

FCC TEST REPORT FOR CERTIFICATION

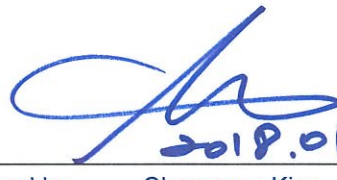
Report No. : N1801R-0056
 Model and/or type referene : Air Conduction Hearing Aids
 Test item description : Digital Transmission System (DTS)
 Trade Mark/Brand name :  / Olive Union
 Additional model name : N/A
 Applicant : Olive Union inc.

| | | |
|-------------------------|---|-----------------------------------|
| Test Device Serial No.: | : | N/A |
| Test Standards | : | FCC 47 CFR Part 15C |
| Classification | : | Digital Transmission System (DTS) |

Data of issue : January 09, 2018
 Test result : Complied


 2018.01.09

Tested by Yeonghwan Hong
 (+ signature) / Project Engineer


 2018.01.09

Reviewed by Changwoo Kim
 (+ signature) / Technical Manager

The device bearing the brand name and model specified above has been shown to comply with the applicable technical standards as indicated in the measurement report and was tested in accordance with the measurement procedures specified in ANSI C63.10-2013. The client should not use it to claim product endorsement by TAF or any government agencies.

The test results in the report only apply to the tested sample.

I attest to the accuracy of data and all measurements reported herein were performed by me or were made under my supervision and are correct to the best of my knowledge and belief. I assume full responsibility for the completeness of these measurements and vouch for the qualifications of all persons taking them.

It is not allowed to copy this report even partly without the allowance of the test laboratory.

TABLE OF CONTENTS

| | |
|----------------------------------|----|
| TABLE OF CONTENTS | 2 |
| CERTIFICATE OF INFORMATION | 3 |
| GENERAL INFORMATION'S | 5 |
| SUMMARY OF TEST RESULTS | 11 |
| RECOMMENDATION/CONCLUSION | 12 |
| <i>8. TEST DATA</i> | 19 |
| <i>PLOTS OF EMISSIONS</i> | 20 |
| <i>PLOTS OF EMISSIONS</i> | 21 |
| <i>TEST DATA</i> | 22 |
| <i>PLOTS OF EMISSIONS</i> | 24 |
| <i>TEST DATA</i> | 25 |
| <i>PLOTS OF EMISSIONS</i> | 26 |
| <i>PLOTS OF EMISSIONS</i> | 27 |
| <i>TEST DATA</i> | 28 |
| <i>TEST DATA</i> | 31 |
| <i>TEST DATA</i> | 34 |
| <i>TEST DATA</i> | 44 |
| <i>PLOTS OF EMISSIONS</i> | 44 |
| <i>PLOTS OF EMISSIONS</i> | 45 |
| <i>PLOTS OF EMISSIONS</i> | 46 |
| <i>PLOTS OF EMISSIONS</i> | 47 |
| <i>PLOTS OF EMISSIONS</i> | 48 |
| <i>PLOTS OF EMISSIONS</i> | 49 |
| <i>TEST DATA</i> | 50 |
| <i>9. TEST EQUIPMENT</i> | 52 |

Certificate of Information

Applicant / Manufacture

Company name : Olive Union inc
Address : 286, Seocho-daero, Seocho-gu, Seoul, Republic of Korea
Telephone : +82-2-3454-0701
/Facsimile :

Equipment Under Test (EUT)

FCC ID : 2AOLH-OLV-01
Classification of installation : Digital Transmission System (DTS)
Test item particulars : FCC 47 CFR Part 15 subpart C
Trademark : N/A
Model and/or type reference : Air Conduction Hearing Aids
Additional model name : N/A
Serial number : N/A
Date (s) of performance of tests: : December 26, 2017 to January 03, 2018
Date of receipt of test item : January 09, 2018
EUT condition : Pre-production, not damaged
Interface Ports : AC IN
EUT Power Source : Operating Voltage : 3.33 Vac ~ 4.07 Vac
Test Voltage : 3.70 Vac
Internal clock frequency : 2402 MHz ~ 2480 MHz
Firmware version : N/A
Note : N/A

Model Description

- NONE

Model Specification

- NONE

Test Performed

Test started & completed : December 26, 2017 to January 03, 2018
Location : NTREE Co., Ltd.

*** To be continued next page ***

Certification –cont.-

Test Specification

Purpose of the test : Compliance test to the following standard
 Applied standard : FCC 47 CFR Part 15C
 Classification : Class B
 Deviations from
 Standard : N/A
 Test Method
 FCC KDB 558074 D01 DTS Meas Guidance V03R05

Summary of Test Results

| FCC Part15(15.247), Subpart C | | | |
|-------------------------------|----------------------------|---------|--------|
| Standard Section | Test Item | Verdict | Remark |
| 15.207 | Conducted Emission | PASS | |
| 15.209 | Radiated Emission | PASS | |
| 15.247(a)(2) | 6dB Bandwidth | PASS | |
| 15.247(b) | Peak Output Power | PASS | |
| 15.247(c) | Radiated Spurious Emission | PASS | |
| 15.247(d) | Power Spectral Density | PASS | |
| 15.205 | Band Edge Emission | PASS | |
| 15.203 | Antenna Requirement | PASS | |

Remark

* N/A: denote test is not applicable in this test report.

* All test items were verified and recorded according to the standards and without any deviation during the test.

General information's

Purpose

This document is based on the Electromagnetic Interference (EMI) tests performed on the “Air Conduction Hearing Aids”. The measurements were performed according to the measurement procedure described in ANSI C 63.4:2014. The tests were carried out in order to confirm whether the electromagnetic emissions from the EUT(Equipment Under Test), are within the class B limits defined in FCC Part 15, Subpart C- “Section 15.207- Conducted limits” and “Section 15.209-Radiated emission limits”.

Test Performed

The Electromagnetic compatibility measurement facilities are located on at 30,Pajangcheon-ro 44beon-gil,Jangan-gu, Suwon-si, Gyeonggi-do Korea. Description details of test facilities were submitted to the RRA(National Radio Research Agency) according to the requirement of ISO/IEC 17025 and KOLAS(Korea Laboratory Accreditation Scheme) and FCC(Federal Communications Commission) and Vietnam MRA and TuV SUD CARAT and TuV NORD, UL WTDP.

RRA Designation No.: KR0175

KOLAS Accreditation No. : KT511

FCC(DoC) Test Firm Registration No. : 838085

Vietnam MRA Designation No.: KR0175

(QCVN 18:2014/BTTTT, QCVN 54:2011/BTTTT,TCVN 7317:2003(CISPR 24:1997),TCVN 7189:2009(CISPR 22:2006)

TuV SUD CARAT : ROK1211C

TuV NORD : KL-3879/11

UL WTDP .: 1107-S-131

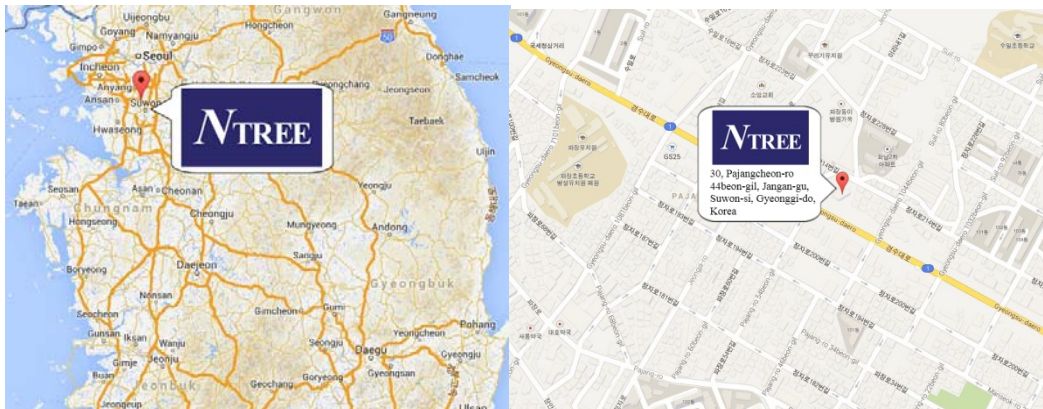
Laboratory : NTREE Co., Ltd.

Address : 30,Pajangcheon-ro 44beon-gil,Jangan-gu, Suwon-si, Gyeonggi-do Korea

Telephone : +82-31-893-1000

Facsimile : +82-31-893-0111

SITE MAP



Measurement uncertainty

| | | |
|-----------------------|--------------------|--------|
| Radiated disturbance | 30 MHz to 1 GHz | 3.6dB |
| | 1 GHz to 18 GHz | 7.8 dB |
| Conducted disturbance | 0.15 MHz to 30 MHz | 1.8 dB |

The coverage factor $k=2$ yields approx. a 95% level of confidence for near-normal distribution typical of most measurement results.

NTREE

TEST CONDITIONS & EUT INFORMATION

Operation During Test

The EUT is the transceiver which is the Bluetooth LE mode.

The Laptop was used to control the EUT to transmit the wanted TX channel by the testing program (BlueCore-BlueSuite) which manufacturer supported. The Laptop was removed after controlling the EUT to transmit the wanted signal. The EUT was tested at the lowest channel, middle channel and the highest channel with the maximum output power in accordance with the manufacturer's specifications. The worst data were recorded in the report.

Table of test power setting

| Frequency band | Mode | Power setting Level |
|----------------|------|---------------------|
| 2402~2480 MHz | LE | Default |

3.1.2 Table of test channels

| Frequency band | Mode | Test Channel (CH) | Frequency (MHz) |
|----------------|------|-------------------|-----------------|
| 2.4 GHz | LE | 0 | 2402 |
| | | 20 | 2442 |
| | | 39 | 2480 |

Table of test modes

| Test Items | Mode | Modulation | Test Channel (CH) |
|---|------|------------|-------------------|
| Radiated Emissions | LE | GFSK | 0/20/39 |
| Conducted Emissions | LE | GFSK | 0/20/39 |
| 6 dB Bandwidth | LE | GFSK | 0/20/39 |
| Peak Output Power | | | 0/20/39 |
| Peak Power Spectral Density | | | 0/20/39 |
| Conducted Spurious Emission | | | 0/20/39 |
| Radiated Spurious Emission, Band edge Emission | | | 0/20/39 |

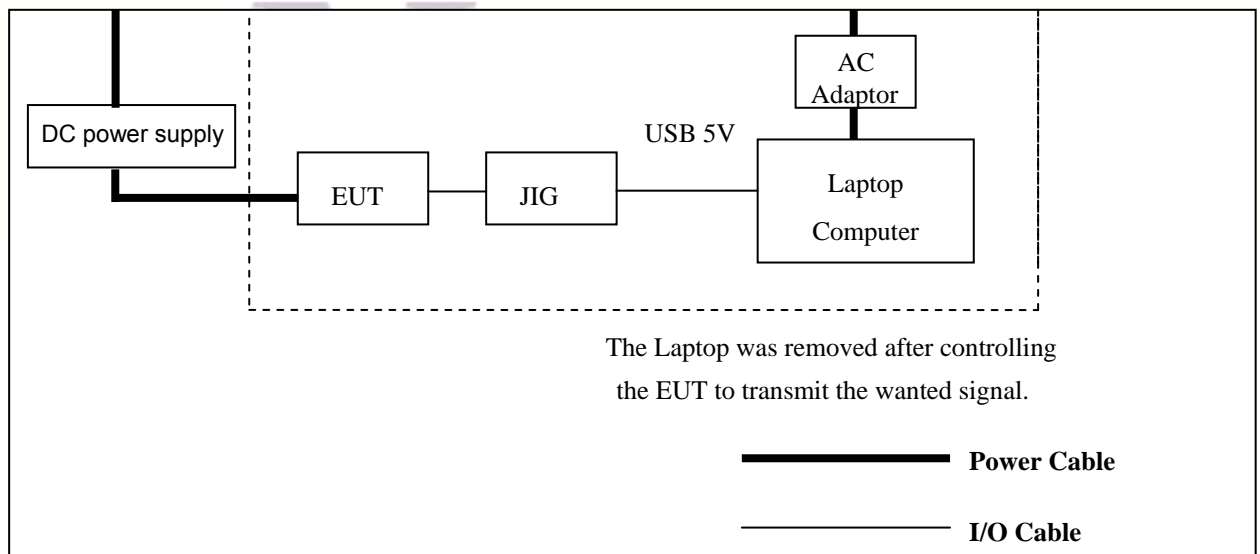
Antenna TX mode information:

| Frequency band | Mode | Antenna TX mode | Support MIMO |
|----------------|------|---|--|
| 2.4 GHz | LE | <input checked="" type="checkbox"/> 1TX, <input type="checkbox"/> 2TX | <input type="checkbox"/> Yes, <input checked="" type="checkbox"/> No |

Support Equipment

| | | |
|-----------------|---|-----------------------------------|
| EUT | Olive Union inc Model : OLV-01 | S/N: N/A |
| Laptop Computer | HP Model : HP ProBook 645 G1 | FCC DOC S/N : 5CG4453BBP |
| AC/DC Adapter | HP Model : PPP009C 1.5 m unshielded power cable | FCC DOC S/N : F220881440018755 |

Setup Drawing



EUT Information

The EUT is the **Bluetooth Transceiver FCC ID: 2AOLH-OLV-01**. This unit supports full qualified Bluetooth 4.1 with LE standard system.

Specifications:

| | |
|--------------------------------|-----------------------------|
| Category | Air Conduction Hearing Aids |
| Model Name | OLV-01 |
| Brand Name | Olive Union |
| RF Frequency | 2402 MHz ~ 2480 MHz |
| Maximum Conducted Output Power | -5.90 dBm |
| Channels | 40ch |
| Antenna Gain (peak) | 3.5 dBi |
| Antenna Setup | 1TX / 1RX |
| Modulations | GFSK(BLE) |
| Temperature Range | 10 °C ~ 40 °C |
| Voltage | 3.7 Vdc |
| Dimensions (H x W x D) | About 20 mm x 15 mm X 20 mm |
| Weight | About 3 g |
| H/W Status | |
| S/W Status | |
| Remarks | - |

SUMMARY OF TEST RESULTS

The EUT has been tested according to the following specification:

| Name of Test | FCC Paragraph No. | Result | Remark |
|--|-------------------|--------|--------|
| Conducted Emission | 15.207 | C | |
| Radiated Emission | 15.209 | C | |
| 6 dB Bandwidth | 15.247(a)(2) | C | |
| Peak Output Power and E.I.R.P | 15.247(b)(3) | C | |
| Power Spectral Density | 15.247(e) | C | |
| Conducted Spurious Emission | 15.247(d) | C | |
| Radiated Spurious Emission | 15.247(d) | C | |
| Maximum Permissible Exposure | 1.1307(b) | N/A | |
| Note 1: C=Complies NC=Not Complies NT=Not Tested NA=Not Applicable * The data in this test report are traceable to the national or international standards. | | | |

RECOMMENDATION/CONCLUSION

The data collected shows that the **Olive Union inc. Air Conduction Hearing Aids FCC ID: 2AOLH-OLV-01** is in compliance with Part 15.247 of the FCC Rule specification.

