

Shenzhen Honeycomb Technologies Company Limited

TEST REPORT

SCOPE OF WORK

FCC Testing – HRF24B21AN

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Shenzhen Honeycomb Technologies Company Limited

Application For Certification

FCC ID: 2AAUWHRF24B21AN

RF 2.4G Module

Model: HRF24B21AN

Honeycomb

2.4GHz Transmitter

Report No.: 210128011SZN-001

We hereby certify that the sample of the above item is considered to comply with the
requirements of FCC Part 15, Subpart C for Intentional Radiator,
mention 47 CFR [10-1-19]

Prepared and Checked by:

Approved by:

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Engineer

Kidd Yang
Technical Supervisor
Date: 03 March 2021

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MEASUREMENT/TECHNICAL REPORT

This report concerns (check one): Original Grant X Class II Change

Equipment Type: DXX - Part 15 Low Power Communication Device Transmitter

Deferred grant requested per 47 CFR 0.457(d)(1)(ii)? Yes _____ No X

If yes, defer until: _____
date

Company Name agrees to notify the Commission by: _____
date
of the intended date of announcement of the product so that the grant can be issued on that date.

Transition Rules Request per 15.37? Yes _____ No X

If no, assumed Part 15, Subpart C for intentional radiator – the new 47 CFR [10-1-19 Edition] provision.

Report prepared by:

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1.0 Summary of Test Result

Applicant: Shenzhen Honeycomb Technologies Company Limited
 Address: Floor 4th, Building 7, Xinhe XinXing Industrial Park, Block 3A, Fuyong Town, Bao'an District, Shenzhen, China
 Manufacturer: Shenzhen Honeycomb Technologies Company Limited
 Address: Floor 4th, Building 7, Xinhe XinXing Industrial Park, Block 3A, Fuyong Town, Bao'an District, Shenzhen, China

Model: HRF24B21AN

FCC ID: 2AAUWHRF24B21AN

| Test Specification | Reference | Results |
|--|------------------------|---------|
| Transmitter Radiated Emission Bandedge | 15.249 &15.209 &15.205 | Pass |
| 20dB Bandwidth | 15.215(c) | Pass |

Notes: The EUT uses an Integral Antenna which in accordance to Section 15.203 is considered sufficient to comply with the provisions of this section.

2.0 General Description

2.1 Product Description

The equipment under test (EUT) is a RF 2.4G Module with 2.4GHz transmitter function operating at 2.4G Band. The EUT is powered by DC 3.3V. For more detail information pls. refer to the user manual.

Antenna Type: PCB antenna

Modulation Type: O-QPSK

Antenna Gain: 0dBi

For electronic filing, the brief circuit description is saved with filename: descri.pdf.

2.2 Related Submittal(s) Grants

This is an application for certification of transceiver for the RF 2.4G Module which has 2.4GHz Transmitter Function.

2.3 Test Methodology

Radiated emission measurements were performed according to the procedures in ANSI C63.10 (2013). Radiated emission measurement was performed in Semi-anechoic chamber. For radiated emission measurement, preliminary scans were performed in the semi-anechoic chamber only to determine the worst-case modes. All radiated tests were performed at an antenna to EUT distance of 3 meters, unless stated otherwise in the "**Justification Section**" of this Application. All other measurements were made in accordance with the procedures in part 2 of CFR 47.

2.4 Test Facility

The Semi-Anechoic chamber used to collect the radiated data is **Intertek Testing Services Shenzhen Ltd. Longhua Branch** and located at 101, 201, Building B, No. 308 Wuhe Avenue, Zhangkengjing Community, GuanHu Subdistrict, LongHua District, ShenZhen, P.R. China. This test facility and site measurement data have been fully placed on file with the FCC (Registration Number: CN1188).

3.0 System Test Configuration

3.1 Justification

The system was configured for testing in a typical fashion (as a customer would normally use it), and in the confines as outlined in ANSI C63.10 (2013).

The EUT was powered by DC 3V during the test, only the worst case data is recorded in this report.

For maximizing emissions below 30 MHz, the EUT was rotated through 360°, the centre of the loop antenna was placed 1 meter above the ground, and the antenna polarization was changed. For maximizing emissions, the EUT was rotated through 360°, the antenna height was varied from 1 meter to 4 meters above the ground plane, and the antenna polarization was changed. This step by step procedure for maximizing emissions led to the data reported in Section 4.

The EUT was operated standalone and placed in the central of the turntable.

The equipment under test (EUT) was configured for testing in a typical fashion (as a customer would normally use it). The EUT was placed on a turn table, which enabled the engineer to maximize emissions through its placement in the three orthogonal axes.

3.2 EUT Exercising Software

There was no special software to exercise the device.

3.3 Special Accessories

N/A

3.4 Equipment Modification

Any modifications installed previous to testing by Shenzhen Honeycomb Technologies Company Limited will be incorporated in each production model sold / leased in the United States.

No modifications were installed by Intertek Testing Services Shenzhen Ltd Longhua Branch.

