TESTING LABORATORY
CERTIFICATE#4323.01

# FCC PART 15.247
# TEST REPORT

**For**

## Murata Manufacturing Co., Ltd.

10-1, Higashikotari 1-chome, Nagaokakyo-shi, Kyoto 617-8555, Japan

## FCC ID: VPYLBAA0QB1SJ

| **Report Type:** | **Product Type:** |
|---|---|
| Original Report | LoRa Module |

| | |
|---|---|
| **Project Engineer:** | Chao Gao |
| **Report Number:** | RKSA210416001-00A |
| **Report Date:** | 2021-05-28 |
| **Reviewed By:** | Oscar Ye<br>EMC Manager |
| **Prepared By:** | Bay Area Compliance Laboratories Corp. (Kunshan)<br>No.248 Chenghu Road,Kunshan,Jiangsu province,China<br>Tel: +86-0512-86175000<br>Fax: +86-0512-88934268<br>www.baclcorp.com.cn |

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# GENERAL INFORMATION

## Product Description for Equipment under Test (EUT)

| | |
|---|---|
| Applicant | Murata Manufacturing Co., Ltd. |
| Tested Model | 1SJ |
| Product Type | LoRa Module |
| Power Supply | DC 3.3V |
| Maximum Output Power | 21.77dBm |
| RF Function | LoRa (125kHz) |
| Operating Frequency | 902.3-914.9MHz |
| Channel Number | 64 |
| Channel Separation | 200kHz |
| Modulation Type | LoRa |
| Antenna Type | PCB antenna, FPC antenna with IPEX connector |
| Maximum Antenna Gain | PCB antenna/ FPC antenna: 1dBi |
| Firmware Version | Test FW V0.0.15 |

**All measurement and test data in this report was gathered from production sample serial number: RKSA210416001-1. (Assigned by the BACL. The EUT supplied by the applicant was received on 2021-04-16)*

## Objective

This test report is prepared on behalf of *Murata Manufacturing Co., Ltd.* in accordance with Part 2-Subpart J, Part 15-Subparts A and C of the Federal Communication Commissions rules.

The tests were performed in order to determine Compliance with FCC Part 15, Subpart C, section 15.203, 15.205, 15.207, 15.209 and 15.247 rules.

## Related Submittal(s)/Grant(s)

Part 15.247 DTS submissions with FCC ID: VPYLBAA0QB1SJ

## Test Methodology

All measurements contained in this report were conducted with ANSI C63.10-2013, American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices and 558074 D01 15.247 Meas Guidance v05r02.

All emissions measurement was performed and Bay Area Compliance Laboratories Corp. (Kunshan). The radiated testing was performed at an antenna-to-EUT distance of 3 meters.

## Measurement Uncertainty

| Item | | Uncertainty |
|---|---|---|
| AC Power Lines Conducted Emissions | | 3.19dB |
| RF conducted test with spectrum | | 0.9dB |
| RF Output Power with Power meter | | 0.5dB |
| Radiated emission | 30MHz~1GHz | 6.11dB |
| | 1GHz~6GHz | 4.45dB |
| | 6GHz~18GHz | 5.23dB |
| | 18GHz~40GHz | 5.65dB |
| Occupied Bandwidth | | 0.5kHz |
| Temperature | | 1.0℃ |
| Humidity | | 6% |

Otherwise required by the applicant or Product Regulations, Decision Rule in this report did not consider the uncertainty.

## Test Facility

The Test site used by Bay Area Compliance Laboratories Corp. (Kunshan) to collect test data is located on the No.248 Chenghu Road, Kunshan, Jiangsu province, China.

Bay Area Compliance Laboratories Corp. (Kunshan) Lab is accredited to ISO/IEC 17025 by A2LA (Lab code: 4323.01), the FCC designation No. CN1185 under the FCC KDB 974614 D01 and CAB identifier CN0004 under the ISED requirement. The facility also complies with the radiated and AC line conducted test site criteria set forth in ANSI C63.4-2014.

# SYSTEM TEST CONFIGURATION

## Description of Test Configuration

The frequencies is F(MHz)=902.3+0.2*n (0<=n<=63). The lowest, middle, highest channel numbers of the EUT used and tested in this report are below:

| Channel | Frequency (MHz) |
|---|---|
| 0 | 902.3 |
| 32 | 908.7 |
| 63 | 914.9 |

## EUT Exercise Software

RF test software: FSKLoRaCmd

Power level: 22.

Data rate: SF7.

## Support Equipment List and Details

| Manufacturer | Description | Model | Serial Number |
|---|---|---|---|
| Murata Manufacturing Co., Ltd. | Base plate 1 | JS-0909 Type1SJ EVB_PCB Antenna | / |
| Molex | FPC antenna | 2111400100 | / |
| ZHAOXIN | DC Power Supply | RXN-605D | DC002 |

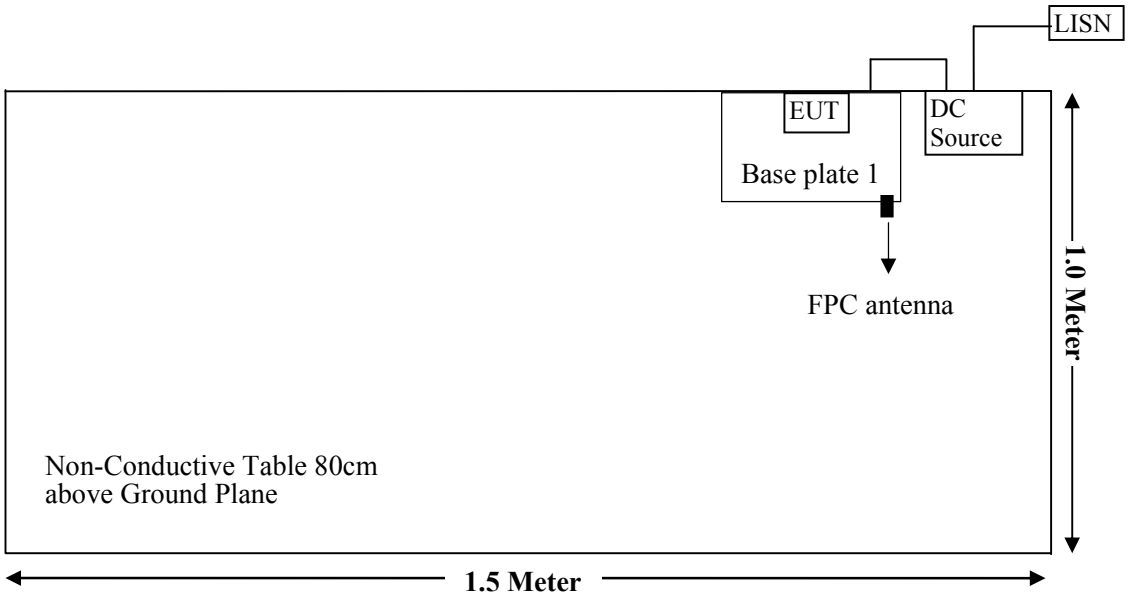
## External I/O Cable

| Cable Description | Length (m) | From Port | To Port |
|---|---|---|---|
| DC Cable | 1.0 | Base plate 1 | DC Source |

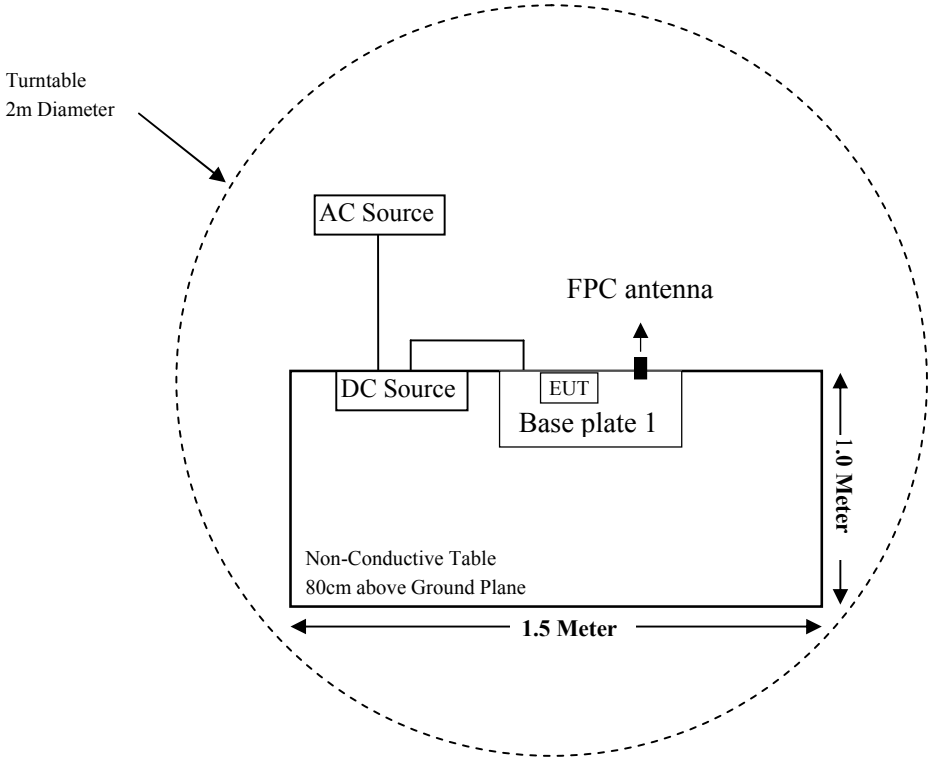
## Block Diagram of Test Setup

**For FPC antenna:**

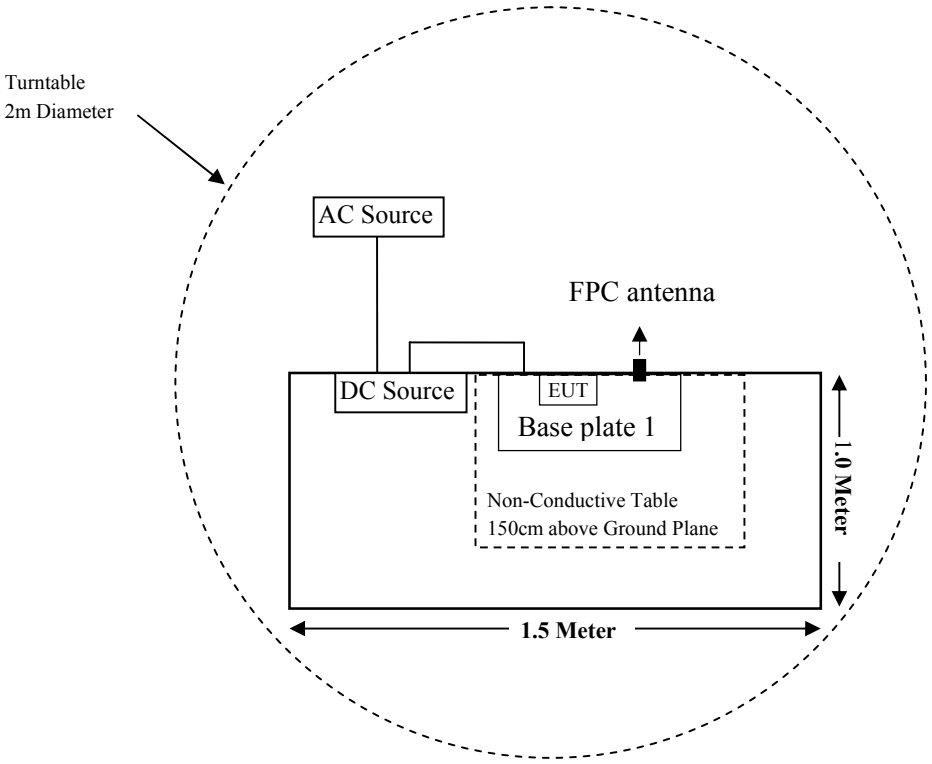
For Conducted Emissions:




For Radiated Emissions(Below 1GHz):

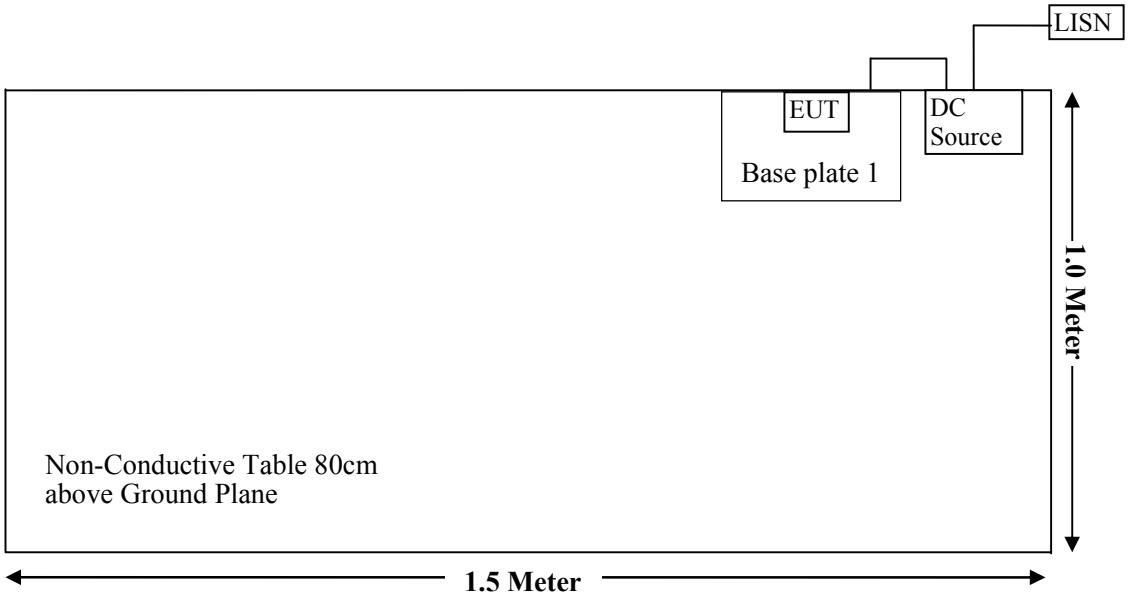


For Radiated Emissions(Above 1GHz):

