# Nemko Korea Co., Ltd.

155 & 159, Osan-Ro, Mohyeon-Myeon, Cheoin-Gu, Yongin-Si, Gyeonggi-Do 449-852 KOREA, REPUBLIC OF
TEL:+82 31 330-1700 FAX:+82 31 322 2332

## FCC EVALUATION REPORT FOR CERTIFICATION

**Applicant :**

**Ray Co., Ltd.**
**332-7, Samsung 1-ro, Hwaseong-si,**
**Gyeonggi-do, Korea**
**(Post code : 445-330)**
**Attn. : Mr. Seho Lee**

**Dates of Issue : January 14, 2014**
**Test Report No. : NK-13-R-194**
**Test Site : Nemko Korea Co., Ltd.**

| | |
|---|---|
| **FCC ID** | **2ABBPRPMR500** |
| **Brand Name** | **Ray** |
| **Contact Person** | **Ray Co., Ltd.**<br>**332-7, Samsung 1-ro, Hwaseongi-si,**<br>**Gyeonggi-do, Korea**<br>**Telephone No. : +82-70-7601-0275** |

| | |
|---|---|
| Applied Standard: | FCC 47 CFR Part 15.247 |
| Classification: | Digital modulation Transmitter |
| EUT Type: | Zigbee module |

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 C63.4-2003, ANSI C63.10-2009. 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.

Jan 14, 2014
Tested By : Won-ho Son
Engineer

Jan 14. 2014
Reviewed By : Deokha Ryu
Technical Manager

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# 1. SCOPE

*Measurement and determination of electromagnetic emissions (EME) of radio frequency devices including intentional and/or unintentional radiators for compliance with the technical rules and regulations of the Federal Communications Commission under FCC part 15.247.*

| | |
|---|---|
| **Responsible Party :**<br>**Contact Person :** | Ray Co., Ltd.<br>Mr. Seho Lee |
| **Manufacturer :** | Ray Co., Ltd.<br>332-7, Samsung 1-ro, Hwaseong-si, Gyeonggi-do, Korea, 445-330 |

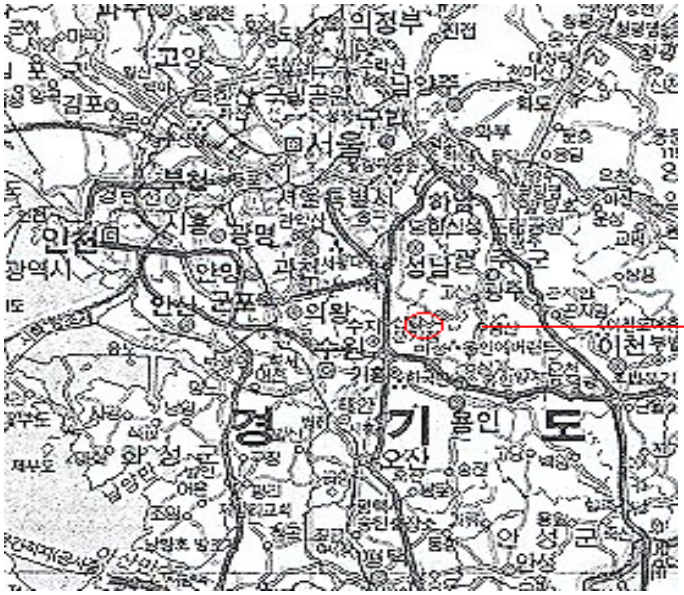
- FCC ID: 2ABBPRPMR500
- Model: RP-MR500
- Brand Name: Ray
- EUT Type: Zigbee Module
- Classification: Digital modulation Transmitter
- Applied Standard: FCC 47 CFR Part 15.247
- Test Procedure(s): ANSI C63.4-2003, ANSI C63.10 and FCC guidance of Guidance 558074 D01 DTS Meas. Guidance v03r01
- Dates of Test: Aug. 06, 2013 ~ Sep. 05, 2013
- Place of Tests: Nemko Korea Co., Ltd.

# 2. INTRODUCTION

## 2.1 Test facility

The measurement procedure described in American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz (ANSI C63.4-2003), the American National Standard for Testing Unlicensed Wireless Devices (ANSI C63.10-2009) was used in determining radiated and conducted emissions emanating from **Ray Co., Ltd. FCC ID : 2ABBPRPMR500**

These measurement tests were conducted at ***Nemko Korea Co., Ltd. EMC Laboratory*** .
The site address 155 & 159, Osan-Ro, Mohyeon-Myeon, Cheoin-Gu, Yongin-Si, Gyeonggi-Do 449-852 KOREA, REPULIC OF.
The area of Nemko Korea Corporation Ltd. EMC Test Site is located in a mountain area at 80 km (48 miles) southeast and Incheon International Airport (Incheon Airport), 30 km (18miles) south-southeast from central Seoul.
It is located in the valley surrounded by mountains in all directions where ambient radio signal conditions are quiet and a favorable area to measure the radio frequency interference on open field test site for the computing and ISM devices manufactures.
The detailed description of the measurement facility was found to be in compliance with the requirements of §2.948 according to ANSI C63.4-2003.




Nemko Korea Co., Ltd.
EMC Lab.
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Fig. 1. The map above shows the Seoul in Korea vicinity area.
The map also shows Nemko Korea Corporation Ltd. EMC Lab. and Incheon Airport.

## 2.2 Accreditation and listing

| Accreditation type | | Accreditation number |
|---|---|---|
| FC | FCC part 15/18 Filing site | Registration No. 97992 |
| | CAB Accreditation for DOC | Designation No. KR0026 |
| KOLAS | KOLAS Accredited Lab.<br>(Korea Laboratory Accreditation Scheme) | Registration No. 155 |
| Industry Canada | Canada IC Registered site | Site No. 2040E |
| VCCI | VCCI registration site(RE/CE/Telecom CE) | Member No. 2118 |
| IECEE CB SCHEME | EMC CBTL | - |
| 방송통신위원회 | KCC(RRL)Designated Lab. | Registration No. KR0026 |
| | SASO registered Lab and Certification Body | Registration No. 2008-15 |

# 3. TEST CONDITIONS & EUT INFORMATION

## 3.1 Operation During Test

During the test, the EUT was connected to laptop PC and then a test program was executed to operate EUT continuously (Duty cycle ≥ 98%).
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.

