



TESTING LABORATORY  
CERTIFICATE # 4821.01



# FCC PART 15.247

## TEST REPORT

For

### Astera LED-Technology GmbH

Stahlgruberring 36, Munich, Germany 81829

**FCC ID: X55PB15**

|   |                                     |
|---|-------------------------------------|
| <b>Report Type:</b><br>Original Report  | <b>Product Type:</b><br>Pixel Brick |
| <b>Report Number:</b> SZ4210722-30587E-RF-00  |                                     |
| <b>Report Date:</b> 2021-09-02  |                                     |
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## GENERAL INFORMATION

### Product Description for Equipment under Test (EUT)

|                       |   |
|-----------------------|---|
| Product               | Pixel Brick   |
| Tested Model          | PB15  |
| Frequency Range       | 917~922.2MHz  |
| Transmit Power        | 8.83dBm   |
| Modulation Technique  | GFSK  |
| Antenna Specification | PCB Antenna, 2 dBi (It is provided by the applicant)                                    |
| Voltage Range         | DC18.0V from battery or DC 24.0V from adapter   |
| Date of Test          | 2021-08-06 to 2021-08-12  |
| Sample serial number  | SZ4210722-30587E-RF-S1(Assigned by BACL, Shenzhen)                                      |
| Received date         | 2021-07-22  |
| Sample/EUT Status     | Good condition  |
| Adapter information   | Model: PA1050-240IB200<br>Input: 100-240V,50/60Hz, 1.8A<br>Output: 24.0V,2.0A,48.0W Max |

### Objective

This report is in accordance with Part 2-Subpart J, Part 15-Subparts A and C of the Federal Communication Commission's rules.

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

### 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.

All emissions measurement was performed at Bay Area Compliance Laboratories Corp. (Shenzhen). The radiated testing was performed at an antenna-to-EUT distance of 3 meters. Each test item follows test standards and with no deviation.

## Measurement Uncertainty

| Parameter                    |            | uncertainty |
|------------------------------|------------|-------------|
| Occupied Channel Bandwidth   |            | ±5%         |
| RF output power, conducted   |            | ±0.73dB     |
| Unwanted Emission, conducted |            | ±1.95dB     |
| Radiated Emissions           | Below 1GHz | ±4.75dB     |
|                              | Above 1GHz | ±4.88dB     |
| Temperature                  |            | ±1 °C       |
| Supply voltages              |            | ±0.4%       |

*Note: The extended uncertainty given in this report is obtained by combining the standard uncertainty times the coverage factor K with the 95% confidence interval. 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. (Shenzhen) to collect test data is located on the 5F(B-West) , 6F, 7F, the 3rd Phase of Wan Li Industrial Building D, Shihua Rd, FuTian Free Trade Zone, Shenzhen, China.

The test site has been approved by the FCC under the KDB 974614 D01 and is listed in the FCC Public Access Link (PAL) database, FCC Registration No.: 342867, the FCC Designation No.: CN1221.

The test site has been registered with ISED Canada under ISED Canada Registration Number 3062B.

The lab has been recognized by Innovation, Science and Economic Development Canada to test to Canadian radio equipment requirements, the CAB identifier: CN0023.

## SYSTEM TEST CONFIGURATION

### Description of Test Configuration

The system was configured for testing in engineering mode.

| Channel | Frequency (MHz) | Channel | Frequency (MHz) |
|---------|-----------------|---------|-----------------|
| 0       | 917.00          | 27      | 919.70          |
| 1       | 917.10          | 28      | 919.80          |
| 2       | 917.20          | 29      | 919.90          |
| 3       | 917.30          | 30      | 920.00          |
| 4       | 917.40          | 31      | 920.10          |
| 5       | 917.50          | 32      | 920.20          |
| 6       | 917.60          | 33      | 920.30          |
| 7       | 917.70          | 34      | 920.40          |
| 8       | 917.80          | 35      | 920.50          |
| 9       | 917.90          | 36      | 920.60          |
| 10      | 918.00          | 37      | 920.70          |
| 11      | 918.10          | 38      | 920.80          |
| 12      | 918.20          | 39      | 920.90          |
| 13      | 918.30          | 40      | 921.00          |
| 14      | 918.40          | 41      | 921.10          |
| 15      | 918.50          | 42      | 921.20          |
| 16      | 918.60          | 43      | 921.30          |
| 17      | 918.70          | 44      | 921.40          |
| 18      | 918.80          | 45      | 921.50          |
| 19      | 918.90          | 46      | 921.60          |
| 20      | 919.00          | 47      | 921.70          |
| 21      | 919.10          | 48      | 921.80          |
| 22      | 919.20          | 49      | 921.90          |
| 23      | 919.30          | 50      | 922.00          |
| 24      | 919.40          | 51      | 922.10          |
| 25      | 919.50          | 52      | 922.20          |
| 26      | 919.60          |         |                 |

EUT was test on channel 0, 26, 52.

### EUT Exercise Software

“AsterApp\_9.96” software was used for the test and the power level is default. The software and power level was provided by the applicant.

### Special Accessories

No special accessory.

**Equipment Modifications**

No modification was made to the EUT tested.

**Support Equipment List and Details**

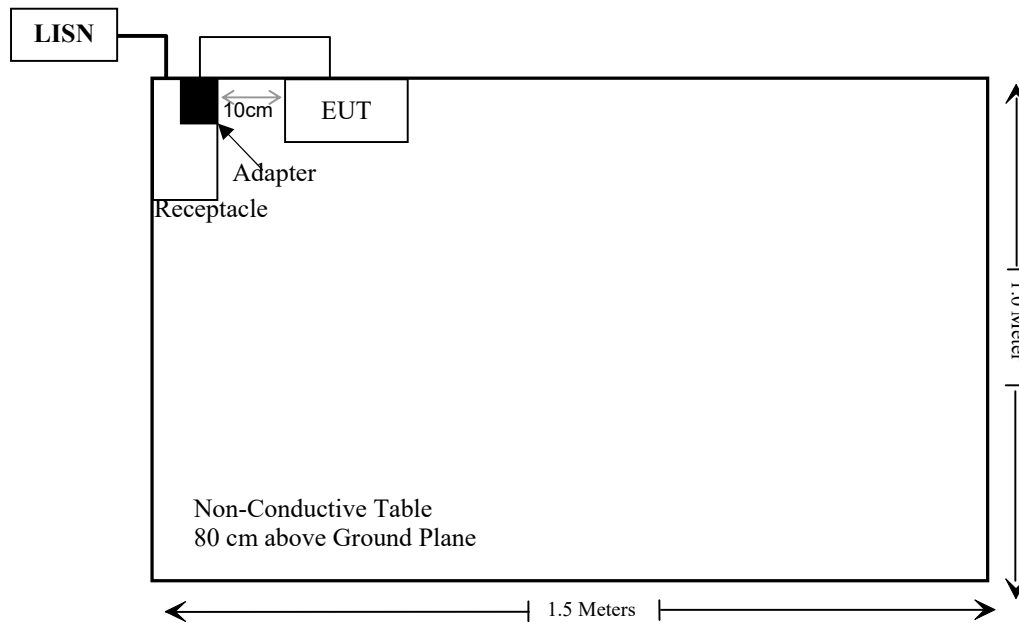
| Manufacturer | Description | Model | Serial Number |
|--------------|-------------|-------|---------------|
| /            | /           | /     | /             |

**External I/O Cable**

| Cable Description                    | Length (m) | From Port | To  |
|--------------------------------------|------------|-----------|-----|
| Un-shielding Un-Detachable USB Cable | 1.5        | Adapter   | EUT |

**Block Diagram of Test Setup**

For conducted emission;



**SUMMARY OF TEST RESULTS**

| <b>FCC Rules</b>                 | <b>Description of Test</b>        | <b>Result</b> |
|----------------------------------|-----------------------------------|---------------|
| §15.247 (i), §2.1091             | Maximum Permissible Exposure(MPE) | Compliant     |
| §15.203                          | Antenna Requirement               | Compliant     |
| §15.207(a)                       | AC Line Conducted Emissions       | Compliant     |
| §15.205, §15.209 &<br>§15.247(d) | Radiated Emissions                | Compliant     |
| §15.247(a)(1)                    | 20 dB Emission Bandwidth          | Compliant     |
| §15.247(a)(1)(i)                 | Channel Separation Test           | Compliant     |
| §15.247(a)(1)(i)                 | Time of Occupancy (Dwell Time)    | Compliant     |
| §15.247(a)(1)(i)                 | Quantity of hopping channel Test  | Compliant     |
| §15.247(b)(2)                    | Peak Output Power Measurement     | Compliant     |
| §15.247(d)                       | Band edges                        | Compliant     |



**TEST EQUIPMENT LIST**

| Manufacturer                    | Description        | Model           | Serial Number          | Calibration Date | Calibration Due Date |
|---------------------------------|--------------------|-----------------|------------------------|------------------|----------------------|
| <b>Conducted Emissions Test</b> |                    |                 |                        |                  |                      |
| Rohde & Schwarz                 | EMI Test Receiver  | ESCI            | 101120                 | 2021/07/07       | 2022/07/06           |
| Rohde & Schwarz                 | LISN               | ENV216          | 101613                 | 2021/07/07       | 2022/07/06           |
| Rohde & Schwarz                 | Transient Limiter  | ESH3Z2          | DE25985                | 2020/11/29       | 2021/11/28           |
| Unknown                         | CE Cable           | CE Cable        | UF A210B-1-0720-504504 | 2020/11/29       | 2021/11/28           |
| Rohde & Schwarz                 | CE Test software   | EMC 32          | V8.53.0                | NCR              | NCR                  |
| <b>Radiated Emission Test</b>   |                    |                 |                        |                  |                      |
| R&S                             | EMI Test Receiver  | ESR3            | 102455                 | 2021/07/06       | 2022/07/05           |
| Sonoma instrument               | Pre-amplifier      | 310 N           | 186238                 | 2021/08/03       | 2022/08/02           |
| Sunol Sciences                  | Broadband Antenna  | JB1             | A040904-2              | 2020/12/22       | 2023/12/21           |
| Unknown                         | Cable 2            | RF Cable 2      | F-03-EM197             | 2020/11/29       | 2021/11/28           |
| Unknown                         | Cable              | Chamber Cable 4 | EC-007                 | 2021/08/03       | 2022/08/02           |
| Rohde & Schwarz                 | Auto test software | EMC 32          | V9.10.00               | NCR              | NCR                  |
| Rohde & Schwarz                 | Spectrum Analyzer  | FSV40-N         | 102259                 | 2021/07/06       | 2022/07/05           |
| COM-POWER                       | Pre-amplifier      | PA-122          | 181919                 | 2020/11/29       | 2021/11/28           |
| Sunol Sciences                  | Horn Antenna       | 3115            | 9107-3694              | 2021/01/15       | 2024/01/14           |
| Insulted Wire Inc.              | RF Cable           | SPS-2503-3150   | 02222010               | 2020/11/29       | 2021/11/28           |
| Unknown                         | RF Cable           | W1101-EQ1 OUT   | F-19-EM005             | 2020/11/29       | 2021/11/28           |
| Unknown                         | High Pass filter   | 1.3GHz          | 101120                 | 2021/04/20       | 2022/04/20           |
| <b>RF Conducted Test</b>        |                    |                 |                        |                  |                      |
| Rohde & Schwarz                 | SPECTRUM ANALYZER  | FSU26           | 200120                 | 2021/04/02       | 2022/04/01           |
| WEINSCHL                        | 3dB Attenuator     | Unknown         | F-03-EM121             | 2020/11/29       | 2021/11/28           |

