz, Horizontal, AV | Complied d), e) | Conducted (below 30 MHz)/ Radiated (above 30 MHz) *2) |
| | **ISED:** RSS-Gen 6.13 | **ISED:** RSS-247 5.5 RSS-Gen 8.9 RSS-Gen 8.10 | | | |

Note: UL Japan, Inc.'s EMI Work Procedures No. 13-EM-W0420 and 13-EM-W0422.
*1) The test is not applicable since the EUT is not the device that is designed to be connected to the public utility (AC) power line.
*2) Radiated test was selected over 30 MHz based on section 15.247(d) and KDB 558074 D01 15.247 Meas Guidance v05r02 8.5 and 8.6.

a) Refer to APPENDIX 1 (data of 6 dB Bandwidth and 99 % Occupied Bandwidth)
b) Refer to APPENDIX 1 (data of Maximum Peak Output Power)
c) Refer to APPENDIX 1 (data of Power Density)
d) Refer to APPENDIX 1 (data of Conducted Spurious Emission)
e) Refer to APPENDIX 1 (data of Radiated Spurious Emission)

Symbols:
Complied The data of this test item has enough margin, more than the measurement uncertainty.
Complied# The data of this test item meets the limits unless the measurement uncertainty is taken into consideration.

* In case any questions arise about test procedure, ANSI C63.10: 2013 is also referred.

**FCC Part 15.31 (e)**
The test was performed with the New Battery and the stable voltage was supplied to the EUT during the tests. Therefore, the EUT complies with the requirement.

**FCC Part 15.203 Antenna requirement**
It is impossible for end users to replace the antenna, because the antenna is mounted inside of the EUT. Therefore, the equipment complies with the antenna requirement of Section 15.203.

## 3.3 Addition to standard

| Item | Test Procedure | Specification | Worst margin | Results | Remarks |
|---|---|---|---|---|---|
| 99% Occupied Bandwidth | **ISED:** RSS-Gen 6.7 | **ISED:** - | N/A | - a) | Conducted |
| a) Refer to APPENDIX 1 (data of 6 dB Bandwidth and 99 % Occupied Bandwidth) | | | | | |

Other than above, no addition, exclusion nor deviation has been made from the standard.

## 3.4 Uncertainty

There is no applicable rule of uncertainty in this applied standard. Therefore, the results are derived depending on whether or not laboratory uncertainty is applied.

The following uncertainties have been calculated to provide a confidence level of 95 % using a coverage factor *k*=2.
Ise EMC Lab.

**Antenna Terminal test**

| Test Item | Uncertainty (+/-) |
|---|---|
| 20 dB Bandwidth / 99 % Occupied Bandwidth | 0.96 % |
| Maximum Peak Output Power / Average Output Power | 1.4 dB |
| Carrier Frequency Separation | 0.42 % |
| Dwell time / Burst rate | 0.10 % |
| Conducted Spurious Emission | 2.6 dB |

**Radiated emission**

| Measurement distance | Frequency range | Uncertainty (+/-) |
|---|---|---|
| 3 m | 9 kHz to 30 MHz | 3.3 dB |
| 10 m | | 3.2 dB |
| | | |
| 3 m | 30 MHz to 200 MHz (Horizontal) | 4.8 dB |
| | (Vertical) | 5.0 dB |
| | 200 MHz to 1000 MHz (Horizontal) | 5.2 dB |
| | (Vertical) | 6.3 dB |
| 10 m | 30 MHz to 200 MHz (Horizontal) | 4.8 dB |
| | (Vertical) | 4.8 dB |
| | 200 MHz to 1000 MHz (Horizontal) | 5.0 dB |
| | (Vertical) | 5.0 dB |
| | | |
| 3 m | 1 GHz to 6 GHz | 4.9 dB |
| | 6 GHz to 18 GHz | 5.2 dB |
| 1 m | 10 GHz to 26.5 GHz | 5.5 dB |
| | 26.5 GHz to 40 GHz | 5.5 dB |
| 10 m | 1 GHz to 18 GHz | 5.2 dB |

## 3.5 Test Location

UL Japan, Inc. Ise EMC Lab.
*A2LA Certificate Number: 5107.02 / FCC Test Firm Registration Number: 199967 / ISED Lab Company Number: 2973C
4383-326 Asama-cho, Ise-shi, Mie-ken 516-0021 JAPAN
Telephone: +81 596 24 8999, Facsimile: +81 596 24 8124

| Test site | Width x Depth x Height (m) | Size of reference ground plane (m) / horizontal conducting plane | Other rooms | Maximum measurement distance |
|---|---|---|---|---|
| No.1 semi-anechoic chamber | 19.2 x 11.2 x 7.7 | 7.0 x 6.0 | No.1 Power source room | 10 m |
| No.2 semi-anechoic chamber | 7.5 x 5.8 x 5.2 | 4.0 x 4.0 | - | 3 m |
| No.3 semi-anechoic chamber | 12.0 x 8.5 x 5.9 | 6.8 x 5.75 | No.3 Preparation room | 3 m |
| No.3 shielded room | 4.0 x 6.0 x 2.7 | N/A | - | - |
| No.4 semi-anechoic chamber | 12.0 x 8.5 x 5.9 | 6.8 x 5.75 | No.4 Preparation room | 3 m |
| No.4 shielded room | 4.0 x 6.0 x 2.7 | N/A | - | - |
| No.5 semi-anechoic chamber | 6.0 x 6.0 x 3.9 | 6.0 x 6.0 | - | - |
| No.5 measurement room | 6.4 x 6.4 x 3.0 | 6.4 x 6.4 | - | - |
| No.6 shielded room | 4.0 x 4.5 x 2.7 | 4.0 x 4.5 | - | - |
| No.6 measurement room | 4.75 x 5.4 x 3.0 | 4.75 x 4.15 | - | - |
| No.7 shielded room | 4.7 x 7.5 x 2.7 | 4.7 x 7.5 | - | - |
| No.8 measurement room | 3.1 x 5.0 x 2.7 | 3.1 x 5.0 | - | - |
| No.9 measurement room | 8.8 x 4.6 x 2.8 | 2.4 x 2.4 | - | - |
| No.11 measurement room | 6.2 x 4.7 x 3.0 | 4.8 x 4.6 | - | - |

* Size of vertical conducting plane (for Conducted Emission test) : 2.0 x 2.0 m for No.1, No.2, No.3, and No.4 semi-anechoic chambers and No.3 and No.4 shielded rooms.

## 3.6 Test data, Test instruments, and Test set up

Refer to APPENDIX.