3.5 Measurement Uncertainty

When determining the test conclusion, the Measurement Uncertainty of test has been considered.

3.6 Support Equipment List and Description

| Description | Manufacturer | Model No. |
|---------------------------------------|---|-----------|
| Test Board (Provided by Applicant) | Shenzhen Honeycomb Technologies Company Limited | N/A |

4.0 Emission Results

Data is included worst-case configuration (the configuration which resulted in the highest emission levels).

4.1 Radiated Test Results

A sample calculation, configuration photographs and data tables of the emissions are included.

4.1.1 Field Strength Calculation

The field strength is calculated by adding the reading on the Spectrum Analyzer to the factors associated with preamplifiers (if any), antennas, cables, pulse desensitization and average factors (when specified limit is in average and measurements are made with peak detectors). A sample calculation is included below.

$$FS = RA + AF + CF - AG + PD + AV$$

Where FS = Field Strength in dBμV/m
 RA = Receiver Amplitude (including preamplifier) in dBμV
 CF = Cable Attenuation Factor in dB
 AF = Antenna Factor in dB
 AG = Amplifier Gain in dB
 PD = Pulse Desensitization in dB
 AV = Average Factor in -dB

In the radiated emission table which follows, the reading shown on the data table may reflect the preamplifier gain. An example of the calculations, where the reading does not reflect the preamplifier gain, follows:

$$FS = RA + AF + CF - AG + PD + AV$$

Assume a receiver reading of 62.0 dBμV is obtained. The antenna factor of 7.4 dB and cable factor of 1.6 dB is added. The amplifier gain of 29 dB is subtracted. The pulse desensitization factor of the spectrum analyzer was 0 dB, and the resultant average factor was -10 dB. The net field strength for comparison to the appropriate emission limit is 32 dBμV/m. This value in dBμV/m was converted to its corresponding level in μV/m.

RA = 62.0 dBμV
AF = 7.4 dB
CF = 1.6 dB
AG = 29.0 dB
PD = 0 dB
AV = -10 dB
FS = 62 + 7.4 + 1.6 - 29 + 0 = 42 dBμV/m

Level in μV/m = Common Antilogarithm [(42 dBμV/m)/20] = 125.9 μV/m

4.1.2 Radiated Emission Configuration Photograph

For electronic filing, the worst case radiated emission configuration photograph is saved with filename: radiated photos. pdf.

4.1.3 Radiated Emissions

The data on the following page lists the significant emission frequencies, the limit and the margin of compliance. Numbers with a minus sign are below the limit.

Worst Case Radiated Emission
at
900.542667 MHz

Judgement: Passed by 10.6 dB

TEST PERSONNEL:

Sign on file

Ryan Chen, Engineer
Typed/Printed Name

26 February 2021
Date

Applicant: Shenzhen Honeycomb Technologies Company Limited

Date of Test: 26 February 2021

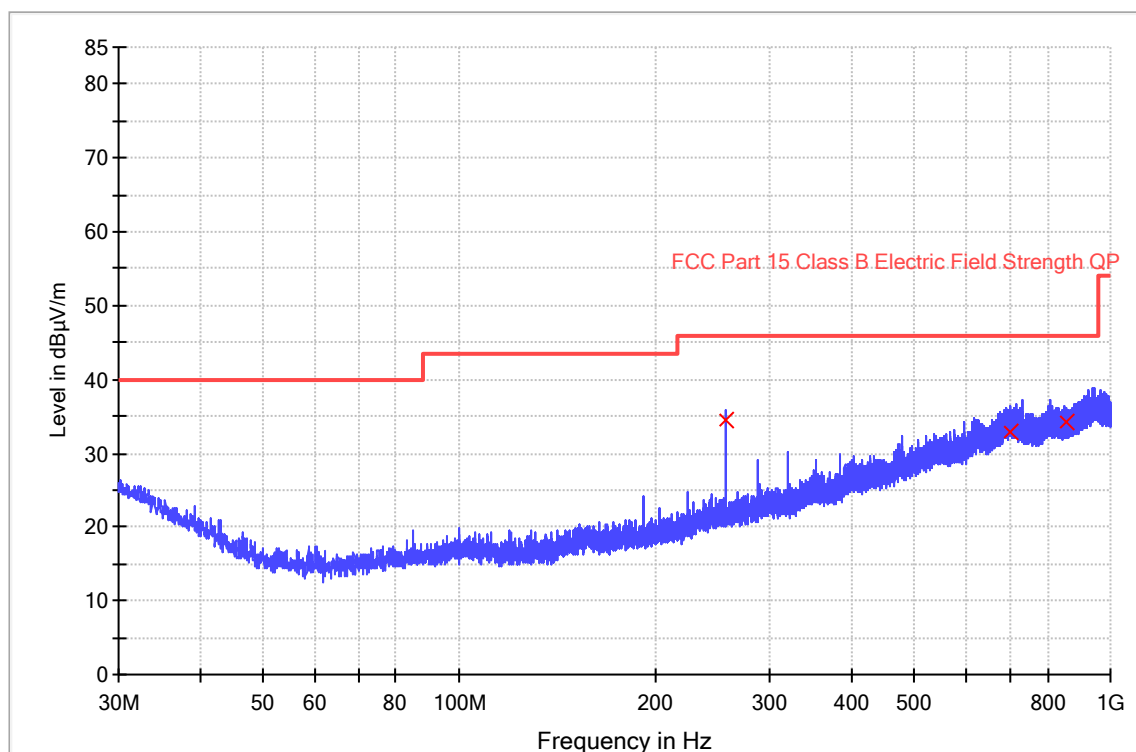
Model: HRF24B21AN

Worst Case Operating Mode:

Transmitting(2430MHz)

ANT Polarity: Horizontal

FCC Part 15



| Frequency (MHz) | QuasiPeak (dBμV/m) | Meas. Time (ms) | Bandwidth (kHz) | Height (cm) | Polarization | Corr. (dB) | Margin - QPK (dB) | Limit - QPK (dBμV/m) |
|-----------------|--------------------|-----------------|-----------------|-------------|--------------|------------|-------------------|----------------------|
| 256.010000 | 34.4 | 1000.0 | 120.000 | 0.0 | H | 14.3 | 11.6 | 46.0 |
| 701.466333 | 32.8 | 1000.0 | 120.000 | 0.0 | H | 25.5 | 13.2 | 46.0 |
| 857.216000 | 34.2 | 1000.0 | 120.000 | 0.0 | H | 25.6 | 11.8 | 46.0 |

Remark:

1. Corr. = Antenna Factor (dB/m) + Cable Loss (dB)
2. QuasiPeak (dBμV/m)= Corr. (dB/m)+ Read Level (dBμV)
3. Margin (dB) = Limit Line(dBμV/m) – Level (dBμV/m)

Applicant: Shenzhen Honeycomb Technologies Company Limited

Date of Test: 26 February 2021

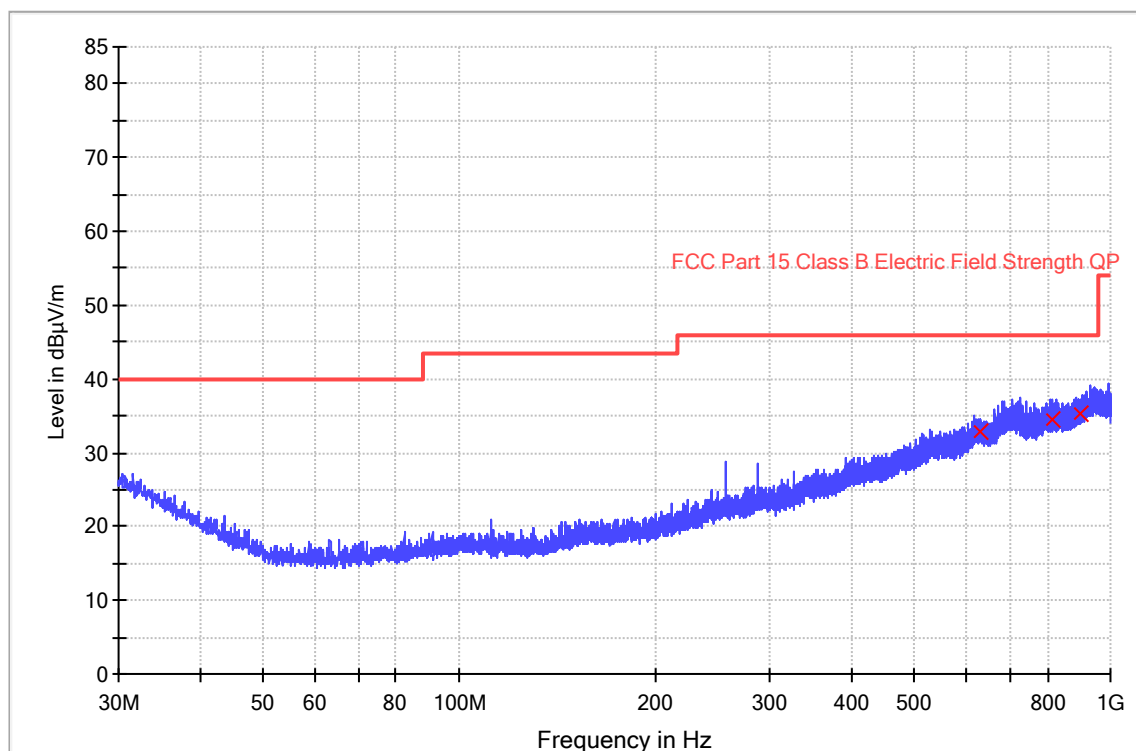
Model: HRF24B21AN

Worst Case Operating Mode:

Transmitting(2430MHz)