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

**FCC §15.247 (i) & §2.1091- MAXIMUM PERMISSIBLE EXPOSURE (MPE)**

**Applicable Standard**

According to subpart 15.247 (i) and subpart 2.1091 systems operating under the provisions of this section shall be operated in a manner that ensures the public is not exposed to RF energy level in excess of the communication guidelines.

Limits for General Population/Uncontrolled Exposure

| Limits for General Population/Uncontrolled Exposure |                               |                               |                                     |                          |
|---|-------------------------------|-------------------------------|-------------------------------------|--------------------------|
| Frequency Range (MHz)                               | Electric Field Strength (V/m) | Magnetic Field Strength (A/m) | Power Density (mW/cm <sup>2</sup> ) | Averaging Time (Minutes) |
| 0.3-1.34  | 614                           | 1.63                          | *(100)                              | 30                       |
| 1.34-30   | 824/f                         | 2.19/f                        | *(180/f <sup>2</sup> )              | 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

**Result**

**Calculated Formulary:**

Predication of MPE limit at a given distance

$$S = \frac{PG}{4\pi R^2}$$

S = power density (in appropriate units, e.g. mW/cm<sup>2</sup>)

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)

For simultaneously transmit system, the calculated power density should comply with:

$$\sum_i \frac{S_i}{S_{Limit,i}} \leq 1$$

| Mode  | Frequency (MHz) | Antenna Gain |           | Tune up conducted power |        | Evaluation Distance (cm) | Power Density (mW/cm <sup>2</sup> ) | MPE Limit (mW/cm <sup>2</sup> ) |
|-------|-----------------|--------------|-----------|-------------------------|--------|--------------------------|-------------------------------------|---------------------------------|
|       |                 | (dBi)        | (numeric) | (dBm)                   | (mW)   |                          |                                     |                                 |
| UHF   | 917~922.2       | 2.0          | 1.58      | 9.0                     | 7.94   | 20                       | 0.0025                              | 0.61                            |
| BT    | 2402-2480       | 3.4          | 2.19      | 9.0                     | 7.94   | 20                       | 0.0035                              | 1.0                             |
| BLE   | 2402-2480       | 3.4          | 2.19      | 7.0                     | 5.01   | 20                       | 0.0022                              | 1.0                             |
| Wi-Fi | 2412-2462       | 3.4          | 2.19      | 27.0                    | 501.19 | 20                       | 0.2183                              | 1.0                             |

Note: 1. EUT contains a certified BT/Wi-Fi module (FCC ID: 2AC7Z-ESP32WROVERE), the tune-up power of BT/BLE/Wi-Fi was refer to the module report.  
 2. the UHF and BT/BLE/Wi-Fi can transmit at the same time, the BT/BLE/Wi-Fi cannot transmit at the same time

#### Simultaneous transmitting consideration:

The ratio= $MPE_{Wi-Fi}/limit + MPE_{UHF}/limit = 0.2183/1 + 0.0025/0.61 = 0.2224 < 1.0$

So simultaneous exposure comply with the limit.

Note: To maintain compliance with the FCC's RF exposure guidelines, place the equipment at least 20cm from nearby persons.

#### Result: Compliance

## **FCC §15.203 - ANTENNA REQUIREMENT**

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### **Applicable Standard**

According to § 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 user of a standard antenna jack or electrical connector is prohibited. The structure and application of the EUT were analyzed to determine compliance with section §15.203 of the rules. §15.203 state that the subject device must meet the following criteria:

- a. Antenna must be permanently attached to the unit.
- b. Antenna must use a unique type of connector to attach to the EUT.

Unit must be professionally installed, and installer shall be responsible for verifying that the correct antenna is employed with the unit.

And according to FCC 47 CFR section 15.247 (b), if the transmitting antennas of directional gain greater than 6dBi are used, the power shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

### **Antenna Connector Construction**

The EUT has an internal antenna arrangement, which was permanently attached and the antenna gain is 2.0 dBi, fulfill the requirement of this section. Please refer to the EUT photos.

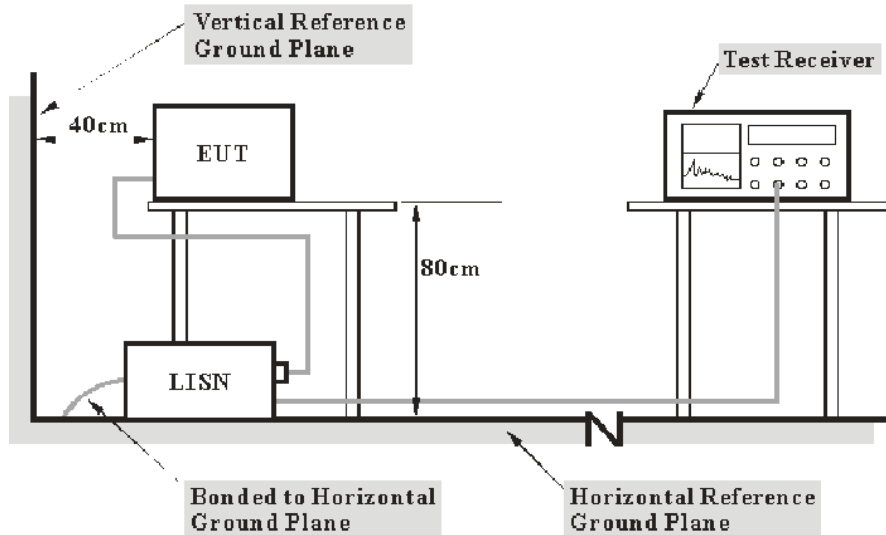
**Result:** Compliance.

**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.

The spacing between the peripherals was 10 cm.

**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 adapter 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 & Margin 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:

$$\text{Correction Factor} = \text{LISN VDF} + \text{Cable Loss} + \text{Transient Limiter Attenuation}$$

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

$$\text{Margin} = \text{Limit} - \text{Corrected Amplitude}$$

## Test Data

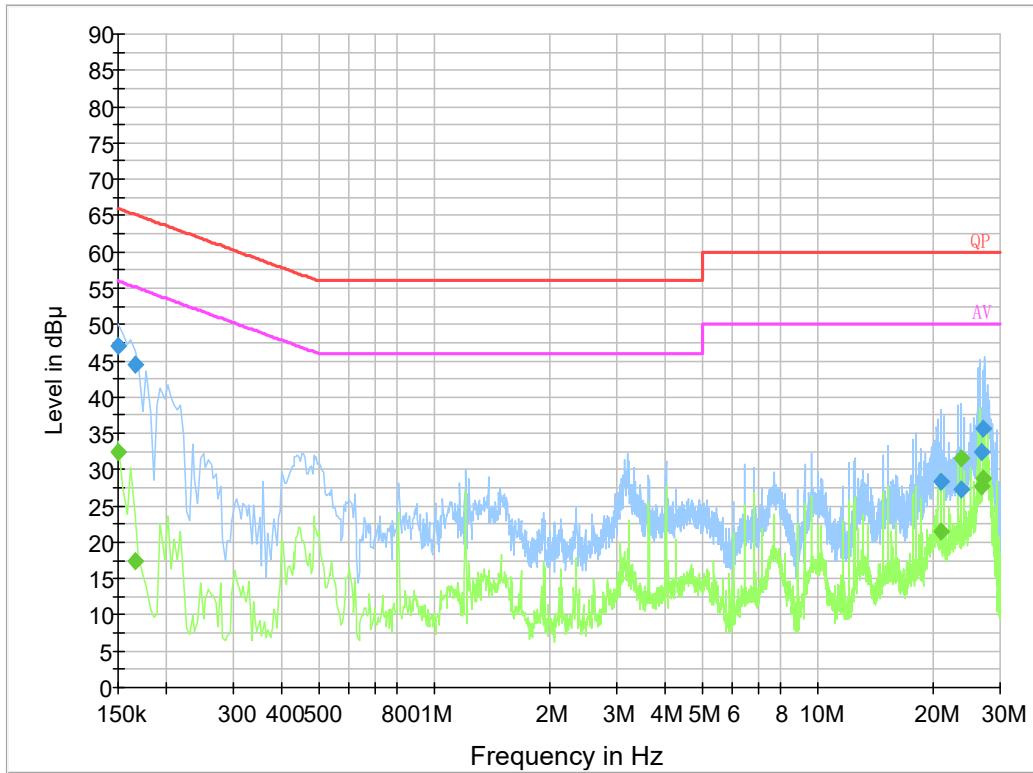
### Environmental Conditions

|                           |           |
|---------------------------|-----------|
| <b>Temperature:</b>       | 25°C      |
| <b>Relative Humidity:</b> | 70 %      |
| <b>ATM Pressure:</b>      | 101.0 kPa |