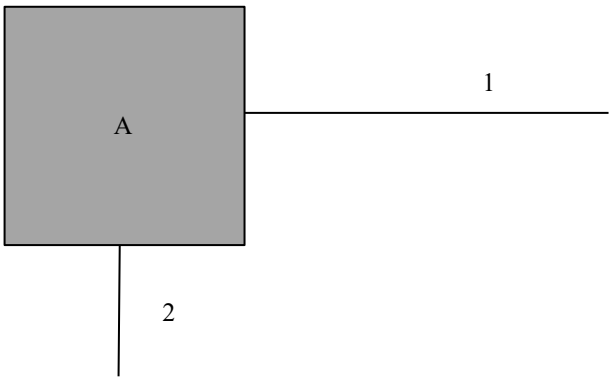
# SECTION 4: Operation of EUT during testing

## 4.1 Operating Mode(s)

| Mode | Remarks* |
|---|---|
| Transmitting (Tx) | Maximum Packet Size, SCRAMBLED |
| *Transmitting duty was 100 % on all tests. | |
| *Power of the EUT was set by the software as follows;<br>Power settings: -5 dBm<br>Software: RDR9250.4.15.202.1.dat<br>(Date: October 12, 2020, Storage location: EUT memory)<br>*This setting of software is the worst case.<br>Any conditions under the normal use do not exceed the condition of setting.<br>In addition, end users cannot change the settings of the output power of the product. | |

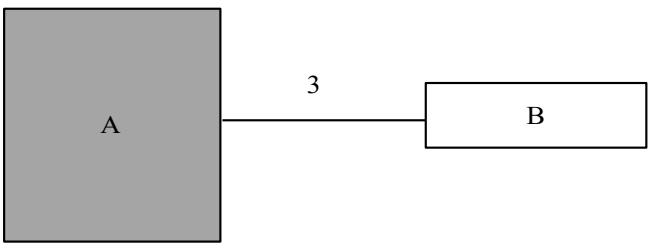
## 4.2 Configuration and peripherals

**Antenna Terminal Conducted tests**




DC 7.4 V

**Radiated Spurious Emission test**




* Cabling and setup(s) were taken into consideration and test data was taken under worse case conditions.

**Description of EUT and Support equipment**

| No. | Item | Model number | Serial number | Manufacturer | Remarks |
|---|---|---|---|---|---|
| A | Rear Derailleur | 3GK1 | 43 for AT*<br>50 for RE* | SHIMANO INC. | EUT |
| B | Li-ion Battery | BT-DN300 | 7HKSCK00033 SC | SHIMANO INC. | - |

**List of cables used**

| No. | Name | Length (m) | Shield | | Remarks |
|---|---|---|---|---|---|
| | | | Cable | Connector | |
| 1 | RF Cable | 0.3 | Shielded | Shielded | - |
| 2 | DC Cable | 0.6 | Unshielded | Unshielded | - |
| 3 | PLC Cable | 0.6 | Unshielded | Unshielded | - |

*AT: Antenna Terminal Conducted test, RE: Radiated Spurious Emission test

## SECTION 5: Radiated Spurious Emission

**Test Procedure**

It was measured based on "8.5 and 8.6 of KDB 558074 D01 15.247 Meas Guidance v05r02".

[For below 1 GHz]
EUT was placed on a urethane platform of nominal size, 0.5 m by 1.0 m, raised 0.8 m above the conducting ground plane.
The Radiated Electric Field Strength has been measured in a Semi Anechoic Chamber with a ground plane.

[For above 1 GHz]
EUT was placed on a urethane platform of nominal size, 0.5 m by 0.5 m, raised 1.5 m above the conducting ground plane.
The Radiated Electric Field Strength has been measured in a Semi Anechoic Chamber with absorbent materials lined on a ground plane.

The height of the measuring antenna varied between 1 m and 4 m and EUT was rotated a full revolution in order to obtain the maximum value of the electric field strength.
Test antenna was aimed at the EUT for receiving the maximum signal and always kept within the illumination area of the 3 dB beamwidth of the antenna.
The measurements were performed for both vertical and horizontal antenna polarization with the Test Receiver, or the Spectrum Analyzer.
The measurements were made with the following detector function of the test receiver and the Spectrum analyzer (in linear mode).
The test was made with the detector (RBW/VBW) in the following table.
When using Spectrum analyzer, the test was made with adjusting span to zero by using peak hold.

**Test Antennas are used as below;**

| Frequency | 30 MHz to 200 MHz | 200 MHz to 1 GHz | Above 1 GHz |
|---|---|---|---|
| Antenna Type | Biconical | Logperiodic | Horn |

In any 100 kHz bandwidth outside the restricted band in which the spread spectrum intentional radiator is operating, the radio frequency power that is produced by the intentional radiator confirmed 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on a radiated measurement.

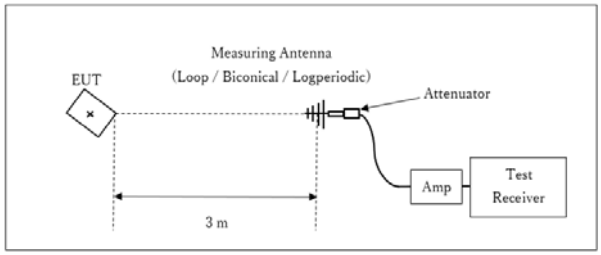
**20 dBc was applied to the frequency over the limit of FCC 15.209 / Table 4 of RSS-Gen 8.9(ISED) and outside the restricted band of FCC15.205 / Table 6 of RSS-Gen 8.10 (ISED).**

| Frequency | Below 1 GHz | Above 1 GHz | | 20 dBc |
|---|---|---|---|---|
| Instrument used | Test Receiver | Spectrum Analyzer | | Spectrum Analyzer |
| Detector | QP | PK | AV *1) | PK |
| IF Bandwidth | BW 120 kHz | RBW: 1 MHz<br>VBW: 3 MHz | 11.12.2.5.1<br>RBW: 1 MHz<br>VBW: 3 MHz<br>Detector:<br>Power Averaging (RMS)<br>Trace: 100 traces | RBW: 100 kHz<br>VBW: 300 kHz |

*1) Average Power Measurement was performed based on ANSI C63.10-2013.

**Figure 2: Test Setup**

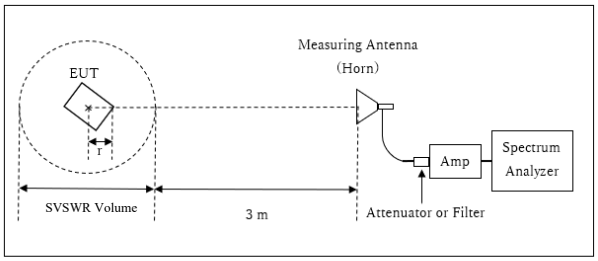
Below 1 GHz




× : Center of turn table

Test Distance: 3 m

1 GHz - 10 GHz

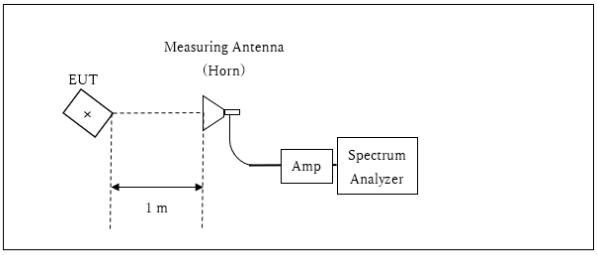



r : Radius of an outer periphery of EUT
× : Center of turn table

Distance Factor: 20 x log (3.65 m / 3.0 m) = 1.70 dB
* Test Distance: (3 + SVSWR Volume /2) - r = 3.65 m

SVSWR Volume : 1.5 m
(SVSWR Volume has been calibrated based on CISPR 16-1-4.)
r = 0.10 m

10 GHz – 26.5 GHz




× : Center of turn table

Distance Factor: 20 x log (1.0 m / 3.0 m) = -9.5 dB
*Test Distance: 1 m

- The carrier level and noise levels were confirmed at each position of X, Y and Z axes of EUT to see the position of maximum noise, and the test was made at the position that has the maximum noise.