The EUT was programmed with the following output power setting that was used during testing:

| Test frequency | 2425 MHz | 2440 MHz | 2470 MHz |
|---|---|---|---|
| Power Level | 05 | 05 | 05 |

### 3.1.1 Table of test channels

| Test Items | Mode | Data rate (Mbps) | Test Channel (CH) |
|---|---|---|---|
| Conducted Emissions | 802.15.4 | 250 kbps | 18 |
| Radiated Emissions | 802.15.4 | 250 kbps | 18 |
| 6 dB Bandwidth | 802.15.4 | 250 kbps | 15/18/24 |
| Peak Output Power | 802.15.4 | 250 kbps | 15/18/24 |
| Peak Power Spectral Density | 802.15.4 | 250 kbps | 15/18/24 |
| Conducted Spurious Emission | 802.15.4 | 250 kbps | 15/18/24 |
| Radiated Spurious Emission, Band edge Emission | 802.15.4 | 250 kbps | 15/18/24 |

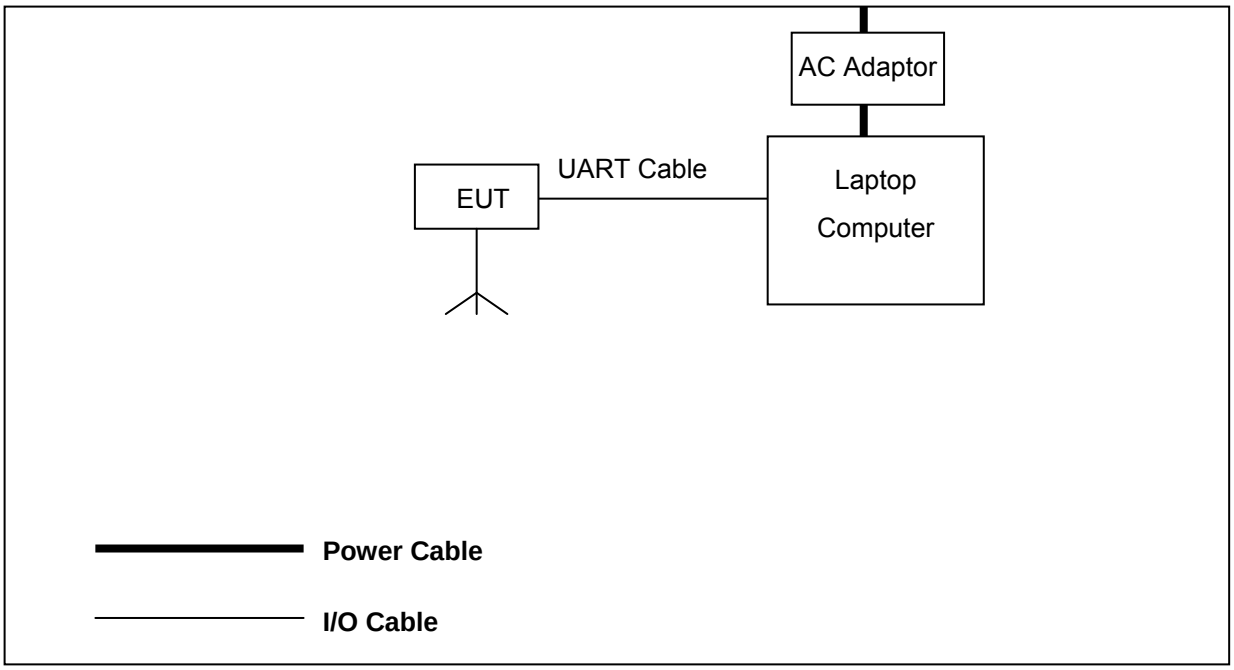
### 3.1.2 Antenna TX mode information:

| Frequency band | Mode | Antenna TX mode | Support MIMO |
|---|---|---|---|
| 2.4 GHz | 802.15.4 | ■ 1TX, □ 2TX | □ Yes, ■ No |

## 3.2 Support Equipment

| | | |
|---|---|---|
| EUT | RAY Co., Ltd.<br>Model: RP-MR500 | FCC ID: 2ABBPRPMR500<br>S/N: N/A |
| Laptop Computer | HP<br>Model : G62-355TU<br>0.3 m Unshielded 6 pin UART cable | FCC DOC<br>S/N : CNF0452FN3 |
| AC/DC Adapter | LITE-ON TECHNOLOGY (CHANGZHOU) CO., LTD.<br>Model : Series PPP009L-E<br>1.5 m unshielded power cable | FCC DOC<br>S/N : WBGST03UZOFQ6 |

## 3.3 Setup Drawing



## 3.4 EUT Information

The EUT is the **Ray Co., Ltd. Zigbee Module, FCC ID: 2ABBPRPMR500.**

Specifications:

| | |
|---|---|
| Category | Zigbee module |
| Model Name | RP-MR500 |
| Brand Name | RAY |
| Frequency of Operation | 2425 MHz ~ 2470 MHz |
| Maximum Peak Conducted Output Power | 3.94 dBm |
| Channels | 4 CH (2425, 2440, 2455, 2470 MHz) |
| Antenna Gain (peak) | 3.0 dBi |
| Antenna Setup | 1TX / 1RX |
| Modulations | DSSS(OQPSK) for 802.15.4 |
| Temperature Range | 0 ℃ ~ +40 ℃ |
| Voltage | 1.9 Vdc ~ 3.3 Vdc |
| Dimensions (H x W x D) | 24.2 mm x 41.0 mm x 4.52 mm |
| Weight | 4 g |
| Remarks | - |

# 4. 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 | Complies | |
| Radiated Emission | 15.209 | Complies | |
| 6 dB Bandwidth | 15.247(a)(2) | Complies | |
| Peak Power Output | 15.247(b)(3) | Complies | |
| Power Spectral Density | 15.247(e) | Complies | |
| Conducted Spurious Emission | 15.247(d) | Complies | |
| Radiated Spurious Emission | 15.247(d) | Complies | |
| Maximum Permissible Exposure | 1.1307(b) | Complies | |

# 5. RECOMMENDATION/CONCLUSION

The data collected shows that the **Ray Co., Ltd. Zigbee Module, FCC ID: 2ABBPRPMR500** is in compliance with Part 15.247 of the FCC rule.

# 6. 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 **Ray Co., Ltd. Zigbee Module, FCC ID: 2ABBPRPMR500** is **permanently attached** and there are no provisions for connection to an. It complies with the requirement of §15.203.

# 7. DESCRIPTION OF TESTS

## 7.1 Conducted Emissions

The Line conducted emission test facility is located inside a 4 x 7 x 2.5 meter shielded enclosure. It is manufactured by EM engineering. The shielding effectiveness of the shielded room is in accordance with MIL-STD-285 or NSA 65-6. A 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 (ESH3-Z5) and (ESH2-Z5) of the 50 ohm/50 μH Line Impedance Stabilization Network (LISN) are bonded to the shielded room. The EUT is powered from the Rohde & Schwarz LISN (ESH3-Z5) and the support equipment is powered from the Rohde & Schwarz LISN (ESH2-Z5). 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 (serpentinefashion) 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 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.