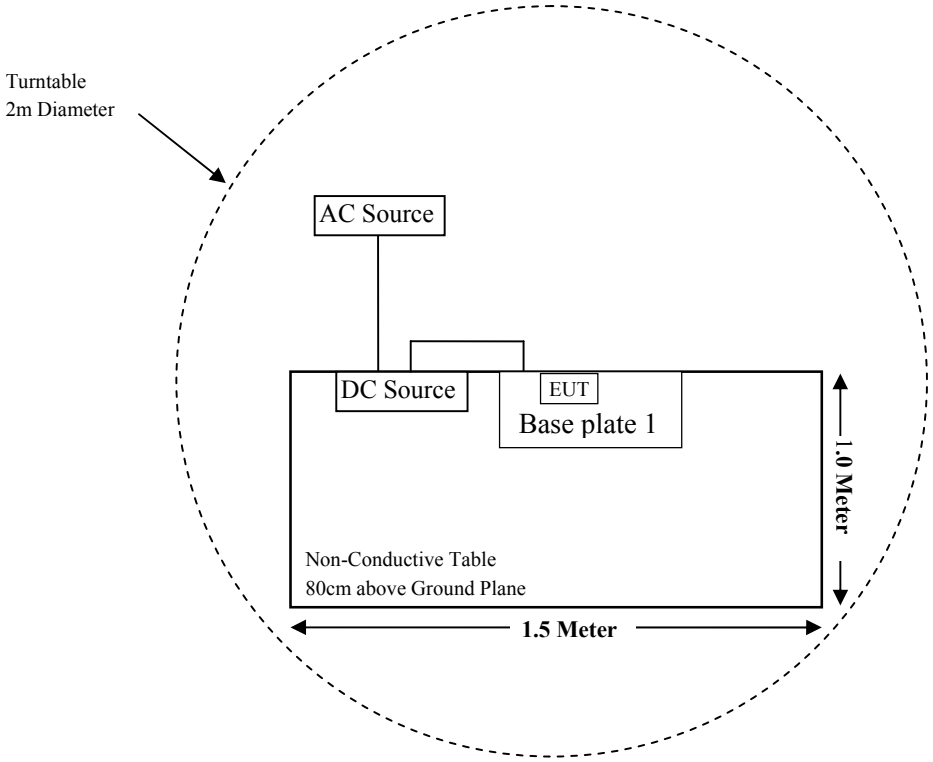



**For PCB antenna:**

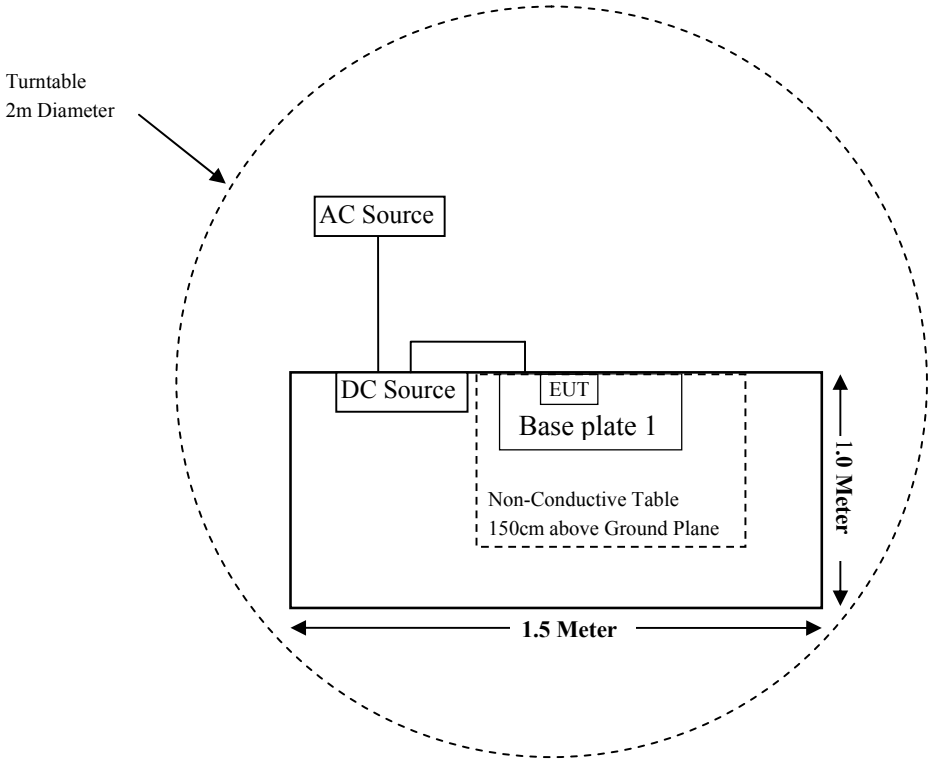
For Conducted Emissions:



For Radiated Emissions(Below 1GHz):




For Radiated Emissions(Above 1GHz):



# SUMMARY OF TEST RESULTS

| FCC Rules | Description of Test | Result |
|---|---|---|
| FCC §1.1310& §2.1091 | Maximum Permissible Exposure (MPE) | Compliant |
| §15.203 | Antenna Requirement | Compliant |
| §15.207(a) | AC Line Conducted Emissions | Compliant |
| §15.205, §15.209 & §15.247(d) | Radiated Emissions | Compliant |
| §15.247(a)(1) | Channel Separation Test | Compliant |
| §15.247(a)(1)(i) | 20 dB Emission Bandwidth | Compliant |
| §15.247(a)(1)(i) | Quantity of Hopping Channel Test | Compliant |
| §15.247(f) | Time of Occupancy (Dwell Time) of hybrid systems | Compliant (See Note) |
| §15.247(f) | Power Spectral Density of hybrid systems | Compliant (See Note) |
| §15.247(b)(3) | Maximum conducted(average) output power | Compliant |
| §15.247(d) | Band edges Testing | Compliant |

Note: The EUT use a hybrid systems in the band.

# TEST EQUIPMENT LIST

| Manufacturer | Description | Model | Serial Number | Calibration Date | Calibration Due Date |
|---|---|---|---|---|---|
| **Radiated Emission Test（Chamber 3#）** | | | | | |
| Rohde & Schwarz | EMI Test Receiver | ESCI | 100195 | 2020-12-14 | 2021-12-13 |
| Sunol Sciences | Hybrid Antenna | JB3 | A090314-1 | 2020-08-05 | 2023-08-04 |
| Sonoma Instrunent | Pre-amplifier | 310N | 185700 | 2020-08-14 | 2021-08-13 |
| Audix | Test Software | e3 | V9 | / | / |
| MICRO-TRONICS | Band Reject Filter | BRC50722 | G013 | 2020-08-05 | 2021-08-04 |
| MICRO-COAX | Coaxial Cable | Cable-8 | 008 | 2020-08-15 | 2021-08-14 |
| MICRO-COAX | Coaxial Cable | Cable-9 | 009 | 2020-08-15 | 2021-08-14 |
| MICRO-COAX | Coaxial Cable | Cable-10 | 010 | 2020-08-15 | 2021-08-14 |
| **Radiated Emission Test（Chamber 2#）** | | | | | |
| Rohde & Schwarz | EMI Test Receiver | ESU40 | 100207 | 2021-04-01 | 2022-03-31 |
| ETS-LINDGREN | Horn Antenna | 3115 | 9311-4159 | 2020-07-15 | 2023-07-14 |
| A.H.Systems, inc | Amplifier | 2641-1 | 491 | 2021-02-20 | 2022-02-19 |
| Narda | Attenuator | 10dB | 010 | 2020-08-15 | 2021-08-14 |
| Rohde & Schwarz | Auto test Software | EMC32 | 100361 | / | / |
| MICRO-TRONICS | Band Reject Filter | BRC50722 | G013 | 2020-08-05 | 2021-08-04 |
| MICRO-COAX | Coaxial Cable | Cable-6 | 006 | 2020-12-12 | 2021-12-11 |
| MICRO-COAX | Coaxial Cable | Cable-11 | 011 | 2020-08-15 | 2021-08-14 |
| MICRO-COAX | Coaxial Cable | Cable-12 | 012 | 2020-08-15 | 2021-08-14 |
| MICRO-COAX | Coaxial Cable | Cable-13 | 013 | 2020-08-15 | 2021-08-14 |
| **RF Conducted Test** | | | | | |
| Agilent | Power Meter | N1912A | MY5000492 | 2020-11-18 | 2021-11-17 |
| Agilent | Power Sensor | N1921A | MY54210024 | 2020-11-18 | 2021-11-17 |
| Rohde & Schwarz | Signal Analyzer | FSV40 | 101116 | 2020-07-28 | 2021-07-27 |
| Narda | Attenuator | 10dB | 010 | 2020-08-15 | 2021-08-14 |
| Murata | RF Cable | Murata C01 | C01 | Each Time | / |
| **Conducted Emission Test** | | | | | |
| Rohde & Schwarz | EMI Test Receiver | ESR | 1316.3003K03-101746-zn | 2020-08-05 | 2021-08-04 |
| Audix | Test Software | e3 | V9 | / | / |
| Rohde & Schwarz | LISN | ENV216 | 101115 | 2020-12-14 | 2021-12-13 |
| Rohde & Schwarz | Pulse limiter | ESH3-Z5 | 862770/011 | 2020-11-30 | 2021-11-29 |
| MICRO-COAX | Coaxial Cable | Cable-15 | 015 | 2020-08-15 | 2021-08-14 |

*** Statement of Traceability:** Bay Area Compliance Laboratories Corp. (Kunshan) attests that all calibrations have been performed in accordance to requirements that traceable to National Primary Standards and International System of Units (SI).

# FCC §1.1310& §2.1091 - MAXIMUM PERMISSIBLE EXPOSURE (MPE)

## Applicable Standard

According to subpart 15.247(i) and subpart §1.1310, systems operating under the provisions of this section shall be operated in a manner that ensures that the public is not exposed to radio frequency energy level in excess of the Commission's guidelines.

Limits for Maximum Permissible Exposure (MPE) (§1.1310, §2.1091)

| (B) Limits for General Population/Uncontrolled Exposure | | | | |
|---|---|---|---|---|
| **Frequency Range (MHz)** | **Electric Field Strength (V/m)** | **Magnetic Field Strength (A/m)** | **Power Density ($mW/cm^2$)** | **Averaging Time (minutes)** |
| 0.3-1.34 | 614 | 1.63 | *(100) | 30 |
| 1.34-30 | 824/f | 2.19/f | *(180/$f^2$) | 30 |
| 30-300 | 27.5 | 0.073 | 0.2 | 30 |
| 300-1500 | / | | f/1500 | 30 |
| 1500-100,000 | / | | 1.0 | 30 |

f = frequency in MHz; * = Plane-wave equivalent power density;

According to §1.1310 and §2.1091 RF exposure is calculated.

## Calculated Formulary:

Predication of MPE limit at a given distance
$S = PG/4\pi R^2$ = power density (in appropriate units, e.g. $mW/cm^2$);
P = power input to the antenna (in appropriate units, e.g., mW);
G = power gain of the antenna in the direction of interest relative to an isotropic radiator, the power gain factor, is normally numeric gain;
R = distance to the center of radiation of the antenna (appropriate units, e.g., cm);

## Calculated Data:

**For worst case:**

| Mode | Frequency Range (MHz) | Antenna Gain | | Tune-up Conducted average Power | | Evaluation Distance (cm) | Power Density ($mW/cm^2$) | MPE Limit ($mW/cm^2$) |
|---|---|---|---|---|---|---|---|---|
| | | (dBi) | (numeric) | (dBm) | (mW) | | | |
| LoRa (125kHz) | 902.3-914.9 | 1 | 1.26 | 22.00 | 158.49 | 20 | 0.0397 | 0.60 |
| LoRa (500kHz) | 903-914.2 | 1 | 1.26 | 22.00 | 158.49 | 20 | 0.0397 | 0.60 |

**Conclusion:** The EUT meets requirement - RF exposure evaluation greater than 20cm distance specified in § 2.1091. If the device built into a host as a portable usage, the additional RF exposure evaluation may be required as specified by§ 2.1093.

# FCC §15.203 – ANTENNA REQUIREMENT

## Applicable Standard

According to FCC § 15.203, an intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses 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 a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited.

## Antenna Connector Construction

The EUT has been tested with two antennas for Lora, one FPC antenna with IPEX connector which the antenna gain is 1dBi and one PCB antenna which the antenna gain is 1dBi, fulfill the requirement of this section. Please refer to the EUT photos.

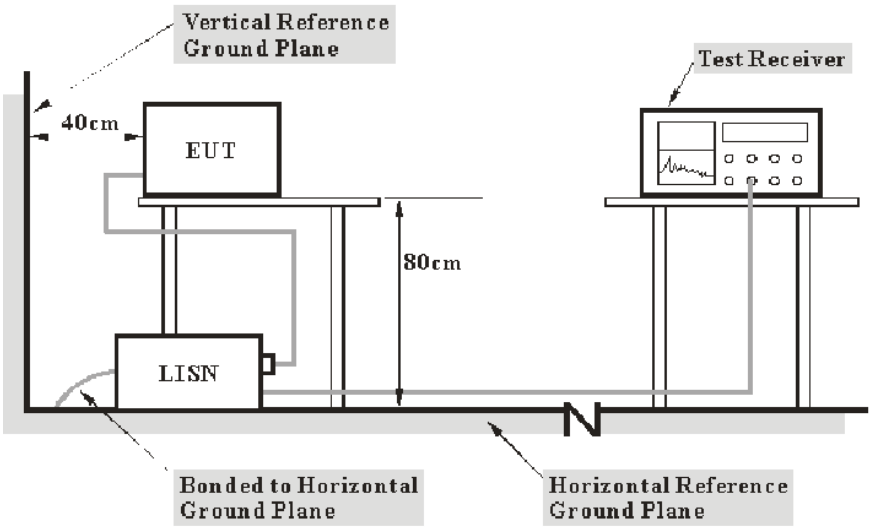
**Result:** Compliant.

# FCC §15.207 (a) – AC LINE CONDUCTED EMISSIONS

## Applicable Standard

FCC §15.207(a)

## EUT Setup




Note: 1. Support units were connected to second LISN.
2. Both of LISNs (AMN) 80 cm from EUT and at the least 80 cm from other units and other metal planes support units.

The measurement procedure of EUT setup is according with ANSI C63.10-2013. The related limit was specified in FCC Part 15.207.

## EMI Test Receiver Setup

The EMI test receiver was set to investigate the spectrum from 150 kHz to 30 MHz.

During the conducted emission test, the EMI test receiver was set with the following configurations:

| Frequency Range | IF B/W |
|---|---|
| 150 kHz – 30 MHz | 9 kHz |

## Test Procedure

During the conducted emission test, the DC Source was connected to the outlet of the LISN.

Maximizing procedure was performed on the six (6) highest emissions of the EUT.

All final data was recorded in the Quasi-peak and average detection mode.

## Corrected Factor & Over Limit Calculation

The Corrected factor is calculated by adding LISN VDF (Voltage Division Factor), Cable Loss and Transient Limiter Attenuation. The basic equation is as follows:

Factor (dB) = LISN VDF (dB) + Cable Loss (dB) + Transient Limiter Attenuation (dB)

The "**Over Limit**" column of the following data tables indicates the degree of compliance with the applicable limit. For example, an over limit of 7dB means the emission is 7 dB above the limit. The equation for over limit calculation is as follows:

Over Limit (dB) = Read level (dBμV) + Factor (dB) - Limit (dBμV)

## Test Results Summary

According to the recorded data in following table, the EUT complied with the FCC Part 15.207.