The test results and limit are rounded off to one decimal place, so some differences might be observed.

**Measurement range : 30 MHz - 26.5 GHz**
**Test data : APPENDIX**
**Test result : Pass**

# SECTION 6: Antenna Terminal Conducted Tests

**Test Procedure**

The tests were made with below setting connected to the antenna port.

| Test | Span | RBW | VBW | Sweep time | Detector | Trace | Instrument used |
|---|---|---|---|---|---|---|---|
| 6 dB Bandwidth | 3 MHz | 100 kHz | 300 kHz | Auto | Peak | Max Hold | Spectrum Analyzer |
| 99 % Occupied Bandwidth | Enough width to display emission skirts | 1 to 5 % of OBW | Three times of RBW | Auto | Sample | Clear Write | Spectrum Analyzer |
| Maximum Peak Output Power | - | - | - | Auto | Peak/ Average *1) | - | Power Meter (Sensor: 50 MHz BW) |
| Peak Power Density | 1.5 times the 6 dB Bandwidth | 3 kHz | 10 kHz | Auto | Peak | Max Hold | Spectrum Analyzer *2) |
| Conducted Spurious Emission *3) *4) | 9 kHz to 150 kHz | 200 Hz | 620 Hz | Auto | Peak | Max Hold | Spectrum Analyzer |
| | 150 kHz to 30 MHz | 9.1 kHz | 27 kHz | | | | |

*1) Reference data
*2) Section 11.10.2 Method PKPSD (peak PSD) of "ANSI C63.10-2013".
*3) In the frequency range below 30MHz, RBW was narrowed to separate the noise contents.
Then, wide-band noise near the limit was checked separately, however the noise was not detected as shown in the chart.
(9 kHz - 150 kHz: RBW = 200 Hz, 150 kHz - 30 MHz: RBW = 9.1 kHz)
*4) The limits in CFR 47, Part 15, Subpart C, paragraph 15.209(a), are identical to those in RSS-Gen section 8.9, Table 6, since the measurements are performed in terms of magnetic field strength and converted to electric field strength levels (as reported in the table) using the free space impedance of 377 Ohmes. For example, the measurement at frequency 9 kHz resulted in a level of 45.5 dBuV/m, which is equivalent to 45.5 – 51.5 = -6.0 dBuA/m, which has the same margin, 3 dB, to the corresponding RSS-Gen Table 6 limit as it has to 15.209(a) limit.

The test results and limit are rounded off to two decimals place, so some differences might be observed.
The equipment and cables were not used for factor 0 dB of the data sheets.

**Test data : APPENDIX**
**Test result : Pass**

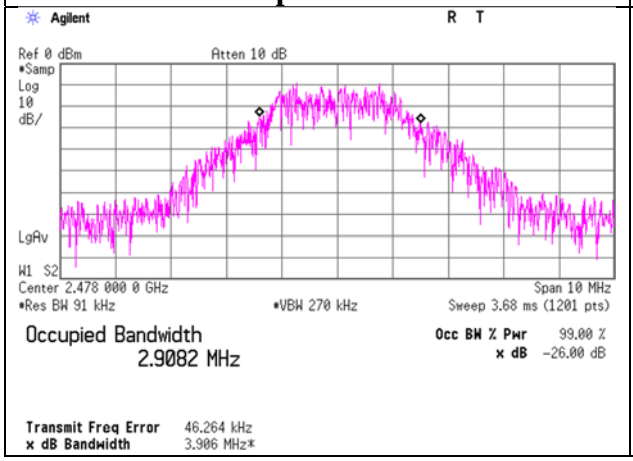
# APPENDIX 1: Test data

## 6 dB Bandwidth and 99 % Occupied Bandwidth

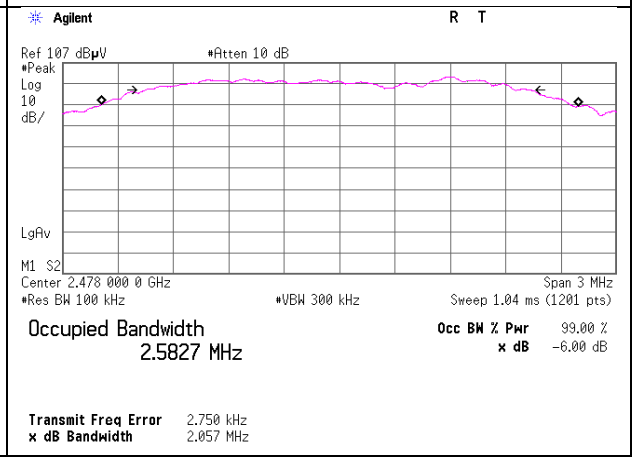
| | |
|---|---|
| Report No. | 13525959H |
| Test place | Ise EMC Lab. No.6 Shielded Room |
| Date | October 12, 2020 |
| Temperature / Humidity | 21 deg. C / 60 % RH |
| Engineer | Tomohisa Nakagawa |
| Mode | Tx |

| Mode | Frequency [MHz] | 99% Occupied Bandwidth [kHz] | 6dB Bandwidth [MHz] | Limit for 6dB Bandwidth [MHz] |
|---|---|---|---|---|
| Tx | 2478 | 2908.2 | 2.057 | > 0.5000 |

**99%Occupied Bandwidth**




**6dB Bandwidth**



# Maximum Peak Output Power

| | |
|---|---|
| Report No. | 13525959H |
| Test place | Ise EMC Lab. No.6 Shielded Room |
| Date | October 12, 2020 |
| Temperature / Humidity | 21 deg. C / 60 % RH |
| Engineer | Tomohisa Nakagawa |
| Mode | Tx |

| | | | | Conducted Power | | | | | e.i.r.p. for RSS-247 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Freq. | Reading | Cable Loss | Atten. Loss | Result | | Limit | | Margin | Antenna Gain | Result | | Limit | | Margin |
| [MHz] | [dBm] | [dB] | [dB] | [dBm] | [mW] | [dBm] | [mW] | [dB] | [dBi] | [dBm] | [mW] | [dBm] | [mW] | [dB] |
| 2478 | -2.10 | 1.65 | 10.01 | 9.56 | 9.04 | 30.00 | 1000 | 20.44 | -3.70 | 5.86 | 3.85 | 36.02 | 4000 | 30.16 |