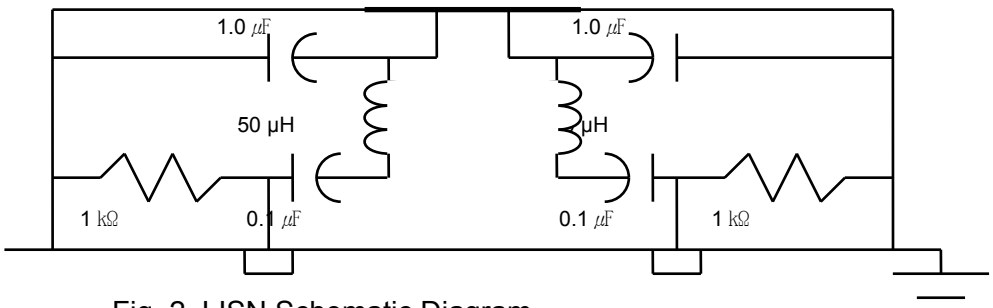



Fig. 2. LISN Schematic Diagram

## 7.2 Radiated Emissions

The measurement was performed at the test site that is specified in accordance with ANSI C63.4-2003 and ANCI C63.10-2009.
The spurious emission was scanned from 9 kHz to 30 MHz using Loop Antenna(Rohde&Schwarz, HFH2-Z2) and 30 to 1000 MHz using Trilog broadband test antenna(Schwarzbeck, VULB 9163). Above 1 GHz, Horn antenna (Schwarzbeck BBHA 9120D: up to 18 GHz, Q-par Angus QSH20S20 : 18 to 26.5 GHz, QSH22K20: up to 40 GHz) was used.
The test equipment was placed on turntable with 0.8 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.

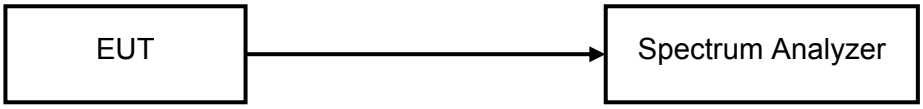
At frequencies below 1000 MHz, measurements performed using the CISPR quasi-peak detection.
At frequencies above 1000 MHz, measurements performed using the peak and average measurement procedures described in KDB “558074D01 DTS Meas Guidance v03r01” in section 12.2.4 and 12.2.5.1. Peak emission levels 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 = 3 MHz, Detector = RMS, Trace averaging in power averaging (RMS) mode over a minimum of 100 traces, If continuous transmission of the EUT couldn’t be achieved and duty cycle was constant, a correction factor (10 log (1 / x)) was added to the measurement result.

| 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)

## 7.3 6 dB Bandwidth

### Test Setup

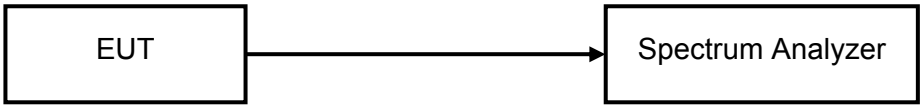



### Test Procedure

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 ≥ 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.

## 7.4 Maximum Peak Output Power

### Test Setup

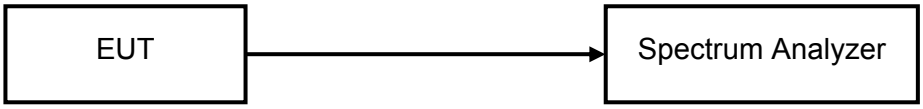



### Test Procedure

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 ≥ DTS bandwidth
VBW ≥ 3 x RBW
Span ≥ 3 x RBW
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.

## 7.5 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 to : 3 kHz ≤ RBW ≤ 100 kHz

VBW ≥ 3 x RBW

Detector = peak

Sweep time = auto couple

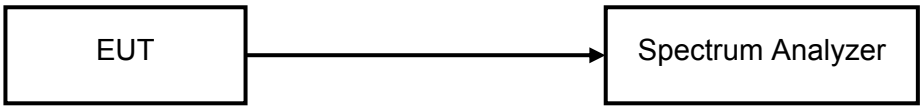
Trace mode = max hold

Allow the trace to stabilize.

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

## 7.6 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 ≥ 3 x RBW
Span = 1.5 times the DTS channel bandwidth
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 PSD level.

2) Emission level measurement
RBW = 100 kHz
VBW ≥ 3 x RBW
Set the center frequency and span to encompass frequency range to be measured
Ensure that the number of measurement points ≥ span / RBW
Detector = peak
Sweep time = auto couple
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:**

| Frequency (MHz) | Level(dBµV) | | *)Factor (dB) | **) Line | Limit(dBµV) | | Margin(dB) | |
|---|---|---|---|---|---|---|---|---|
| | Q-Peak | Average | | | Q-Peak | Average | Q-Peak | Average |
| 0.15 | 46.4 | 34.8 | 0.2 | L | 66.0 | 56.0 | 19.6 | 21.2 |
| 0.18 | 42.3 | 31.1 | 0.2 | N | 64.5 | 54.5 | 22.2 | 23.4 |
| 0.20 | 43.2 | 34.8 | 0.2 | N | 63.6 | 53.6 | 20.4 | 18.8 |
| 0.20 | 40.9 | 34.1 | 0.2 | N | 63.6 | 53.6 | 22.7 | 19.5 |
| 0.26 | 38.2 | 31.1 | 0.2 | N | 61.4 | 51.4 | 23.2 | 20.3 |
| 0.50 | 32.6 | 28.3 | 0.2 | N | 56.0 | 46.0 | 23.4 | 17.7 |