## Test Data

### Environmental Conditions

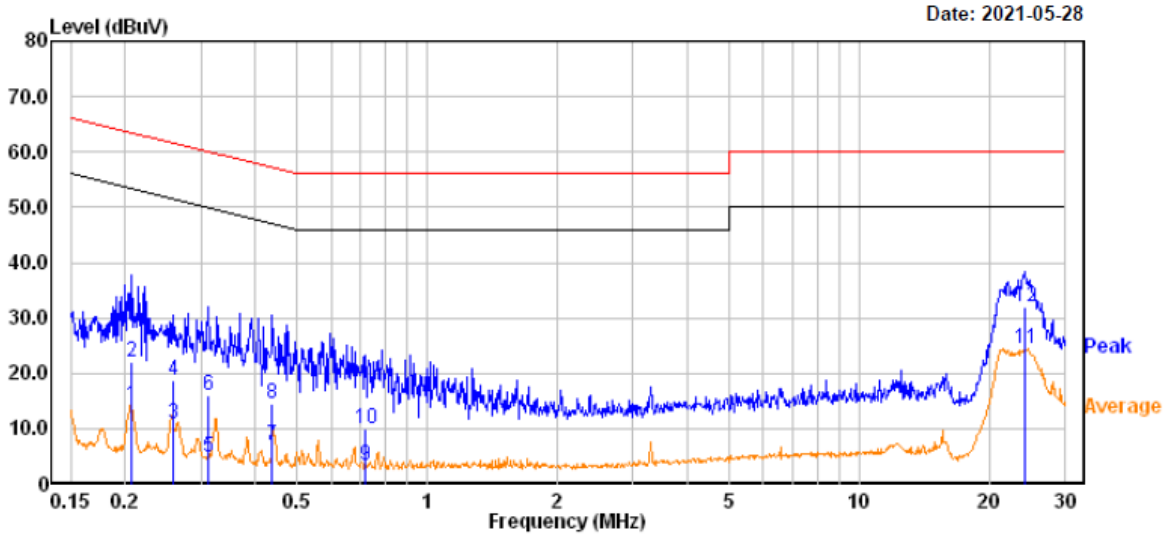
| | |
|---|---|
| **Temperature:** | 22 ℃ |
| **Relative Humidity:** | 50 % |
| **ATM Pressure:** | 101.3 kPa |

*The testing was performed by Chao Gao on 2021-05-28.*

*EUT operation mode: Transmitting in low channel (worst case)*

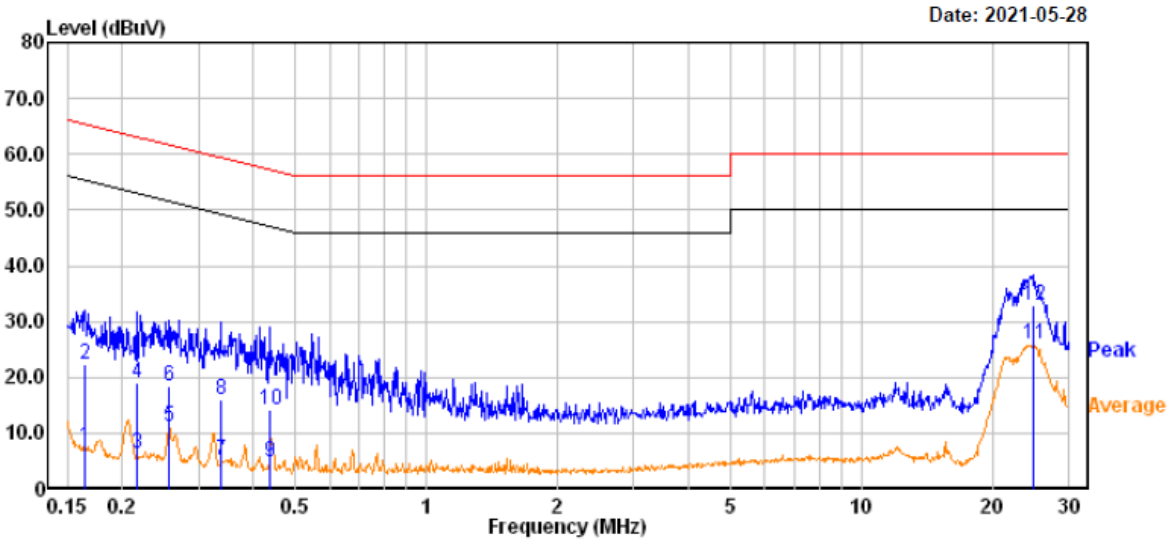
**For FPC antenna**

**AC 120V/60 Hz, Line**




| | Freq | Read Level | Factor | Level | Limit Line | Over Limit | Remark |
|---|---|---|---|---|---|---|---|
| | MHz | dBuV | dB | dBuV | dBuV | dB | |
| 1 | 0.207 | -5.70 | 19.82 | 14.12 | 53.31 | -39.19 | Average |
| 2 | 0.207 | 2.30 | 19.82 | 22.12 | 63.31 | -41.19 | QP |
| 3 | 0.260 | -9.10 | 19.82 | 10.72 | 51.45 | -40.73 | Average |
| 4 | 0.260 | -1.00 | 19.82 | 18.82 | 61.45 | -42.63 | QP |
| 5 | 0.312 | -15.00 | 19.82 | 4.82 | 49.91 | -45.09 | Average |
| 6 | 0.312 | -3.70 | 19.82 | 16.12 | 59.91 | -43.79 | QP |
| 7 | 0.438 | -12.90 | 19.75 | 6.85 | 47.10 | -40.25 | Average |
| 8 | 0.438 | -5.40 | 19.75 | 14.35 | 57.10 | -42.75 | QP |
| 9 | 0.717 | -16.40 | 19.74 | 3.34 | 46.00 | -42.66 | Average |
| 10 | 0.717 | -9.90 | 19.74 | 9.84 | 56.00 | -46.16 | QP |
| 11 | 24.213 | 4.70 | 19.73 | 24.43 | 50.00 | -25.57 | Average |
| 12 | 24.213 | 12.20 | 19.73 | 31.93 | 60.00 | -28.07 | QP |

**AC 120V/60 Hz, Neutral**



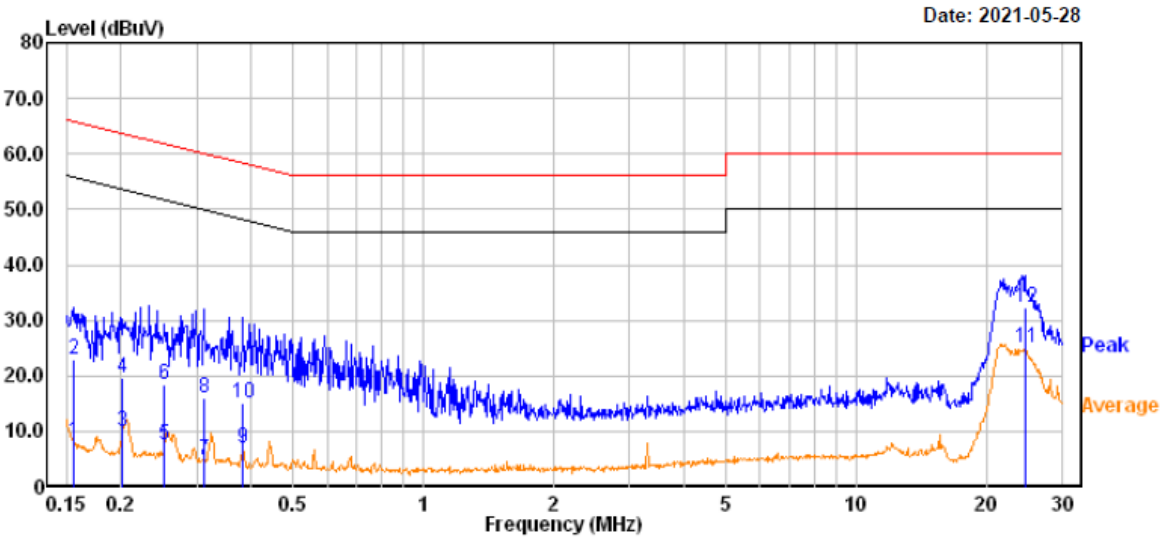

| | Freq | Read Level | Factor | Level | Limit Line | Over Limit | Remark |
|---|---|---|---|---|---|---|---|
| | MHz | dBuV | dB | dBuV | dBuV | dB | |
| 1 | 0.164 | -12.40 | 19.83 | 7.43 | 55.25 | -47.82 | Average |
| 2 | 0.164 | 2.50 | 19.83 | 22.33 | 65.25 | -42.92 | QP |
| 3 | 0.216 | -13.60 | 19.82 | 6.22 | 52.98 | -46.76 | Average |
| 4 | 0.216 | -0.70 | 19.82 | 19.12 | 62.98 | -43.86 | QP |
| 5 | 0.256 | -8.80 | 19.82 | 11.02 | 51.57 | -40.55 | Average |
| 6 | 0.256 | -1.30 | 19.82 | 18.52 | 61.57 | -43.05 | QP |
| 7 | 0.336 | -14.81 | 19.82 | 5.01 | 49.29 | -44.28 | Average |
| 8 | 0.336 | -3.91 | 19.82 | 15.91 | 59.29 | -43.38 | QP |
| 9 | 0.436 | -14.90 | 19.75 | 4.85 | 47.14 | -42.29 | Average |
| 10 | 0.436 | -5.60 | 19.75 | 14.15 | 57.14 | -42.99 | QP |
| 11 | 24.824 | 6.40 | 19.70 | 26.10 | 50.00 | -23.90 | Average |
| 12 | 24.824 | 13.20 | 19.70 | 32.90 | 60.00 | -27.10 | QP |

**Note:**

1) Factor (dB) = LISN VDF (dB) + Cable Loss (dB) + Transient Limiter Attenuation (dB)
2) Over Limit (dB) = Read level (dBµV) + Factor (dB) - Limit (dBµV)

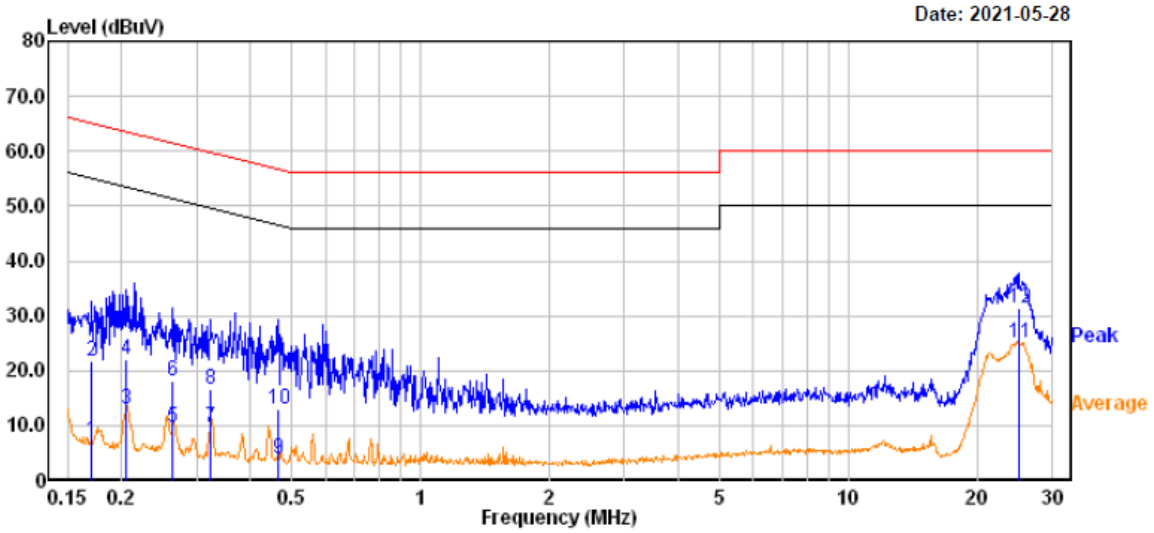
**For PCB antenna**

**AC 120V/60 Hz, Line**




| | Freq | Read Level | Factor | Level | Limit Line | Over Limit | Remark |
|---|---|---|---|---|---|---|---|
| | MHz | dBuV | dB | dBuV | dBuV | dB | |
| 1 | 0.156 | -11.60 | 19.82 | 8.22 | 55.67 | -47.45 | Average |
| 2 | 0.156 | 3.10 | 19.82 | 22.92 | 65.67 | -42.75 | QP |
| 3 | 0.202 | -10.00 | 19.82 | 9.82 | 53.52 | -43.70 | Average |
| 4 | 0.202 | -0.10 | 19.82 | 19.72 | 63.52 | -43.80 | QP |
| 5 | 0.252 | -12.40 | 19.82 | 7.42 | 51.69 | -44.27 | Average |
| 6 | 0.252 | -1.50 | 19.82 | 18.32 | 61.69 | -43.37 | QP |
| 7 | 0.311 | -15.01 | 19.83 | 4.82 | 49.96 | -45.14 | Average |
| 8 | 0.311 | -3.81 | 19.83 | 16.02 | 59.96 | -43.94 | QP |
| 9 | 0.383 | -12.80 | 19.76 | 6.96 | 48.22 | -41.26 | Average |
| 10 | 0.383 | -4.70 | 19.76 | 15.06 | 58.22 | -43.16 | QP |
| 11 | 24.577 | 5.20 | 19.71 | 24.91 | 50.00 | -25.09 | Average |
| 12 | 24.577 | 12.50 | 19.71 | 32.21 | 60.00 | -27.79 | QP |

**AC 120V/60 Hz, Neutral**




| | Freq | Read Level | Factor | Level | Limit Line | Over Limit | Remark |
|---|---|---|---|---|---|---|---|
| | MHz | dBuV | dB | dBuV | dBuV | dB | |
| 1 | 0.171 | -12.50 | 19.83 | 7.33 | 54.92 | -47.59 | Average |
| 2 | 0.171 | 1.80 | 19.83 | 21.63 | 64.92 | -43.29 | QP |
| 3 | 0.204 | -6.90 | 19.82 | 12.92 | 53.43 | -40.51 | Average |
| 4 | 0.204 | 2.10 | 19.82 | 21.92 | 63.43 | -41.51 | QP |
| 5 | 0.263 | -10.10 | 19.82 | 9.72 | 51.32 | -41.60 | Average |
| 6 | 0.263 | -1.70 | 19.82 | 18.12 | 61.32 | -43.20 | QP |
| 7 | 0.322 | -10.30 | 19.82 | 9.52 | 49.67 | -40.15 | Average |
| 8 | 0.322 | -3.30 | 19.82 | 16.52 | 59.67 | -43.15 | QP |
| 9 | 0.465 | -15.70 | 19.75 | 4.05 | 46.60 | -42.55 | Average |
| 10 | 0.465 | -6.70 | 19.75 | 13.05 | 56.60 | -43.55 | QP |
| 11 | 25.072 | 5.40 | 19.69 | 25.09 | 50.00 | -24.91 | Average |
| 12 | 25.072 | 11.70 | 19.69 | 31.39 | 60.00 | -28.61 | QP |

**Note:**

1) Factor (dB) = LISN VDF (dB) + Cable Loss (dB) + Transient Limiter Attenuation (dB)
2) Over Limit (dB) = Read level (dBµV) + Factor (dB) - Limit (dBµV)

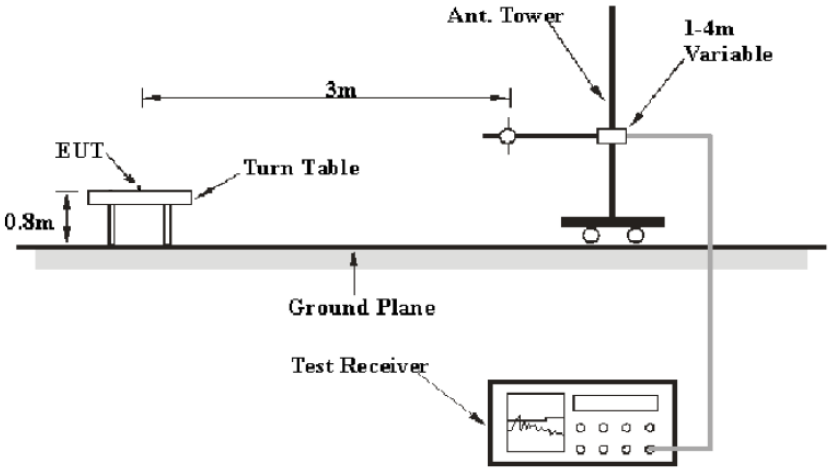
# FCC §15.205, §15.209 & §15.247(d) – RADIATED EMISSIONS

## Applicable Standard

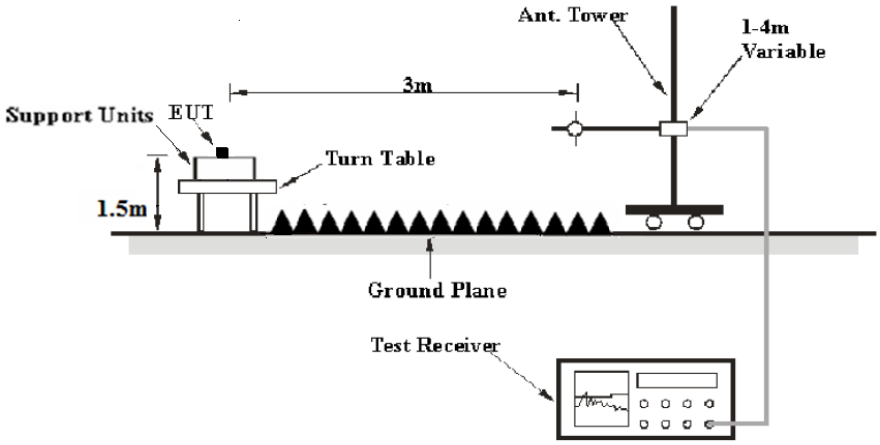
FCC §15.205; §15.209; §15.247(d)

## EUT Setup

**Below 1 GHz:**




**Above 1GHz:**




The radiated emission tests were performed in the 3 meters, using the setup accordance with the ANSI C63.10-2013. The specification used was the FCC 15.209 and FCC 15.247 limits.