Sample Calculation:
Result = Reading + Cable Loss (including the cable(s) customer supplied) + Attenuator Loss
e.i.r.p. Result = Conducted Power Result + Antenna Gain

# Average Output Power
# (Reference data for RF Exposure)

| | |
|---|---|
| Report No. | 13525959H |
| Test place | Ise EMC Lab. No.6 Shielded Room |
| Date | October 12, 2020 |
| Temperature / Humidity | 21 deg. C / 60 % RH |
| Engineer | Tomohisa Nakagawa |
| Mode | Tx |

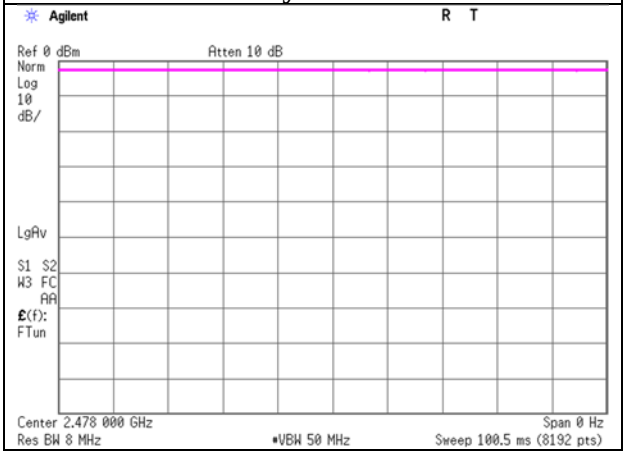
| | | Cable Loss | Atten. Loss | Result (Time average) | | Duty factor | Result (Burst power average) | |
|---|---|---|---|---|---|---|---|---|
| [MHz] | [dBm] | [dB] | [dB] | [dBm] | [mW] | [dB] | [dBm] | [mW] |
| 2478 | -2.45 | 1.65 | 10.01 | 9.21 | 8.34 | 0.00 | 9.21 | 8.34 |

Sample Calculation:
Result (Time average) = Reading + Cable Loss (including the cable(s) customer supplied) + Attenuator Loss
Result (Burst power average) = Time average + Duty factor

# Burst rate confirmation

| | |
|---|---|
| Report No. | 13525959H |
| Test place | Ise EMC Lab. No.6 Shielded Room |
| Date | October 12, 2020 |
| Temperature / Humidity | 21 deg. C / 60 % RH |
| Engineer | Tomohisa Nakagawa |
| Mode | Tx |

## Duty 100 %



# Radiated Spurious Emission

| | | |
|---|---|---|
| Report No. | 13525959H | |
| Test place | Ise EMC Lab. | |
| Semi Anechoic Chamber | No.2 | No.2 |
| Date | October 15, 2020 | October 18, 2020 |
| Temperature / Humidity | 21 deg. C / 55 % RH | 23 deg. C / 53 % RH |
| Engineer | Junya Okuno | Tomohisa Nakagawa |
| | (Above 1 GHz) | (Below 1 GHz) |
| Mode | Tx 2478 MHz | |

| Polarity | Frequency [MHz] | Detector | Reading [dBuV] | Ant.Fac. [dB/m] | Loss [dB] | Gain [dB] | Duty Factor [dB] | Result [dBuV/m] | Limit [dBuV/m] | Margin [dB] | Remark |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Hori. | 38.160 | QP | 22.0 | 15.5 | 6.8 | 28.6 | - | 15.7 | 40.0 | 24.3 | |
| Hori. | 60.558 | QP | 21.7 | 7.8 | 7.1 | 28.6 | - | 8.0 | 40.0 | 32.0 | |
| Hori. | 114.388 | QP | 26.5 | 12.2 | 7.6 | 28.5 | - | 17.8 | 43.5 | 25.7 | |
| Hori. | 171.313 | QP | 23.1 | 15.5 | 8.0 | 28.2 | - | 18.4 | 43.5 | 25.1 | |
| Hori. | 224.000 | QP | 29.6 | 11.2 | 8.4 | 27.9 | - | 21.2 | 46.0 | 24.8 | |
| Hori. | 281.800 | QP | 30.0 | 13.5 | 8.7 | 27.8 | - | 24.4 | 46.0 | 21.6 | |
| Hori. | 2390.000 | PK | 44.0 | 27.6 | 5.1 | 35.2 | - | 41.4 | 73.9 | 32.5 | |
| Hori. | 2483.500 | PK | 57.7 | 27.4 | 5.1 | 35.2 | - | 55.0 | 73.9 | 18.9 | |
| Hori. | 4956.000 | PK | 41.7 | 31.6 | 7.2 | 34.5 | - | 46.0 | 73.9 | 27.9 | Floor noise |
| Hori. | 7434.000 | PK | 39.0 | 36.0 | 8.7 | 34.4 | - | 49.2 | 73.9 | 24.7 | Floor noise |
| Hori. | 9912.000 | PK | 38.2 | 38.9 | 9.1 | 34.9 | - | 51.4 | 73.9 | 22.5 | Floor noise |
| Hori. | 15366.920 | PK | 55.5 | 37.3 | -0.3 | 33.7 | - | 58.8 | 73.9 | 15.1 | |
| Hori. | 15416.330 | PK | 57.2 | 37.4 | -0.3 | 33.7 | - | 60.5 | 73.9 | 13.4 | |
| Hori. | 2390.000 | AV | 35.8 | 27.6 | 5.1 | 35.2 | - | 33.2 | 53.9 | 20.7 | |
| Hori. | 2483.500 | AV | 47.7 | 27.4 | 5.1 | 35.2 | - | 45.0 | 53.9 | 8.9 | |
| Hori. | 4956.000 | AV | 34.3 | 31.6 | 7.2 | 34.5 | - | 38.6 | 53.9 | 15.3 | Floor noise |
| Hori. | 7434.000 | AV | 34.5 | 36.0 | 8.7 | 34.4 | - | 44.8 | 53.9 | 9.1 | Floor noise |
| Hori. | 9912.000 | AV | 32.4 | 38.9 | 9.1 | 34.9 | - | 45.6 | 53.9 | 8.3 | Floor noise |
| Hori. | 15366.920 | AV | 44.4 | 37.3 | -0.3 | 33.7 | - | 47.7 | 53.9 | 6.2 | |
| Hori. | 15416.330 | AV | 44.5 | 37.4 | -0.3 | 33.7 | - | 47.8 | 53.9 | 6.1 | |
| Vert. | 32.083 | QP | 28.0 | 17.7 | 6.8 | 28.6 | - | 23.8 | 40.0 | 16.2 | |
| Vert. | 37.905 | QP | 32.2 | 15.6 | 6.8 | 28.6 | - | 26.0 | 40.0 | 14.0 | |
| Vert. | 40.115 | QP | 32.1 | 14.8 | 6.9 | 28.6 | - | 25.1 | 40.0 | 14.9 | |
| Vert. | 64.000 | QP | 38.4 | 6.9 | 7.1 | 28.6 | - | 23.9 | 40.0 | 16.1 | |
| Vert. | 164.258 | QP | 28.0 | 15.3 | 8.0 | 28.3 | - | 23.0 | 43.5 | 20.6 | |
| Vert. | 183.595 | QP | 31.8 | 15.9 | 8.1 | 28.2 | - | 27.6 | 43.5 | 15.9 | |
| Vert. | 2390.000 | PK | 45.7 | 27.6 | 5.1 | 35.2 | - | 43.1 | 73.9 | 30.8 | |
| Vert. | 2483.500 | PK | 59.6 | 27.4 | 5.1 | 35.2 | - | 56.9 | 73.9 | 17.0 | |
| Vert. | 4956.000 | PK | 42.0 | 31.6 | 7.2 | 34.5 | - | 46.3 | 73.9 | 27.6 | Floor noise |
| Vert. | 7434.000 | PK | 42.4 | 36.0 | 8.7 | 34.4 | - | 52.7 | 73.9 | 21.2 | Floor noise |
| Vert. | 9912.000 | PK | 42.8 | 38.9 | 9.1 | 34.9 | - | 55.9 | 73.9 | 18.0 | Floor noise |
| Vert. | 15416.330 | PK | 54.4 | 37.4 | -0.3 | 33.7 | - | 57.7 | 73.9 | 16.2 | |
| Vert. | 2390.000 | AV | 36.6 | 27.6 | 5.1 | 35.2 | - | 34.0 | 53.9 | 19.9 | |
| Vert. | 2483.500 | AV | 50.4 | 27.4 | 5.1 | 35.2 | - | 47.8 | 53.9 | 6.2 | |
| Vert. | 4956.000 | AV | 33.9 | 31.6 | 7.2 | 34.5 | - | 38.2 | 53.9 | 15.7 | Floor noise |
| Vert. | 7434.000 | AV | 34.3 | 36.0 | 8.7 | 34.4 | - | 44.6 | 53.9 | 9.3 | Floor noise |
| Vert. | 9912.000 | AV | 32.7 | 38.9 | 9.1 | 34.9 | - | 45.9 | 53.9 | 8.0 | Floor noise |
| Vert. | 15416.330 | AV | 43.4 | 37.4 | -0.3 | 33.7 | - | 46.7 | 53.9 | 7.2 | |