ANT Polarity: Vertical

FCC Part 15



| Frequency (MHz) | QuasiPeak (dBμV/m) | Meas. Time (ms) | Bandwidth (kHz) | Height (cm) | Polarization | Corr. (dB) | Margin - QPK (dB) | Limit - QPK (dBμV/m) |
|-----------------|--------------------|-----------------|-----------------|-------------|--------------|------------|-------------------|----------------------|
| 629.686333 | 32.8 | 1000.0 | 120.000 | 0.0 | V | 24.1 | 13.2 | 46.0 |
| 812.757667 | 34.4 | 1000.0 | 120.000 | 0.0 | V | 26.1 | 11.6 | 46.0 |
| 900.542667 | 35.4 | 1000.0 | 120.000 | 0.0 | V | 26.7 | 10.6 | 46.0 |

Remark:

1. Corr. = Antenna Factor (dB/m) + Cable Loss (dB)
2. QuasiPeak (dBμV/m) = Corr. (dB/m) + Read Level (dBμV)
3. Margin (dB) = Limit Line(dBμV/m) – Level (dBμV/m)

4.1.4 Transmitter Spurious Emissions (Radiated)

Worst Case Radiated Emission
at
2388.764 MHz

For electronic filing, the worst case radiated emission configuration photograph is saved with filename: radiated photos. pdf.

The data on the following page lists the significant emission frequencies, the limit and the margin of compliance. Numbers with a minus sign are below the limit.

Judgement: Passed by 4.8 dB

TEST PERSONNEL:

Sign on file

Ryan Chen, Engineer
Typed/Printed Name

26 February 2021
Date

Applicant: Shenzhen Honeycomb Technologies Company Limited
Date of Test: 26 February 2021 Model: HRF24B21AN
Worst Case Operating Mode: Transmitting

Table 1

Radiated Emissions
(2430.000 MHz)

| Polarization | Frequency (MHz) | Reading (dBμV) | Pre-Amp Gain (dB) | Antenna Factor (dB) | Net at 3m (dBμV/m) | Peak Limit at 3m (dBμV/m) | Margin (dB) |
|--------------|-----------------|----------------|-------------------|---------------------|--------------------|---------------------------|-------------|
| Vertical | 2430MHz | 94.6 | 36.7 | 28.4 | 86.3 | 114.0 | -27.7 |
| Vertical | 4860.000 | 64.3 | 36.7 | 35.0 | 62.6 | 74.0 | -11.4 |
| Vertical | 7290.000 | 66.0 | 36.8 | 36.2 | 65.4 | 74.0 | -8.6 |

| Polarization | Frequency (MHz) | Reading (dBμV) | Pre-Amp Gain (dB) | Antenna Factor (dB) | Average Factor (-dB) | Net at 3m (dBμV/m) | Average Limit at 3m (dBμV/m) | Margin (dB) |
|--------------|-----------------|----------------|-------------------|---------------------|----------------------|--------------------|------------------------------|-------------|
| Vertical | 2430.000 | 94.6 | 36.7 | 28.4 | 22.3 | 64.0 | 94.0 | -30.0 |
| Vertical | 4860.000 | 64.3 | 36.7 | 35.0 | 22.3 | 40.3 | 54.0 | -13.7 |
| Vertical | 7290.000 | 66.0 | 36.8 | 36.2 | 22.3 | 43.1 | 54.0 | -10.9 |

- Notes:
1. Peak detector is used for the emission measurement.
 2. All measurements were made at 3 meters. Harmonic emissions not detected at the 3-meter distance were measured at 0.3-meter and an inverse proportional extrapolation was performed to compare the signal level to the 3-meter limit. No other harmonic emissions than those reported were detected at a test distance of 0.3-meter.
 3. Negative value in the margin column shows emission below limit.
 4. Horn antenna is used for the emission over 1000MHz.

5.0 Equipment Photographs

For electronic filing, the photographs of the tested EUT are saved with filename: external photos.pdf & internal photos.pdf.

6.0 Product Labelling

For electronic filing, the FCC ID label artwork and the label location are saved with filename: label.pdf.

7.0 Technical Specifications

For electronic filing, the block diagram and schematics of the tested EUT are saved with filename: block.pdf and circuit.pdf respectively.

8.0 Instruction Manual

For electronic filing, a preliminary copy of the Instruction Manual is saved with filename: manual.pdf.

This manual will be provided to the end-user with each unit sold/leased in the United States.

9.0 Miscellaneous Information

This miscellaneous information includes details of the measured bandedge, 20dB Bandwidth, the test procedure and calculation of factor such as pulse desensitization.

9.1 Bandedge Plot

The test plots are attached as below. From the plot, the field strength of any emissions outside of the specified frequency band are attenuated to the general radiated emission limits in section 15.209. It fulfils the requirement of 15.249(d).

Peak Measurement

Restricted-band band-edge tests shall be performed as radiated measurements, i.e (Band-edge Plot).