## EMI Test Receiver Setup

The system was investigated from 30 MHz to 10 GHz.

During the radiated emission test, the EMI test receiver Setup was set with the following configurations:

| Frequency Range | RBW | Video B/W | IF B/W | Detector |
|---|---|---|---|---|
| 30 MHz – 1000 MHz | 120 kHz | 300 kHz | 120 kHz | QP |
| Above 1GHz | 1MHz | 3 MHz | / | PK |
| | 1MHz | 3 MHz | 1MHz | AVG. |

## Test Procedure

Maximizing procedure was performed on the highest emissions to ensure that the EUT complied with all installation combinations.

All final data was recorded in Quasi-peak detection mode for frequency range of 30 MHz -1 GHz and peak and Average detection modes for frequencies above 1 GHz.

## Corrected Amplitude & Margin Calculation

The Corrected Amplitude is calculated by adding the Antenna Factor and Cable Loss, and subtracting the Amplifier Gain from the Meter Reading. The basic equation is as follows:

Corrected Amplitude (dBμV/m) = Meter Reading (dBμV) + Antenna Factor (dB/m) + Cable Loss (dB) - Amplifier Gain (dB)

The "**Margin**" column of the following data tables indicates the degree of compliance with the applicable limit. For example, a margin of 7dB means the emission is 7dB below the limit. The equation for margin calculation is as follows:

Margin (dB) = Limit (dBμV/m) - Corrected Amplitude (dBμV/m)

## Test Results Summary

According to the recorded data in following table, the EUT complied with the FCC Title 47, Part 15, Subpart C, section 15.205, 15.209 and 15.247.

## Test Data

### Environmental Conditions

| | |
|---|---|
| **Temperature:** | 21.8~23.2 ℃ |
| **Relative Humidity:** | 48~50 % |
| **ATM Pressure:** | 101.2~101.3 kPa |

*The testing was performed by Chao Gao from 2021-04-25 to 2021-04-30.*

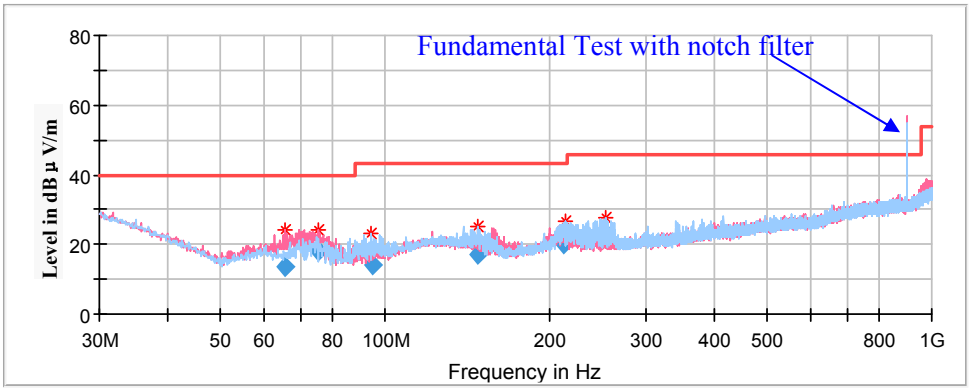
*EUT operation mode: Transmitting*

### For FPC antenna:

## Spurious Emission Test:

### 30MHz-1GHz

*Pre-scan with low, middle, high channel of operation in the X,Y and Z axes of orientation, the worst case **low channel in X-axis of orientation** was recorded*



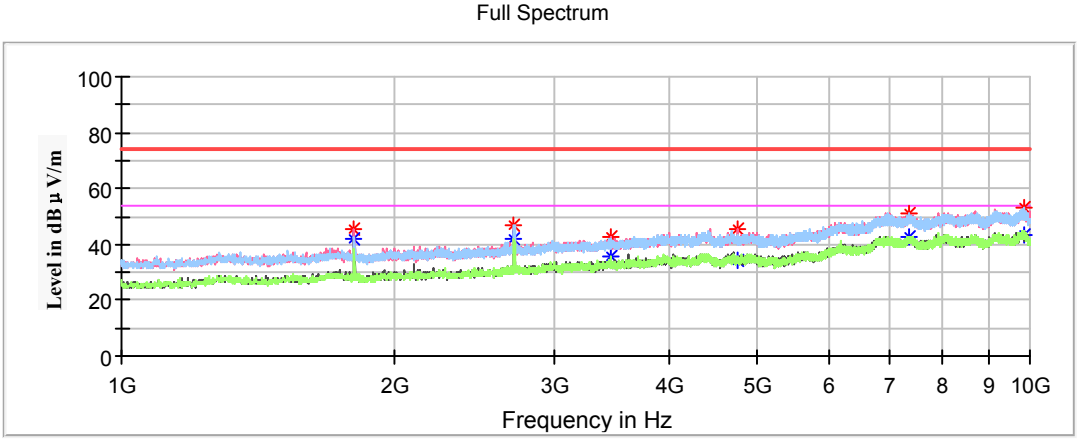

| Frequency (MHz) | Corrected Amplitude | Rx Antenna | | Turntable Degree | Corrected Factor (dB/m) | Limit (dBµV/m) | Margin (dB) |
|---|---|---|---|---|---|---|---|
| | QuasiPeak (dBµV/m) | Height (cm) | Polar (H/V) | | | | |
| 65.552400 | 13.69 | 100.0 | V | 0.0 | -15.8 | 40.00 | 26.31 |
| 75.606200 | 18.35 | 100.0 | V | 262.0 | -17.0 | 40.00 | 21.65 |
| 94.843100 | 14.27 | 199.0 | H | 223.0 | -15.8 | 43.50 | 29.23 |
| 147.919800 | 17.34 | 199.0 | H | 235.0 | -12.7 | 43.50 | 26.16 |
| 212.367650 | 20.00 | 100.0 | H | 260.0 | -12.0 | 43.50 | 23.50 |
| 254.238950 | 23.21 | 100.0 | H | 248.0 | -11.8 | 46.00 | 22.79 |

**1GHz-10GHz**

*Pre-scan in the X,Y and Z axes of orientation, the worst case **X-axis of orientation** was recorded.*

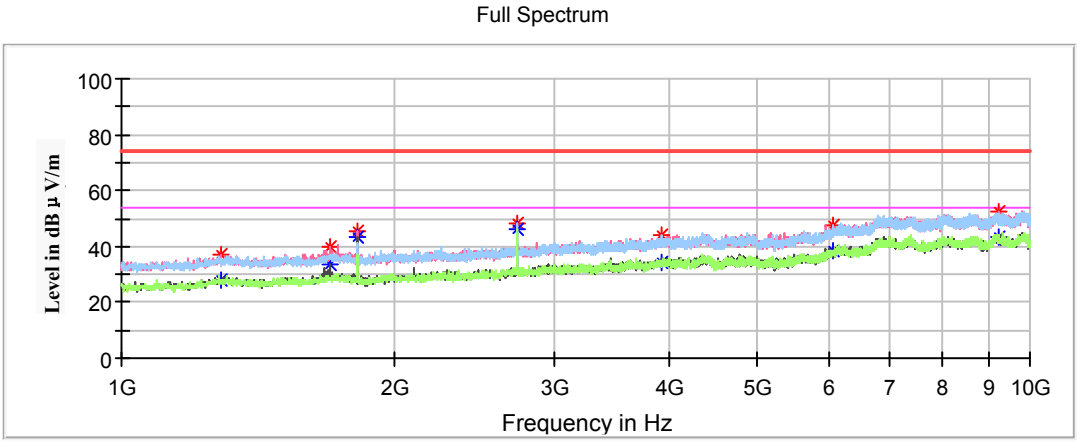
Note:
1. The test was performed with a 10dB Attenuator.
2. Corrected Factor (dB/m) = Antenna factor (RX) (dB/m) + Cable Loss (dB) – Amplifier Factor (dB) + Attenuator(dB)
   Corrected Amplitude (dBμV/m) = Corrected Factor (dB/m) + Reading (dBμV)
   Margin (dB) = Limit (dBμV/m) – Corrected Amplitude (dBμV/m)

**Low Channel: 902.3MHz**



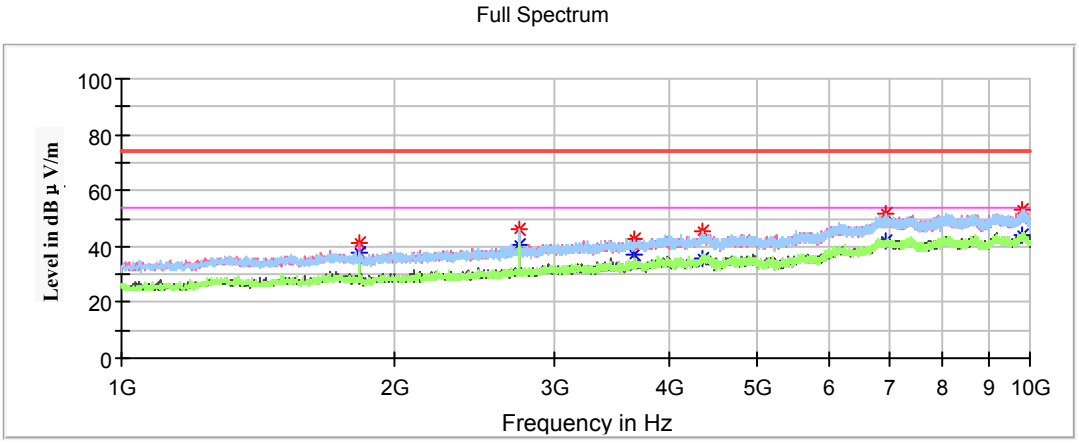

| Frequency (MHz) | Corrected Amplitude | | Rx Antenna | | Turntable Degree | Corrected Factor (dB/m) | Limit (dBμV/m) | Margin (dB) |
|---|---|---|---|---|---|---|---|---|
| | MaxPeak (dBμV/m) | Average (dBμV/m) | Height (cm) | Polar (H/V) | | | | |
| 1804.600000 | --- | 41.80 | 200.0 | V | 41.0 | -8.3 | 54.00 | 12.20 |
| 1804.600000 | 45.53 | --- | 200.0 | V | 41.0 | -8.3 | 74.00 | 28.47 |
| 2706.400000 | --- | 42.17 | 150.0 | H | 353.0 | -4.7 | 54.00 | 11.83 |
| 2706.400000 | 47.07 | --- | 150.0 | H | 353.0 | -4.7 | 74.00 | 26.93 |
| 3456.100000 | --- | 35.68 | 150.0 | H | 262.0 | -1.9 | 54.00 | 18.32 |
| 3456.100000 | 42.88 | --- | 150.0 | H | 262.0 | -1.9 | 74.00 | 31.12 |
| 4756.600000 | --- | 34.37 | 150.0 | V | 323.0 | 1.0 | 54.00 | 19.63 |
| 4756.600000 | 45.53 | --- | 150.0 | V | 323.0 | 1.0 | 74.00 | 28.47 |
| 7365.700000 | --- | 42.39 | 150.0 | V | 115.0 | 9.1 | 54.00 | 11.61 |
| 7365.700000 | 51.14 | --- | 150.0 | V | 115.0 | 9.1 | 74.00 | 22.86 |
| 9833.500000 | --- | 43.55 | 150.0 | H | 29.0 | 11.9 | 54.00 | 10.45 |
| 9833.500000 | 52.96 | --- | 150.0 | H | 29.0 | 11.9 | 74.00 | 21.04 |

**Middle Channel: 908.7MHz**




| Frequency (MHz) | Corrected Amplitude | | Rx Antenna | | Turntable Degree | Corrected Factor (dB/m) | Limit (dBµV/m) | Margin (dB) |
|---|---|---|---|---|---|---|---|---|
| | MaxPeak (dBµV/m) | Average (dBµV/m) | Height (cm) | Polar (H/V) | | | | |
| 1288.000000 | --- | 28.05 | 150.0 | V | 2.0 | -10.7 | 54.00 | 25.95 |
| 1288.000000 | 36.83 | --- | 150.0 | V | 2.0 | -10.7 | 74.00 | 37.17 |
| 1695.700000 | 39.85 | --- | 150.0 | V | 270.0 | -8.7 | 74.00 | 34.15 |
| 1695.700000 | --- | 33.23 | 150.0 | V | 270.0 | -8.7 | 54.00 | 20.77 |
| 1817.200000 | 45.34 | --- | 200.0 | V | 36.0 | -8.3 | 74.00 | 28.66 |
| 1817.200000 | --- | 43.33 | 200.0 | V | 36.0 | -8.3 | 54.00 | 10.67 |
| 2726.200000 | 48.60 | --- | 200.0 | H | 0.0 | -4.6 | 74.00 | 25.40 |
| 2726.200000 | --- | 46.19 | 200.0 | H | 0.0 | -4.6 | 54.00 | 7.81 |
| 3927.700000 | 43.99 | --- | 150.0 | H | 353.0 | 0.1 | 74.00 | 30.01 |
| 3927.700000 | --- | 34.02 | 150.0 | H | 353.0 | 0.1 | 54.00 | 19.98 |
| 6079.600000 | --- | 38.59 | 200.0 | H | 90.0 | 5.4 | 54.00 | 15.41 |
| 6079.600000 | 47.68 | --- | 200.0 | H | 90.0 | 5.4 | 74.00 | 26.32 |
| 9226.900000 | 52.48 | --- | 200.0 | V | 345.0 | 11.2 | 74.00 | 21.52 |
| 9226.900000 | --- | 43.24 | 200.0 | V | 345.0 | 11.2 | 54.00 | 10.76 |