Result = Reading + Ant Factor + Loss (Cable+Attenuator+Filter+Distance factor(above 1 GHz)) - Gain(Amplifier)

*Other frequency noises omitted in this report were not seen or had enough margin (more than 20 dB).

Distance factor: 1 GHz - 10 GHz 20log (3.65 m / 3.0 m) = 1.70 dB
10 GHz - 26.5 GHz 20log (1.0 m / 3.0 m) = -9.5 dB

**20dBc Data Sheet**

| Polarity | Frequency [MHz] | Detector | Reading [dBuV] | Ant Factor [dB/m] | Loss [dB] | Gain [dB] | Result [dBuV/m] | Limit [dBuV/m] | Margin [dB] | Remark |
|---|---|---|---|---|---|---|---|---|---|---|
| Hori | 2478.000 | PK | 98.4 | 27.4 | 5.1 | 35.2 | 95.7 | - | - | Carrier |
| Hori | 2400.000 | PK | 36.2 | 27.6 | 5.1 | 35.2 | 33.6 | 75.7 | 42.1 | |
| Vert | 2478.000 | PK | 98.5 | 27.4 | 5.1 | 35.2 | 95.8 | - | - | Carrier |
| Vert | 2400.000 | PK | 39.3 | 27.6 | 5.1 | 35.2 | 36.7 | 75.8 | 39.1 | |

Result = Reading + Ant Factor + Loss (Cable+Attenuator+Filter+Distance factor(above 1 GHz)) - Gain(Amprifier)

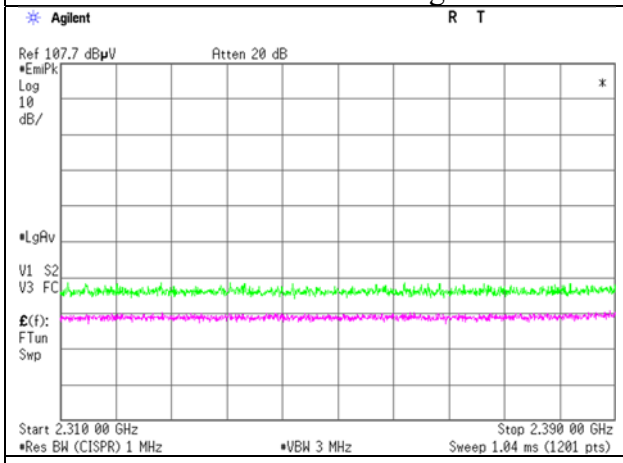
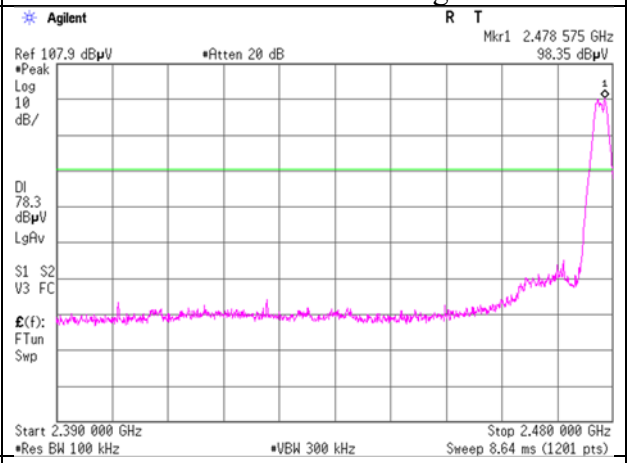
Distance factor: 1 GHz - 10 GHz 20log (3.65 m / 3.0 m) = 1.70 dB

**UL Japan, Inc.**
**Ise EMC Lab.**
4383-326 Asama-cho, Ise-shi, Mie-ken 516-0021 JAPAN
Telephone : +81 596 24 8999
Facsimile : +81 596 24 8124

# Radiated Spurious Emission
## (Reference Plot for band-edge)

| | |
|---|---|
| Report No. | 13525959H |
| Test place | Ise EMC Lab. |
| Semi Anechoic Chamber | No.2 |
| Date | October 15, 2020 |
| Temperature / Humidity | 21 deg. C / 55 % RH |
| Engineer | Junya Okuno |
| Mode | Tx 2478 MHz |