*The testing was performed by Haiguo Li on 2021-08-06.*

*EUT operation mode: Transmitting*

AC 120V/60 Hz, Line



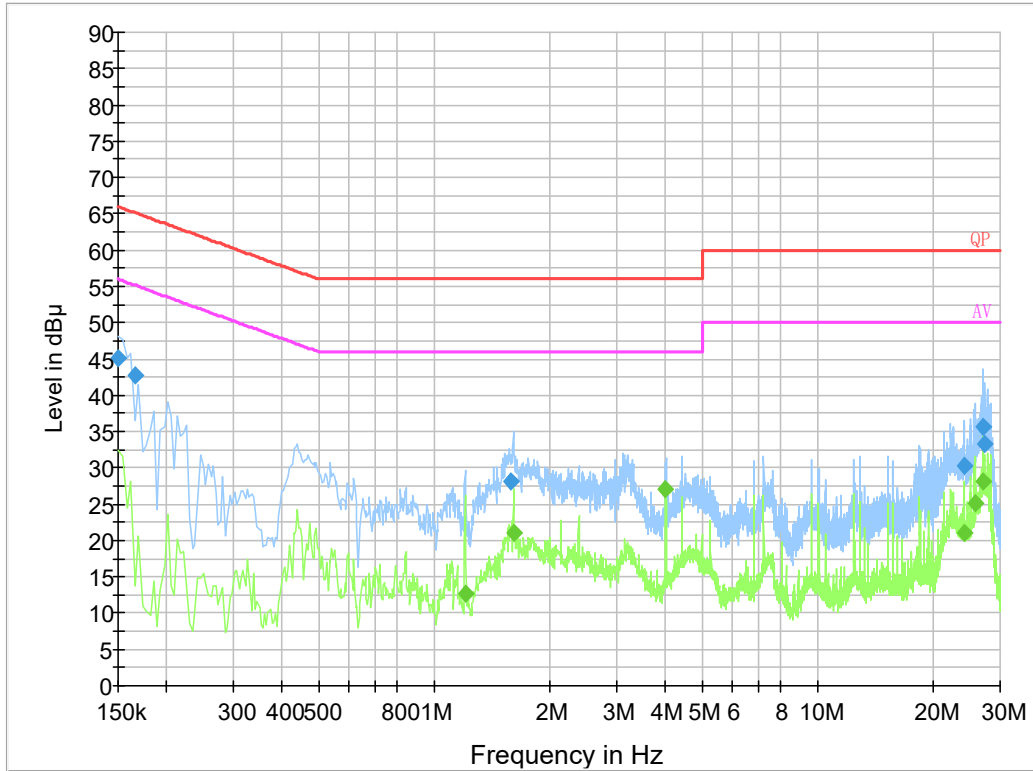
Final Result 1

| Frequency (MHz) | QuasiPeak (dB µ V) | Bandwidth (kHz) | Line | Corr. (dB) | Margin (dB) | Limit (dB µ V) |
|-----------------|--------------------|-----------------|------|------------|-------------|----------------|
| 0.150000        | 47.0               | 9.000           | L1   | 19.8       | 19.0        | 66.0           |
| 0.165500        | 44.5               | 9.000           | L1   | 19.9       | 20.6        | 65.2           |
| 20.951330       | 28.3               | 9.000           | L1   | 20.5       | 31.7        | 60.0           |
| 23.793090       | 27.4               | 9.000           | L1   | 20.3       | 32.6        | 60.0           |
| 26.738850       | 32.4               | 9.000           | L1   | 20.2       | 27.6        | 60.0           |
| 27.040050       | 35.6               | 9.000           | L1   | 20.2       | 24.4        | 60.0           |

Final Result 2

| Frequency (MHz) | Average (dB µ V) | Bandwidth (kHz) | Line | Corr. (dB) | Margin (dB) | Limit (dB µ V) |
|-----------------|------------------|-----------------|------|------------|-------------|----------------|
| 0.150000        | 32.4             | 9.000           | L1   | 19.8       | 23.6        | 56.0           |
| 0.165500        | 17.3             | 9.000           | L1   | 19.9       | 37.9        | 55.2           |
| 20.951330       | 21.4             | 9.000           | L1   | 20.5       | 28.6        | 50.0           |
| 23.793090       | 31.5             | 9.000           | L1   | 20.3       | 18.5        | 50.0           |
| 26.738850       | 27.7             | 9.000           | L1   | 20.2       | 22.3        | 50.0           |
| 27.040050       | 28.7             | 9.000           | L1   | 20.2       | 21.3        | 50.0           |

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



**Final Result 1**

| Frequency (MHz) | QuasiPeak (dB µ V) | Bandwidth (kHz) | Line | Corr. (dB) | Margin (dB) | Limit (dB µ V) |
|-----------------|--------------------|-----------------|------|------------|-------------|----------------|
| 0.150000        | 45.2               | 9.000           | N    | 19.8       | 20.8        | 66.0           |
| 0.165500        | 42.6               | 9.000           | N    | 19.8       | 22.5        | 65.2           |
| 1.593850        | 28.1               | 9.000           | N    | 19.8       | 27.9        | 56.0           |
| 24.231450       | 30.2               | 9.000           | N    | 20.3       | 29.8        | 60.0           |
| 27.012970       | 35.6               | 9.000           | N    | 20.2       | 24.4        | 60.0           |
| 27.254410       | 33.2               | 9.000           | N    | 20.2       | 26.8        | 60.0           |

**Final Result 2**

| Frequency (MHz) | Average (dB µ V) | Bandwidth (kHz) | Line | Corr. (dB) | Margin (dB) | Limit (dB µ V) |
|-----------------|------------------|-----------------|------|------------|-------------|----------------|
| 1.206000        | 12.6             | 9.000           | N    | 19.8       | 33.4        | 46.0           |
| 1.614000        | 21.0             | 9.000           | N    | 19.8       | 25.0        | 46.0           |
| 4.026000        | 27.0             | 9.000           | N    | 19.9       | 19.0        | 46.0           |
| 24.166000       | 21.1             | 9.000           | N    | 20.3       | 28.9        | 50.0           |
| 25.858000       | 25.2             | 9.000           | N    | 20.2       | 24.8        | 50.0           |
| 27.002000       | 28.1             | 9.000           | N    | 20.2       | 21.9        | 50.0           |



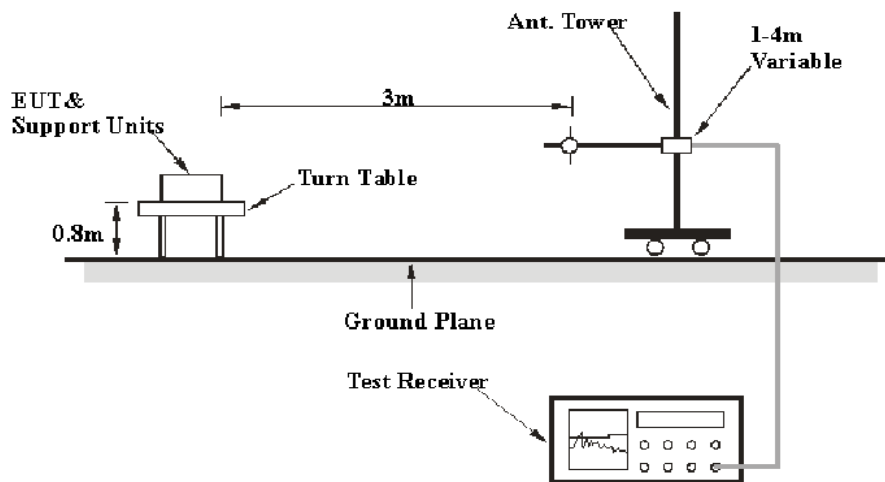
## FCC §15.209, §15.205 & §15.247(d) - SPURIOUS EMISSIONS

### Applicable Standard

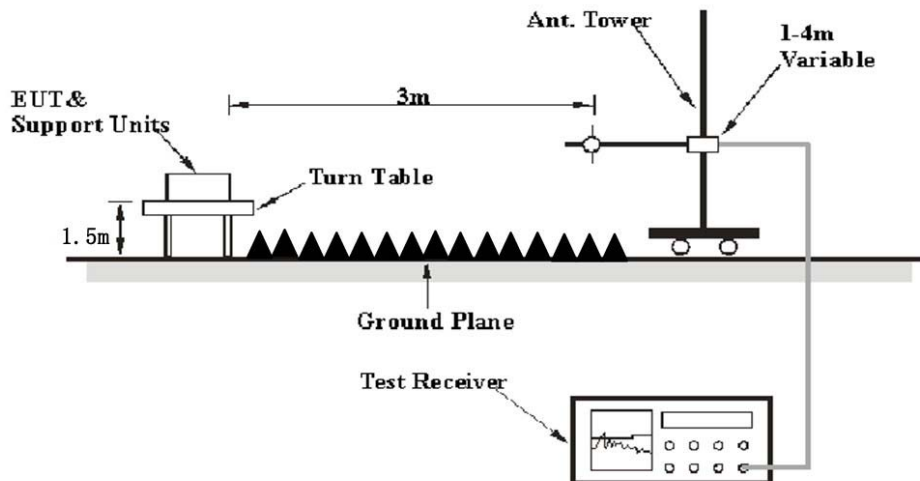
FCC §15.205; §15.209; §15.247(d)

### 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 & Spectrum Analyzer Setup

During the radiated emission test, the EMI test receiver & Spectrum Analyzer Setup were set with the following configurations:

| Frequency Range   | RBW     | Video B/W | IF B/W  | Measurement |
|-------------------|---------|-----------|---------|-------------|
| 30 MHz – 1000 MHz | 100 kHz | 300 kHz   | 120 kHz | QP          |
| Above 1 GHz       | 1 MHz   | 3 MHz     | /       | PK          |
|                   | 1 MHz   | 10 Hz     | /       | Average     |

## 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:

$$\text{Corrected Amplitude} = \text{Meter Reading} + \text{Antenna Factor} + \text{Cable Loss} - \text{Amplifier Gain}$$