**High Channel: 914.9MHz**



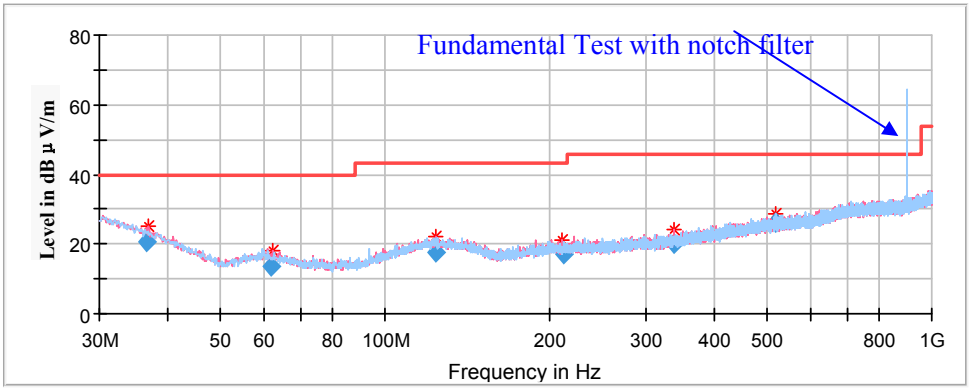

| Frequency (MHz) | Corrected Amplitude | | Rx Antenna | | Turntable Degree | Corrected Factor (dB/m) | Limit (dBµV/m) | Margin (dB) |
|---|---|---|---|---|---|---|---|---|
| | MaxPeak (dBµV/m) | Average (dBµV/m) | Height (cm) | Polar (H/V) | | | | |
| 1829.800000 | --- | 37.73 | 150.0 | V | 73.0 | -8.3 | 54.00 | 16.27 |
| 1829.800000 | 41.54 | --- | 150.0 | V | 73.0 | -8.3 | 74.00 | 32.46 |
| 2744.200000 | --- | 40.47 | 200.0 | H | 357.0 | -4.5 | 54.00 | 13.53 |
| 2744.200000 | 46.21 | --- | 200.0 | H | 357.0 | -4.5 | 74.00 | 27.79 |
| 3659.500000 | --- | 37.00 | 200.0 | V | 95.0 | -1.1 | 54.00 | 17.00 |
| 3659.500000 | 42.94 | --- | 200.0 | V | 95.0 | -1.1 | 74.00 | 31.06 |
| 4370.500000 | --- | 35.38 | 200.0 | V | 46.0 | 0.8 | 54.00 | 18.62 |
| 4370.500000 | 45.50 | --- | 200.0 | V | 46.0 | 0.8 | 74.00 | 28.50 |
| 6942.700000 | --- | 41.93 | 150.0 | H | 0.0 | 8.7 | 54.00 | 12.07 |
| 6942.700000 | 51.71 | --- | 150.0 | H | 0.0 | 8.7 | 74.00 | 22.29 |
| 9813.700000 | --- | 43.84 | 150.0 | V | 197.0 | 11.9 | 54.00 | 10.16 |
| 9813.700000 | 53.40 | --- | 150.0 | V | 197.0 | 11.9 | 74.00 | 20.60 |

**For PCB antenna:**

## Spurious Emission Test:

### 30MHz-1GHz

*Pre-scan with low, middle, high channel of operation in the X,Y and Z axes of orientation, the worst case* ***low channel in X-axis of orientation*** *was recorded*



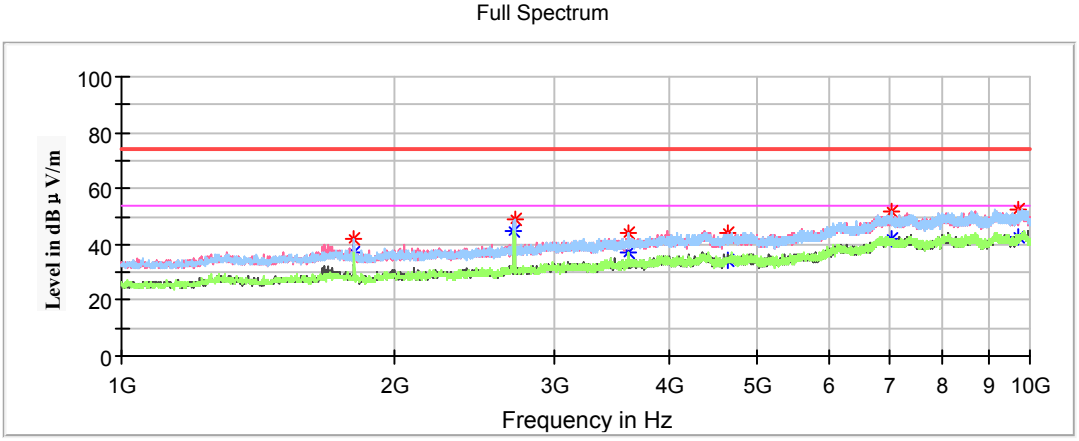

| Frequency (MHz) | Corrected Amplitude | Rx Antenna | | Turntable Degree | Corrected Factor (dB/m) | Limit (dBµV/m) | Margin (dB) |
|---|---|---|---|---|---|---|---|
| | QuasiPeak (dBµV/m) | Height (cm) | Polar (H/V) | | | | |
| 36.738550 | 20.58 | 100.0 | V | 352.0 | -7.5 | 40.00 | 19.42 |
| 61.818150 | 13.39 | 199.0 | V | 164.0 | -14.9 | 40.00 | 26.61 |
| 123.947150 | 17.46 | 199.0 | V | 70.0 | -11.0 | 43.50 | 26.04 |
| 212.184300 | 17.09 | 100.0 | V | 64.0 | -12.0 | 43.50 | 26.41 |
| 337.469750 | 20.27 | 100.0 | V | 106.0 | -9.8 | 46.00 | 25.73 |
| 517.443650 | 26.38 | 100.0 | H | 231.0 | -5.4 | 46.00 | 19.62 |

**1GHz-10GHz**

*Pre-scan in the X,Y and Z axes of orientation, the worst case **X-axis of orientation** was recorded.*

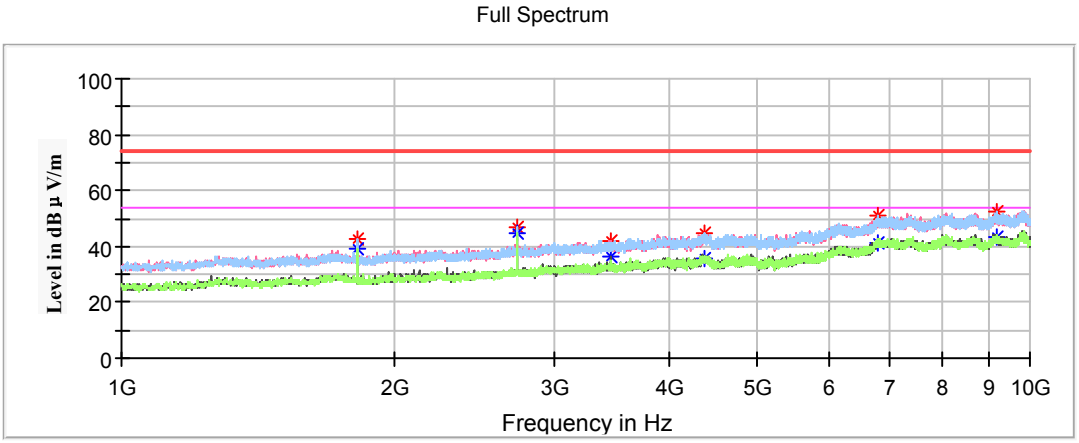
Note:
1. The test was performed with a 10dB Attenuator.
2. Corrected Factor (dB/m) = Antenna factor (RX) (dB/m) + Cable Loss (dB) – Amplifier Factor (dB) + Attenuator(dB)
   Corrected Amplitude (dBμV/m) = Corrected Factor (dB/m) + Reading (dBμV)
   Margin (dB) = Limit (dBμV/m) – Corrected Amplitude (dBμV/m)

**Low Channel: 902.3MHz**



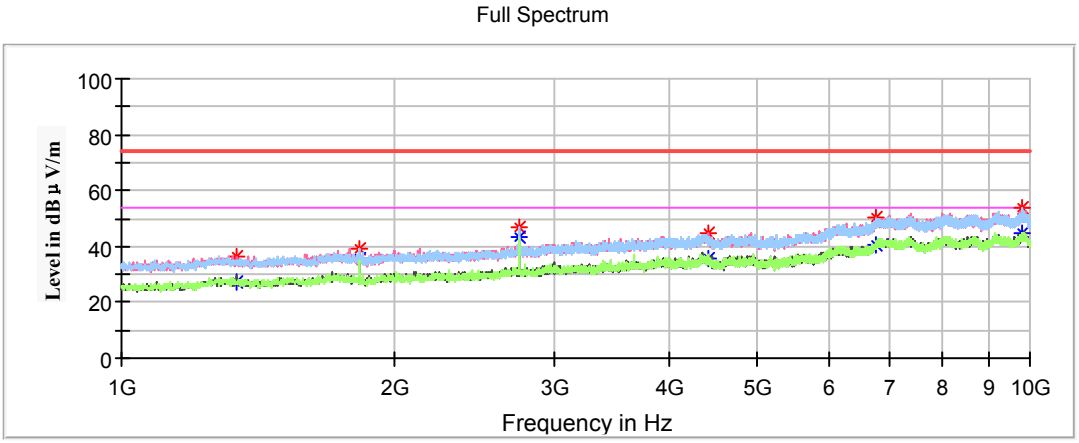

| Frequency (MHz) | Corrected Amplitude | | Rx Antenna | | Turntable Degree | Corrected Factor (dB/m) | Limit (dBμV/m) | Margin (dB) |
|---|---|---|---|---|---|---|---|---|
| | MaxPeak (dBμV/m) | Average (dBμV/m) | Height (cm) | Polar (H/V) | | | | |
| 1804.600000 | --- | 36.73 | 150.0 | H | 2.0 | -8.3 | 54.00 | 17.27 |
| 1804.600000 | 41.68 | --- | 150.0 | H | 2.0 | -8.3 | 74.00 | 32.32 |
| 2707.300000 | --- | 44.79 | 150.0 | H | 359.0 | -4.7 | 54.00 | 9.21 |
| 2707.300000 | 48.65 | --- | 150.0 | H | 351.0 | -4.7 | 74.00 | 25.35 |
| 3609.100000 | 44.13 | --- | 150.0 | H | 359.0 | -1.3 | 74.00 | 29.87 |
| 3609.100000 | --- | 37.29 | 150.0 | H | 359.0 | -1.3 | 54.00 | 16.71 |
| 4646.800000 | --- | 34.15 | 200.0 | H | 115.0 | 1.0 | 54.00 | 19.85 |
| 4646.800000 | 44.40 | --- | 200.0 | H | 115.0 | 1.0 | 74.00 | 29.60 |
| 7026.400000 | 51.49 | --- | 150.0 | H | 122.0 | 8.9 | 74.00 | 22.51 |
| 7026.400000 | --- | 42.13 | 150.0 | H | 122.0 | 8.9 | 54.00 | 11.87 |
| 9724.600000 | --- | 42.80 | 150.0 | V | 63.0 | 11.9 | 54.00 | 11.20 |
| 9724.600000 | 52.54 | --- | 150.0 | V | 63.0 | 11.9 | 74.00 | 21.46 |

**Middle Channel: 908.7MHz**




| Frequency (MHz) | Corrected Amplitude | | Rx Antenna | | Turntable Degree | Corrected Factor (dB/m) | Limit (dBµV/m) | Margin (dB) |
|---|---|---|---|---|---|---|---|---|
| | MaxPeak (dBµV/m) | Average (dBµV/m) | Height (cm) | Polar (H/V) | | | | |
| 1817.200000 | --- | 39.47 | 150.0 | H | 0.0 | -8.3 | 54.00 | 14.53 |
| 1817.200000 | 42.60 | --- | 150.0 | H | 0.0 | -8.3 | 74.00 | 31.40 |
| 2726.200000 | --- | 44.57 | 150.0 | H | 357.0 | -4.6 | 54.00 | 9.43 |
| 2726.200000 | 46.89 | --- | 150.0 | H | 357.0 | -4.6 | 74.00 | 27.11 |
| 3456.100000 | --- | 36.48 | 150.0 | V | 326.0 | -1.9 | 54.00 | 17.52 |
| 3456.100000 | 41.74 | --- | 150.0 | V | 326.0 | -1.9 | 74.00 | 32.26 |
| 4385.800000 | --- | 35.79 | 150.0 | H | 14.0 | 0.8 | 54.00 | 18.21 |
| 4385.800000 | 44.71 | --- | 150.0 | H | 14.0 | 0.8 | 74.00 | 29.29 |
| 6797.800000 | --- | 40.99 | 150.0 | H | 357.0 | 8.0 | 54.00 | 13.01 |
| 6797.800000 | 50.80 | --- | 150.0 | H | 357.0 | 8.0 | 74.00 | 23.20 |
| 9199.000000 | --- | 43.10 | 150.0 | H | 293.0 | 11.2 | 54.00 | 10.90 |
| 9199.000000 | 52.63 | --- | 150.0 | H | 293.0 | 11.2 | 74.00 | 21.37 |

**High Channel: 914.9MHz**




| Frequency (MHz) | Corrected Amplitude | | Rx Antenna | | Turntable Degree | Corrected Factor (dB/m) | Limit (dBµV/m) | Margin (dB) |
|---|---|---|---|---|---|---|---|---|
| | MaxPeak (dBµV/m) | Average (dBµV/m) | Height (cm) | Polar (H/V) | | | | |
| 1341.100000 | --- | 27.60 | 200.0 | V | 248.0 | -10.4 | 54.00 | 26.40 |
| 1341.100000 | 36.08 | --- | 200.0 | V | 248.0 | -10.4 | 74.00 | 37.92 |
| 1829.800000 | --- | 35.38 | 200.0 | V | 161.0 | -8.3 | 54.00 | 18.62 |
| 1829.800000 | 38.91 | --- | 200.0 | V | 161.0 | -8.3 | 74.00 | 35.09 |
| 2744.200000 | --- | 43.53 | 150.0 | H | 15.0 | -4.5 | 54.00 | 10.47 |
| 2744.200000 | 47.09 | --- | 150.0 | H | 15.0 | -4.5 | 74.00 | 26.91 |
| 4419.100000 | --- | 35.41 | 200.0 | V | 224.0 | 0.8 | 54.00 | 18.59 |
| 4419.100000 | 44.92 | --- | 200.0 | V | 224.0 | 0.8 | 74.00 | 29.08 |
| 6769.900000 | --- | 40.61 | 150.0 | H | 123.0 | 7.9 | 54.00 | 13.39 |
| 6769.900000 | 50.09 | --- | 150.0 | H | 123.0 | 7.9 | 74.00 | 23.91 |
| 9827.200000 | --- | 45.03 | 150.0 | H | 160.0 | 11.9 | 54.00 | 8.97 |
| 9827.200000 | 54.12 | --- | 150.0 | H | 160.0 | 11.9 | 74.00 | 19.88 |

## Bandedge Emissions Test:

*(Pre-scan in the X,Y and Z axes of orientation, the worst case **X-axis of orientation** was recorded.)*

Note:
1. The test is performed with a 10dB Attenuator.
2. Corrected Factor = Antenna factor (RX) + Cable Loss – Amplifier Factor+ Attenuator
   Corrected Amplitude = Corrected Factor + Reading
   Margin = Limit - Corrected. Amplitude

**For FPC antenna:**

| Frequency (MHz) | Corrected Amplitude | Rx Antenna | | Turntable Degree | Corrected Factor (dB/m) | Limit (dBμV/m) | Margin (dB) |
|---|---|---|---|---|---|---|---|
| | QuasiPeak (dBμV/m) | Height (cm) | Polar (H/V) | | | | |
| **902.3MHz** | | | | | | | |
| 902.00 | 35.11 | 200 | H | 143 | 1.02 | 46 | 10.89 |
| 902.00 | 33.61 | 100 | V | 36 | 1.02 | 46 | 12.39 |
| **914.9MHz** | | | | | | | |
| 928.00 | 36.23 | 100 | H | 304 | 1.68 | 46 | 9.77 |
| 928.00 | 34.49 | 200 | V | 110 | 1.68 | 46 | 11.51 |

**For PCB antenna:**

| Frequency (MHz) | Corrected Amplitude | Rx Antenna | | Turntable Degree | Corrected Factor (dB/m) | Limit (dBμV/m) | Margin (dB) |
|---|---|---|---|---|---|---|---|
| | QuasiPeak (dBμV/m) | Height (cm) | Polar (H/V) | | | | |
| **902.3MHz** | | | | | | | |
| 902.00 | 32.61 | 100 | H | 357 | 1.02 | 46 | 13.39 |
| 902.00 | 37.34 | 100 | V | 162 | 1.02 | 46 | 8.66 |
| **914.9MHz** | | | | | | | |
| 928.00 | 33.15 | 200 | H | 149 | 1.68 | 46 | 12.85 |
| 928.00 | 36.53 | 100 | V | 201 | 1.68 | 46 | 9.47 |

# FCC §15.247(a) (1) - CHANNEL SEPARATION TEST

## Applicable Standard

(1) Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater.