ANTENNA REQUIREMENTS

§15.203 of the FCC Rules part 15 Subpart C

: 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 antenna of the **Olive Union inc. Air Conduction Hearing Aids FCC ID: 2AOLH-OLV-01** is **permanently attached** and there are no provisions for connection to an internal antenna. It complies with the requirement of §15.203.

NTREE

DESCRIPTION OF TESTS

7.1 Conducted Emissions

The Line conducted emission test facility is located inside a 8.0 x 5.0 x 3.0 meter shielded enclosure.

It is manufactured by DAMSTec's. The shielding effectiveness of the shielded room is in accordance with IEEE 299, MIL-STD-285 or NSA CISPR 16-1-4 1 m x 1.5 m wooden table 0.8 m height is placed 0.4 m away from the vertical wall and 1.5 m away from the side of wall of the shielded room Rohde & Schwarz (ENV216) and (ENV216) of the 50 ohm/50 μ H Line Impedance Stabilization Network (LISN) are bonded to the shielded room. The EUT is powered from the Rohde & Schwarz LISN (ENV216) and the support equipment is powered from the Rohde & Schwarz LISN (ENV216). Power to the LISNs are filtered by high-current high insertion loss Power line filters. The purpose of filter is to attenuate ambient signal interference and this filter is also bonded to shielded enclosure. All electrical cables are shielded by tinned copper zipper tubing with inner diameter of 1 / 2 ".

If DC power device, power will be derived from the source power supply it normally will be powered

from and this supply lines will be connected to the LISNs, All interconnecting cables more than 1 meter were shortened by non inductive bundling (serpentine fashion) to a 1 meter length.

Sufficient time for EUT, support equipment, and test equipment was allowed in order for them to warm up to their normal operating condition. The RF output of the LISN was connected to the spectrum analyzer to determine the frequency producing the maximum EME from the EUT.

The spectrum was scanned from 150 kHz to 30 MHz with 200 msec sweep time.

The frequency producing the maximum level was re-examined using the EMI test receiver.

(Rohde & Schwarz ESR3 and ESCS30). The detector functions were set to CISPR quasi-peak mode & average mode. The bandwidth of receiver was set to 9 kHz. The EUT, support equipment, and interconnecting cables were arranged and manipulated to maximize each EME emission.

Each emission was maximized by; switching power lines; varying the mode of operation or resolution; clock or data exchange speed; scrolling H pattern to the EUT and of support equipment, and powering the monitor from the floor mounted outlet box and computer aux AC outlet, if applicable; whichever determined the worst case emission.

Each EME reported was calibrated using the R&S signal generator.

7.2 Radiated Emissions

The measurement was performed at the test site that is specified in accordance with ANSI C63.10-2013.

The spurious emission was scanned from 9 kHz to 30 MHz using Loop Antenna(Schwarzbeck, FMZB1519) and 30 to 1000 MHz using Trilog broadband test antenna(Schwarzbeck, VULB 9168). Above 1 GHz, Horn antenna (Schwarzbeck BBHA 9120D: up to 18 GHz, Schwarzbeck BBHA9170 : 18 to 40 GHz) was used.

For emissions testing at below 1GHz, The test equipment was placed on turntable with 0.8 m above ground. For emission measurements above 1 GHz, The test equipment was placed on turntable with 1.5 m above ground. Sufficient time for the EUT, support equipment, and test equipment was allowed in order for them to warm up to their normal operating condition. The EUT, cable, wire arrangement and mode of operation that has the highest amplitude relative to the limit was selected. Then, the turn table was rotated from 0° to 360° and an antenna mast was moved from 1 m to 4 m height to maximize the suspected highest amplitude signal. The final maximized level was recorded.

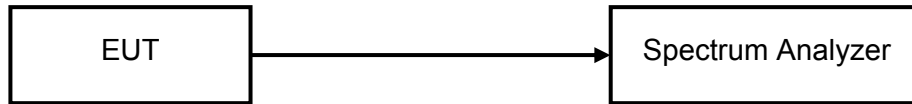
At frequencies below 1000 MHz, measurements performed using the CISPR quasi-peak detection. At frequencies above 1000 MHz, measurements performed using the peak and average measurement procedures described in KDB “558074 D01 DTS Meas Guidance v03r03” in section 12.2.4 and 12.2.5.3. Peak emission levels were measured by setting the analyzer RBW = 1 MHz, VBW = 3 MHz, Detector = Peak, Trace mode = max hold. Average emission levels were measured by setting the analyzer RBW = 1 MHz, VBW = 3kHz, Detector = Peak, Trace mode = max hold. Allow max hold to run for at least 50 times (1/duty cycle) traces.

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

Radiated Emissions Limits per 47 CFR 15.209(a)

6 dB Bandwidth

Test Setup



Test Procedure

EUTs 6 dB bandwidth is measured at low, middle, high channels with a spectrum analyzer connected to the antenna terminal while the EUTs operating at its maximum power control level.

The spectrum analyzer setting is as follows.

RBW = 100 kHz

VBW \geq 3 x RBW

Detector = Peak

Trace mode = max hold

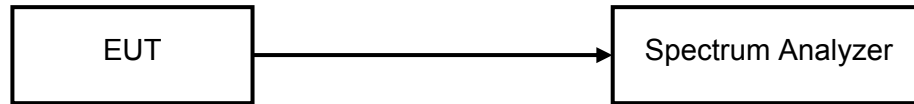
Sweep = auto couple

Allow the trace to stabilize.

The bandwidth measurement function on the spectrum analyzer is used to measure the 6 dB bandwidth.

Peak Output Power and E.I.R.P

Test Setup



Test Procedure

EUTs Maximum Peak Conducted Output Power is measured at low, middle, high channels with a spectrum analyzer connected to the antenna terminal while the EUTs operating at its maximum power control level.

The spectrum analyzer setting is as follows.

RBW = 1 MHz

VBW = 3 MHz

Span = fully encompass the DTS bandwidth

Detector = peak

Sweep time = auto couple

Trace mode = max hold

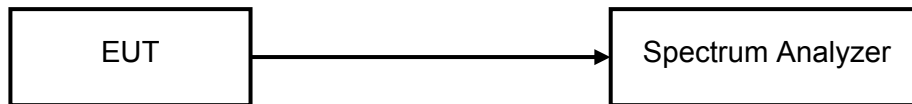
Allow the trace to stabilize.

Use peak marker function to determine the peak amplitude level.

E.I.R.P is calculated according to KDB412172 D01 Determining ERP and EIRP v01

Peak Power Spectral Density

Test Setup



Test Procedure

EUTs Peak Power Spectral Density is measured at low, middle, high channels with a spectrum analyzer connected to the antenna terminal while the EUTs operating at its maximum power control level.

The spectrum analyzer setting is as follows.

Center frequency = DTS channel center frequency

Span = 1.5 times the DTS channel bandwidth

RBW \geq 3 kHz

VBW \geq 3 x RBW

Detector = peak

Sweep time = auto couple

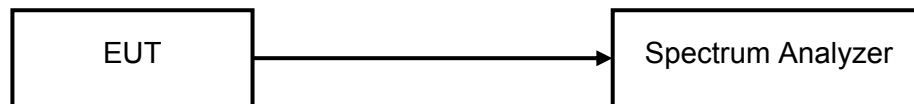
Trace mode = max hold

Allow the trace to stabilize.

The peak search function on the spectrum analyzer is used to determine the maximum amplitude level within the RBW.

Conducted Spurious Emissions

Test Setup



Test Procedure

EUTs Conducted spurious emissions are measured at low, middle, high channels with a spectrum analyzer connected to the antenna terminal while the EUTs operating at its maximum power control level.

The spectrum analyzer setting is as follows.

1) Reference Level

RBW = 100 kHz

VBW \geq 300 kHz

Span = 1.5 times the DTS channel bandwidth

Detector = peak

Sweep time = auto couple

Trace mode = max hold

Allow the trace to stabilize.

Use the peak marker function to determine the maximum PSD level.

Note that the channel found to contain the maximum PSD level can be used to establish the reference level.

2) Unwanted Emissions

RBW = 100 kHz

VBW \geq 300 kHz

Span = encompass the spectrum to be examined

Detector = peak

Sweep time = auto couple

Trace mode = max hold

Allow the trace to stabilize.

The amplitude of all unwanted emissions outside of the authorized frequency band is confirmed that it is attenuated by at least the minimum requirements specified.

8. TEST DATA

8.1 Conducted Emissions

FCC §15.207

Result

This device used to battery.

Line Conducted Emissions Tabulated Data

Notes:

1. *Measurements using CISPR quasi-peak mode & average mode.*
2. *All modes of operation were investigated and the worst -case emission are reported. See attached Plots.*
3. **) Factor = LISN + Cable Loss*
4. ****) LINE : L = Line , N = Neutral*
5. *The limit is on the FCC §15.207*

NTREE

PLOTS OF EMISSIONS

- ***Conducted Emission (Line)***

N/A

NTREE

PLOTS OF EMISSIONS

- ***Conducted Emission (Neutral)***

N/A

NTREE

TEST DATA

8.2 Radiated Emissions

FCC §15.209

Result

| Frequency (MHz) | QuasiPeak (dBμV/m) | DET 2 (dBμV/m) | Limit (dBμV/m) | Margin (dB) | Meas. Time (ms) | Bandwidth h (kHz) | Height (cm) | Pol | Azimuth (deg) |
|-----------------|--------------------|----------------|----------------|-------------|-----------------|-------------------|-------------|-----|---------------|
| 50.154444 | 29.45 | --- | 40.00 | 10.55 | 2000.0 | 120.000 | 100.0 | V | 332.0 |
| 52.256111 | 31.06 | --- | 40.00 | 8.94 | 2000.0 | 120.000 | 100.0 | V | 332.0 |
| 822.005000 | 36.46 | --- | 46.02 | 9.56 | 2000.0 | 120.000 | 100.0 | H | 323.0 |
| 851.051111 | 35.78 | --- | 46.02 | 10.24 | 2000.0 | 120.000 | 100.0 | H | 336.0 |
| 894.323889 | 36.23 | --- | 46.02 | 9.80 | 2000.0 | 120.000 | 100.0 | H | 310.0 |
| 919.867222 | 35.00 | --- | 46.02 | 11.02 | 2000.0 | 120.000 | 100.0 | H | 349.0 |

Radiated Measurements at 3meters

2.31 GHz to 2.39 GHz Result

Lowest Channel

| Frequency (MHz) | MaxPeak (dBμV/m) | Average (dBμV/m) | Limit (dBμV/m) | Margin (dB) | Meas. Time (ms) | Bandwidth h (kHz) | Pol | Azimuth (deg) | Corr. (dB) |
|-----------------|------------------|------------------|----------------|-------------|-----------------|-------------------|-----|---------------|------------|
| 2354.4444 44 | --- | 29.78 | 54.00 | 24.22 | 1000.0 | 1000.000 | V | 84.0 | -7.9 |
| 2354.4444 44 | 42.73 | --- | 74.00 | 31.27 | 1000.0 | 1000.000 | V | 84.0 | -7.9 |

Radiated Measurements at 3meters

2.4835 GHz to 2.50 GHz Result

Highest Channel

| Frequency (MHz) | MaxPeak (dBμV/m) | Average (dBμV/m) | Limit (dBμV/m) | Margin (dB) | Meas. Time (ms) | Bandwidth h (kHz) | Pol | Azimuth (deg) | Corr. (dB) |
|-----------------|------------------|------------------|----------------|-------------|-----------------|-------------------|-----|---------------|------------|
| 2489.7222 22 | --- | 30.70 | 54.00 | 23.30 | 1000.0 | 1000.000 | V | 315.0 | -7.1 |
| 2489.7222 22 | 43.99 | --- | 74.00 | 30.01 | 1000.0 | 1000.000 | V | 315.0 | -7.1 |

Radiated Measurements at 3meters

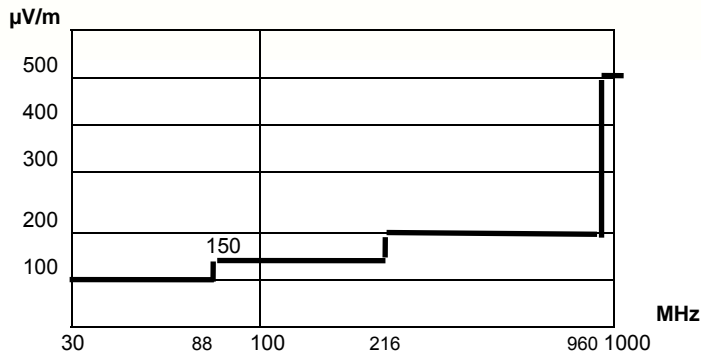


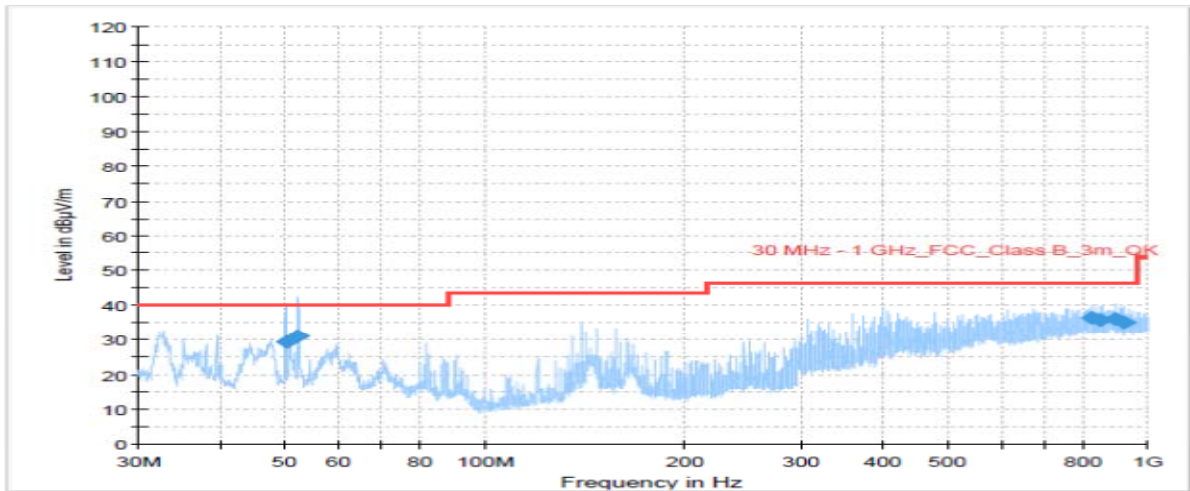
Fig. 3. Limits at 3 meters

Notes:

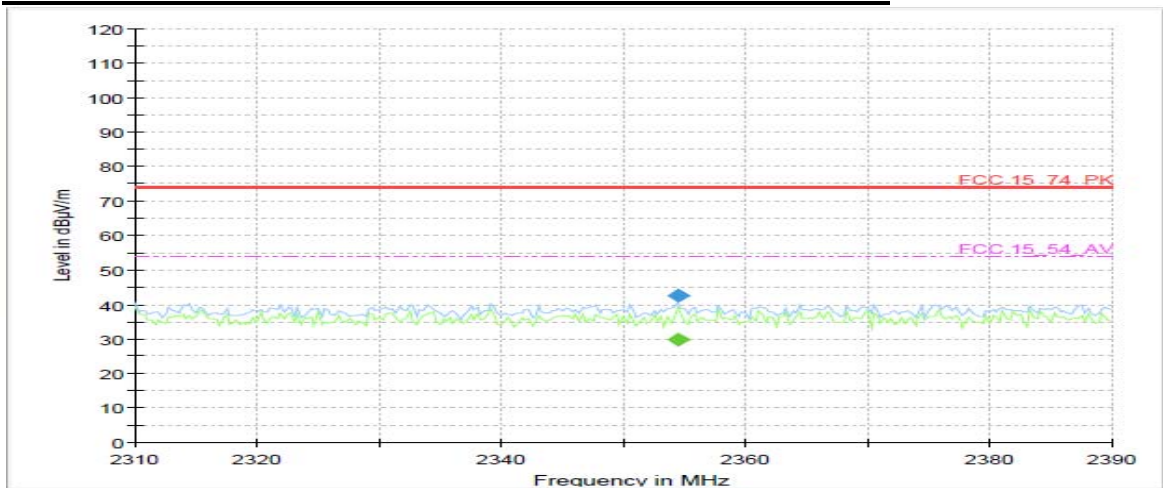
1. All modes were measured and the worst-case emission was reported.
2. The radiated limits are shown on Figure 3. Above 1GHz the limit is 500 $\mu\text{V} / \text{m}$.
3. *Pol. H = Horizontal, V = Vertical
4. **AF + CL + Amp. = Antenna Factor + Cable Loss + Amplifier.
5. Measurements using CISPR quasi-peak mode below 1 GHz.
6. The radiated emissions testing were made by rotating the receive antenna with horizontal, Vertical polarization. The worst date was recorded.
7. GFSK on the middle channel (2442MHz) is the worst case channel.
8. No emission found between lowest internal used/generated frequency to 30MHz (9kHz~30MHz).
9. The limit is on the FCC §15.209

PLOTS OF EMISSIONS

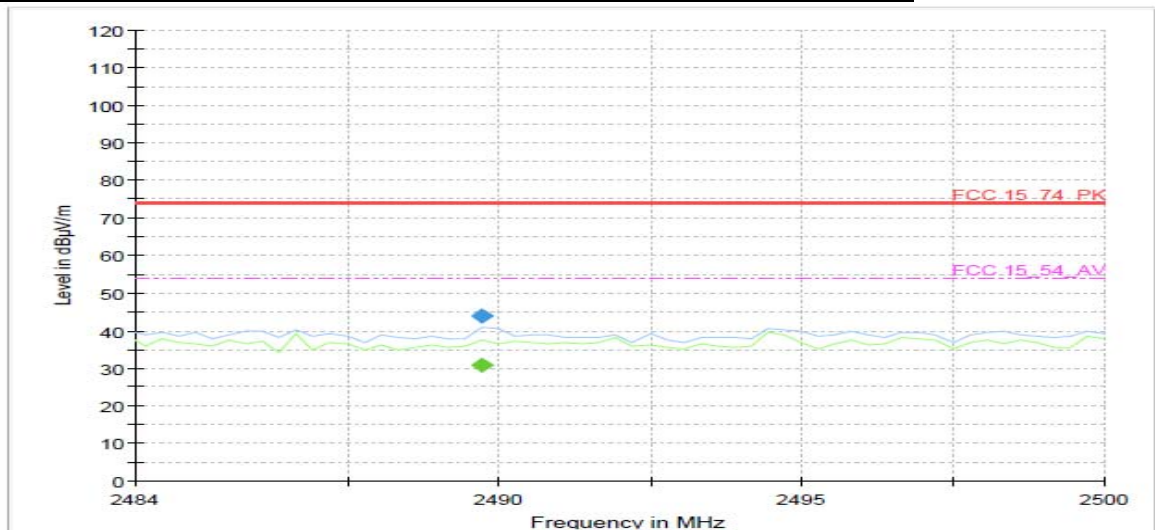
Worst Case : 2442 MHz(below 1GHz) GFSK modulation



Worst Case : 2402MHz GFSK modulation : 2.31 GHz to 2.39 GHz



Worst Case : 2402MHz GFSK modulation : 2.4835 GHz to 2.50 GHz

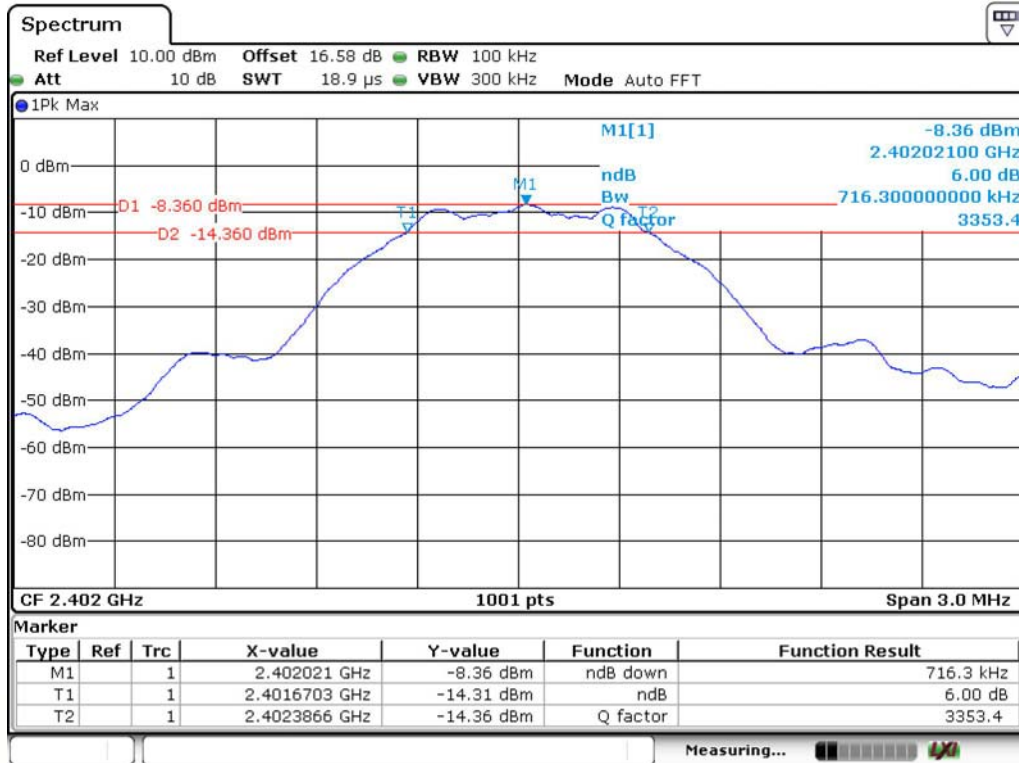


TEST DATA**8.3 6 dB Modulated Bandwidth****FCC §15.247(a)(2)****Test Mode : Set to Lowest channel, Middle channel and Highest channel****Result**

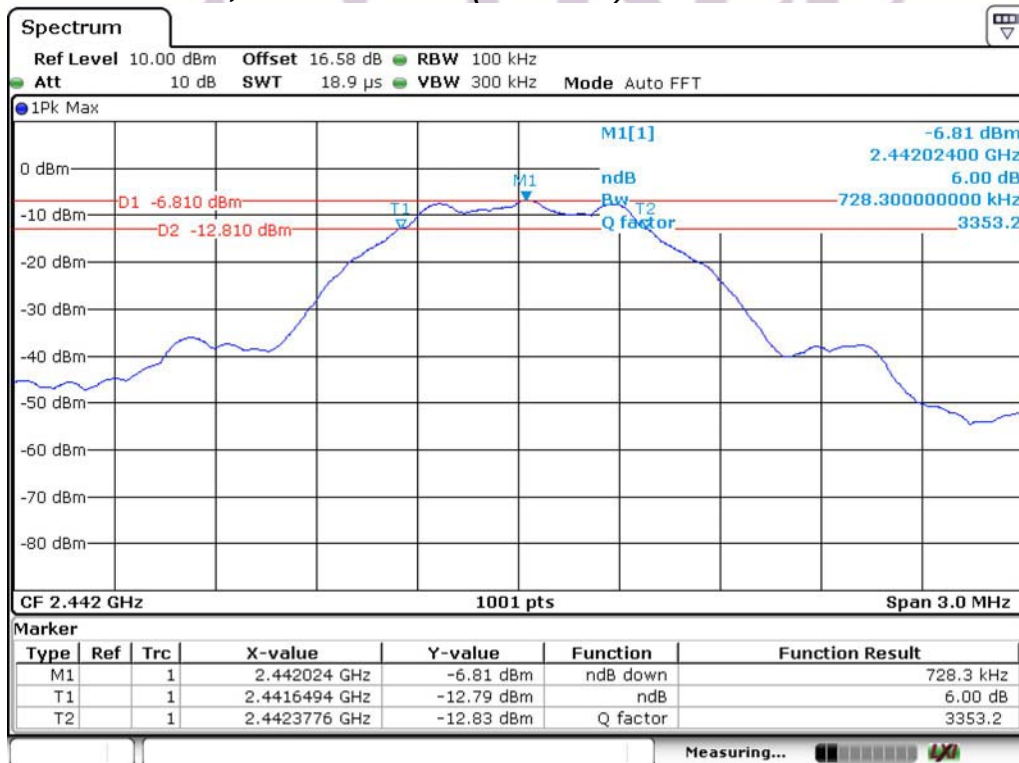
| Channel | Frequency (MHz) | 6 dB modulated bandwidth (MHz) | Limit (MHz) | Margin (MHz) |
|---------|-----------------|--------------------------------|-------------|--------------|
| Lowest | 2402 | 0.716 | 0.500 | 0.216 |
| Middle | 2442 | 0.728 | 0.500 | 0.228 |
| Highest | 2480 | 0.725 | 0.500 | 0.225 |

PLOTS OF EMISSIONS

6 dB Bandwidth, Lowest Channel (2402 MHz)

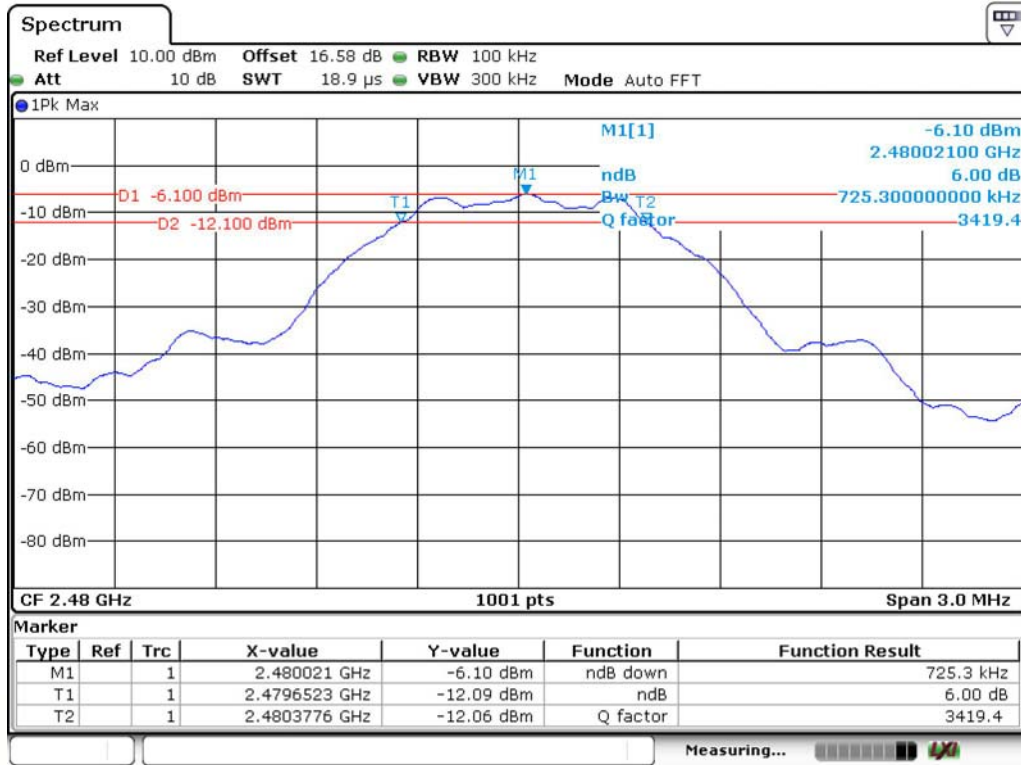


6 dB Bandwidth, Middle Channel (2442 MHz)



PLOTS OF EMISSIONS

6 dB Bandwidth, Highest Channel (2480 MHz)



NTREE

TEST DATA

8.4 Peak Output Power and E.I.R.P.

FCC §15.247(b)(3)

Test Mode : Set to Lowest channel, Middle channel and Highest channel

Result

| Frequency (MHz) | Peak Power (dBm) | Limit (MHz) | E.I.R.P* (dBm) | E.I.R.P* (dBm) | Result |
|-----------------|------------------|-------------|----------------|----------------|----------|
| 2402 | -8.20 | 30.00 | -4.70 | 36.00 | Complies |
| 2442 | -6.61 | 30.00 | -3.11 | 36.00 | Complies |
| 2480 | -5.90 | 30.00 | -2.40 | 36.00 | Complies |

Note:

The following formular was used for spectrum offset:

Spectrum offset (dB) = Attenuator (dB) + Cable Loss (dB) + SMA Type Connector Loss (dB)

*) E.I.R.P was calculated by following equation according to KDB412172 D01 Determining ERP and EIRP v01

$$E.I.R.P = P_T + G_T - L_C$$

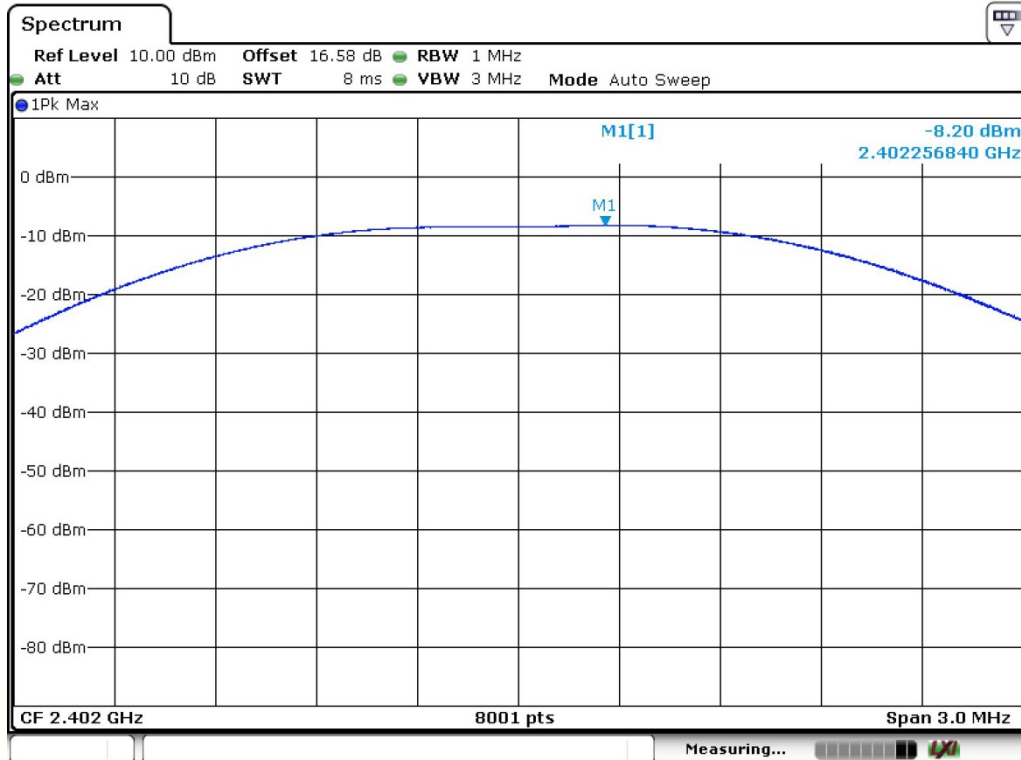
P_T = Peak outputpower (dBm)

G_T = Gain of the transmitting antenna in dBi, Peak antenna gain is 3.5 dBi.