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:

$$\text{Margin} = \text{Limit} - \text{Corrected Amplitude}$$

## Test Data

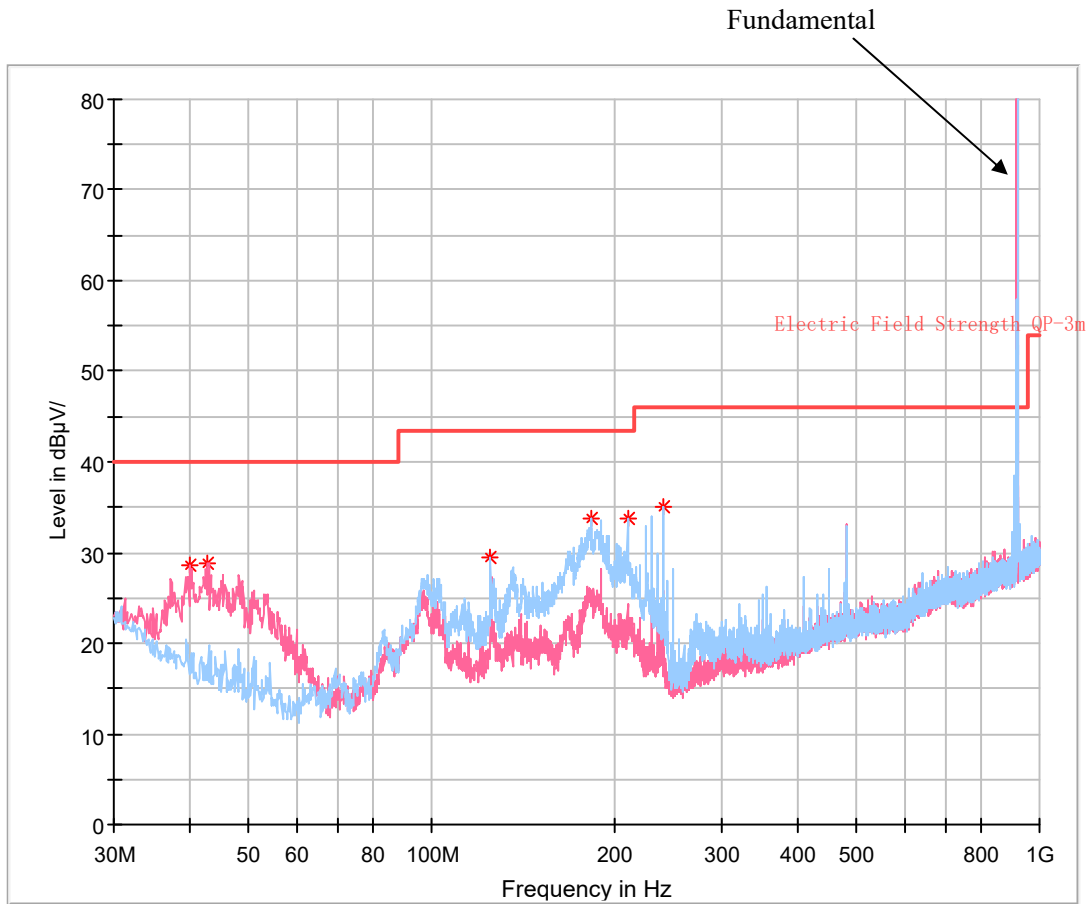
### Environmental Conditions

|                           |            |
|---------------------------|------------|
| <b>Temperature:</b>       | 25.8~26 °C |
| <b>Relative Humidity:</b> | 51~56 %    |
| <b>ATM Pressure:</b>      | 101 kPa    |

*The testing was performed by Cloud Qiu on 2021-08-06 for below 1GHz and Dio Ding on 2021-08-11 for above 1GHz.*

*EUT operation mode: Transmitting*

**30 MHz~1 GHz:**



**Critical Freqs**

| Frequency (MHz) | MaxPeak (dB µ V/m) | Limit (dB µ V/m) | Margin (dB) | Height (cm) | Pol | Azimuth (deg) | Corr. (dB) |
|-----------------|--------------------|------------------|-------------|-------------|-----|---------------|------------|
| 40.063750       | 28.51              | 40.00            | 11.49       | 100.0       | V   | 38.0          | -10.4      |
| 42.852500       | 28.84              | 40.00            | 11.16       | 100.0       | V   | 38.0          | -12.4      |
| 125.060000      | 29.37              | 43.50            | 14.13       | 200.0       | H   | 247.0         | -10.3      |
| 183.138750      | 33.69              | 43.50            | 9.81        | 100.0       | H   | 61.0          | -12.2      |
| 209.935000      | 33.77              | 43.50            | 9.73        | 200.0       | H   | 289.0         | -11.2      |
| 240.005000      | 35.05              | 46.00            | 10.95       | 100.0       | H   | 301.0         | -11.7      |

**1 GHz - 10 GHz:**

| Frequency<br>(MHz)              | Receiver                |                          | Turntable<br>Degree | Rx Antenna    |                | Corrected<br>Factor<br>(dB) | Corrected<br>Amplitude<br>(dB $\mu$ V/m) | FCC Part<br>15.247/205/209 |                |
|---------------------------------|-------------------------|--------------------------|---------------------|---------------|----------------|-----------------------------|--|----------------------------|----------------|
|                                 | Reading<br>(dB $\mu$ V) | Detector<br>(PK/QP/Ave.) |                     | Height<br>(m) | Polar<br>(H/V) |                             |  | Limit<br>(dB $\mu$ V/m)    | Margin<br>(dB) |
| <b>Low Channel (917MHz)</b>     |                         |                          |                     |               |                |                             |  |                            |                |
| 1834.00                         | 54.35                   | PK                       | 244                 | 1.1           | H              | -1.55                       | 52.80                                    | 74                         | 21.20          |
| 1834.00                         | 50.7                    | Ave.                     | 244                 | 1.1           | H              | -1.55                       | 49.15                                    | 54                         | 4.85           |
| 2751.00                         | 46.16                   | PK                       | 310                 | 2.5           | H              | 1.42                        | 47.58                                    | 74                         | 26.42          |
| 2751.00                         | 38.04                   | Ave.                     | 310                 | 2.5           | H              | 1.42                        | 39.46                                    | 54                         | 14.54          |
| 3668.00                         | 49.54                   | PK                       | 226                 | 1.4           | H              | 3.06                        | 52.60                                    | 74                         | 21.40          |
| 3668.00                         | 44.89                   | Ave.                     | 226                 | 1.4           | H              | 3.06                        | 47.95                                    | 54                         | 6.05           |
| <b>Middle Channel(916.6MHz)</b> |                         |                          |                     |               |                |                             |  |                            |                |
| 1839.20                         | 54.76                   | PK                       | 75                  | 1.7           | H              | -1.55                       | 53.21                                    | 74                         | 20.79          |
| 1839.20                         | 52.01                   | Ave.                     | 75                  | 1.7           | H              | -1.55                       | 50.46                                    | 54                         | 3.54           |
| 2758.80                         | 47.68                   | PK                       | 322                 | 1.0           | H              | 1.42                        | 49.10                                    | 74                         | 24.90          |
| 2758.80                         | 35.27                   | Ave.                     | 322                 | 1.0           | H              | 1.42                        | 36.69                                    | 54                         | 17.31          |
| 3678.40                         | 48.51                   | PK                       | 12                  | 1.8           | H              | 3.06                        | 51.57                                    | 74                         | 22.43          |
| 3678.40                         | 43.02                   | Ave.                     | 12                  | 1.8           | H              | 3.06                        | 46.08                                    | 54                         | 7.92           |
| <b>High Channel (922.2 MHz)</b> |                         |                          |                     |               |                |                             |  |                            |                |
| 1844.40                         | 54.35                   | PK                       | 212                 | 1.2           | H              | -1.55                       | 52.80                                    | 74                         | 21.20          |
| 1844.40                         | 52.05                   | Ave.                     | 212                 | 1.2           | H              | -1.55                       | 50.50                                    | 54                         | 3.50           |
| 2766.60                         | 47.51                   | PK                       | 242                 | 1.6           | H              | 1.42                        | 48.93                                    | 74                         | 25.07          |
| 2766.60                         | 38.51                   | Ave.                     | 242                 | 1.6           | H              | 1.42                        | 39.93                                    | 54                         | 14.07          |
| 3688.80                         | 47.85                   | PK                       | 305                 | 1.1           | H              | 3.16                        | 51.01                                    | 74                         | 22.99          |
| 3688.80                         | 42.42                   | Ave.                     | 305                 | 1.1           | H              | 3.16                        | 45.58                                    | 54                         | 8.42           |

**Note:**

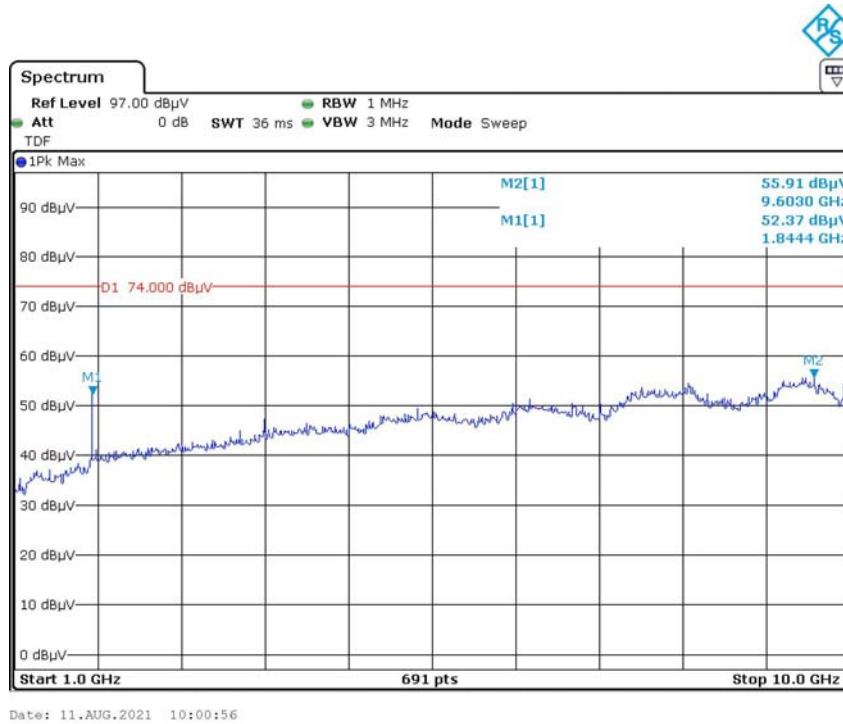
Corrected Factor = Antenna factor (RX) + Cable Loss – Amplifier Factor