## Test Procedure

The EUT shall have its hopping function enabled. Use the following spectrum analyzer settings:

a. Span: Wide enough to capture the peaks of two adjacent channels.
b. RBW: Start with the RBW set to approximately 30% of the channel spacing; adjust as necessary to best identify the center of each individual channel.
c. Video (or average) bandwidth (VBW) ≥ RBW.
d. Sweep: Auto.
e. Detector function: Peak.
f. Trace: Max hold.
g. Allow the trace to stabilize.

Use the marker-delta function to determine the separation between the peaks of the adjacent channels.

## Test Data

### Environmental Conditions

| | |
|---|---|
| **Temperature:** | 23.2 ℃ |
| **Relative Humidity:** | 49 % |
| **ATM Pressure:** | 101.2 kPa |

*The testing was performed by Chao Gao on 2021-04-25.*

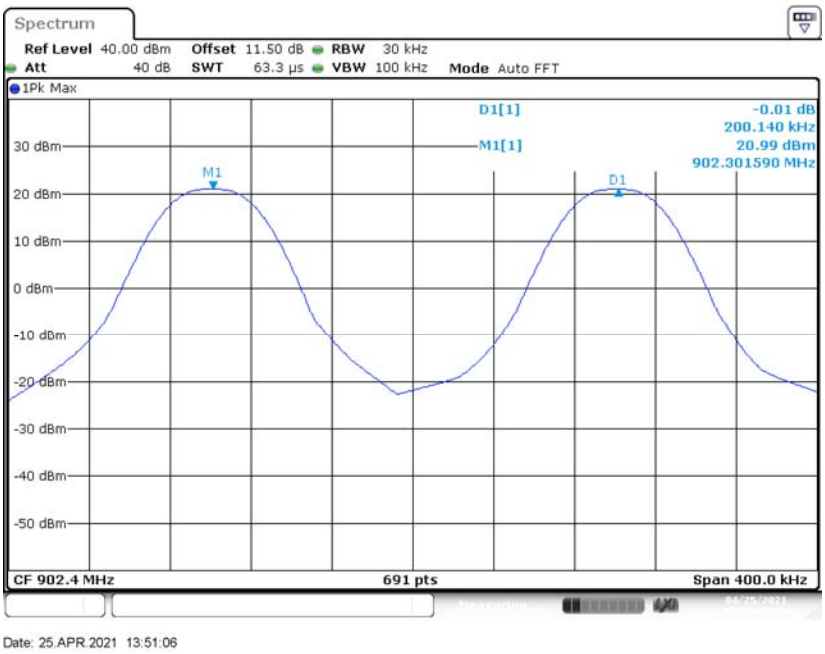
*EUT operation mode: Transmitting*

*Test Result: Compliant.*

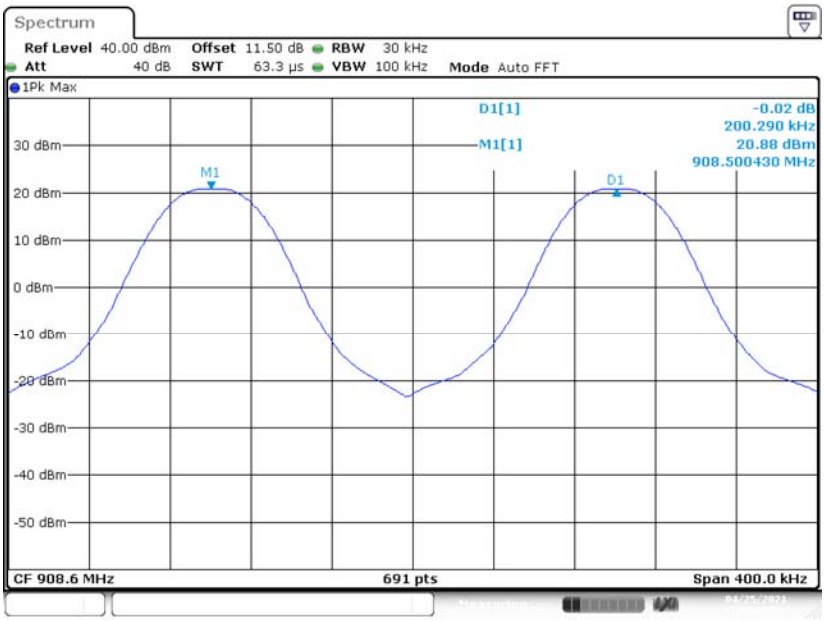
| Channel | Frequency (MHz) | Channel Separation (MHz) | Limit (MHz) | Result |
|---|---|---|---|---|
| Low | 902.3 | 0.200 | 0.138 | Pass |
| Adjacent | 902.5 | | | |
| Middle | 908.7 | 0.200 | 0.138 | Pass |
| Adjacent | 908.5 | | | |
| High | 914.9 | 0.200 | 0.138 | Pass |
| Adjacent | 914.7 | | | |

Note: Limit = 20 dB bandwidth

**Low Channel**



**Middle Channel**

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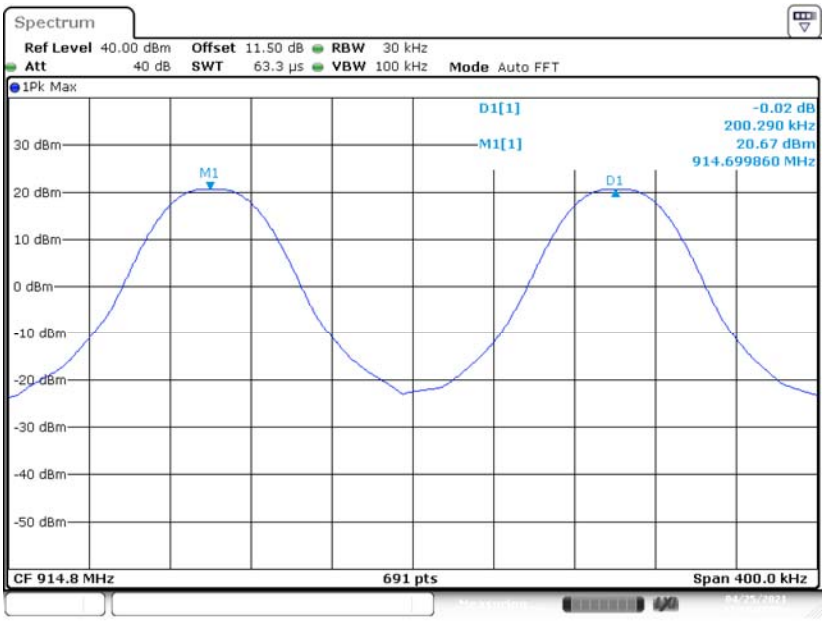
**High Channel**

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# FCC §15.247(a) (1) (i)– 20 dB EMISSION BANDWIDTH

## Applicable Standard

(i) For frequency hopping systems operating in the 902-928 MHz band: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 20 second period; if the 20 dB bandwidth of the hopping channel is 250 kHz or greater, the system shall use at least 25 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 10 second period. The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz.

## Test Procedure

1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Position the EUT without connection to measurement instrument. Turn on the EUT and connect it to measurement instrument. Then set it to any one convenient frequency within its operating range. Set a reference level on the measuring instrument equal to the highest peak value.
3. Measure the frequency difference of two frequencies that were attenuated 20 dB from the reference level. Record the frequency difference as the emission bandwidth.
4. Repeat above procedures until all frequencies measured were complete.

## Test Data

### Environmental Conditions

| | |
|---|---|
| **Temperature:** | 23.2 ℃ |
| **Relative Humidity:** | 48 % |
| **ATM Pressure:** | 101.2 kPa |

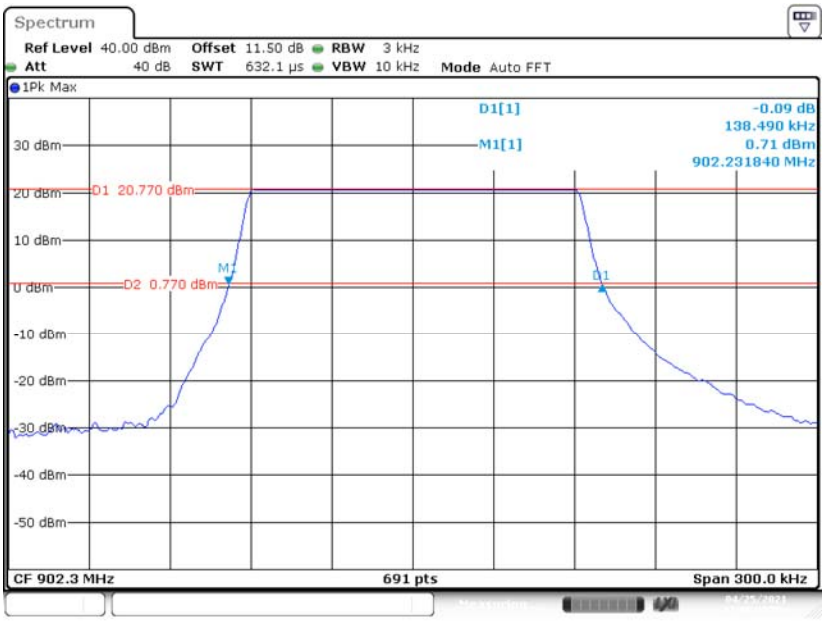
*The testing was performed by Chao Gao on 2021-04-25.*

*EUT operation mode: Transmitting*

*Test Result: Compliant.*

| Channel | Frequency (MHz) | 20 dB Emission Bandwidth (MHz) | Limit (MHz) |
|---|---|---|---|
| Low | 902.3 | 0.138 | ≤0.25 |
| Middle | 908.7 | 0.138 | ≤0.25 |
| High | 914.9 | 0.138 | ≤0.25 |

**Low Channel**

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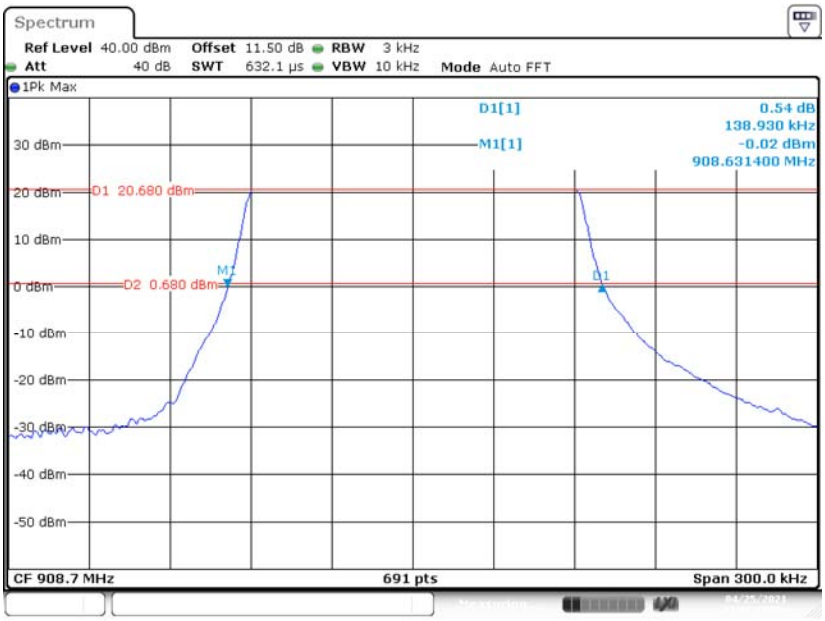
**Middle Channel**

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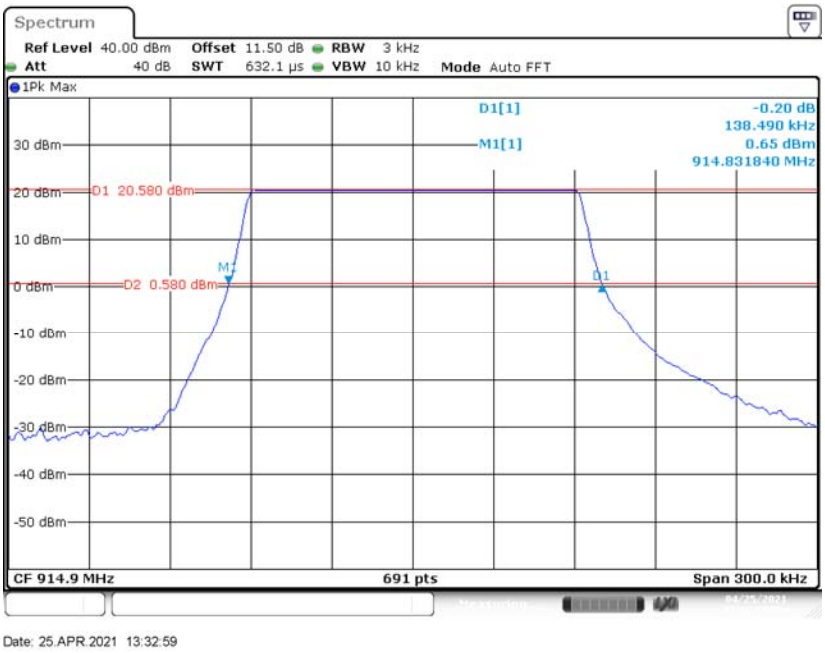
**High Channel**



# FCC §15.247(a) (1) (i) - QUANTITY OF HOPPING CHANNEL TEST

## Applicable Standard

(i) For frequency hopping systems operating in the 902-928 MHz band: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 20 second period; if the 20 dB bandwidth of the hopping channel is 250 kHz or greater, the system shall use at least 25 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 10 second period. The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz.

## Test Procedure

The EUT shall have its hopping function enabled. Use the following spectrum analyzer settings:

a. Span: The frequency band of operation. Depending on the number of channels the device supports, it may be necessary to divide the frequency range of operation across multiple spans, to allow the individual channels to be clearly seen.
b. RBW: To identify clearly the individual channels, set the RBW to less than 30% of the channel spacing or the 20 dB bandwidth, whichever is smaller.
c. VBW ≥ RBW.
d. Sweep: Auto.
e. Detector function: Peak.
f. Trace: Max hold.
g. Allow the trace to stabilize.

It might prove necessary to break the span up into subranges to show clearly all of the hopping frequencies.