(i) channel 2430MHz MHz:

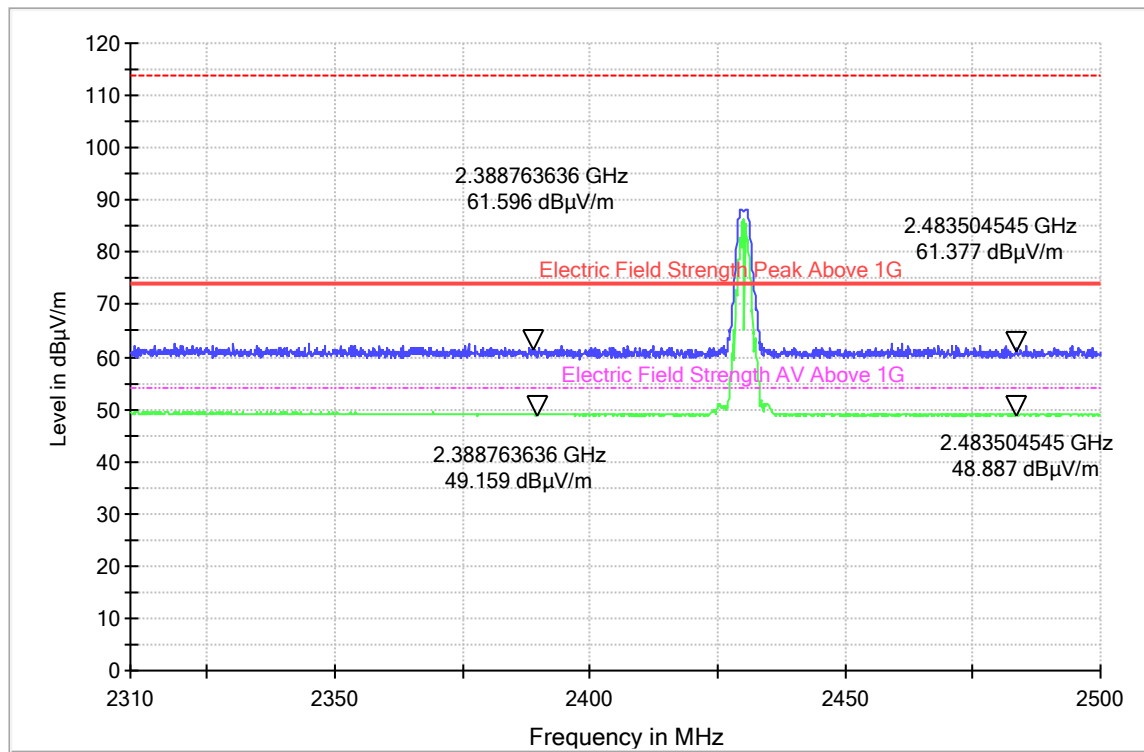
| Polarization | Frequency (MHz) | Reading (dBμV) | Pre-Amp Gain (dB) | Antenna Factor (dB) | Net at 3m (dBμV/m) | Peak Limit at 3m (dBμV/m) | Margin (dB) |
|--------------|-----------------|----------------|-------------------|---------------------|--------------------|---------------------------|-------------|
| Horizontal | 2388.764 | 70.3 | 36.7 | 28.0 | 61.6 | 74.0 | -12.4 |

| Polarization | Frequency (MHz) | Reading (dBμV) | Pre-Amp Gain (dB) | Antenna Factor (dB) | Net at 3m (dBμV/m) | Average Limit at 3m (dBμV/m) | Margin (dB) |
|--------------|-----------------|----------------|-------------------|---------------------|--------------------|------------------------------|-------------|
| Horizontal | 2388.764 | 57.9 | 36.7 | 28.0 | 49.2 | 54.0 | -4.8 |

| Polarization | Frequency (MHz) | Reading (dBμV) | Pre-Amp Gain (dB) | Antenna Factor (dB) | Net at 3m (dBμV/m) | Peak Limit at 3m (dBμV/m) | Margin (dB) |
|--------------|-----------------|----------------|-------------------|---------------------|--------------------|---------------------------|-------------|
| Horizontal | 2483.505 | 69.0 | 36.7 | 29.1 | 61.4 | 74.0 | -12.6 |