**Line Conducted Emissions Tabulated Data**

***Note(s):***

*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 Part section 15.207(a).*

# PLOTS OF EMISSIONS

- ***Conducted Emission at the Mains port (Line)***

NEMKO KOREA (NK-13-R-194) 05 Sep 2013 15:26

Conducted Emissions

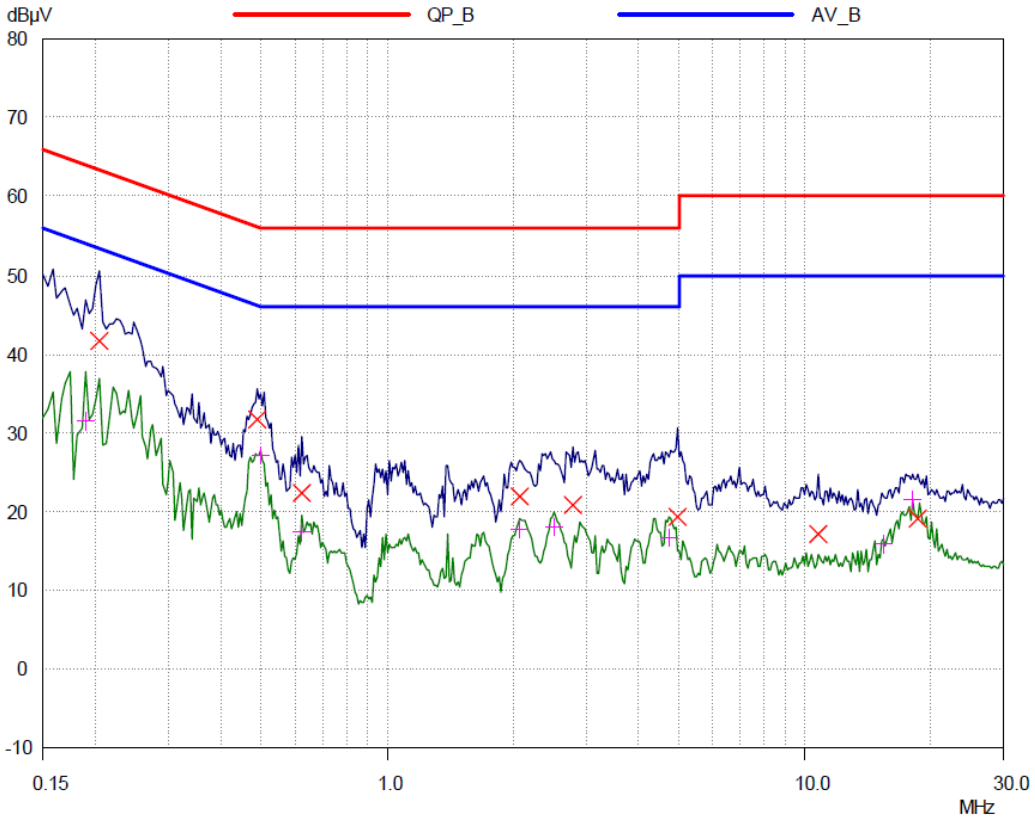
| | |
|---|---|
| EUT: | EUT |
| Manuf: | Ray Co.,Ltd. |
| Op Cond: | a.c. 120 V, 60 Hz |
| Operator: | Wonho Son |
| Test Spec: | FCC Part 15.207 |
| Comment: | MODEL : RP-MR500 |
| | LINE : LINE-PE |

Scan Settings (1 Range)

| Frequencies | | | Receiver Settings | | | | | |
|---|---|---|---|---|---|---|---|---|
| Start | Stop | Step | IF BW | Detector | M-Time | Atten | Preamp | OpRge |
| 150kHz | 30MHz | 3.9063kHz | 9kHz | PK+AV | 20msec | 20 dB | OFF | 60dB |

| Transducer | No. | Start | Stop | Name |
|---|---|---|---|---|
| | 1 | 150kHz | 30MHz | ESH3_Z5_Line |

| Final Measurement: | | |
|---|---|---|
| | Detectors: | X QP / + AV |
| | Meas Time: | 1sec |
| | Subranges: | 8 |
| | Acc Margin: | 60 dB |



# PLOTS OF EMISSIONS

- ***Conducted Emission at the Mains port (Neutral)***

NEMKO KOREA (NK-13-R-194) 05 Sep 2013 15:16

Conducted Emissions

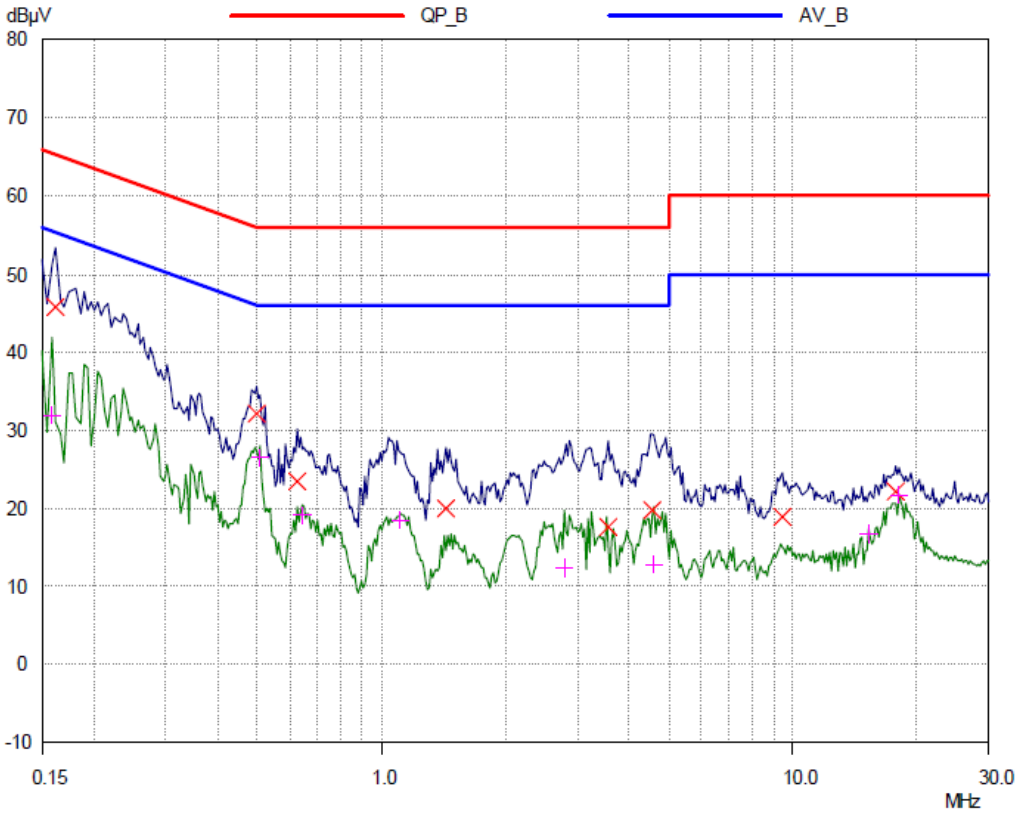
| | |
|---|---|
| EUT: | EUT |
| Manuf: | Ray Co.,Ltd. |
| Op Cond: | a.c. 120 V, 60 Hz |
| Operator: | Wonho Son |
| Test Spec: | FCC Part 15.207 |
| Comment: | MODEL : RP-MR500 |
| | LINE : NEUTRAL-PE |