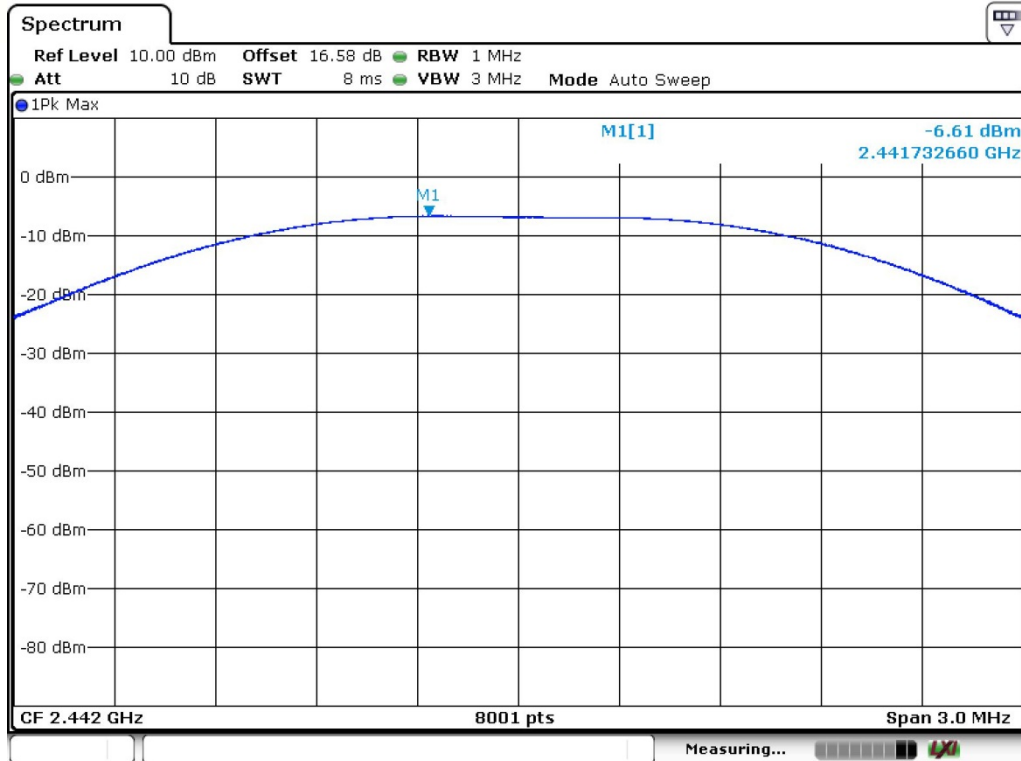
L_C = Signal attenuation in the connecting cable between the transmitter and antenna in dB. This factor of an integral antenna is negligible.

PLOT OF TEST DATA

Maximum Peak Output Power, Lowest Channel (2402 MHz)

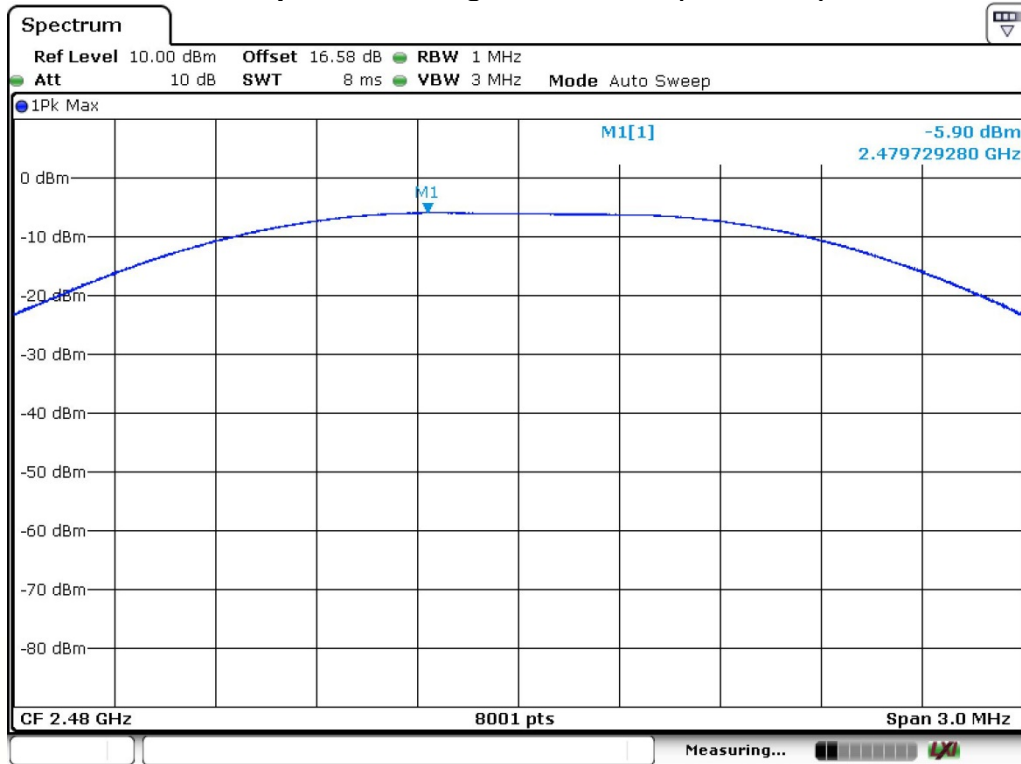


Maximum Peak Output Power, Middle Channel (2442 MHz)



PLOT OF TEST DATA

Maximum Peak Output Power, Highest Channel (2480 MHz)



TEST DATA

8.5 Peak Power Spectral Density

FCC §15.247(e)

Test Mode : Set to Lowest channel, Middle channel and Highest channel

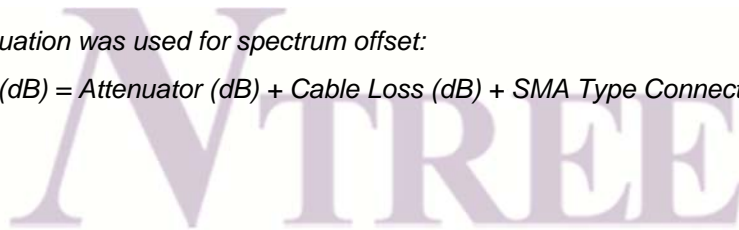
Result

| Channel | Frequency (MHz) | Result (dBm) | Limit (dBm) |
|---------|-----------------|--------------|-------------|
| Lowest | 2402 | -21.96 | 8.00 |
| Middle | 2442 | -21.19 | 8.00 |
| Highest | 2480 | -19.71 | 8.00 |

Note:

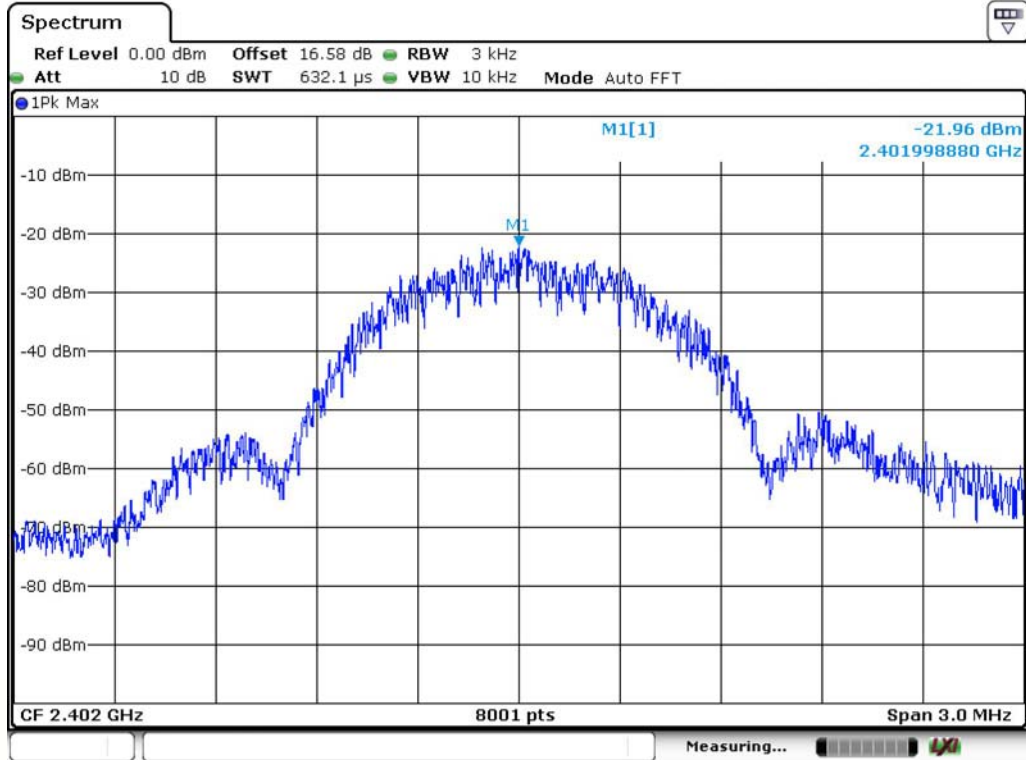
The following equation was used for spectrum offset:

Spectrum offset (dB) = Attenuator (dB) + Cable Loss (dB) + SMA Type Connector Loss (dB)

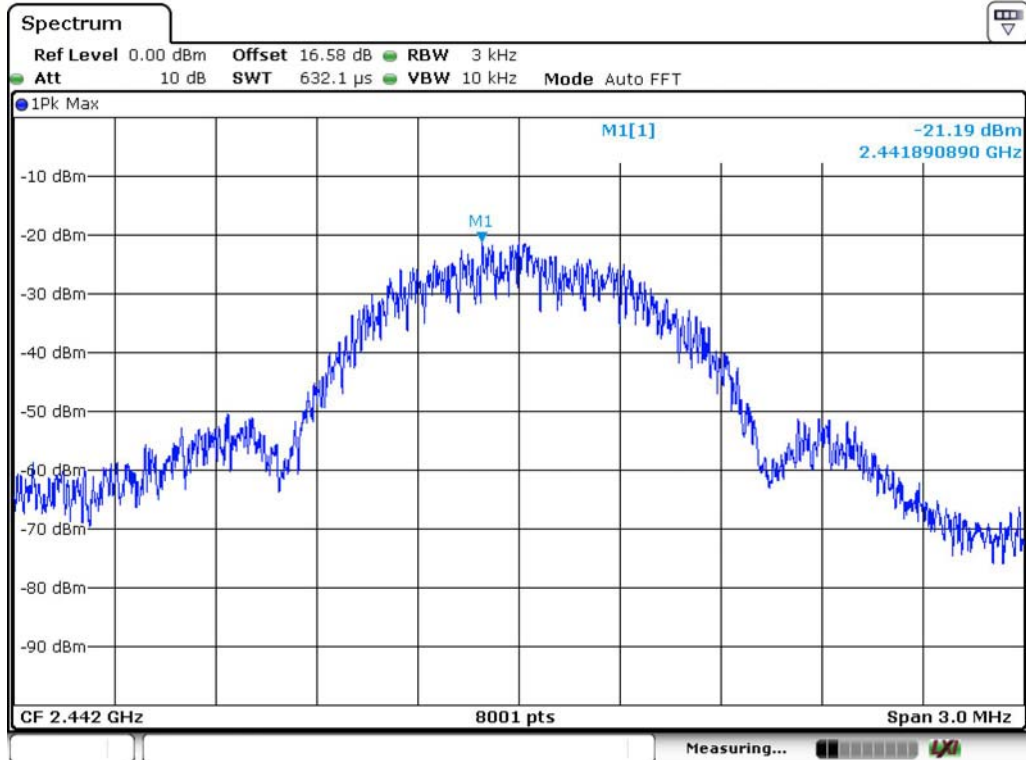


PLOT OF TEST DATA

Peak Power Spectral Density, Lowest Channel (2402 MHz)

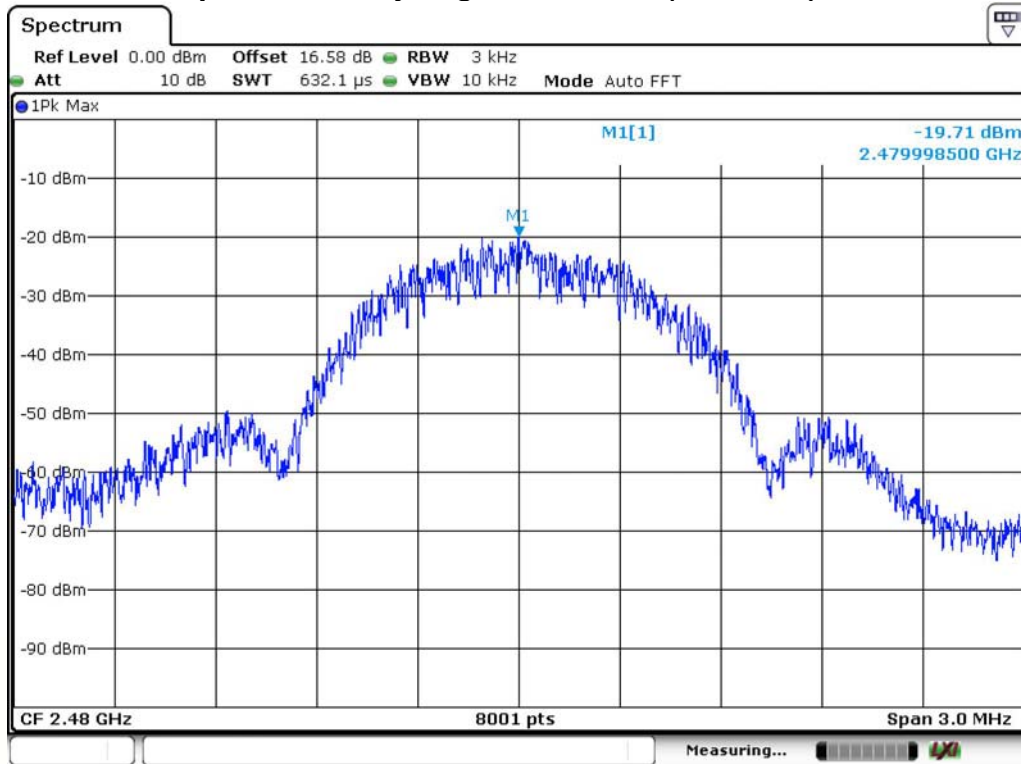


Peak Power Spectral Density, Middle Channel (2442 MHz)