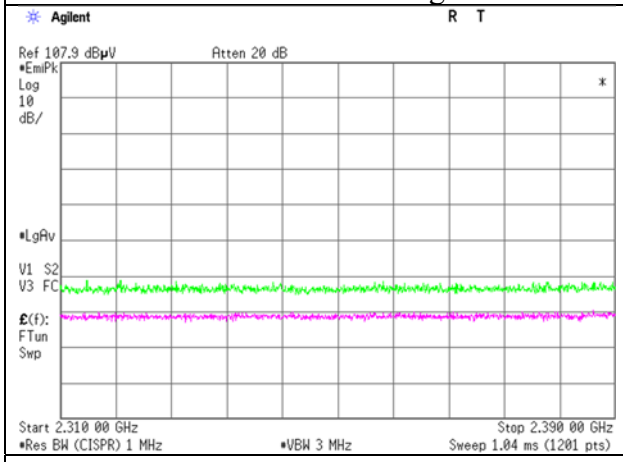
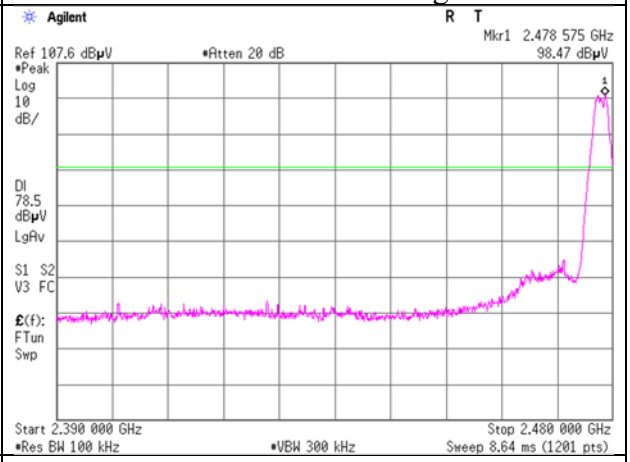
### Horizontal

| Restricted-band band-edge Plot | Authorized-band band-edge Plot |
|---|---|
|  |  |
| Trace Green : Peak Plot<br>Trace Purple : Average Plot | 20dBc Plot |





### Vertical

| Restricted-band band-edge Plot | Authorized-band band-edge Plot |
|---|---|
|  |  |
| Trace Green : Peak Plot<br>Trace Purple : Average Plot | 20dBc Plot |





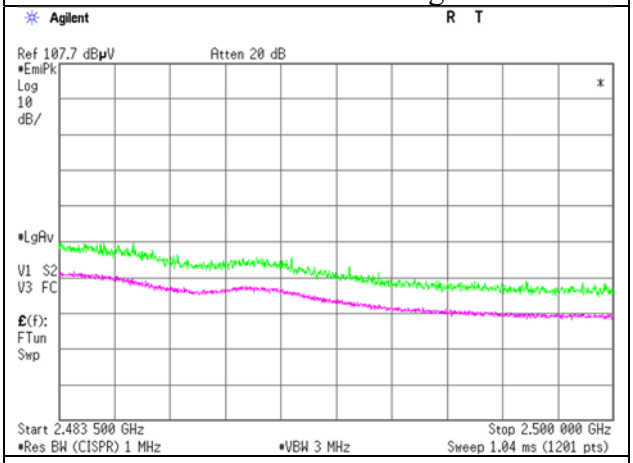
* The measurement was conducted for a sufficiently long enough time to detect any possible spurious emissions.
Final result of restricted band edge was shown in tabular data.

# Radiated Spurious Emission
## (Reference Plot for band-edge)

| | |
|---|---|
| Report No. | 13525959H |
| Test place | Ise EMC Lab. |
| Semi Anechoic Chamber | No.2 |
| Date | October 15, 2020 |
| Temperature / Humidity | 21 deg. C / 55 % RH |
| Engineer | Junya Okuno |
| Mode | Tx 2478 MHz |