Corrected Amplitude = Corrected Factor + Reading

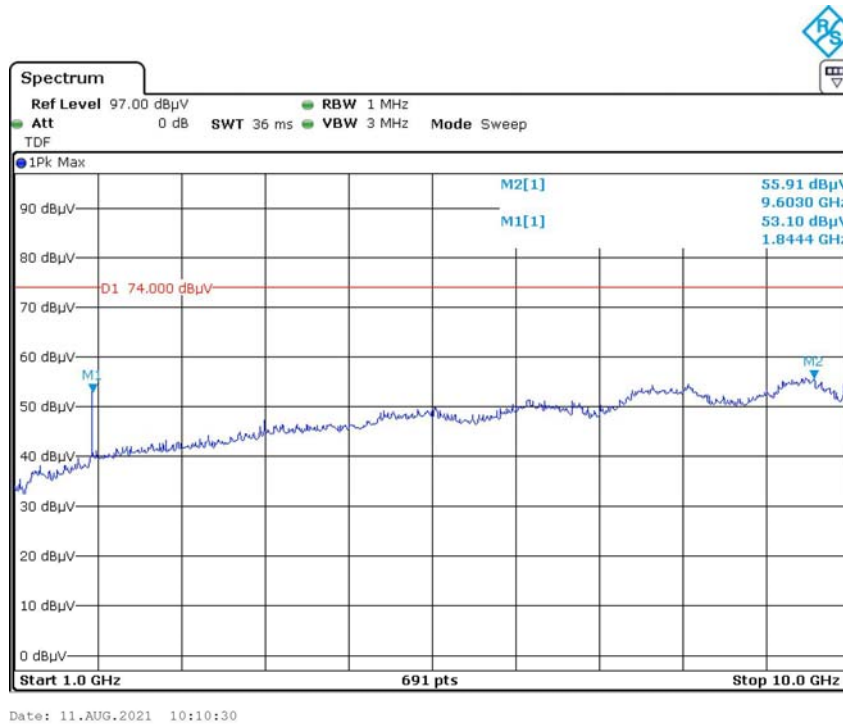
Margin = Limit - Corrected. Amplitude

The other spurious emission which is 20dB to the limit was not recorded.

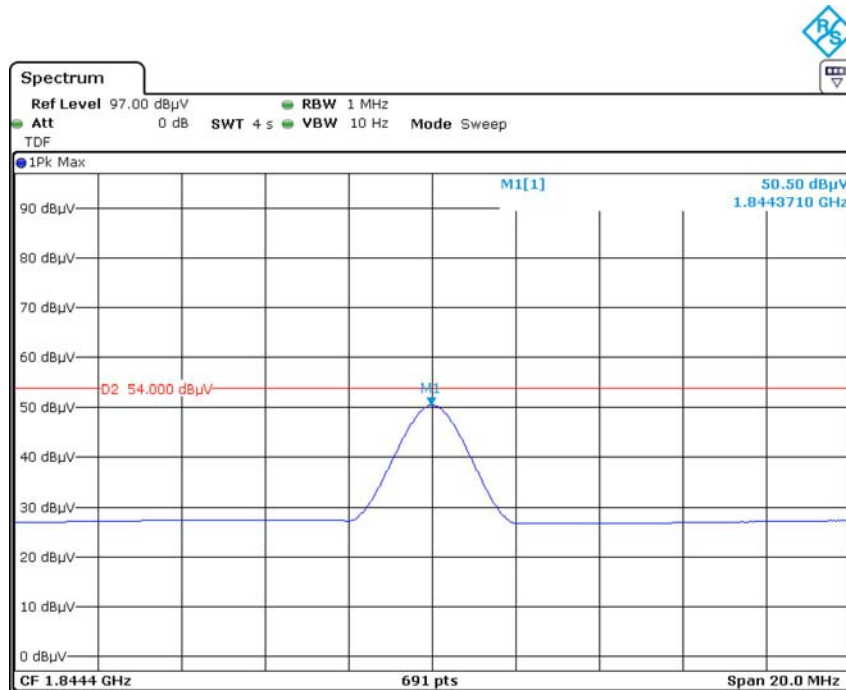
**Pre-scan with High channel for Peak Horizontal**



**Vertical**

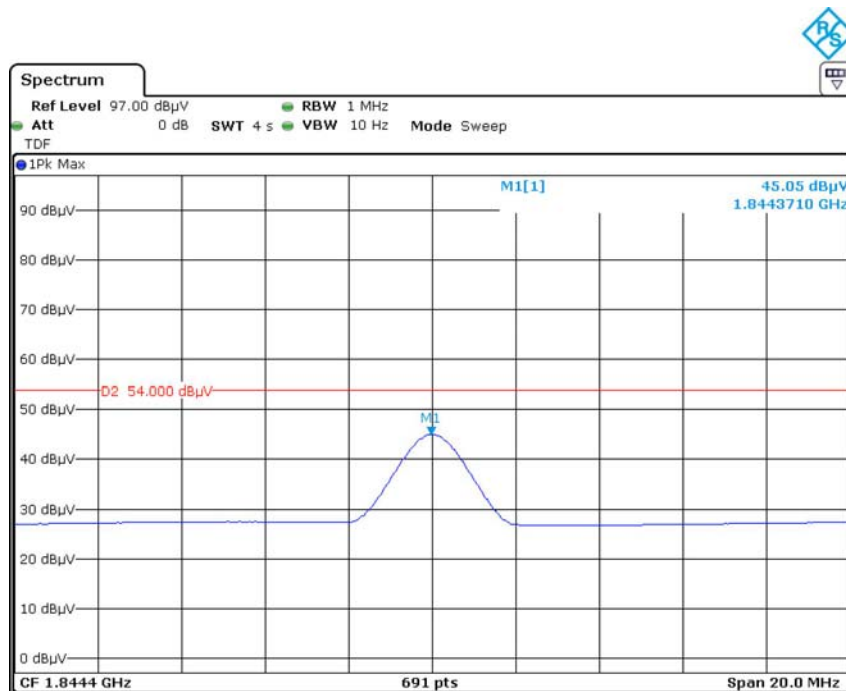


### Average Horizontal



Date: 11.AUG.2021 10:05:44

### Vertical



Date: 11.AUG.2021 10:14:37

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

### Applicable Standard

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. Alternatively, frequency hopping systems operating in the 2400-2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater provided the systems operate with an output power no greater than 125 mW.

### Test Procedure

1. Set the EUT in transmitting mode, maxhold the channel.
2. Set the adjacent channel of the EUT and maxhold another trace.
3. Measure the channel separation.

### Test Data

#### Environmental Conditions

|                           |           |
|---------------------------|-----------|
| <b>Temperature:</b>       | 29.4 °C   |
| <b>Relative Humidity:</b> | 53 %      |
| <b>ATM Pressure:</b>      | 110.0 kPa |

*The testing was performed by Pedro Yun on 2021-08-12.*

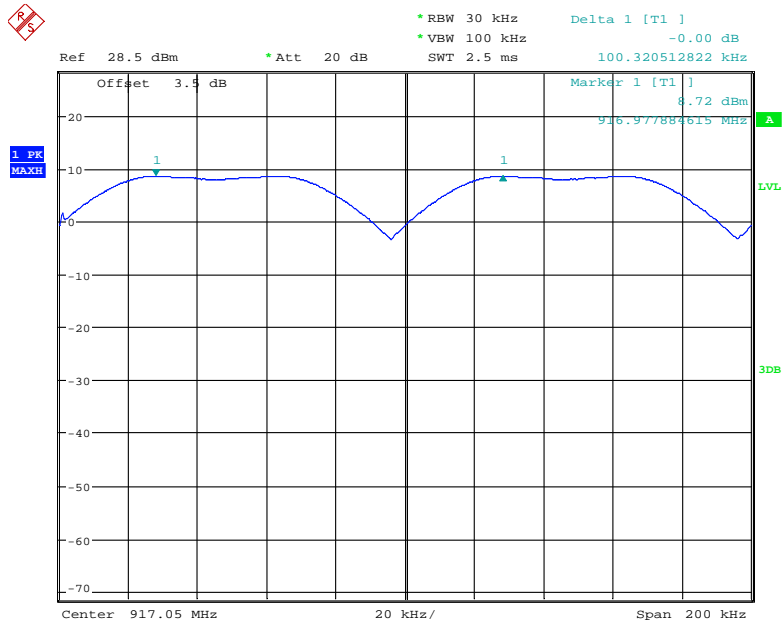
*EUT operation mode: Transmitting*

*Test Result: Compliance. Please refer to following table and plots*

| Mode | Channel  | Frequency (MHz) | Channel Separation (MHz) | 20dB Bandwidth (MHz) | Result |
|------|----------|-----------------|--------------------------|----------------------|--------|
| GFSK | Low      | 917             | 0.100                    | 0.068                | Pass   |
|      | Adjacent | 917.1           |                          |                      |        |
|      | Middle   | 919.6           | 0.100                    | 0.068                | Pass   |
|      | Adjacent | 919.7           |                          |                      |        |
|      | High     | 922.1           | 0.997                    | 0.069                | Pass   |
|      | Adjacent | 922.2           |                          |                      |        |