## Test Data

### Environmental Conditions

| | |
|---|---|
| **Temperature:** | 24.0 ℃ |
| **Relative Humidity:** | 49 % |
| **ATM Pressure:** | 101.6 kPa |

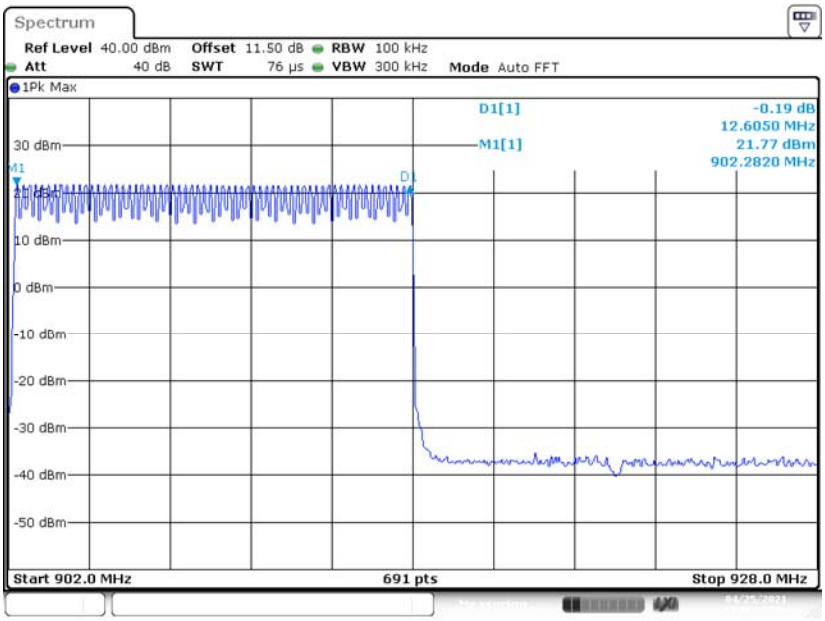
*The testing was performed by Chao Gao on 2021-04-25.*

*EUT operation mode: Hopping*

*Test Result: Compliant.*

| Frequency Range (MHz) | Number of Hopping Channel (CH) | Limit (CH) |
|---|---|---|
| 902~928MHz | 64 | ≥50 |

**Number of Hopping Channels**

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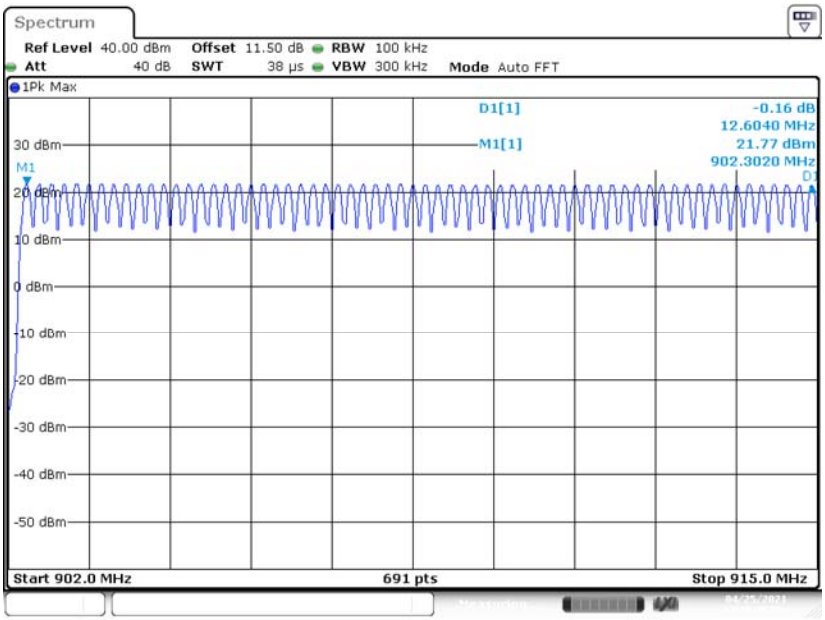


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# FCC §15.247(f) - TIME OF OCCUPANCY (DWELL TIME) OF HYBRID SYSTEMS

## Applicable Standard

(f) For the purposes of this section, hybrid systems are those that employ a combination of both frequency hopping and digital modulation techniques. The frequency hopping operation of the hybrid system, with the direct sequence or digital modulation operation turned-off, shall have an average time of occupancy on any frequency not to exceed 0.4 seconds within a time period in seconds equal to the number of hopping frequencies employed multiplied by 0.4. The power spectral density conducted from the intentional radiator to the antenna due to the digital modulation operation of the hybrid system, with the frequency hopping operation turned off, shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

## Test Procedure

The EUT shall have its hopping function enabled. Use the following spectrum analyzer settings:

a Span: Zero span, centered on a hopping channel.
b RBW shall be ≤ channel spacing and where possible RBW should be set ≥ 1 / T, where T is the expected dwell time per channel.
c Sweep: As necessary to capture the entire dwell time per hopping channel; where possible use a video trigger and trigger delay so that the transmitted signal starts a little to the right of the start of the plot. The trigger level might need slight adjustment to prevent triggering when the system hops on an adjacent channel; a second plot might be needed with a longer sweep time to show two successive hops on a channel.
d Detector function: Peak.
e Trace: Max hold.

## Test Data

### Environmental Conditions

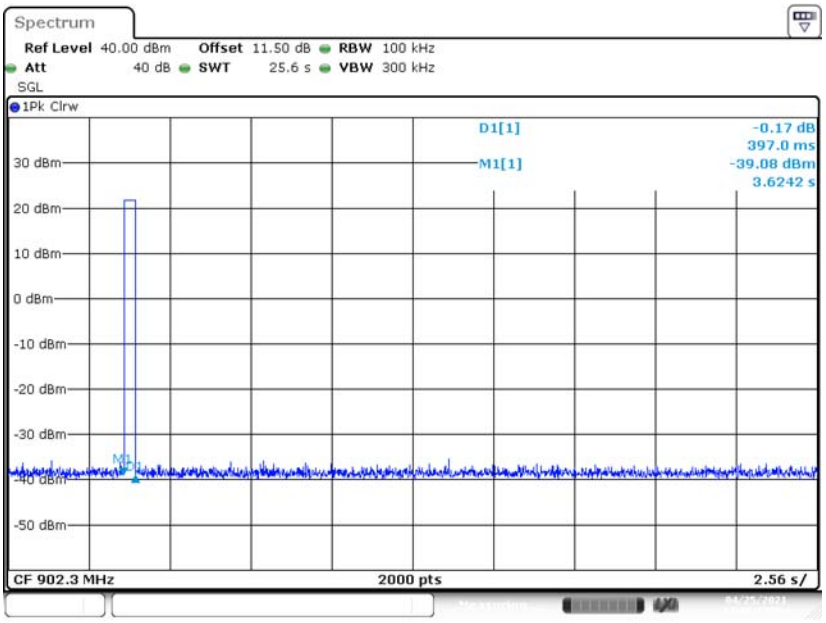
| | |
|---|---|
| **Temperature:** | 23.8℃ |
| **Relative Humidity:** | 48 % |
| **ATM Pressure:** | 101.1kPa |

*The testing was performed by Chao Gao on 2021-04-25.*

*EUT operation mode: Hopping*

| Channel | Dwell Time (s) | Limit (s) | Result |
|---|---|---|---|
| Low | 0.391 | 0.4 | Pass |
| Middle | 0.371 | 0.4 | Pass |
| High | 0.391 | 0.4 | Pass |

**Low Channel**

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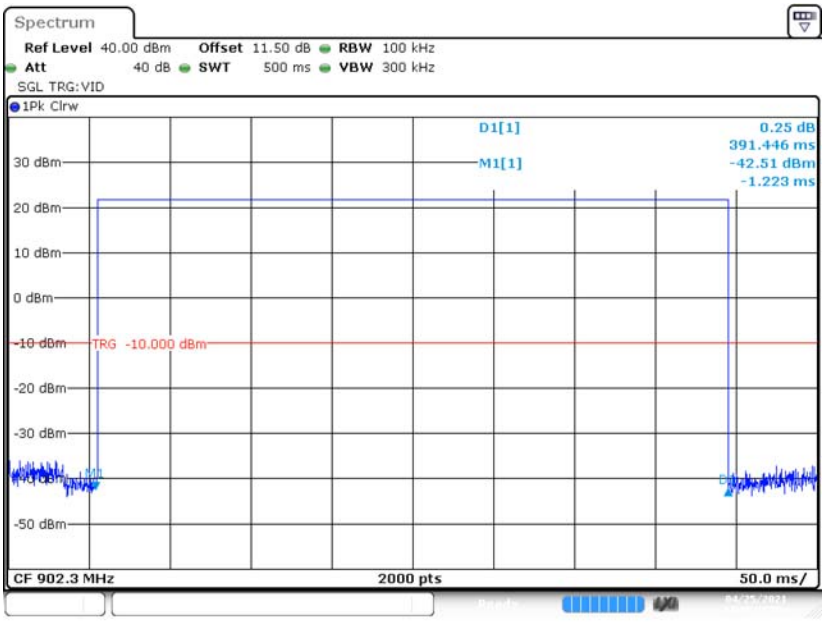


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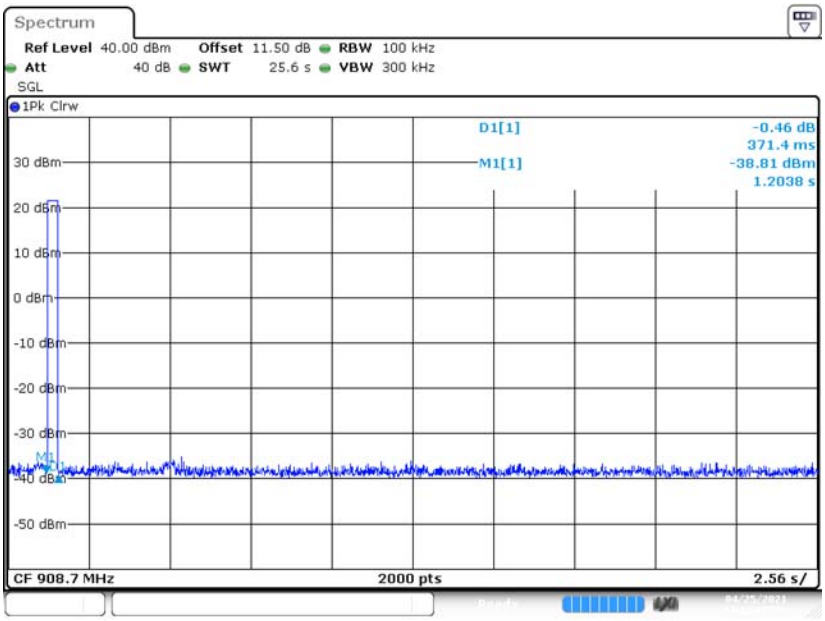
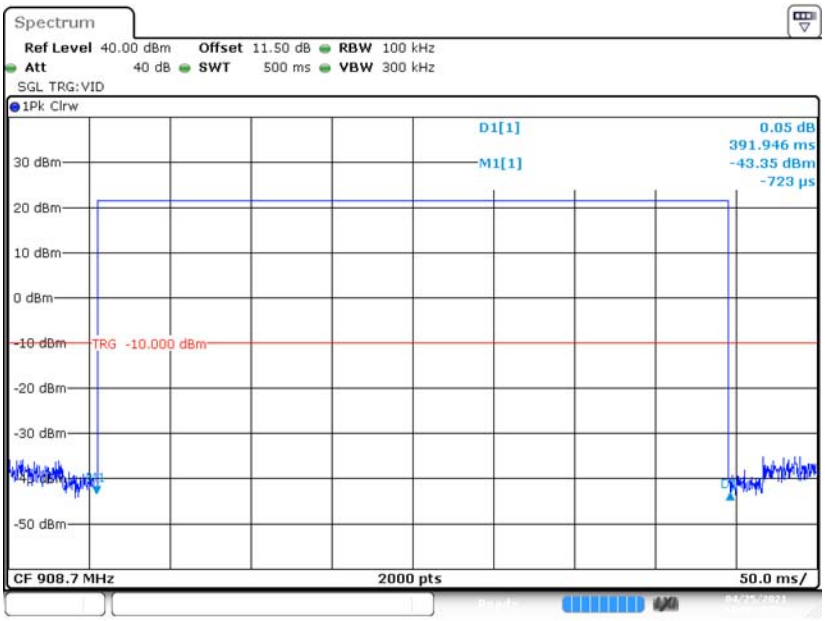
**Middle Channel**




Date: 25.APR.2021 16:12:08

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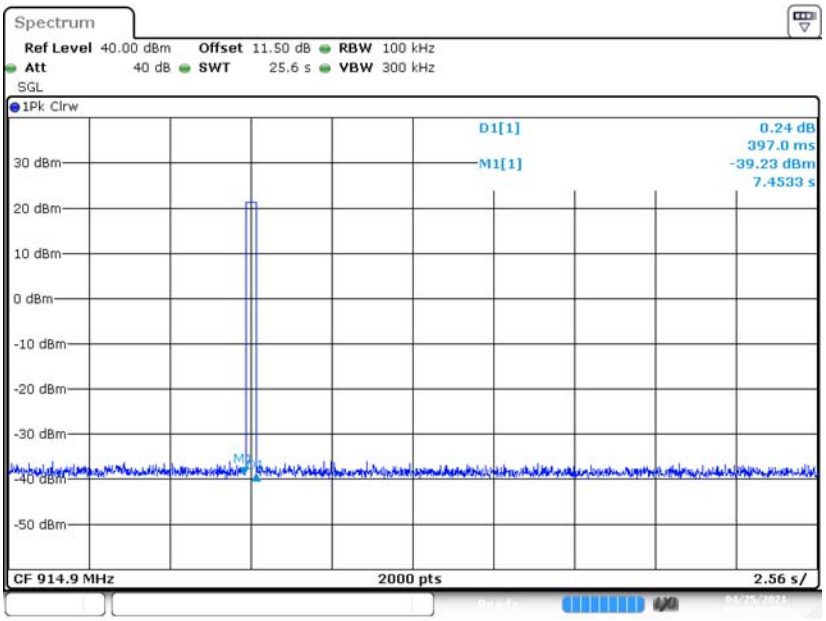
**High Channel**

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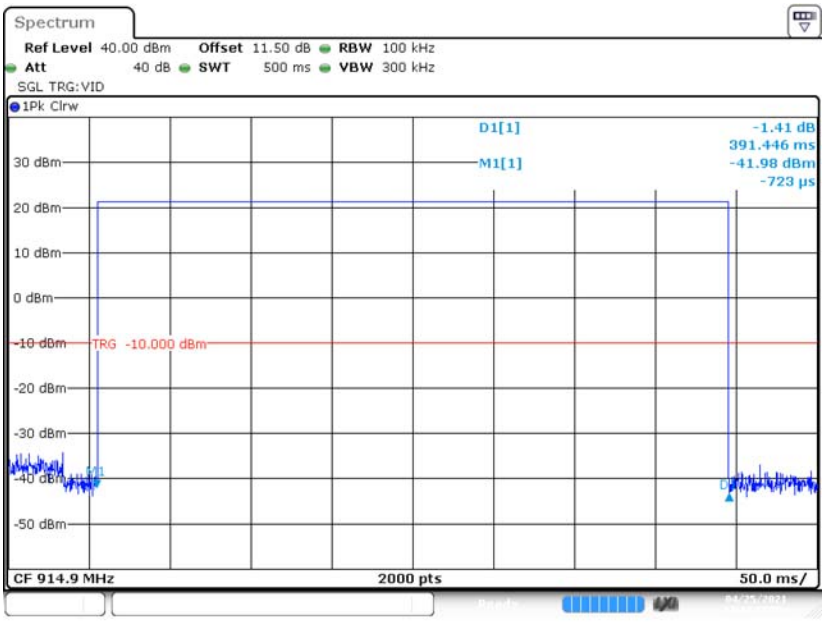


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# FCC §15.247(f) - POWER SPECTRAL DENSITY OF HYBRID SYSTEMS

## Applicable Standard

The power spectral density conducted from the intentional radiator to the antenna due to the digital modulation operation of the hybrid system, with the frequency hopping operation turned off, shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

## Test Procedure

a) Set instrument center frequency to DTS channel center frequency.
b) Set span to at least 1.5 times the OBW.
c) Set RBW to: 3 kHz ≤ RBW ≤ 100 kHz.
d) Set VBW ≥ [3 × RBW].
e) Detector = power averaging (rms)
f) Ensure that the number of measurement points in the sweep ≥ [2 × span / RBW].
g) Manually set the sweep time to: ≥ [10 × (number of measurement points in sweep) × (transmission symbol period)], but no less than the auto sweep time.
h) Perform the measurement over a single sweep.
i) Use the peak marker function to determine the maximum amplitude level.
j) If measured value exceeds requirement, then reduce RBW (but no less than 3 kHz) and repeat (note that this may require zooming in on the emission of interest and reducing the span to meet the minimum measurement point requirement as the RBW is reduced).