PLOT OF TEST DATA

Peak Power Spectral Density, Highest Channel (2480 MHz)



TEST DATA

8.6 Conducted Spurious Emissions

FCC §15.247(d)

Test Mode : Set to Lowest channel, Middle channel and Highest channel

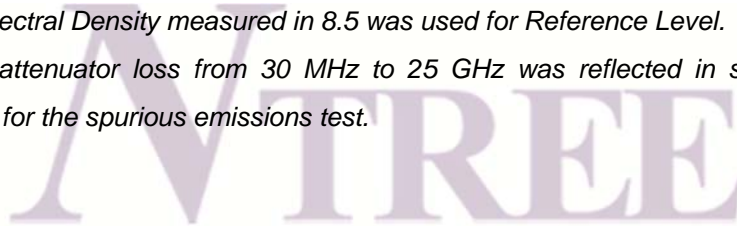
Result

| Channel | Frequency (MHz) | Reference Level (dBm)* | Conducted Spurious Emissions (dBc) | Limit (dBc) |
|---------|-----------------|------------------------|------------------------------------|-------------|
| Low | 2402 | -8.54 | More than 20 dBc | 20 |
| Middle | 2442 | -6.92 | More than 20 dBc | 20 |
| Hlgh | 2480 | -6.20 | More than 20 dBc | 20 |

Note:

**Peak Power Spectral Density measured in 8.5 was used for Reference Level.*

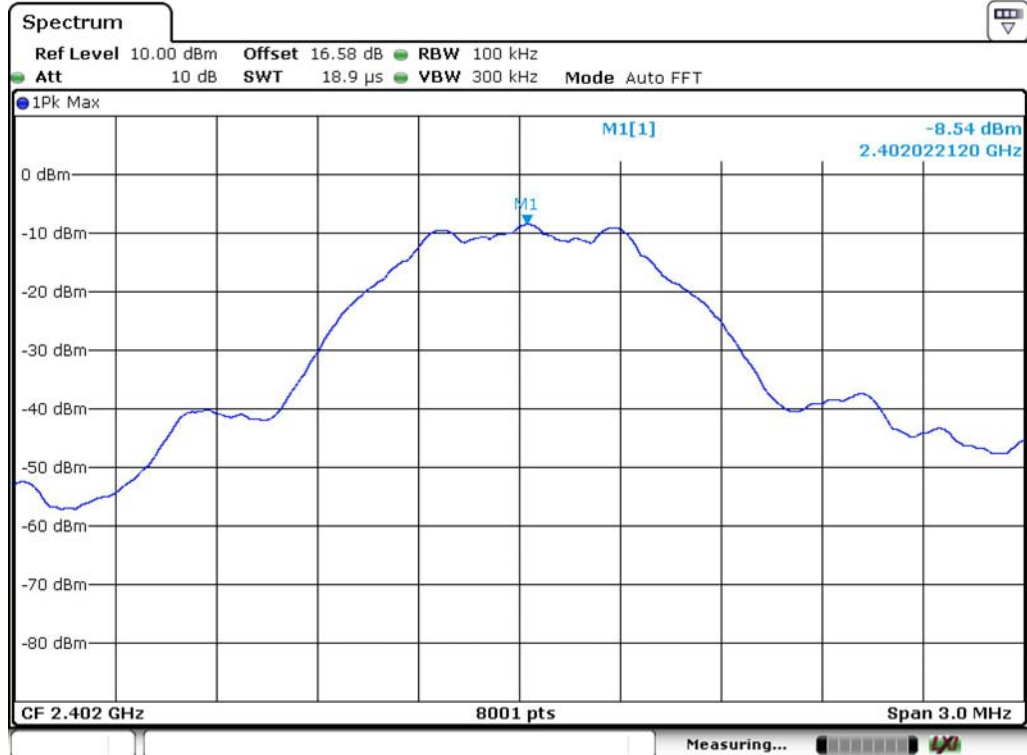
The cable and attenuator loss from 30 MHz to 25 GHz was reflected in spectrum analyzer with correction factor for the spurious emissions test.



PLOT OF TEST DATA

Reference level

Reference Power Spectral Density, Lowest Channel (2402 MHz)

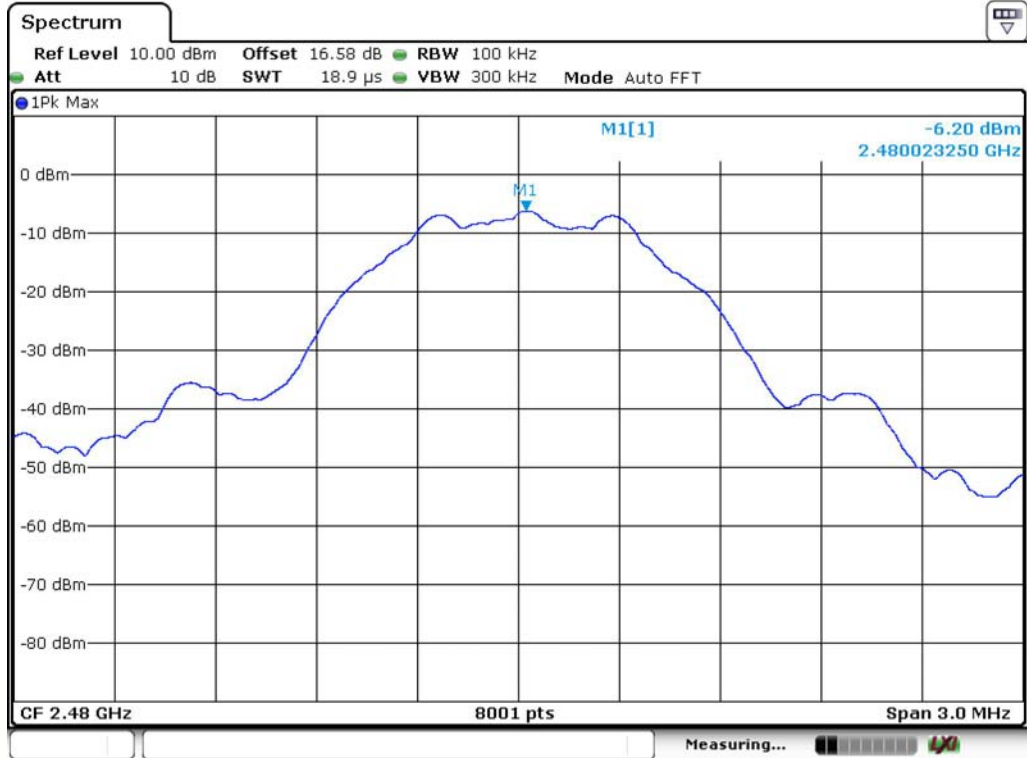


Reference Power Spectral Density, Middle Channel (2442 MHz)



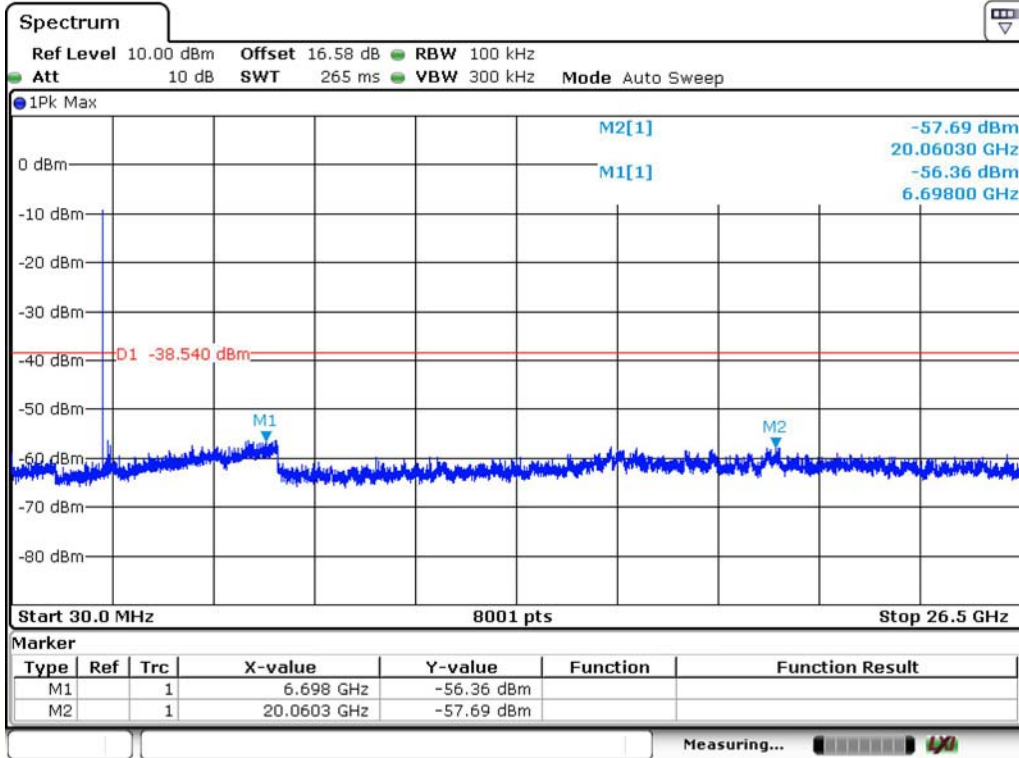
PLOT OF TEST DATA

Reference Power Spectral Density, Highest Channel (2480 MHz)

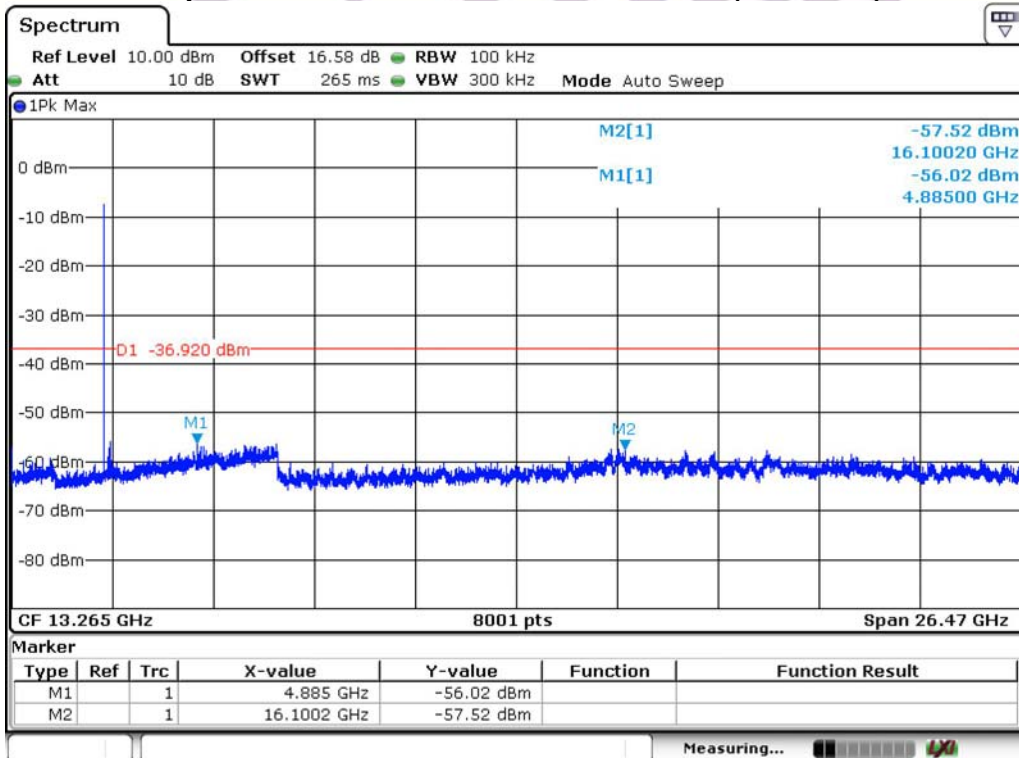


PLOT OF TEST DATA

Conducted Spurious Emissions, 30 MHz ~ 26.5 GHz (2402 MHz)

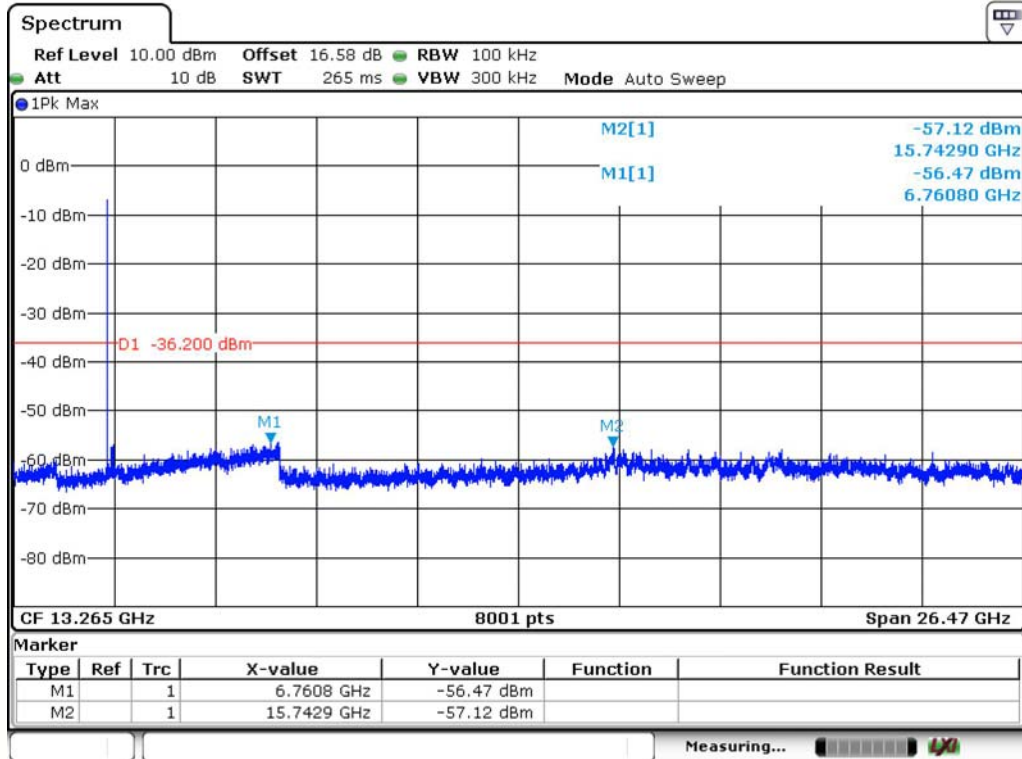


Conducted Spurious Emissions, 30 MHz ~ 26.5 GHz (2442 MHz)