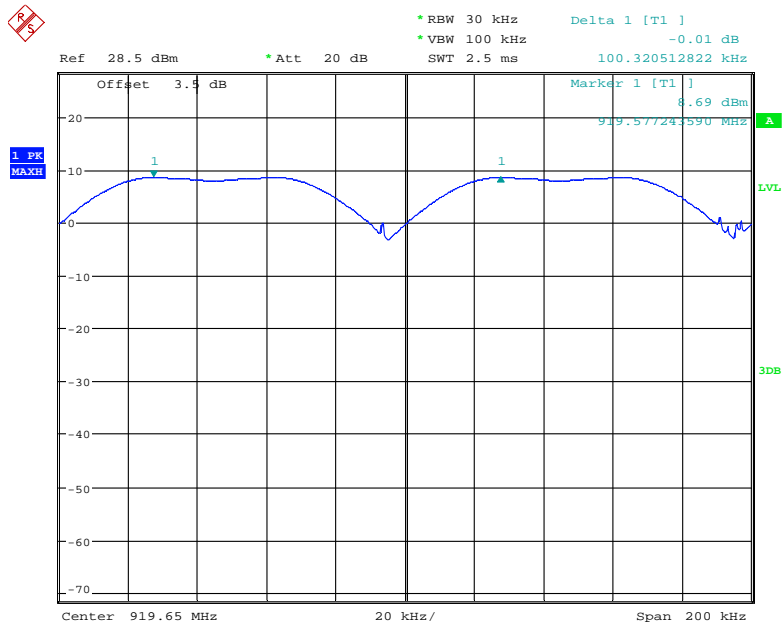
Limit:  $\geq 20$ dB bandwidth

### Low Channel



Date: 12.AUG.2021 22:03:24

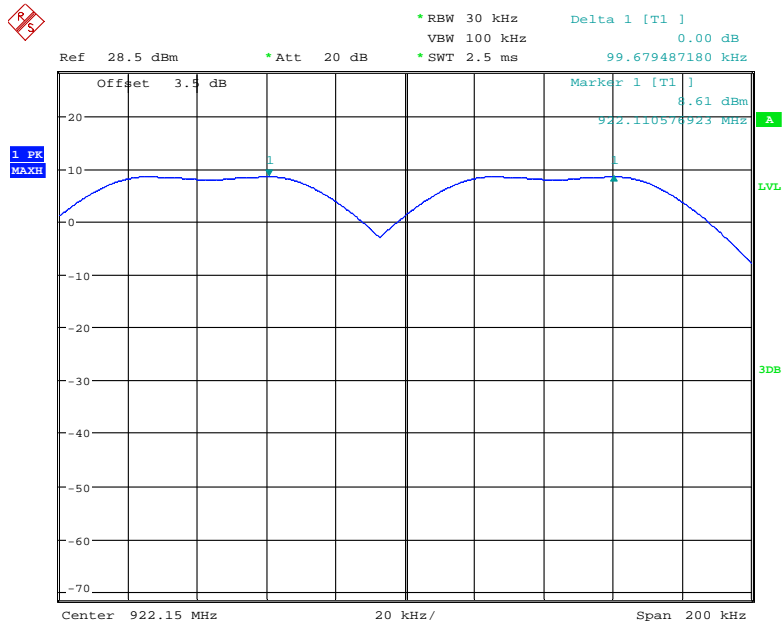
### Middle Channel



Date: 12.AUG.2021 22:05:52



### High Channel



Date: 12.AUG.2021 22:01:29

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

### Applicable Standard

According to §15.247(a) (1) (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

|                           |           |
|---------------------------|-----------|
| <b>Temperature:</b>       | 29.4 °C   |
| <b>Relative Humidity:</b> | 53 %      |
| <b>ATM Pressure:</b>      | 110.0 kPa |

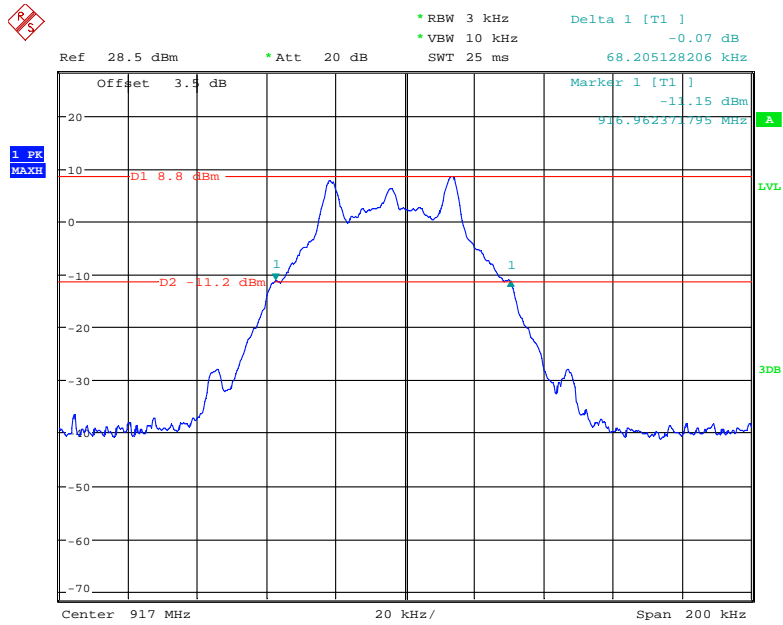
*The testing was performed by Pedro Yun on 2021-08-12.*

*EUT operation mode: Transmitting*

*Test Result: Compliance. Please refer to following table and plots.*

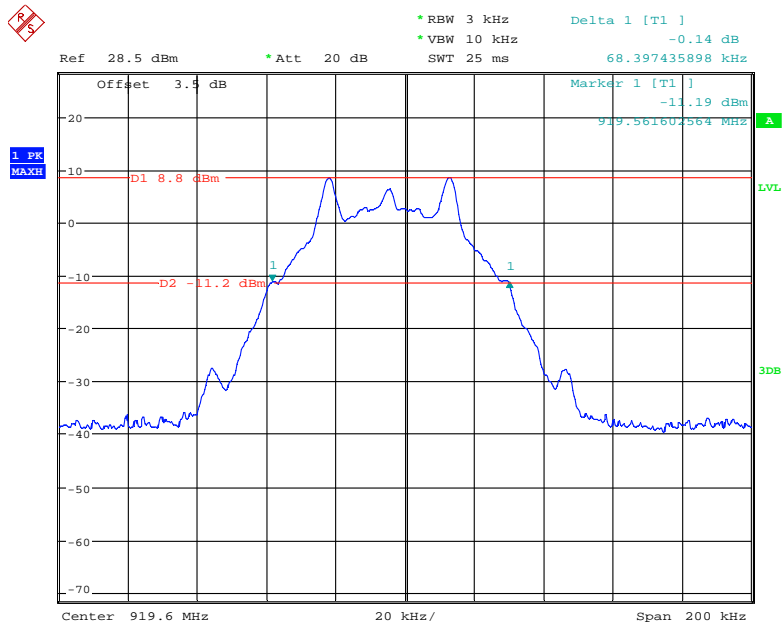
| Channel | Frequency (MHz) | 20 dB Emission Bandwidth (MHz) | Limit (MHz) |
|---------|-----------------|--------------------------------|-------------|
| Low     | 917.0           | 0.068                          | <0.25       |
| Middle  | 919.6           | 0.068                          | <0.25       |
| High    | 922.2           | 0.069                          | <0.25       |

### Low Channel



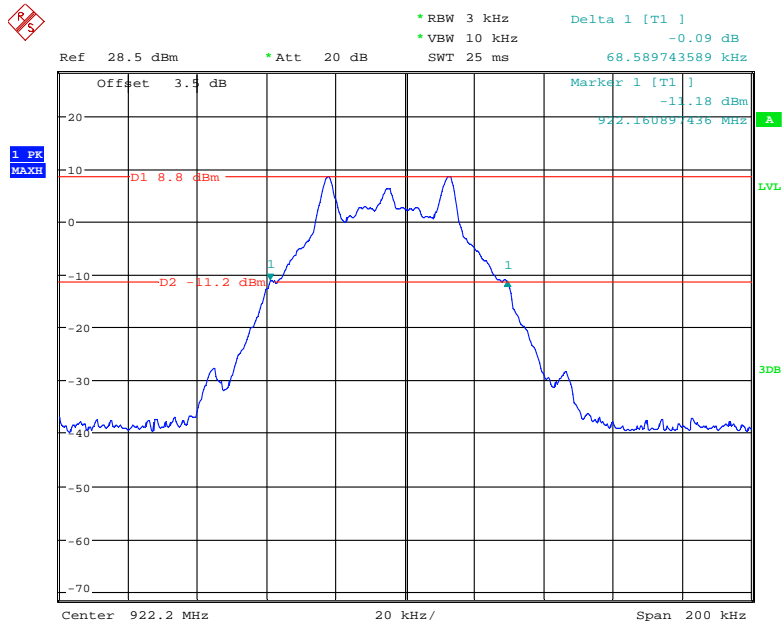
Date: 12.AUG.2021 21:48:16

### Middle Channel



Date: 12.AUG.2021 21:45:55

### High Channel



Date: 12.AUG.2021 21:36:38

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

### **Applicable Standard**

According to §15.247(a) (1) (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 (SA) using either an internal calibrator or a known signal from an external generator.
2. Set the EUT in hopping mode from first channel to last.
3. By using the max-hold function record the quantity of the channel.

### **Test Data**

#### **Environmental Conditions**

|                           |           |
|---------------------------|-----------|
| <b>Temperature:</b>       | 29.4 °C   |
| <b>Relative Humidity:</b> | 53 %      |
| <b>ATM Pressure:</b>      | 110.0 kPa |

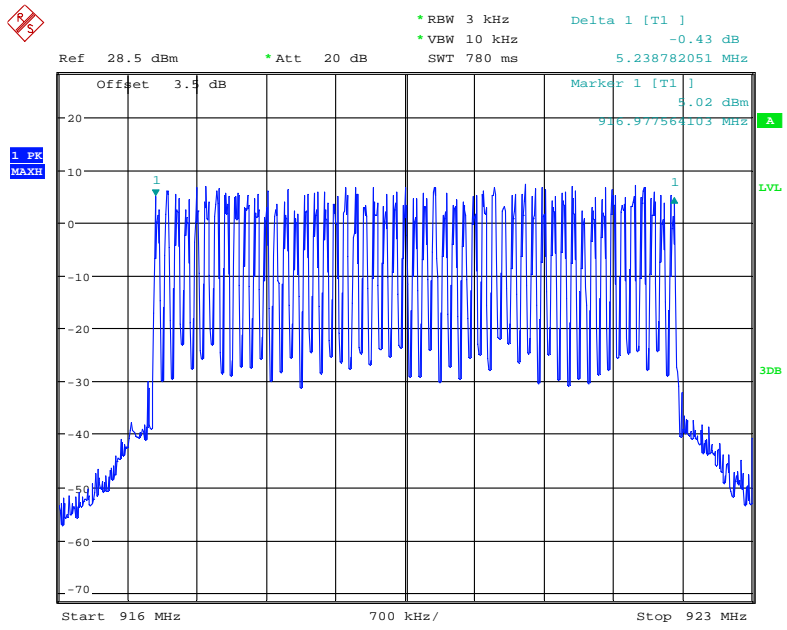
*The testing was performed by Pedro Yun on 2021-08-12.*

*EUT operation mode: Transmitting*

*Test Result: Compliance. Please refer to following table and plots.*

| <b>Mode</b> | <b>Frequency Range (MHz)</b> | <b>Number of Hopping Channel (CH)</b> | <b>Limit (CH)</b> |
|-------------|------------------------------|---------------------------------------|-------------------|
| Hopping     | 902-928                      | 53                                    | ≥50               |

### Number of Hopping Channels



Date: 12.AUG.2021 22:15:44

## **FCC §15.247(a) (1) (i) - TIME OF OCCUPANCY (DWELL TIME)**

### **Applicable Standard**

According to §15.247(a) (1) (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: Zero span, centered on a hopping channel.
- b) RBW shall be  $\leq$  channel spacing and where possible RBW should be set  $\gg 1 / T$ , 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.