Scan Settings (1 Range)

| Frequencies | | | Receiver Settings | | | | | |
|---|---|---|---|---|---|---|---|---|
| Start | Stop | Step | IF BW | Detector | M-Time | Atten | Preamp | OpRge |
| 150kHz | 30MHz | 3.9063kHz | 9kHz | PK+AV | 20msec | 20 dB | OFF | 60dB |

| Transducer | No. | Start | Stop | Name |
|---|---|---|---|---|
| | 1 | 150kHz | 30MHz | ESH3_Z5_Neutral |

| Final Measurement: | | |
|---|---|---|
| | Detectors: | X QP / + AV |
| | Meas Time: | 1sec |
| | Subranges: | 8 |
| | Acc Margin: | 60 dB |



# TEST DATA

## 8.2 Radiated Emissions

### FCC §15.209

**Result:**

| Frequency (MHz) | Reading (dBµV/m) | Pol* (H/V) | Antenna Heights (cm) | Turntable Angles (°) | AF+CL+Amp (dB)** | Result (dBµV/m) | Limit (dBµV/m) | Margin (dB) |
|---|---|---|---|---|---|---|---|---|
| 144.00 | 55.92 | H | 100 | 202 | -24.7 | 31.2 | 43.5 | 12.3 |
| 165.95 | 55.37 | V | 100 | 351 | -23.0 | 32.4 | 43.5 | 11.1 |
| 232.33 | 52.70 | H | 140 | 264 | -25.1 | 27.6 | 46.0 | 18.4 |
| 299.90 | 49.59 | H | 112 | 6 | -22.5 | 27.1 | 46.0 | 18.9 |
| 432.00 | 50.31 | H | 100 | 336 | -17.3 | 33.0 | 46.0 | 13.0 |
| 900.00 | 44.58 | V | 164 | 22 | -7.8 | 36.8 | 46.0 | 9.2 |

**Radiated Measurements at 3meters**

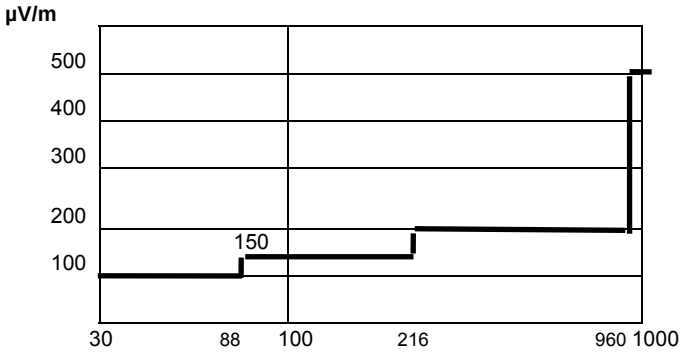



Fig. 3. Limits at 3 meters

***Note(s):***

*1. All modes were measured and the worst-case emission was reported.*

*2 The radiated limits are shown on Figure 3.*

*Above 1 GHz the limit is 500 µV/m.*

*3. *Pol. H = Horizontal, V = Vertical*

*4. **AF + CL + Amp. = Antenna Factor + Cable Loss + Amplifier.*

*5. Measurements using CISPR quasi-peak mode.*

*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. The limit is on the FCC Part section 15.209(a).*

# TEST DATA

## 8.3 6 dB Modulated Bandwidth

**FCC §15.247(a)(2)**

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

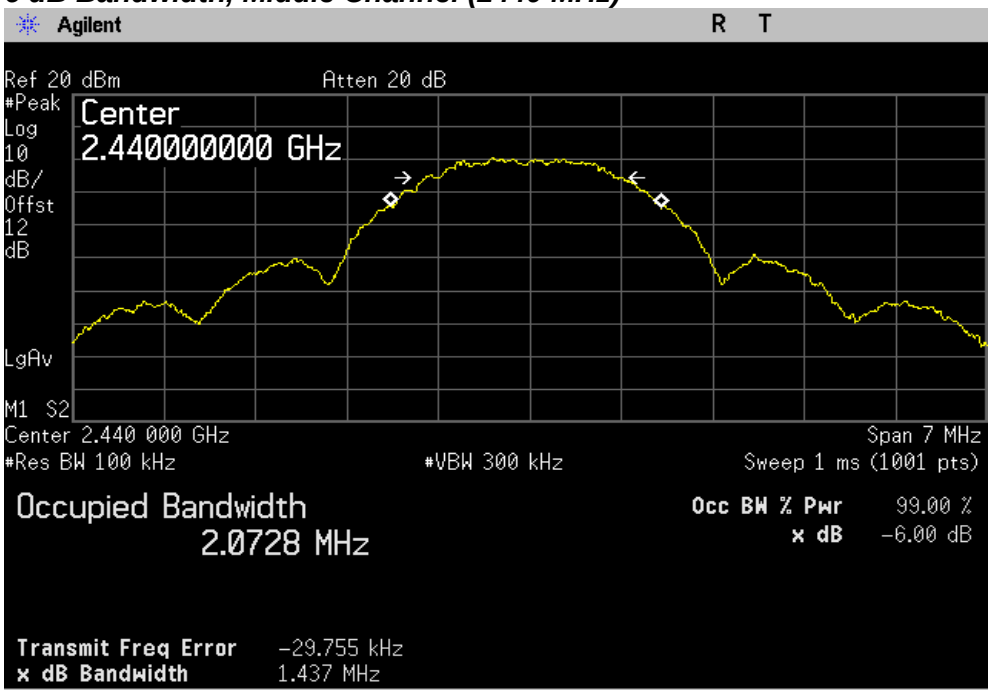
**Result:**

| Channel | Frequency(MHz) | Result(MHz) | Limit (MHz) |
|---|---|---|---|
| Low | 2425 | 1.433 | 0.5 |
| Middle | 2440 | 1.437 | 0.5 |
| High | 2470 | 1.531 | 0.5 |