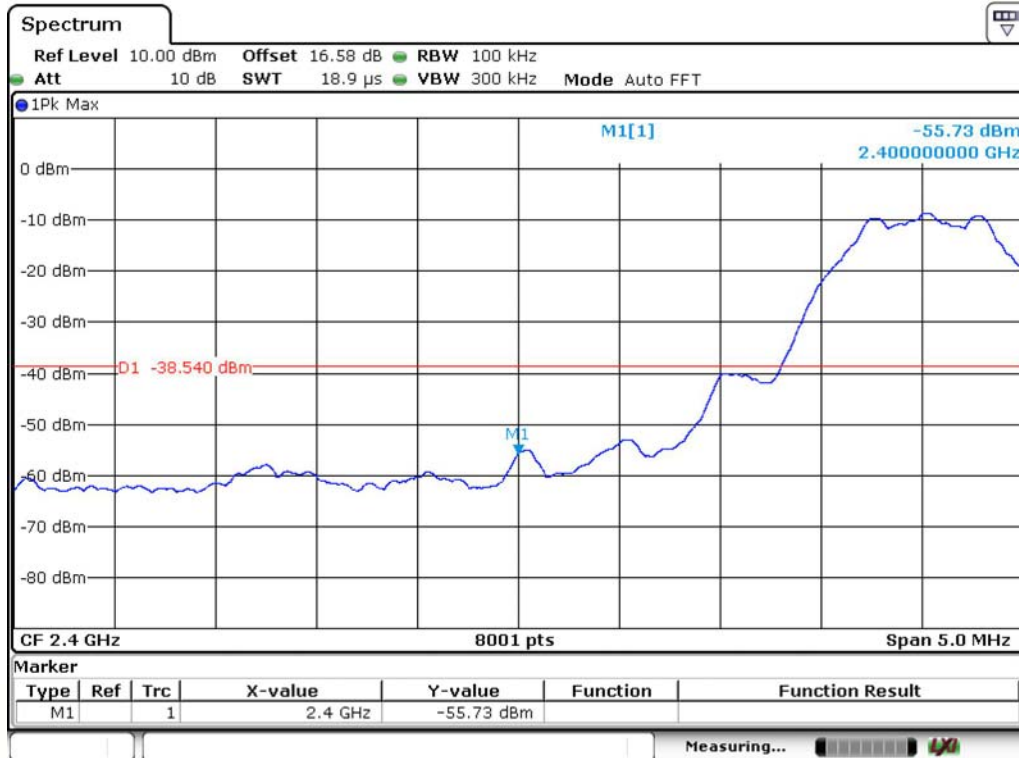
PLOT OF TEST DATA

Conducted Spurious Emissions, 30 MHz ~ 26.5 GHz (2480 MHz)

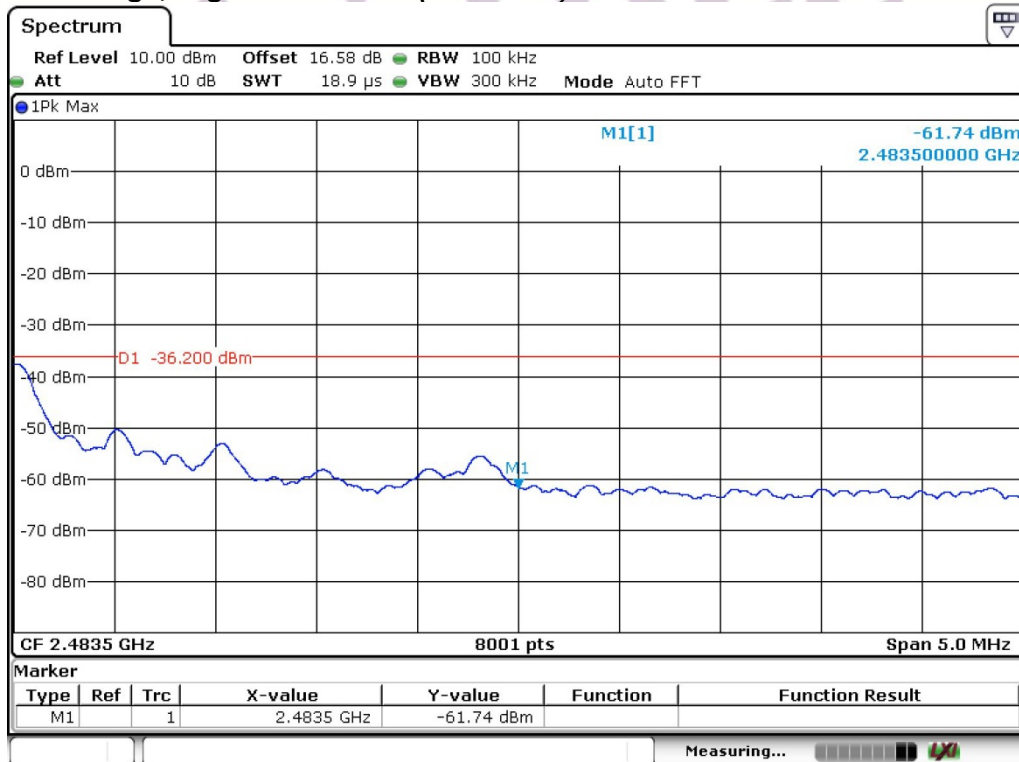


PLOT OF TEST DATA

Band Edge, Lowest Channel (2402 MHz)



Band Edge, Highest Channel (2480 MHz)



TEST DATA

8.7 Radiated Spurious Emissions

FCC §15.247(d)

Test Mode : Set to Lowest channel, Middle channel and Highest channel

1 GHz to 18 GHz Result

Lowest Channel

| Frequency (MHz) | MaxPeak (dBµV/m) | Average (dBµV/m) | Limit (dBµV/m) | Margin (dB) | Meas. Time (ms) | Bandwidth h (kHz) | Height (cm) | Pol | Azimuth (deg) | Corr. (dB) |
|-----------------|------------------|------------------|----------------|-------------|-----------------|-------------------|-------------|-----|---------------|------------|
| 13175.40 | 51.85 | --- | 54.00 | 2.15 | 1000.0 | 1000.000 | 150.0 | H | 0.0 | 13.0 |
| Frequency (MHz) | MaxPeak (dBµV/m) | Average (dBµV/m) | Limit (dBµV/m) | Margin (dB) | Meas. Time (ms) | Bandwidth h (kHz) | Height (cm) | Pol | Azimuth (deg) | Corr. (dB) |
| 8189.30 | 51.61 | --- | 54.00 | 2.39 | 1000.0 | 1000.000 | 150.0 | V | 61.0 | 10.2 |

Middle Channel

| Frequency (MHz) | MaxPeak (dBµV/m) | Average (dBµV/m) | Limit (dBµV/m) | Margin (dB) | Meas. Time (ms) | Bandwidth h (kHz) | Height (cm) | Pol | Azimuth (deg) | Corr. (dB) |
|-----------------|------------------|------------------|----------------|-------------|-----------------|-------------------|-------------|-----|---------------|------------|
| 13661.60 | 51.52 | --- | 54.00 | 2.48 | 1000.0 | 1000.000 | 150.0 | H | 0.0 | 13.0 |
| Frequency (MHz) | MaxPeak (dBµV/m) | Average (dBµV/m) | Limit (dBµV/m) | Margin (dB) | Meas. Time (ms) | Bandwidth h (kHz) | Height (cm) | Pol | Azimuth (deg) | Corr. (dB) |
| 4882.80 | 52.06 | --- | 54.00 | 1.94 | 1000.0 | 1000.000 | 150.0 | V | 0.0 | -0.3 |

Highest Channel

| Frequency (MHz) | MaxPeak (dBµV/m) | Average (dBµV/m) | Limit (dBµV/m) | Margin (dB) | Meas. Time (ms) | Bandwidth h (kHz) | Height (cm) | Pol | Azimuth (deg) | Corr. (dB) |
|-----------------|------------------|------------------|----------------|-------------|-----------------|-------------------|-------------|-----|---------------|------------|
| 13982.90 | 50.22 | --- | 54.00 | 3.78 | 1000.0 | 1000.000 | 150.0 | H | 0.0 | 12.8 |
| Frequency (MHz) | MaxPeak (dBµV/m) | Average (dBµV/m) | Limit (dBµV/m) | Margin (dB) | Meas. Time (ms) | Bandwidth h (kHz) | Height (cm) | Pol | Azimuth (deg) | Corr. (dB) |
| 4959.30 | 49.53 | --- | 54.00 | 4.47 | 1000.0 | 1000.000 | 150.0 | V | 34.0 | -0.3 |

Note:

1. *Pol. H = Horizontal V = Vertical
2. **AF + CL + Amp. = Antenna Factor + Cable Loss + Amplifier.
3. Other spurious was under 20 dB below Fundamental.
4. GFSK modulation on the highest channel (2480MHz) was the worst condition.
5. The radiated emissions testing were made by rotating EUT through three orthogonal axes and rotating the receive antenna with horizontal, Vertical polarization. The worst data was recorded.
6. Peak emissions were measured using RBW = 1 MHz, VBW = 3 MHz, Detector = Peak.
7. Average emissions were measured using RBW = 1 MHz, VBW = 3kHz, Detector = Peak
8. The spectrum was measured from 9 kHz to 10th harmonic and the worst-case emissions were reported. No significant emissions were found beyond the 5nd harmonic for this device.



Test Mode : Set to Lowest channel, Middle channel and Highest channel

18 GHz to 20 GHz Result

Lowest Channel

| Frequency (MHz) | MaxPeak (dB μ V/m) | Limit (dB μ V/m) | Margin (dB) | Meas. Time (ms) | Bandwidth (kHz) | Height (cm) | Pol | Azimuth (deg) | Corr. (dB) |
|-----------------|------------------------|----------------------|-------------|-----------------|-----------------|-------------|-----|---------------|------------|
| 19400.89 | 51.65 | 54.00 | 2.35 | 1000.0 | 1000.000 | 150.0 | H | 0.0 | 8.6 |

Middle Channel

| Frequency (MHz) | MaxPeak (dB μ V/m) | Limit (dB μ V/m) | Margin (dB) | Meas. Time (ms) | Bandwidth (kHz) | Height (cm) | Pol | Azimuth (deg) | Corr. (dB) |
|-----------------|------------------------|----------------------|-------------|-----------------|-----------------|-------------|-----|---------------|------------|
| 19096.89 | 50.67 | 54.00 | 3.33 | 1000.0 | 1000.000 | 150.0 | H | 325.0 | 8.9 |

Highest Channel

| Frequency (MHz) | MaxPeak (dB μ V/m) | Limit (dB μ V/m) | Margin (dB) | Meas. Time (ms) | Bandwidth (kHz) | Height (cm) | Pol | Azimuth (deg) | Corr. (dB) |
|-----------------|------------------------|----------------------|-------------|-----------------|-----------------|-------------|-----|---------------|------------|
| 19376.44 | 51.41 | 54.00 | 2.59 | 1000.0 | 1000.000 | 150.0 | V | 232.0 | 8.7 |

Note:



Test Mode : Set to Lowest channel, Middle channel and Highest channel

2.4 GHz to 2.4835 GHz Result

Lowest Channel

| Frequency (MHz) | MaxPeak (dB μ V/m) | Average (dB μ V/m) | Limit (dB μ V/m) | Margin (dB) | Meas. Time (ms) | Bandwidth h (kHz) | Height (cm) | Pol | Azimuth (deg) | Corr. (dB) |
|-----------------|------------------------|------------------------|----------------------|-------------|-----------------|-------------------|-------------|-----|---------------|------------|
| 2402.31 | 84.85 | --- | 93.98 | 9.13 | 1000.0 | 1000.000 | 150.0 | H | 303.0 | -8.3 |

| Frequency (MHz) | MaxPeak (dB μ V/m) | Average (dB μ V/m) | Limit (dB μ V/m) | Margin (dB) | Meas. Time (ms) | Bandwidth h (kHz) | Height (cm) | Pol | Azimuth (deg) | Corr. (dB) |
|-----------------|------------------------|------------------------|----------------------|-------------|-----------------|-------------------|-------------|-----|---------------|------------|
| 2402.25 | 88.22 | --- | 93.98 | 5.76 | 1000.0 | 1000.000 | 150.0 | V | 60.0 | -8.3 |

Middle Channel

| Frequency (MHz) | MaxPeak (dB μ V/m) | Average (dB μ V/m) | Limit (dB μ V/m) | Margin (dB) | Meas. Time (ms) | Bandwidth h (kHz) | Height (cm) | Pol | Azimuth (deg) | Corr. (dB) |
|-----------------|------------------------|------------------------|----------------------|-------------|-----------------|-------------------|-------------|-----|---------------|------------|
| 2441.75 | 83.72 | --- | 93.98 | 10.26 | 1000.0 | 1000.000 | 150.0 | H | 122.0 | -8.1 |

| Frequency (MHz) | MaxPeak (dB μ V/m) | Average (dB μ V/m) | Limit (dB μ V/m) | Margin (dB) | Meas. Time (ms) | Bandwidth h (kHz) | Height (cm) | Pol | Azimuth (deg) | Corr. (dB) |
|-----------------|------------------------|------------------------|----------------------|-------------|-----------------|-------------------|-------------|-----|---------------|------------|
| 2441.85 | 86.20 | --- | 93.98 | 7.78 | 1000.0 | 1000.000 | 150.0 | V | 49.0 | -8.1 |

Highest Channel

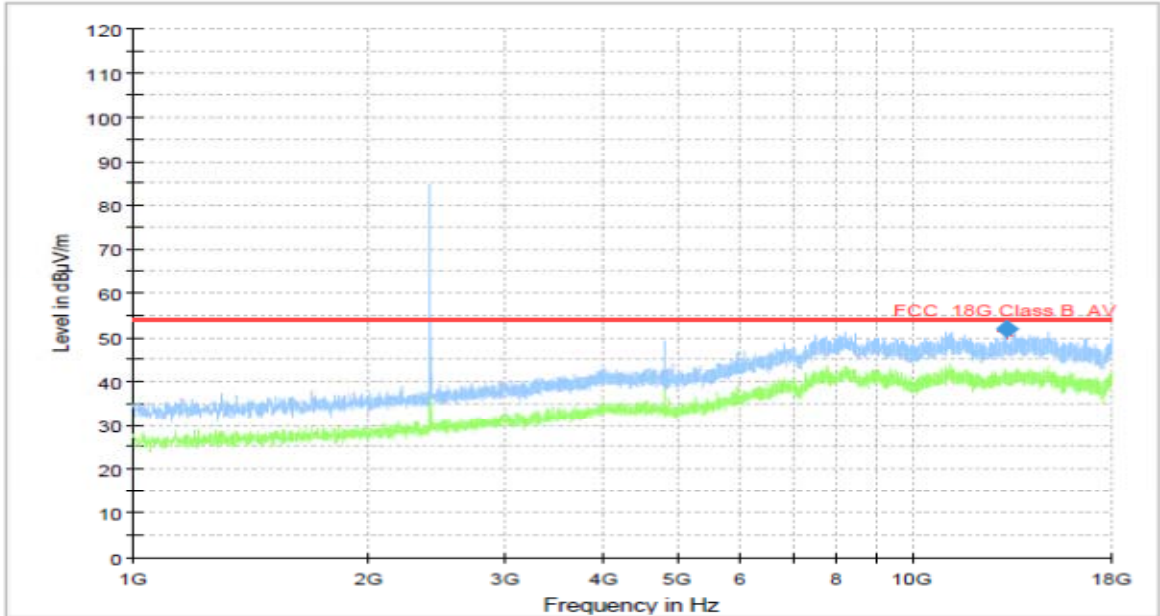
| Frequency (MHz) | MaxPeak (dB μ V/m) | Average (dB μ V/m) | Limit (dB μ V/m) | Margin (dB) | Meas. Time (ms) | Bandwidth h (kHz) | Height (cm) | Pol | Azimuth (deg) | Corr. (dB) |
|-----------------|------------------------|------------------------|----------------------|-------------|-----------------|-------------------|-------------|-----|---------------|------------|
| 2479.69 | 79.96 | --- | 93.98 | 14.02 | 1000.0 | 1000.000 | 150.0 | H | 121.0 | -7.9 |

| Frequency (MHz) | MaxPeak (dB μ V/m) | Average (dB μ V/m) | Limit (dB μ V/m) | Margin (dB) | Meas. Time (ms) | Bandwidth h (kHz) | Height (cm) | Pol | Azimuth (deg) | Corr. (dB) |
|-----------------|------------------------|------------------------|----------------------|-------------|-----------------|-------------------|-------------|-----|---------------|------------|
| 2479.78 | 88.60 | --- | 93.98 | 5.38 | 1000.0 | 1000.000 | 150.0 | V | 25.0 | -7.9 |