Use the marker-delta function to determine the transmit time per hop. If this value varies with different modes of operation (data rate, modulation format, number of hopping channels, etc.), then repeat this test for each variation in transmit time.

Repeat the measurement using a longer sweep time to determine the number of hops over the period specified in the requirements. The sweep time shall be equal to, or less than, the period specified in the requirements. Determine the number of hops over the sweep time and calculate the total number of hops in the period specified in the requirements, using the following equation:

$$\begin{aligned} & \text{(Number of hops in the period specified in the requirements)} = \\ & \text{(number of hops on spectrum analyzer)} \times \text{(period specified in the requirements / analyzer sweep time)} \end{aligned}$$

The average time of occupancy is calculated from the transmit time per hop multiplied by the number of hops in the period specified in the requirements. If the number of hops in a specific time varies with different modes of operation (data rate, modulation format, number of hopping channels, etc.), then repeat this test for each variation.

**Test Data****Environmental Conditions**

|                           |           |
|---------------------------|-----------|
| <b>Temperature:</b>       | 29.4 °C   |
| <b>Relative Humidity:</b> | 53 %      |
| <b>ATM Pressure:</b>      | 101.0 kPa |

*The testing was performed by Pedro Yun on 2021-08-12.*

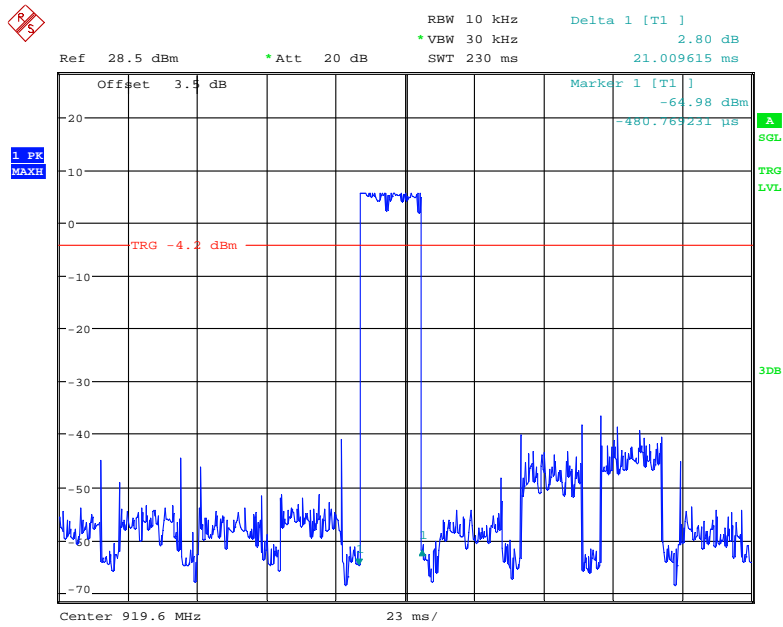
*EUT operation mode: Transmitting*

*Test Result: Compliance. Please refer to following table and plots.*

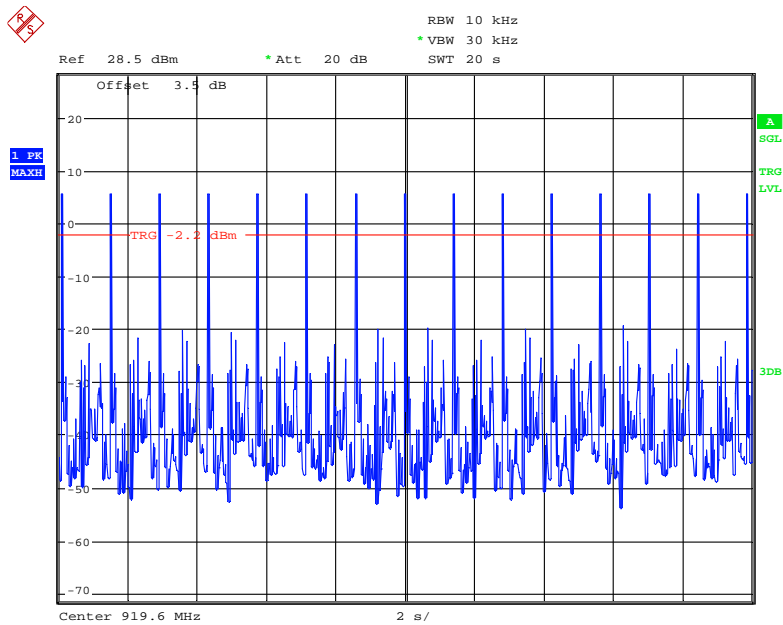
| <b>Frequency (MHz)</b> | <b>Pulse Time (ms)</b> | <b>Hopping Number</b> | <b>Period Time (s)</b> | <b>Total of Dwell (ms)</b> | <b>Limit (ms)</b> | <b>Result</b> |
|------------------------|------------------------|-----------------------|------------------------|----------------------------|-------------------|---------------|
| 919.6                  | 21.01                  | 15                    | 20                     | 315.15                     | <400              | Pass          |



### Pulse time



Date: 12.AUG.2021 22:20:53



Date: 12.AUG.2021 22:24:01

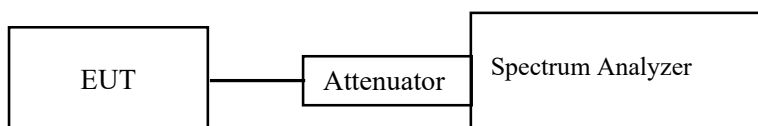
## FCC §15.247(b) (2) - MAXIMUM CONDUCTED OUTPUT POWER

### Applicable Standard

According to FCC §15.247(b) (2), For frequency hopping systems operating in the 902-928 MHz band: 1 watt for systems employing at least 50 hopping channels; and, 0.25 watts for systems employing less than 50 hopping channels, but at least 25 hopping channels, as permitted under paragraph (a)(1)(i) of this section.

### Test Procedure

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 a correction factor to the display.



### Test Data

#### Environmental Conditions

|                           |           |
|---------------------------|-----------|
| <b>Temperature:</b>       | 29.4 °C   |
| <b>Relative Humidity:</b> | 53 %      |
| <b>ATM Pressure:</b>      | 110.0 kPa |

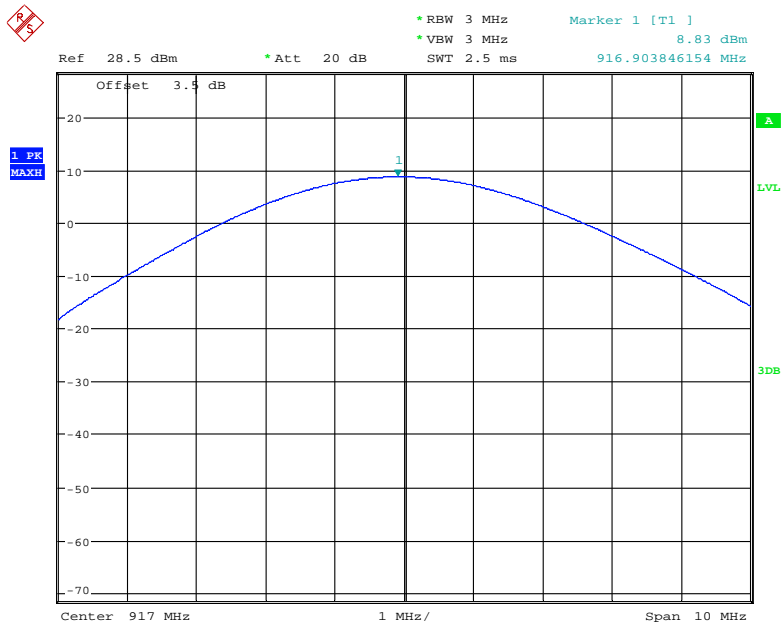
*The testing was performed by Pedro Yun on 2021-08-12.*

*Test Result: Compliance. Please refer to following table and plots.*

*EUT operation mode: Transmitting*

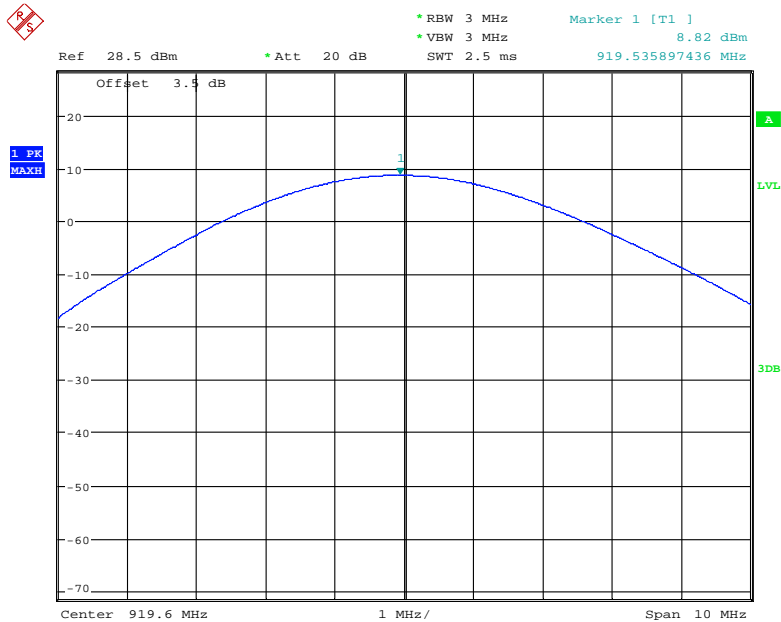
| Mode        | Channel | Frequency (MHz) | Reading power (dBm) | Limit (dBm) |
|-------------|---------|-----------------|---------------------|-------------|
| <b>GFSK</b> | Low     | 917.0           | 8.83                | 30          |
|             | Middle  | 919.6           | 8.82                | 30          |
|             | High    | 922.2           | 8.78                | 30          |