# PLOTS OF EMISSIONS

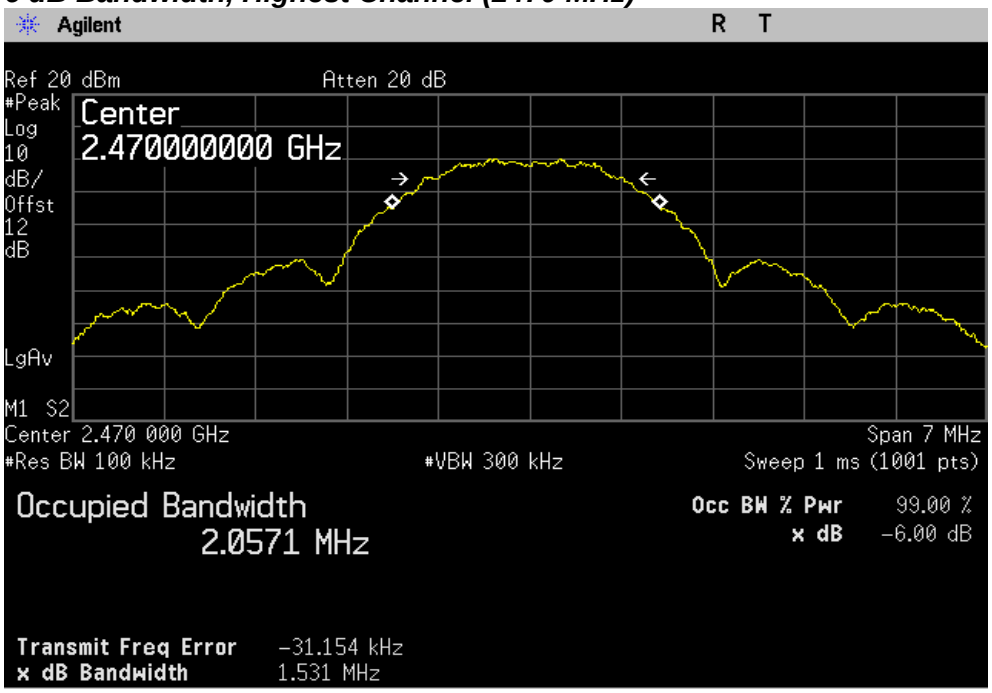
***6 dB Bandwidth, Lowest Channel (2425 MHz)***


***6 dB Bandwidth, Middle Channel (2440 MHz)***



# PLOTS OF EMISSIONS

***6 dB Bandwidth, Highest Channel (2470 MHz)***



# TEST DATA

## 8.4 Maximum peak conducted power

**FCC §15.247(b)(3)**

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

**Result:**

| Frequency (MHz) | Data rate (kbps) | Conducted Output Power (dBm) | Limit (dBm) | Margin (dB) |
|---|---|---|---|---|
| 2425 | 250 | 3.94 | 30.00 | 26.06 |
| 2440 | 250 | 3.77 | 30.00 | 26.23 |
| 2470 | 250 | 3.09 | 30.00 | 26.91 |

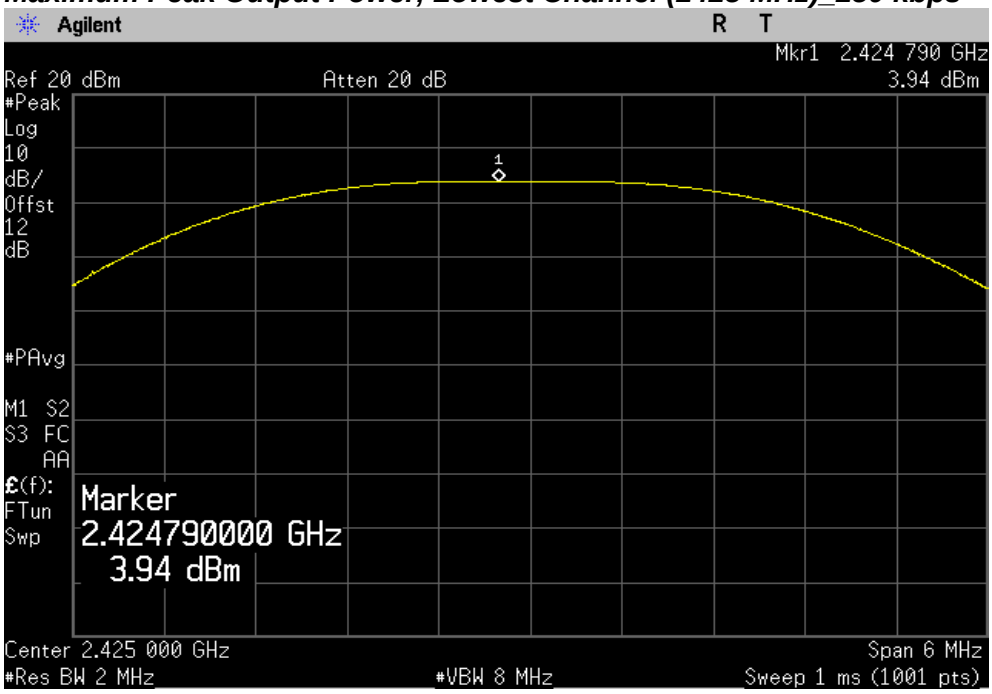
***Note(s):***

*The following equation was used for spectrum offset:*

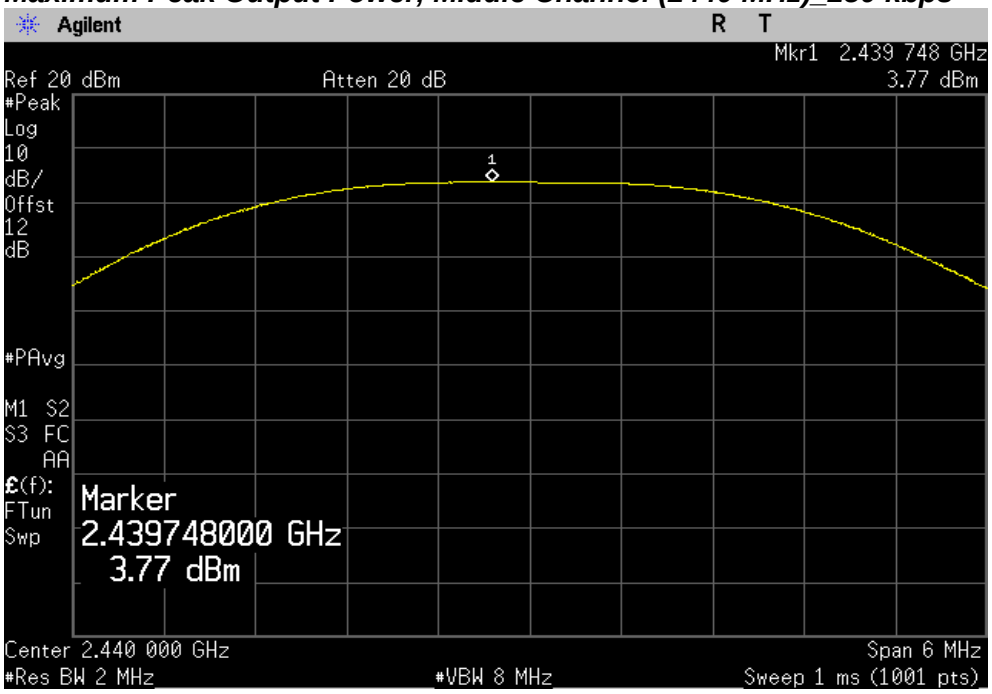
*Spectrum offset (dB) = Attenuator (dB) + Cable Loss (dB) + SMA Type Connector Loss (dB)*