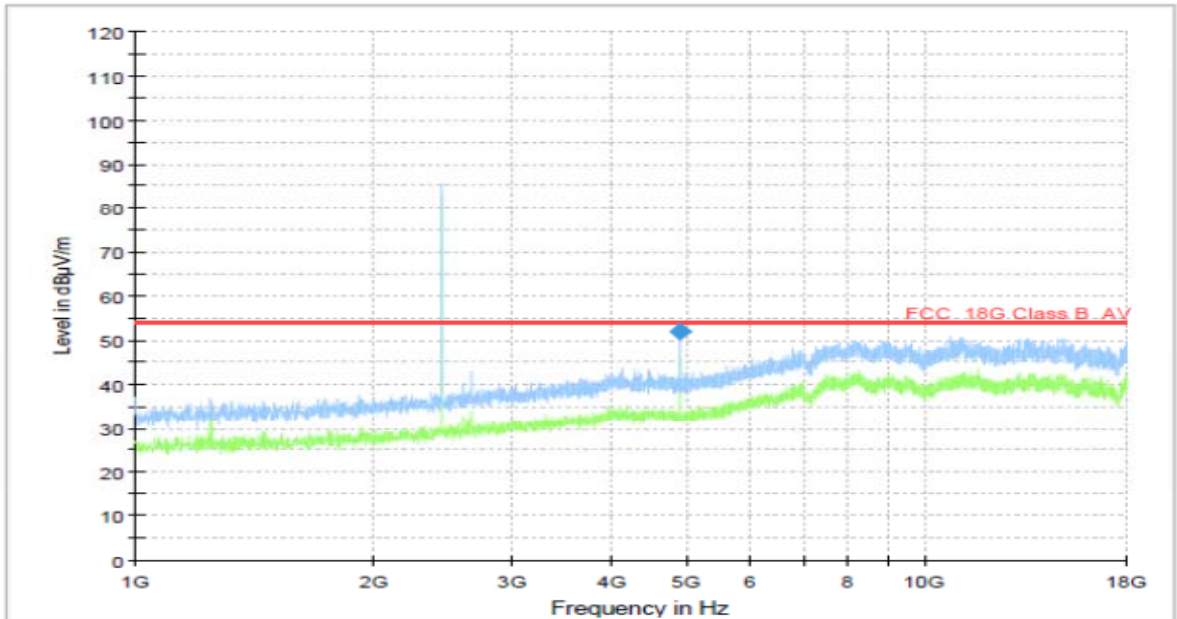
Note:

PLOTS OF EMISSIONS

Worst Case : 2402 MHz GFSK modulation : 1 GHz to 18 GHz

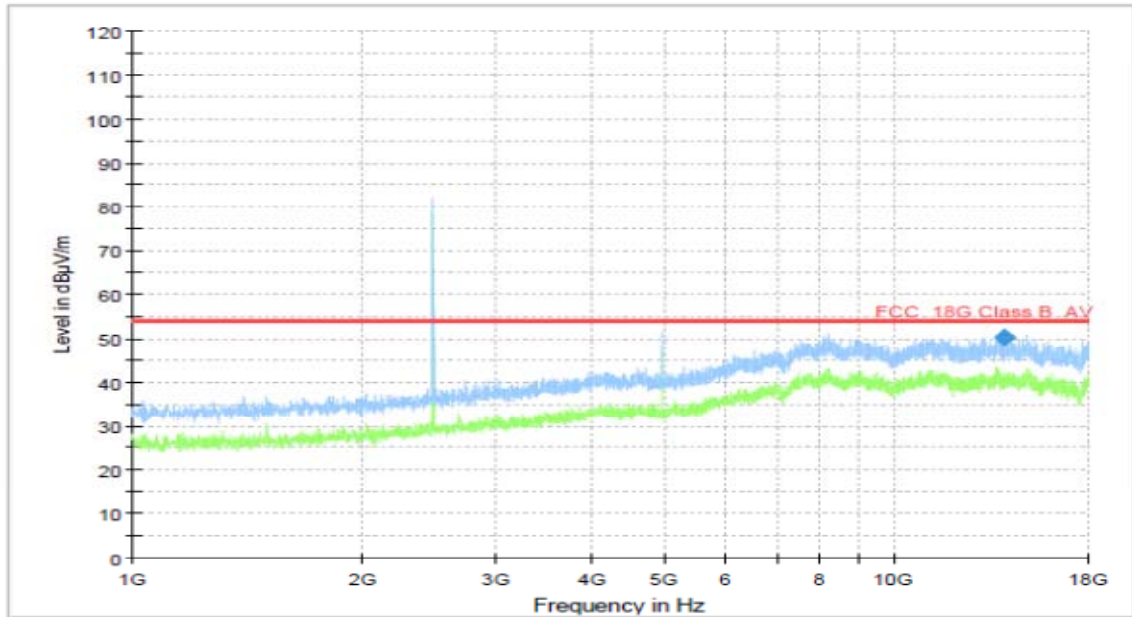


Worst Case : 2442 MHz GFSK modulation : 1 GHz to 18 GHz



PLOTS OF EMISSIONS

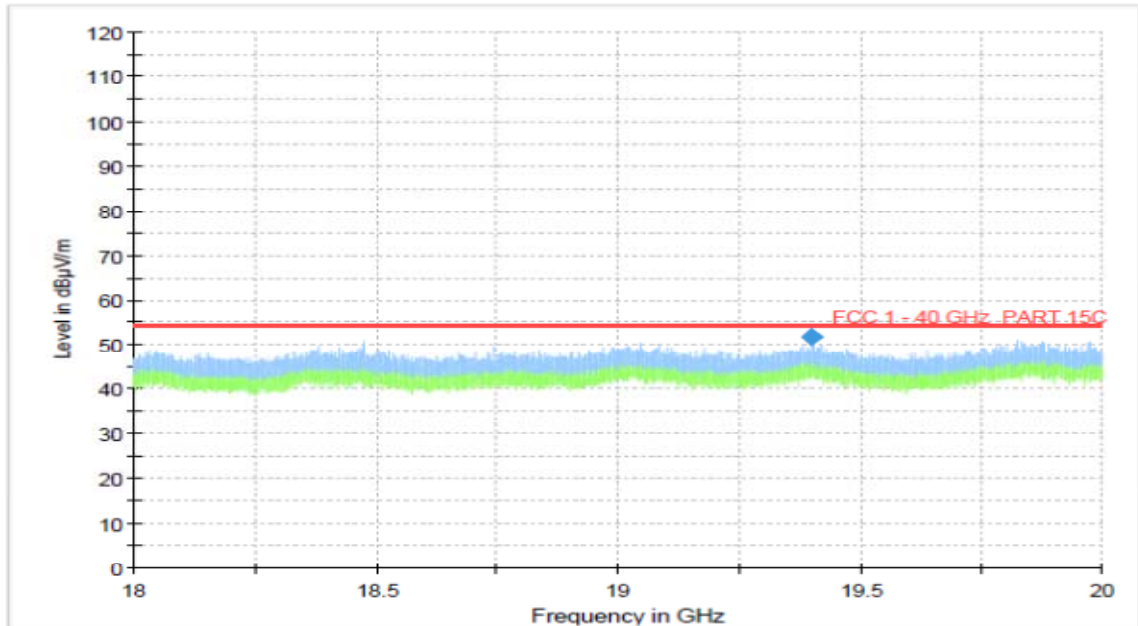
Worst Case : 2480MHz GFSK modulation : 1 GHz to 18 GHz



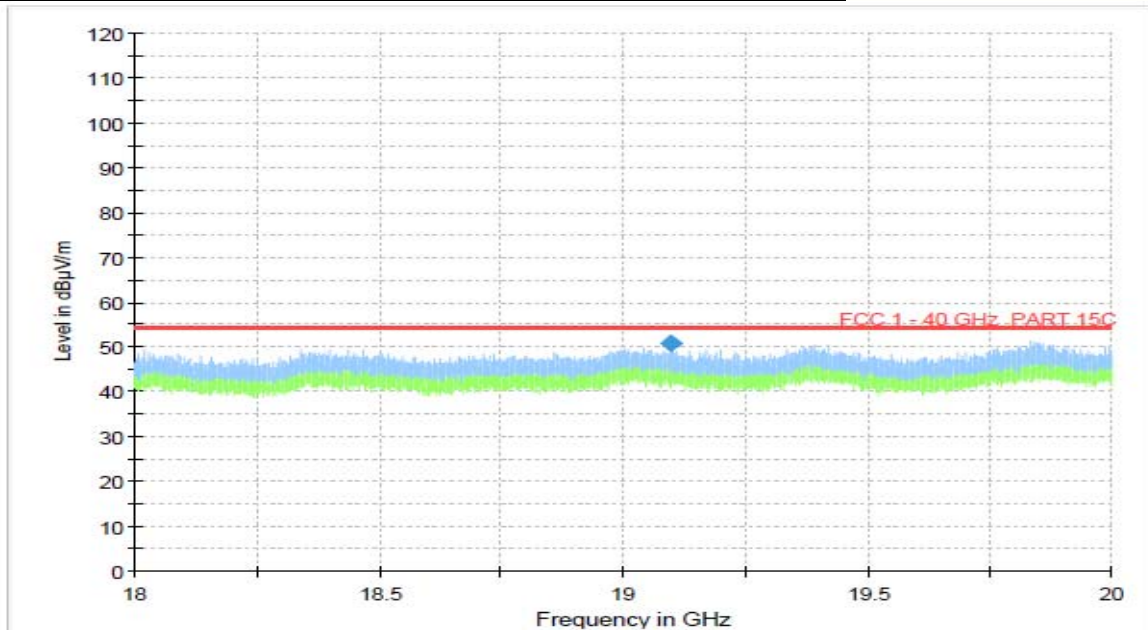
NTREE

PLOTS OF EMISSIONS

Worst Case : 2402 MHz GFSK modulation : 18 GHz to 20 GHz

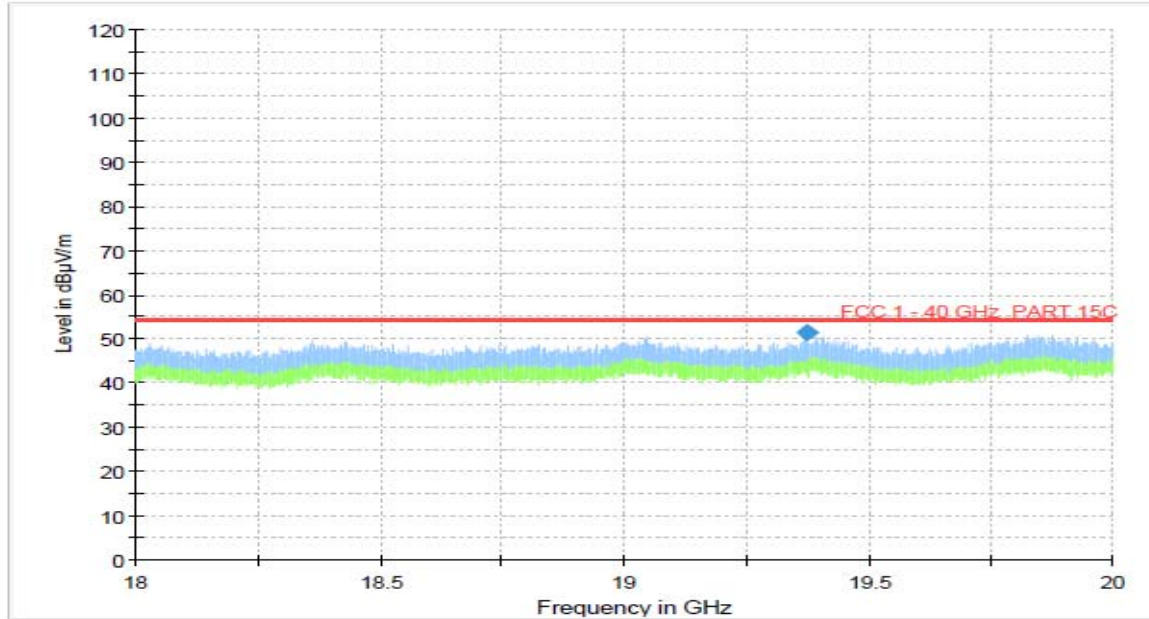


Worst Case : 2442 MHz GFSK modulation : 18 GHz to 20 GHz



PLOTS OF EMISSIONS

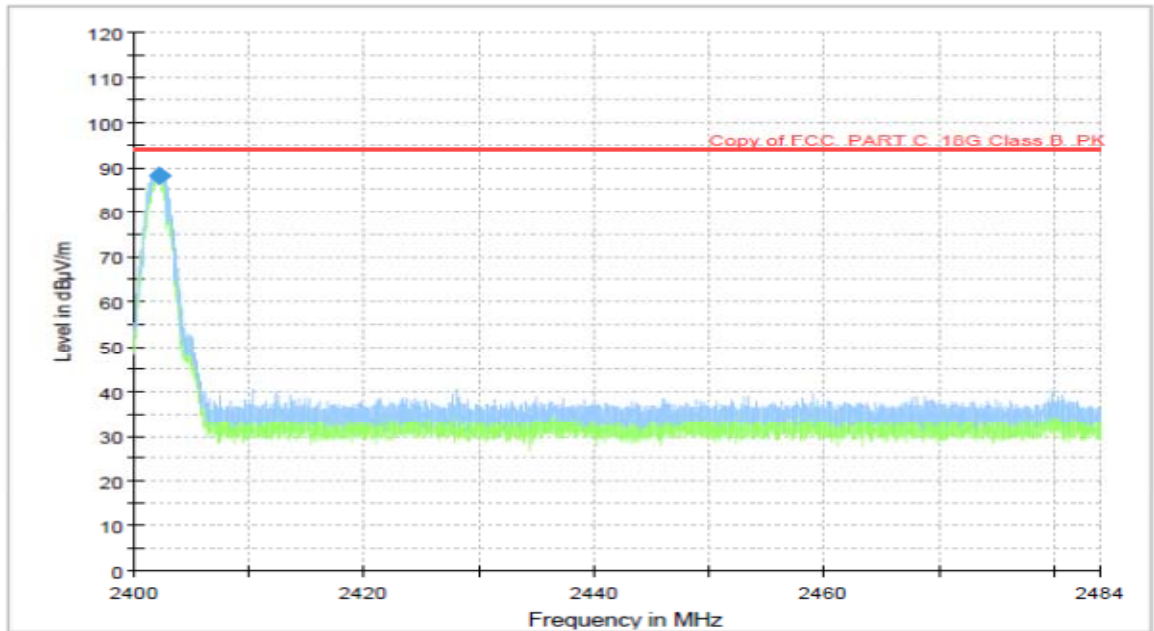
Worst Case : 2480MHz GFSK modulation : 18 GHz to 20 GHz