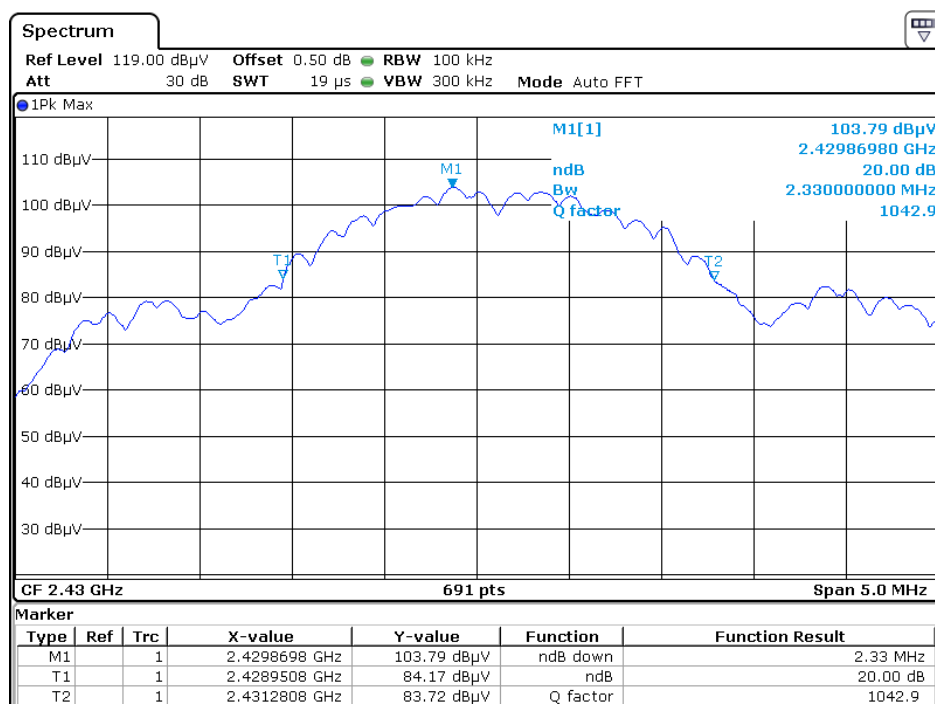
| Polarization | Frequency (MHz) | Reading (dBμV) | Pre-Amp Gain (dB) | Antenna Factor (dB) | Net at 3m (dBμV/m) | Average Limit at 3m (dBμV/m) | Margin (dB) |
|--------------|-----------------|----------------|-------------------|---------------------|--------------------|------------------------------|-------------|
| Horizontal | 2483.505 | 56.5 | 36.7 | 29.1 | 48.9 | 54.0 | -5.1 |

The resultant field strength meets the general radiated emission limit in section 15.209, which does not exceed 74dBμV/m (Peak Limit) and 54dBμV/m (Average Limit).



9.2 20dB Bandwidth

Pursuant to FCC part 15 Section 15.215(c), the 20dB bandwidth of the emission was contained within the frequency band designated (mentioned as above) which the EUT operated. The effects, if any, from frequency sweeping, frequency hopping, other modulation techniques and frequency stability over excepted variations in temperature and supply voltage were considered. The test plots are reported as below.



Date: 25 FEB 2021 09:04:20

9.3 Discussion of Pulse Desensitization

Pulse desensitivity is not applicable for this device. The effective period (T_{eff}) is approximately 0.6667ms for a digital "1" bit, as shown in the plots of Section 9.4. With a resolution bandwidth (3 dB) of 100 kHz, the pulse desensitivity factor was 0 dB

9.4 Calculation of Average Factor

Averaging factor in dB = $20 \log (\text{duty cycle})$

The specification for output field strengths in accordance with the FCC rules specify measurements with an average detector. During testing, a spectrum analyzer incorporating a peak detector was used. Therefore, a reduction factor can be applied to the resultant peak signal level and compared to the limit for measurement instrumentation incorporating an average detector.

The time period over which the duty cycle is measured is 100 milliseconds, or the repetition cycle, whichever is a shorter time frame. The worst case (highest percentage on) duty cycle is used for the calculation. The duty cycle is measured by placing the spectrum analyzer in zero scan (receiver mode) and linear mode at maximum bandwidth (3 MHz at 3 dB down) and viewing the resulting time domain signal output from the analyzer on a Tektronix oscilloscope. The oscilloscope is used because of its superior time base and triggering facilities.

The duty cycle is simply the on-time divided by the period:

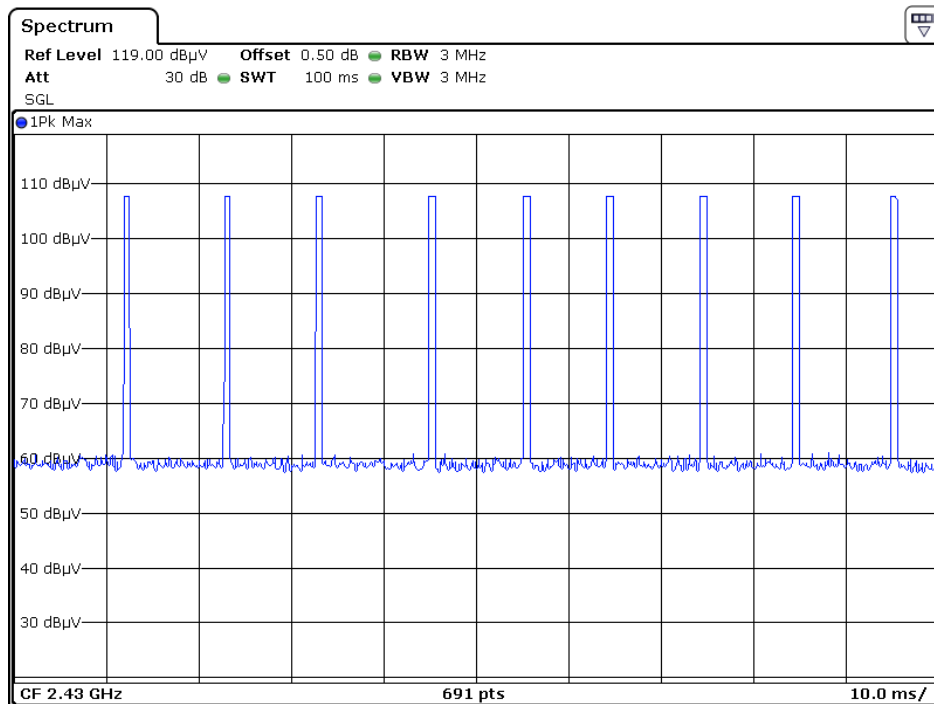
The duration of one cycle = 8.6667ms

Effective period of the cycle = 0.6667ms

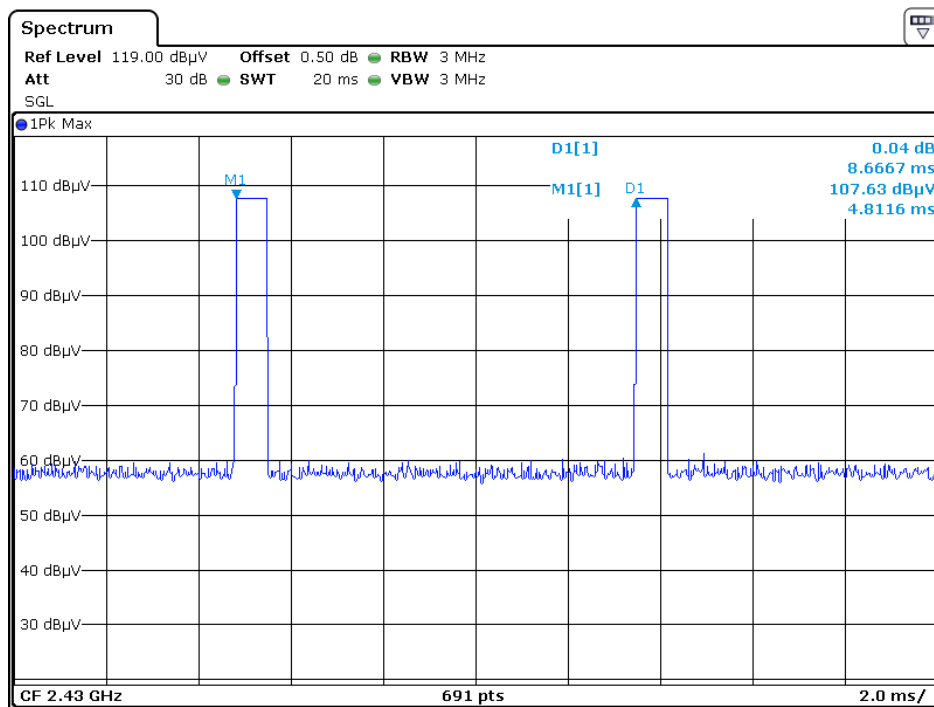
DC = $0.6667\text{ms} / 8.6667\text{ms} = 0.0769$ or 7.69%

Therefore, the averaging factor is found by $20 \log_{10} (0.0769) = -22.3 \text{ dB}$

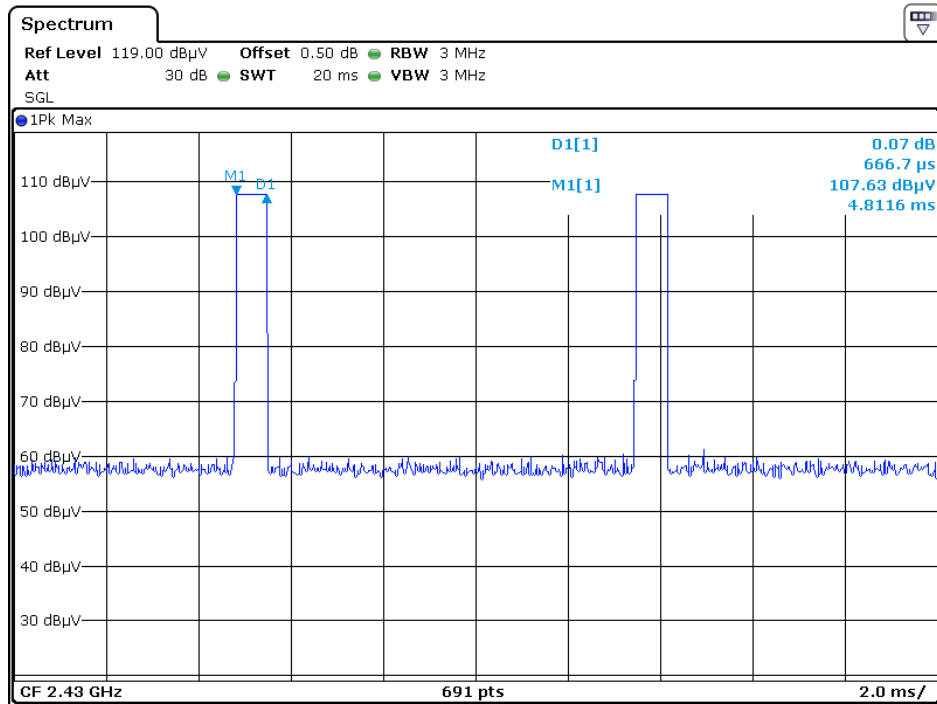
The test plots are attached as below.