## Test Data

### Environmental Conditions

| | |
|---|---|
| **Temperature:** | 24.2 ℃ |
| **Relative Humidity:** | 49 % |
| **ATM Pressure:** | 101.2 kPa |

*The testing was performed by Chao Gao on 2021-05-17.*

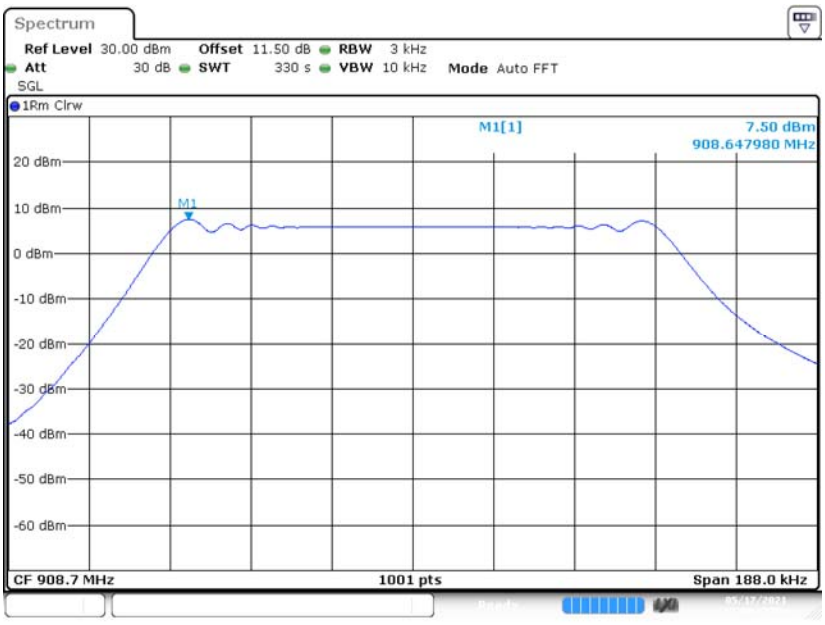
*EUT operation mode: Transmitting*

*Test Result: Compliant.*

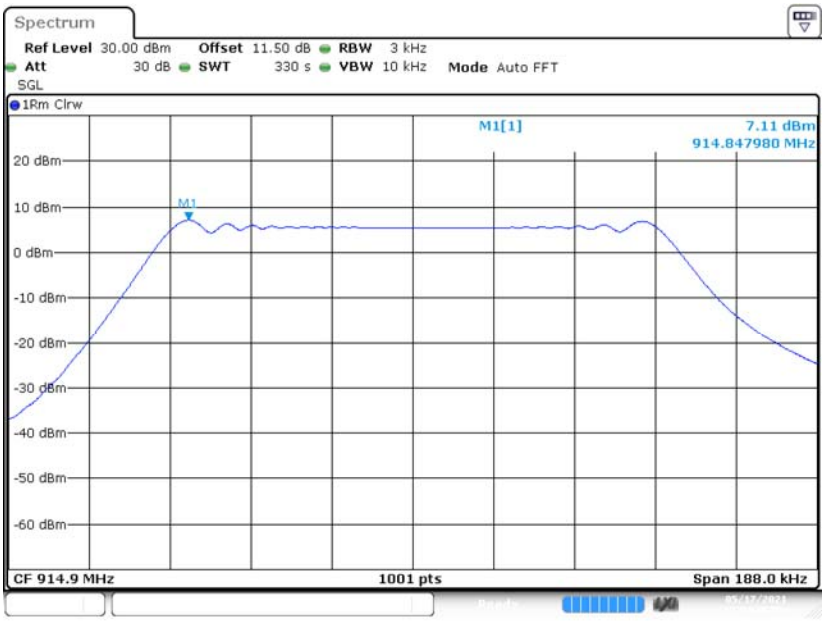
| Channel | Frequency (MHz) | PSD (dBm/3kHz) | Limit (dBm/3kHz) |
|---|---|---|---|
| Low | 902.3 | 7.61 | ≤ 8 |
| Middle | 908.7 | 7.50 | ≤ 8 |
| High | 914.9 | 7.11 | ≤ 8 |

**Low Channel**


**Middle Channel**



**High Channel**



# FCC §15.247(b)(3)-MAXIMUM CONDUCTED (AVERAGE) OUTPUT POWER

## Applicable Standard

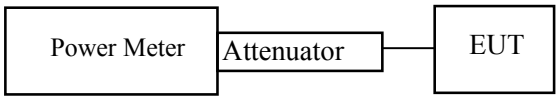
According to FCC §15.247(b) (3), for systems using digital modulation in the 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz bands: 1 Watt. As an alternative to a peak power measurement, Compliant with the one Watt limit can be based on a measurement of the maximum conducted output power. Maximum Conducted Output Power is defined as the total transmit power delivered to all antennas and antenna elements averaged across all symbols in the signaling alphabet when the transmitter is operating at its maximum power control level. Power must be summed across all antennas and antenna elements. The average must not include any time intervals during which the transmitter is off or is transmitting at a reduced power level. If multiple modes of operation are possible (e.g., alternative modulation methods), the maximum conducted output power is the highest total transmit power occurring in any mode.

## Test Procedure

According to ANSI C63.10-2013 sub-clause 11.9.2.3.1

The maximum average conducted output power may be measured using a wideband RF average power meter. The power meter shall have a video bandwidth that is greater than or equal to the DTS bandwidth and shall use a fast-responding diode detector.

1. Place the EUT on a bench and set it in transmitting mode.
2. Remove the antenna from the EUT and then connect a low loss RF cable from the antenna port to one test equipment.
3. Add duty factor to the display.




## Test Data

### Environmental Conditions

| | |
|---|---|
| **Temperature:** | 23.2 ℃ |
| **Relative Humidity:** | 49 % |
| **ATM Pressure:** | 101.2 kPa |

*The testing was performed by Chao Gao on 2021-04-25.*

*EUT operation mode: Transmitting*

| Channel | Frequency (MHz) | Average Output Power (dBm) | Limit (dBm) | Result |
|---|---|---|---|---|
| Low | 902.3 | 21.77 | 30 | Pass |
| Middle | 908.7 | 21.69 | 30 | Pass |
| High | 914.9 | 21.58 | 30 | Pass |

Note: The antenna gain is 1dBi for FPC antenna and 1dBi for PCB antenna.

# FCC §15.247(d) - BAND EDGES TESTING

## Applicable Standard

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates Compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

## Test Procedure

1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Remove the antenna from the EUT and then connect to a low loss RF cable from the antenna port to a EMI test receiver, then turn on the EUT and make it operate in transmitting mode. Then set it to Low Channel and High Channel within its operating range, and make sure the instrument is operated in its linear range.
3. Set RBW of spectrum analyzer to 100 kHz with a convenient frequency span including 100 kHz bandwidth from band edge.
4. Measure the highest amplitude appearing on spectral display and set it as a reference level. Plot the graph with marking the highest point and edge frequency.
5. Repeat above procedures until all measured frequencies were complete.

## Test Data

### Environmental Conditions

| | |
|---|---|
| **Temperature:** | 23.2 ℃ |
| **Relative Humidity:** | 49 % |
| **ATM Pressure:** | 101.2 kPa |

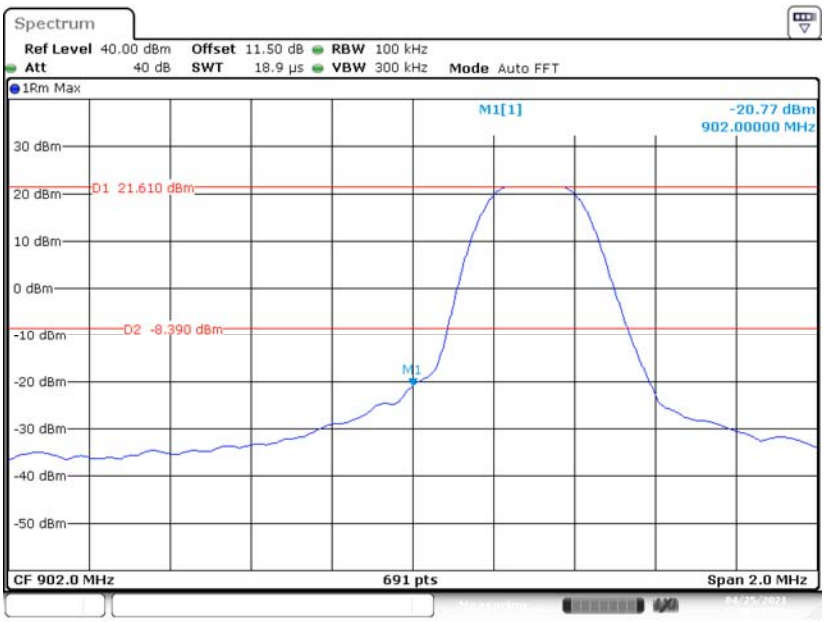
*The testing was performed by Chao Gao on 2021-04-25.*

*EUT operation mode: Transmitting & Hopping*

*Test Result: Compliant.*

**Band Edge**

**Left Side - Transmitting**

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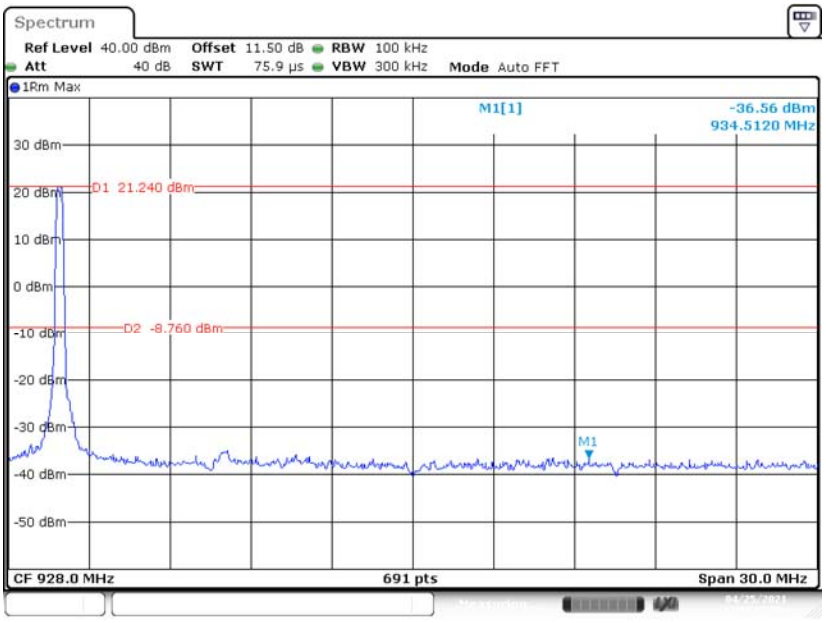
**Right Side - Transmitting**

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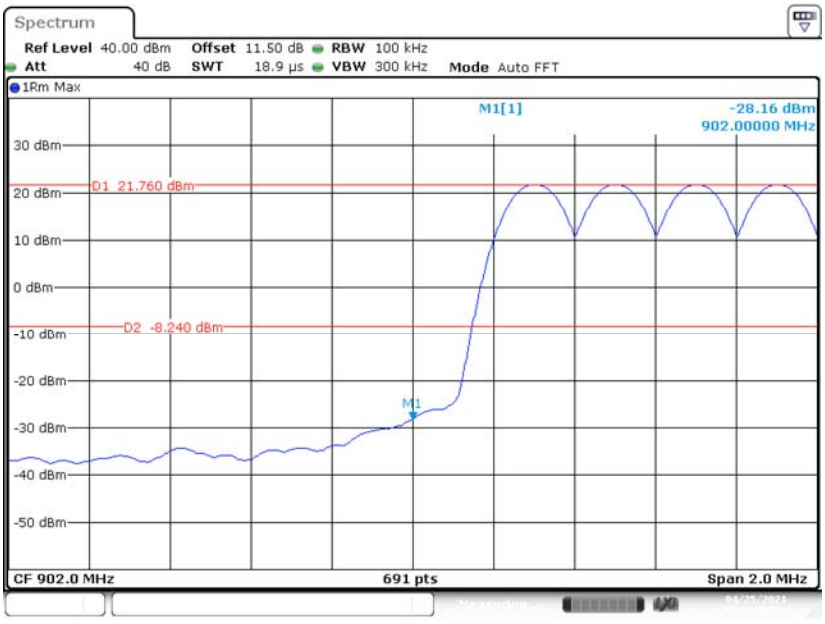
**Left Side - Hopping**

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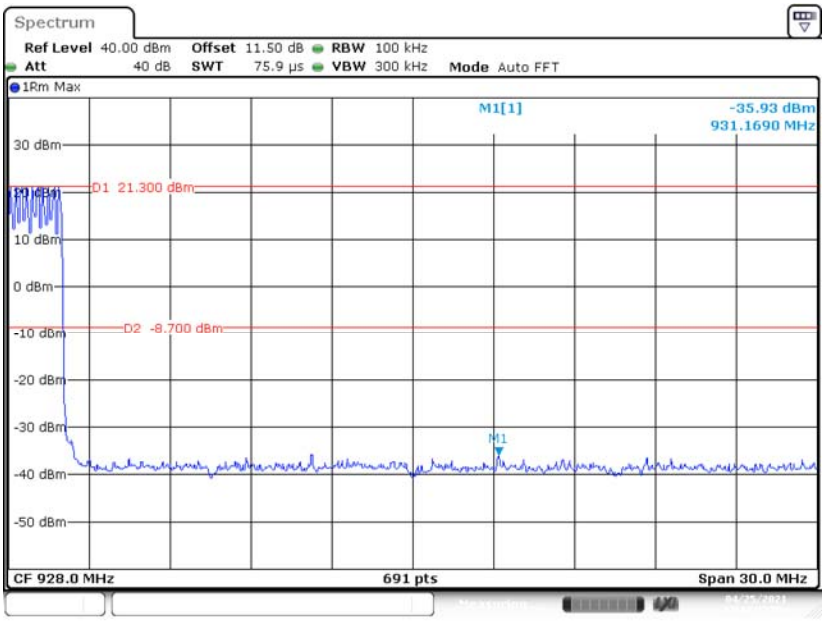
**Right Side- Hopping**

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# Declarations

1: BACL is not responsible for the authenticity of any test data provided by the applicant. Data included from the applicant that may affect test results are marked with an asterisk'*'. Customer model name, addresses, names, trademarks etc. are not considered data.

2: Unless otherwise stated the results shown in this test report refer only to the sample(s) tested.

3: Otherwise required by the applicant or Product Regulations, Decision Rule in this report did not consider the uncertainty.

4: The extended uncertainty given in this report is obtained by combining the standard uncertainty times the coverage factor K with the 95% confidence interval.

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