# PLOT OF TEST DATA

***Maximum Peak Output Power, Lowest Channel (2425 MHz)_250 kbps***

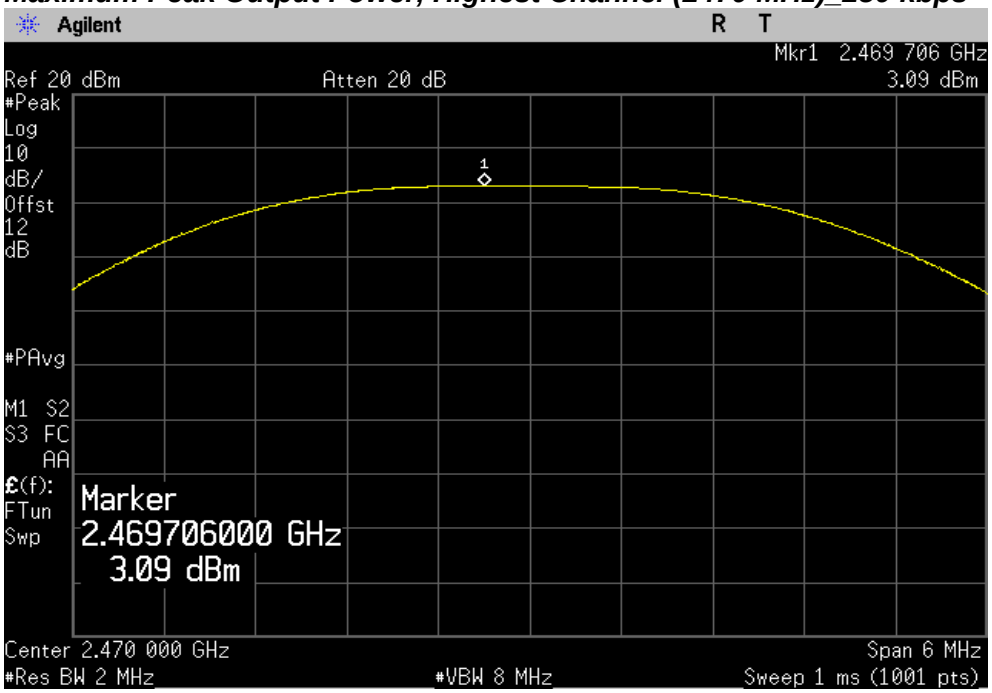



***Maximum Peak Output Power, Middle Channel (2440 MHz)_250 kbps***



# PLOT OF TEST DATA

***Maximum Peak Output Power, Highest Channel (2470 MHz)_250 kbps***



# TEST DATA

## 8.5 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) |
|---|---|---|---|
| Low | 2425 | 1.07 | 8.0 |
| Middle | 2440 | 0.87 | 8.0 |
| High | 2470 | 0.18 | 8.0 |