### Low Channel



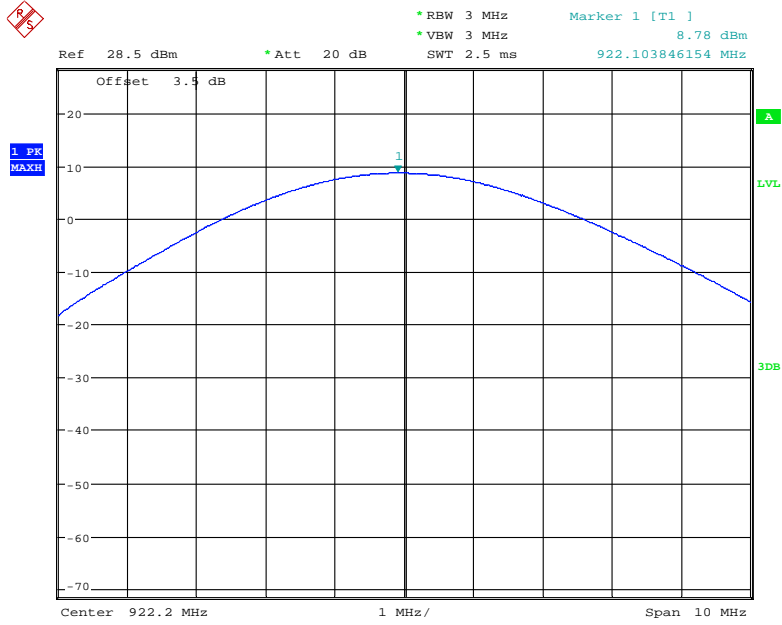
Date: 12.AUG.2021 21:31:05

### Middle Channel



Date: 12.AUG.2021 21:32:39

### High Channel



Date: 12.AUG.2021 21:33:37

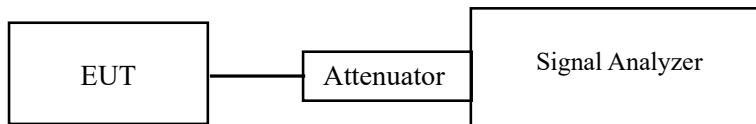
## FCC §15.247(d) – 100 kHz BANDWIDTH OF FREQUENCY BAND EDGE

### 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. Position the EUT without connection to measurement instrument. Turn on the EUT and connect its antenna terminal to measurement instrument via a low loss cable. Then set it to any one measured frequency within its operating range, and make sure the instrument is operated in its linear range.
3. Set RBW to 100 kHz and VBW of spectrum analyzer to 300 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

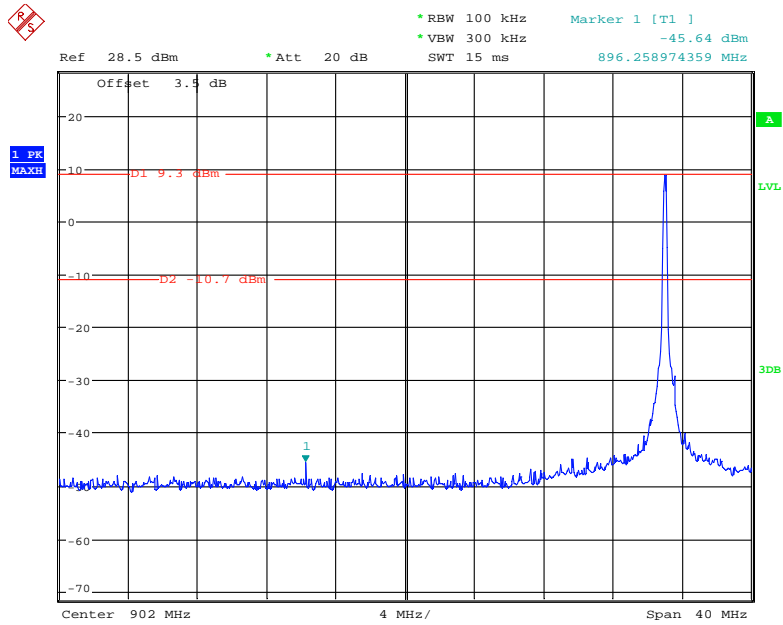
|                           |           |
|---------------------------|-----------|
| <b>Temperature:</b>       | 29.4 °C   |
| <b>Relative Humidity:</b> | 53 %      |
| <b>ATM Pressure:</b>      | 110.0 kPa |

*The testing was performed by Pedro Yun on 2021-08-12.*

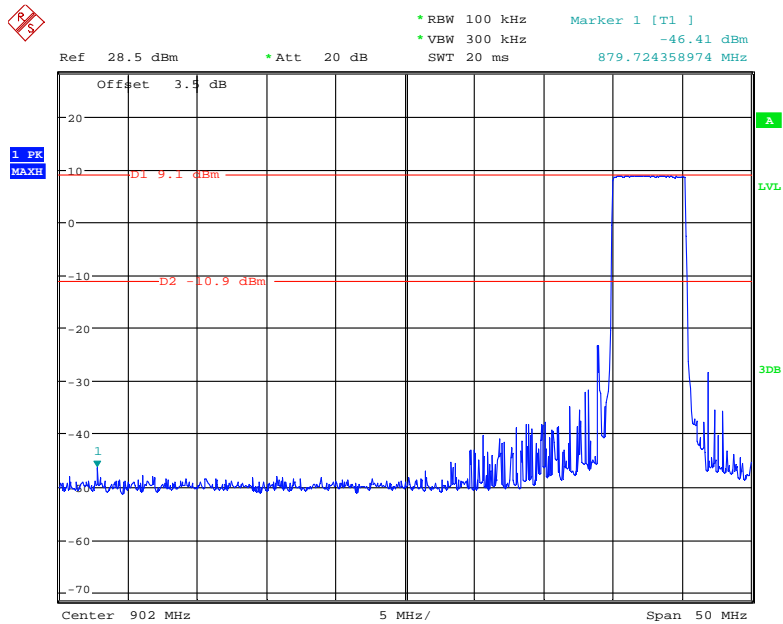
*Test Result: Compliance. Please refer to following table and plots.*

*EUT operation mode: Transmitting*

### Band Edge, Left Side

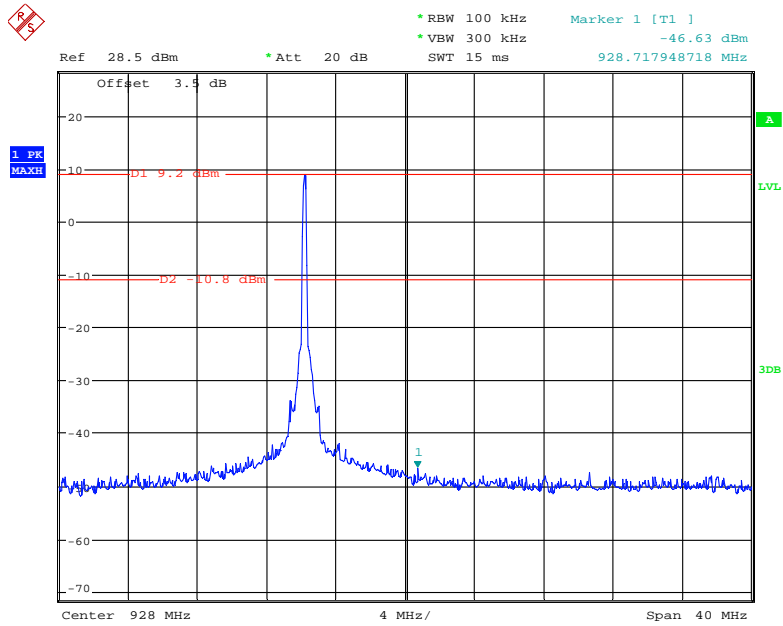


Date: 12.AUG.2021 21:50:10

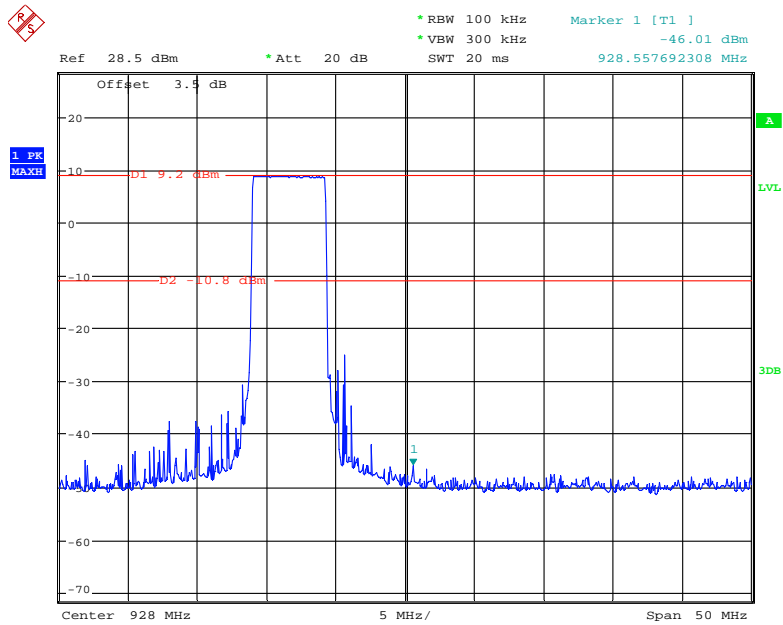


Date: 12.AUG.2021 21:58:48

### Band Edge, Right Side



Date: 12.AUG.2021 21:53:10



Date: 12.AUG.2021 21:54:27

\*\*\*\* END OF REPORT \*\*\*\*