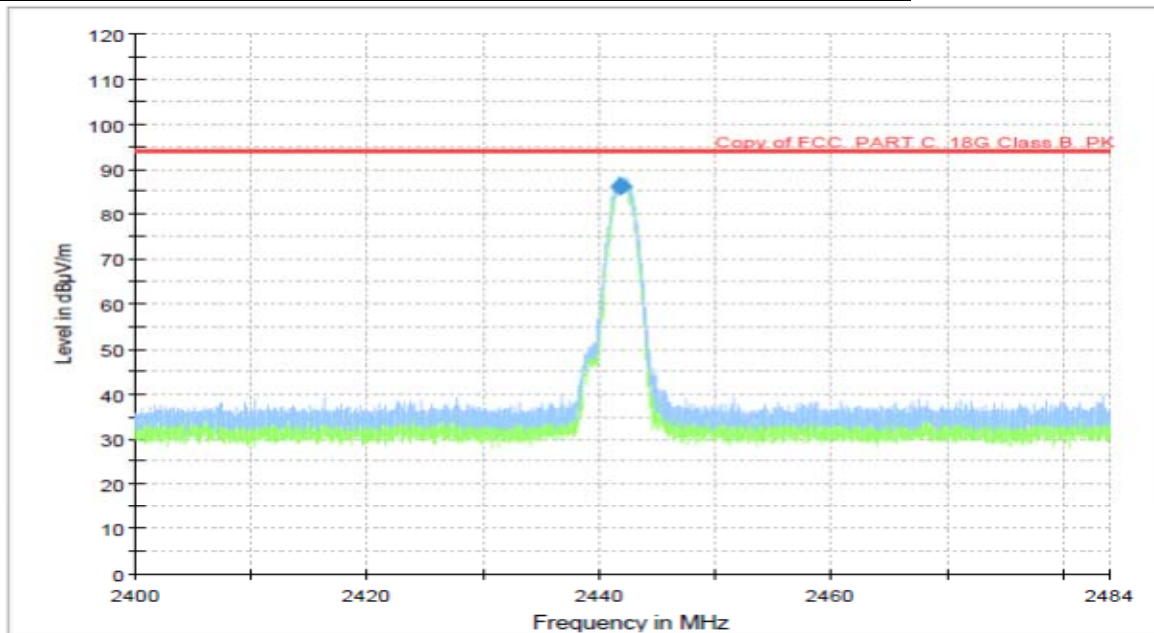
NTREE

PLOTS OF EMISSIONS

Worst Case : 2402 MHz GFSK modulation : 2.4 GHz to 2.4835 GHz

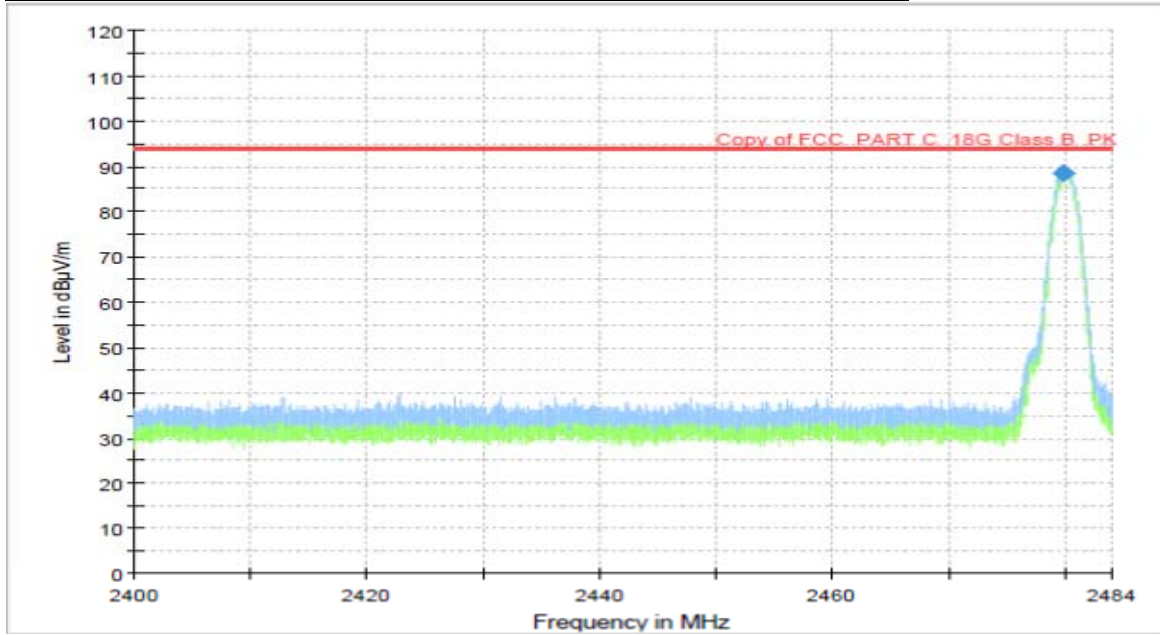


Worst Case : 2442 MHz GFSK modulation : 2.4 GHz to 2.4835 GHz



PLOTS OF EMISSIONS

Worst Case : 2480MHz GFSK modulation : 2.4 GHz to 2.4835 GHz



NTREE

TEST DATA

8.8 Radiated Band Edge

FCC §15.247(d)

Test Mode : Set to Lowest channel and Highest channel

Result

Lowest and Highest Channels

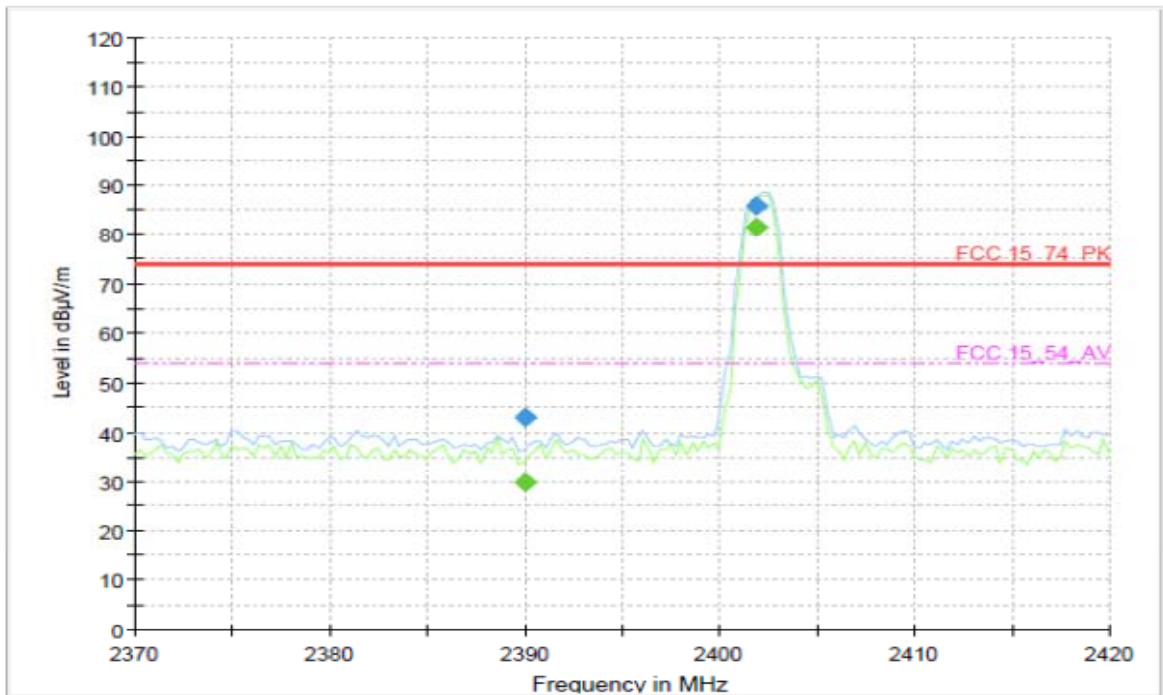
| Frequency (MHz) | MaxPeak (dBμV/m) | Average (dBμV/m) | Limit (dBμV/m) | Margin (dB) | Meas. Time (ms) | Bandwidth h (kHz) | Pol | Azimuth (deg) | Corr. (dB) |
|-----------------|------------------|------------------|----------------|-------------|-----------------|-------------------|-----|---------------|------------|
| 2390.0000 00 | --- | 29.72 | 54.00 | 24.28 | 1000.0 | 1000.000 | H | 249.0 | -7.7 |
| 2390.0000 00 | 43.04 | --- | 74.00 | 30.96 | 1000.0 | 1000.000 | H | 249.0 | -7.7 |
| 2483.6111 11 | 45.10 | --- | 74.00 | 28.90 | 1000.0 | 1000.000 | H | 163.0 | -7.1 |
| 2483.6111 11 | --- | 31.43 | 54.00 | 22.57 | 1000.0 | 1000.000 | H | 163.0 | -7.1 |

Note:

1. *Pol. H = Horizontal V = Vertical
2. **AF + CL + Amp. = Antenna Factor + Cable Loss + Amplifier.
3. Other spurious was under 20 dB below Fundamental.
4. *** Duty Cycle Correction Factor Calculation
 - Channel hop rate = 1600 hops/second
 - Adjusted channel hop rate = 1600 hops/second
 - Time per channel hop = 1/1600 hops/second = 0.625 ms
 - Time to cycle through all channels = 0.625 x 40 channels = 25 ms
 - Number of times transmitter hits on one channel = 100 ms / 25 ms = 4 time(s)
 - Worst case dwell time = 2.5 ms
 - Duty cycle correction factor = $20\log_{10}(2.5\text{ms}/100\text{ms}) = -32.0 \text{ dB}$
5. GFSK modulation mode was the worst condition.
6. The radiated emissions testing were made by rotating EUT through three orthogonal axes and rotating the receive antenna with horizontal, Vertical polarization. The worst data was recorded.
7. Peak emissions were measured using RBW = 1 MHz, VBW = 3 MHz, Detector = Peak.
8. Average emissions were measured using RBW = 1 MHz, VBW = 3kHz, Detector = Peak

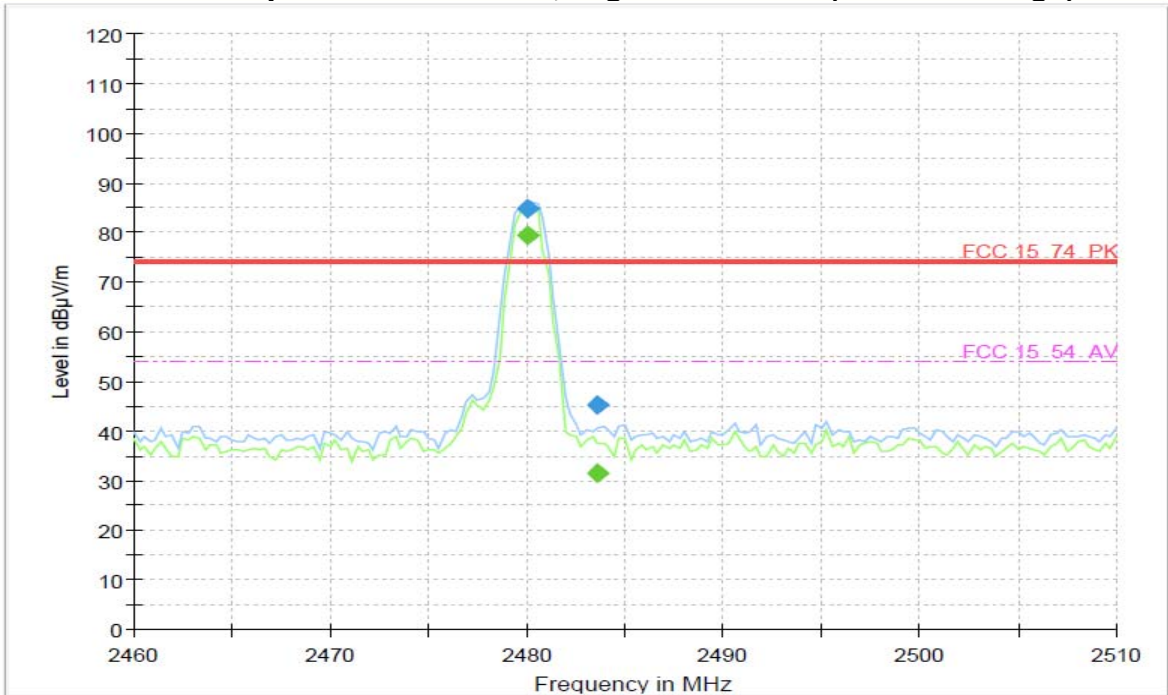
PLOT OF TEST DATA

Restricted Band Spurious Emissions, Lowest channel (Peak / Average)



PLOT OF TEST DATA

Restricted Band Spurious Emissions, Highest channel (Peak / Average)



9. TEST EQUIPMENT

| No | Intrument | Manufacturer | Model | Serial No. | Calibration Date | Calibration Interval |
|----|--|---------------------------|------------|--------------|------------------|----------------------|
| 1 | EMI Test Receiver | ROHDE & SCHWARZ | ESR7 | 101542 | 2018.03.22 | 1 Year |
| 2 | Tri-Log Antenna | Schwarzbeck | VULB9168 | 9168-721 | 2019.04.03 | 2 Year |
| 3 | Amplifier | TESTEK | TK-PA6S | 120018 | 2018.03.16 | 1 Year |
| 4 | Attenuator | SRTechnology Corporate | N-ATTEN | 101785#2 | 2018.03.16 | 1 Year |
| 5 | EMI Test Receiver | ROHDE & SCHWARZ | FSV40 | 100994 | 2018-03-23 | 1 Year |
| 6 | EMI Test Receiver | ROHDE & SCHWARZ | ESR7 | 101302 | 2018-03-23 | 1 Year |
| 7 | Double Ridged Broadband Horn Antenna | Schwarzbeck | BBHA 9120D | 9120D-1245 | 2018.04.06 | 2 Year |
| 8 | BROADBAND HORN ANTENNA | Schwarzbeck | BBHA9170 | BBHA9170 573 | 2018.05.23 | 2 Year |
| 9 | Amplifier | TESTEK | TK-PA1840H | 140003 | 2018.03.23 | 1 Year |
| 10 | Amplifier | TESTEK | TK-PA1840H | 140002 | 2018.03.30 | 1 Year |

*) Test equipment used during the test

NTREE