Horizontal

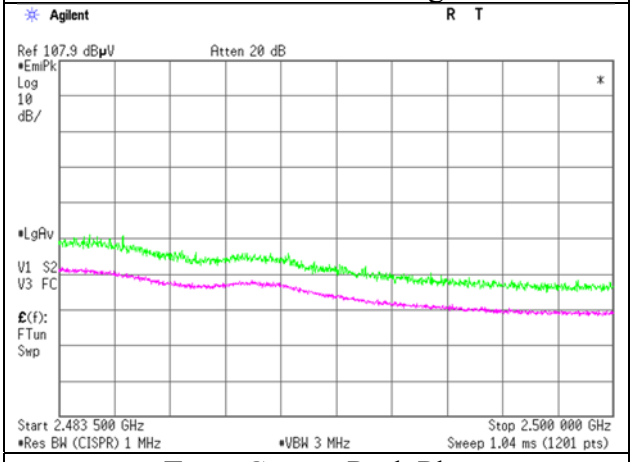
Restricted-band band-edge Plot




Trace Green : Peak Plot
Trace Purple : Average Plot

Vertical

Restricted-band band-edge Plot

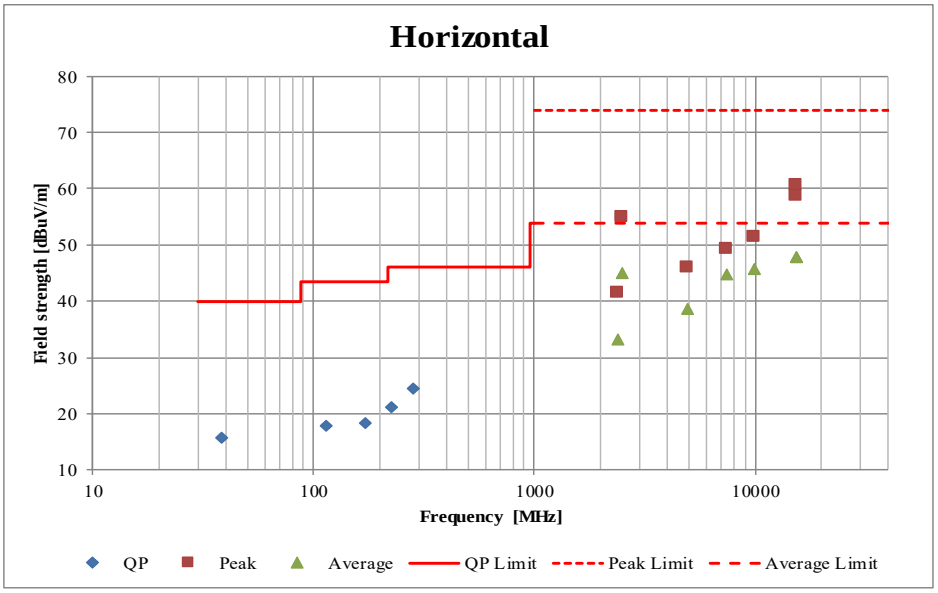


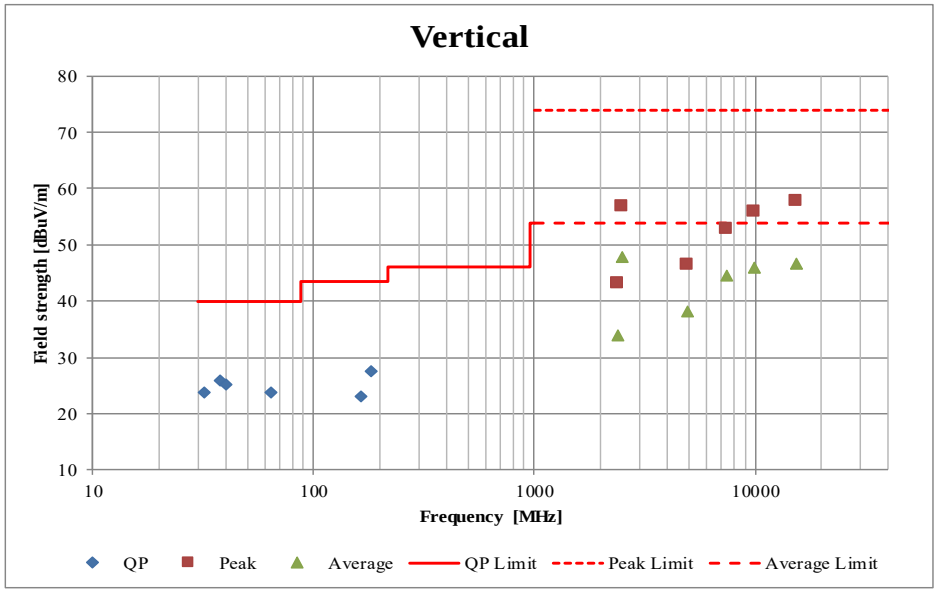

Trace Green : Peak Plot
Trace Purple : Average Plot

* The measurement was conducted for a sufficiently long enough time to detect any possible spurious emissions. Final result of restricted band edge was shown in tabular data.

# Radiated Spurious Emission
## (Plot data, Worst case)

| | | |
|---|---|---|
| Report No. | 13525959H | |
| Test place | Ise EMC Lab. | |
| Semi Anechoic Chamber | No.2 | No.2 |
| Date | October 15, 2020 | October 18, 2020 |
| Temperature / Humidity | 21 deg. C / 55 % RH | 23 deg. C / 53 % RH |
| Engineer | Junya Okuno (Above 1 GHz) | Tomohisa Nakagawa (Below 1 GHz) |
| Mode | Tx 2478 MHz | |



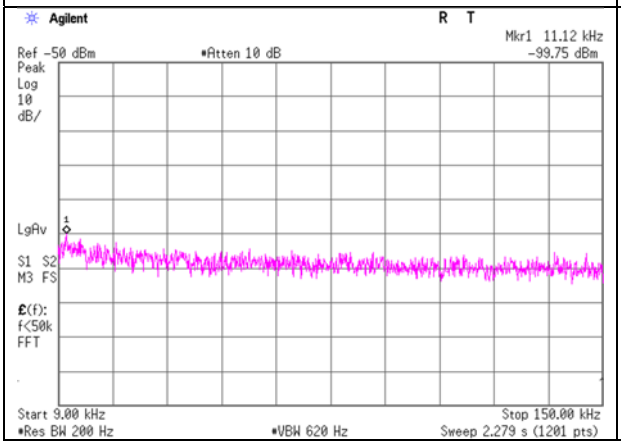




*These plots data contains sufficient number to show the trend of characteristic features for EUT.

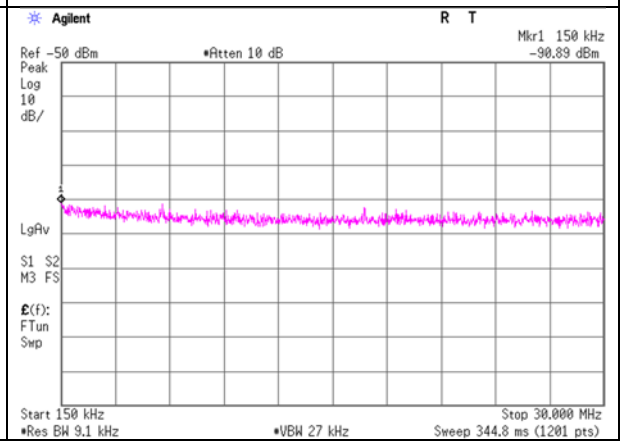
# Conducted Spurious Emission

| | |
|---|---|
| Report No. | 13525959H |
| Test place | Ise EMC Lab. No.6 Shielded Room |
| Date | October 12, 2020 |
| Temperature / Humidity | 21 deg. C / 60 % RH |
| Engineer | Tomohisa Nakagawa |
| Mode | Tx |

## 9 kHz - 150 kHz




## 150 kHz - 30 MHz




| Frequency [kHz] | Reading [dBm] | Cable Loss [dB] | Attenuator Loss [dB] | Antenna Gain* [dBi] | N (Number of Output) | EIRP [dBm] | Distance [m] | Ground bounce [dB] | E (field strength) [dBuV/m] | Limit [dBuV/m] | Margin [dB] | Remark |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 11.12 | -99.8 | 1.65 | 9.9 | 2.0 | 1 | -86.2 | 300 | 6.0 | -25.0 | 46.6 | 71.6 | |
| 150.00 | -90.9 | 1.65 | 9.9 | 2.0 | 1 | -77.4 | 300 | 6.0 | -16.1 | 24.0 | 40.1 | |

E [dBuV/m] = EIRP [dBm] - 20 log (Distance [m]) + Ground bounce [dB] + 104.8 [dBuV/m]

EIRP[dBm] = Reading [dBm] + Cable loss [dB] + Attenuator Loss [dB] + Antenna gain [dBi] + 10 * log (N)

N: Number of output

*2.0 dBi was applied to the test result based on ANSI C63.10 since antenna gain was less than 2.0 dBi.