Date: 25 FEB 2021 09:09:43



Date: 25 FEB 2021 09:11:05



Date: 25 FEB 2021 09:11:22

9.5 Emissions Test Procedures

The following is a description of the test procedure used by Intertek Testing Services in the measurements of transmitters operating under Part 15, Subpart C rules.

The test set-up and procedures described below are designed to meet the requirements of ANSI C63.10 - 2013.

The transmitting equipment under test (EUT) is placed on a styrene turntable which is four feet in diameter and approximately 0.8 meter up to 1GHz and 1.5 meter above 1GHz in height above the ground plane. During the radiated emissions test, the turntable is rotated and any cables leaving the EUT are manipulated to find the configuration resulting in maximum emissions. The EUT is adjusted through all three orthogonal axes to obtain maximum emission levels. The antenna height and polarization are varied during the testing to search for maximum signal levels.

Detector function for radiated emissions is in peak mode. Average readings, when required, are taken by measuring the duty cycle of the equipment under test and subtracting the corresponding amount in dB from the measured peak readings. A detailed description for the calculation of the average factor can be found in Section 9.4.

The frequency range scanned is from the lowest radio frequency signal generated in the device which is greater than 9 kHz to the tenth harmonic of the highest fundamental frequency or 40 GHz, whichever is lower.

9.5 Emissions Test Procedures (cont'd)

The EUT is warmed up for 15 minutes prior to the test.

AC power to the unit is varied from 85% to 115% nominal and variation in the fundamental emission field strength is recorded. If battery powered, a new, fully charged battery is used.

Conducted measurements are made as described in ANSI C63.10 - 2013.

The IF bandwidth used for measurement of radiated signal strength was 10 kHz for emission below 30 MHz and 120 kHz for emission from 30 MHz to 1000 MHz. Where pulsed transmissions of short enough pulse duration warrant, a greater bandwidth is selected according to the recommendations of Hewlett Packard Application Note 150-2. A discussion of whether pulse desensitivity is applicable to this unit is included in this report (See Section 9.3). Above 1000 MHz, a resolution bandwidth of 1 MHz is used, RBW 3MHz used for fundamental emission.

Transmitter measurements are normally conducted at a measurement distance of three meters. However, to assure low enough noise floor in the restricted bands and above 1 GHz, signals are acquired at a distance of one meter or less. All measurements are extrapolated to three meters using inverse scaling, but those measurements taken at a closer distance are so marked.

10.0 Test Equipment List

| Equipment No. | Equipment | Manufacturer | Model No. | Serial No. | Cal. Date | Due Date |
|---------------|---------------------|-----------------|--------------|------------|-------------|-------------|
| SZ061-12 | BiConiLog Antenna | ETS | 3142E | 00166158 | 09-Oct-2019 | 09-Oct-2021 |
| SZ185-01 | EMI Receiver | R&S | ESCI | 100547 | 22-Dec-2020 | 22-Dec-2021 |
| SZ061-08 | Horn Antenna | ETS | 3115 | 00092346 | 07-Sep-2019 | 07-Sep-2021 |
| SZ061-06 | Active Loop Antenna | Electro-Metrics | EM-6876 | 217 | 24-May-2019 | 24-May-2021 |
| SZ056-03 | Spectrum Analyzer | R&S | FSP 30 | 101148 | 27-May-2020 | 27-May-2021 |
| SZ056-06 | Signal Analyzer | R&S | FSV 40 | 101101 | 27-May-2020 | 27-May-2021 |
| SZ181-04 | Preamplifier | Agilent | 8449B | 3008A02474 | 27-May-2020 | 27-May-2021 |
| SZ188-01 | Anechoic Chamber | ETS | RFD-F/A-100 | 4102 | 15-Dec-2018 | 15-Dec-2021 |
| SZ062-02 | RF Cable | RADIAL | RG 213U | -- | 01-Dec-2020 | 01-Jun-2021 |
| SZ062-05 | RF Cable | RADIAL | 0.04-26.5GHz | -- | 01-Dec-2020 | 01-Jun-2021 |
| SZ062-12 | RF Cable | RADIAL | 0.04-26.5GHz | -- | 01-Dec-2020 | 01-Jun-2021 |
| SZ067-04 | Notch Filter | Micro-Tronics | BRM50702-02 | -- | 27-May-2020 | 27-May-2021 |

***** End of Report *****