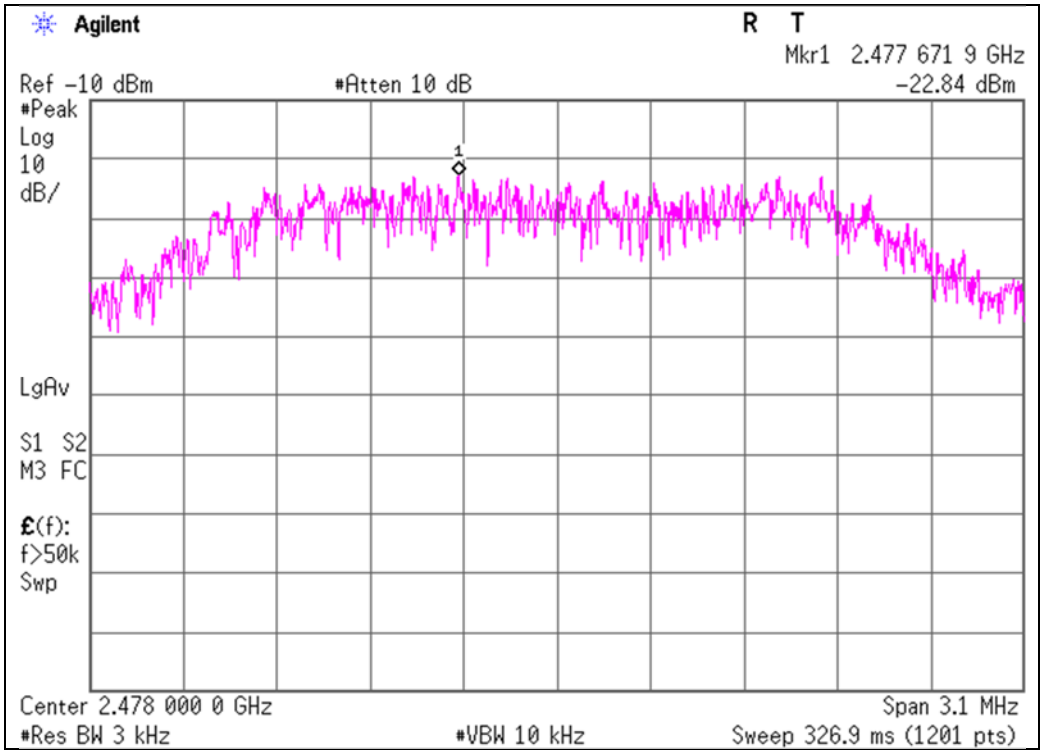
# Power Density

| | |
|---|---|
| Report No. | 13525959H |
| Test place | Ise EMC Lab. No.6 Shielded Room |
| Date | October 12, 2020 |
| Temperature / Humidity | 21 deg. C / 60 % RH |
| Engineer | Tomohisa Nakagawa |
| Mode | Tx |

| Freq. [MHz] | Reading [dBm] | Cable Loss [dB] | Atten. Loss [dB] | Result [dBm] | Limit [dBm] | Margin [dB] |
|---|---|---|---|---|---|---|
| 2478 | -22.84 | 1.65 | 10.01 | -11.18 | 8.00 | 19.18 |

Sample Calculation:

Result = Reading + Cable Loss (including the cable(s) customer supplied) + Attenuator Loss



# APPENDIX 2: Test instruments

**Test equipment**

| Test Item | Local ID | LIMS ID | Description | Manufacturer | Model | Serial | Last Calibration Date | Cal Int |
|---|---|---|---|---|---|---|---|---|
| AT | MOS-14 | 141561 | Thermo-Hygrometer | CUSTOM. Inc | CTH-201 | 1401 | 2020/01/07 | 12 |
| AT | MMM-12 | 141547 | DIGITAL HiTESTER | Hioki | 3805 | 60500120 | 2020/02/03 | 12 |
| AT | MSA-10 | 141899 | Spectrum Analyzer | Keysight Technologies Inc | E4448A | MY46180655 | 2020/08/04 | 12 |
| AT | MPM-12 | 141809 | Power Meter | ANRITSU | ML2495A | 825002 | 2020/05/07 | 12 |
| AT | MPSE-17 | 141830 | Power sensor | ANRITSU | MA2411B | 738285 | 2020/05/07 | 12 |
| AT | MAT-22 | 141269 | Attenuator(10dB) 1-18GHz | Orient Microwave | BX10-0476-00 | - | 2020/03/24 | 12 |
| RE | MAEC-02 | 142004 | AC2_Semi Anechoic Chamber(NSA) | TDK | Semi Anechoic Chamber 3m | DA-06902 | 2020/05/26 | 24 |
| RE | MOS-41 | 192300 | Thermo-Hygrometer | CUSTOM. Inc | CTH-201 | 0013 | 2019/12/19 | 12 |
| RE | MMM-01 | 141542 | Digital Tester | Fluke Corporation | FLUKE 26-3 | 78030611 | 2020/08/18 | 12 |
| RE | MJM-27 | 142228 | Measure | KOMELON | KMC-36 | - | - | - |
| RE | COTS-MEMI-02 | 178648 | EMI measurement program | TSJ (Techno Science Japan) | TEPTO-DV | - | - | - |
| RE | MHA-06 | 141512 | Horn Antenna 1-18GHz | Schwarzbeck Mess - Elektronik | BBHA9120D | 254 | 2020/09/14 | 12 |
| RE | MCC-217 | 141393 | Microwave Cable | Junkosha | MWX221 | 1604S254(1 m) / 1608S088(5 m) | 2020/08/03 | 12 |
| RE | MPA-10 | 141579 | Pre Amplifier | Keysight Technologies Inc | 8449B | 3008A02142 | 2020/01/07 | 12 |
| RE | MHF-25 | 141232 | High Pass Filter 3.5-18.0GHz | UL Japan | HPF SELECTOR | 001 | 2020/09/23 | 12 |
| RE | MSA-13 | 141900 | Spectrum Analyzer | Keysight Technologies Inc | E4440A | MY46185823 | 2020/09/24 | 12 |
| RE | MHA-02 | 141503 | Horn Antenna 18-26.5GHz | EMCO | 3160-09 | 1265 | 2020/06/15 | 12 |
| RE | MAEC-02-SVSWR | 142006 | AC2_Semi Anechoic Chamber(SVSWR) | TDK | Semi Anechoic Chamber 3m | DA-06902 | 2019/04/01 | 24 |
| RE | MAT-07 | 141203 | Attenuator(6dB) | Weinschel Corp | 2 | BK7970 | 2019/11/07 | 12 |
| RE | MBA-08 | 141427 | Biconical Antenna | Schwarzbeck Mess - Elektronik | VHA9103B+BBA9106 | 8031 | 2020/07/29 | 12 |
| RE | MCC-12 | 141317 | Coaxial Cable | UL Japan Inc. | - | - | 2020/09/25 | 12 |
| RE | MLA-21 | 141265 | Logperiodic Antenna(200-1000MHz) | Schwarzbeck Mess - Elektronik | VUSLP9111B | 9111B-190 | 2020/07/29 | 12 |
| RE | MPA-24 | 141594 | Pre Amplifier | Keysight Technologies Inc | 8447D | 2944A10150 | 2019/02/10 | 12 |
| RE | MTR-03 | 141942 | Test Receiver | Rohde & Schwarz | ESCI | 100300 | 2020/08/18 | 12 |
| RE | MAT-10 | 141156 | Attenuator(10dB) | Weinschel Corp | 2 | BL1173 | 2019/11/07 | 12 |

***Hyphens for Last Calibration Date and Cal Int (month) are instruments that Calibration is not required (e.g. software), or instruments checked in advance before use.**

**The expiration date of the calibration is the end of the expired month.**
**As for some calibrations performed after the tested dates, those test equipment have been controlled by means of an unbroken chains of calibrations.**

**All equipment is calibrated with valid calibrations. Each measurement data is traceable to the national or international standards.**

**Test item:** **RE: Radiated Spurious Emission test**
**AT: Antenna Terminal Conducted test**