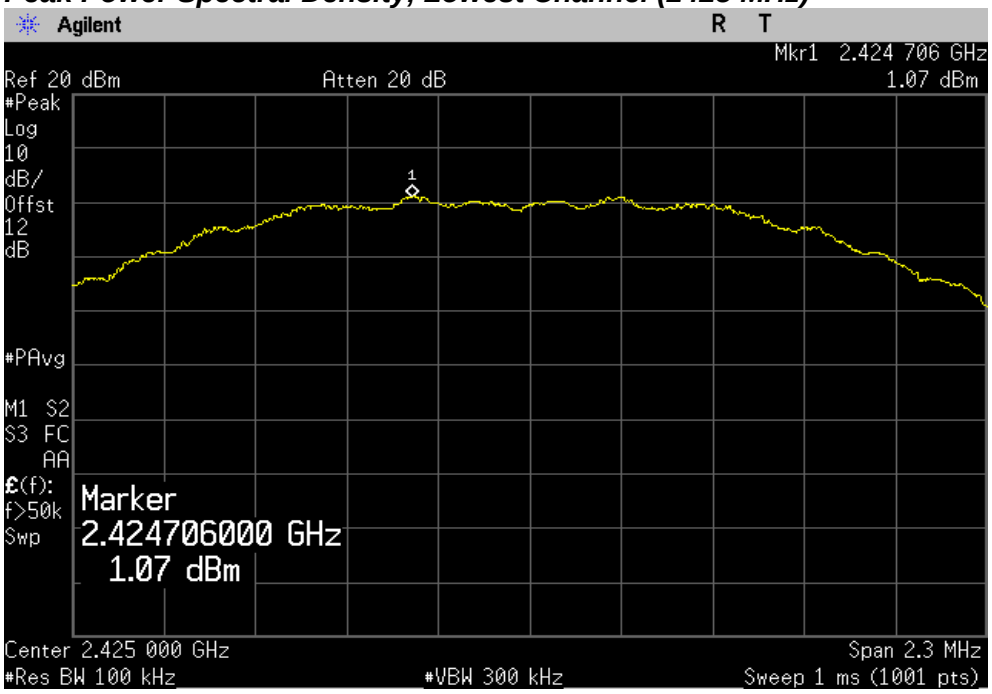
***Note(s):***

*The following equation was used for spectrum offset:*

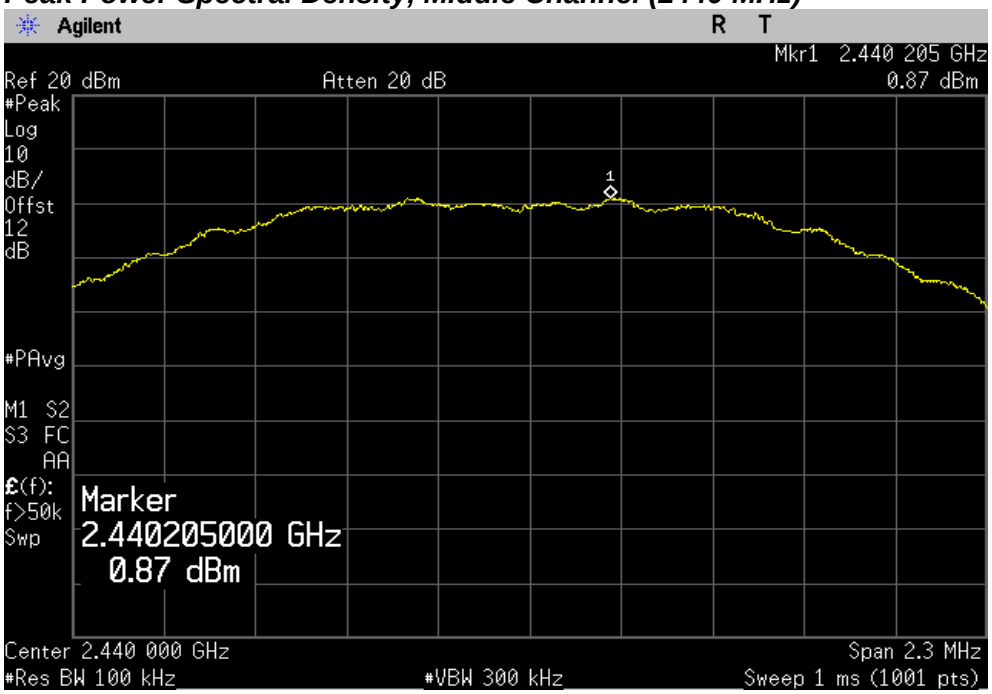
*Spectrum offset (dB) = Attenuator (dB) + Cable Loss (dB) + SMA Type Connector Loss (dB)*

# PLOT OF TEST DATA

***Peak Power Spectral Density, Lowest Channel (2425 MHz)***

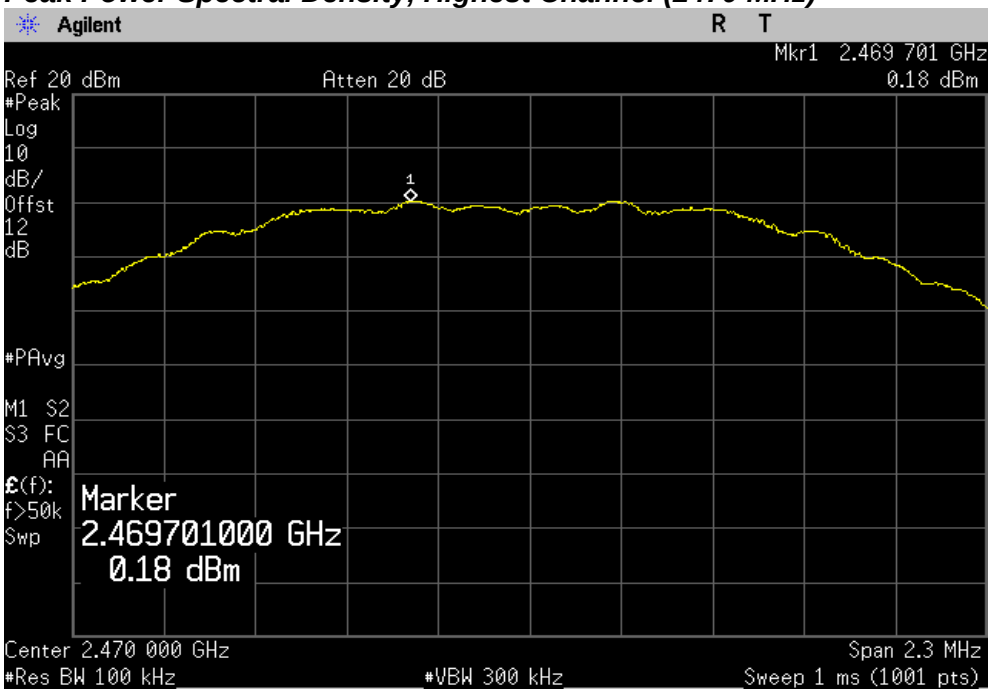



***Peak Power Spectral Density, Middle Channel (2440 MHz)***



# PLOT OF TEST DATA

***Peak Power Spectral Density, Highest Channel (2470 MHz)***



# TEST DATA

## 8.6 Conducted Spurious Emissions

**FCC §15.247(d)**

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

**Result**

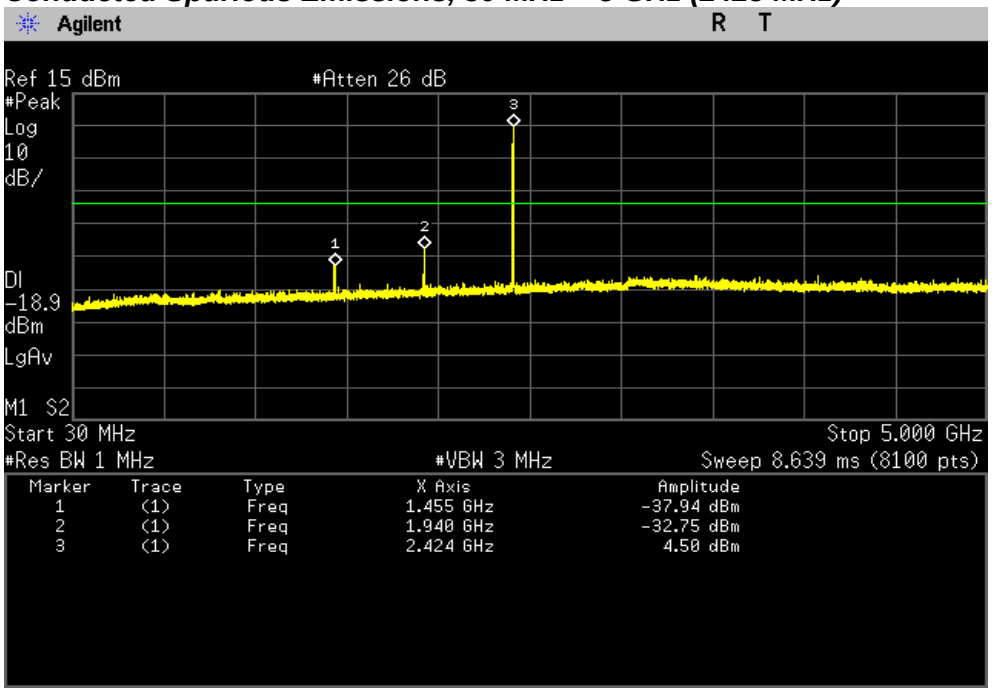
| Channel | Frequency (MHz) | Reference Level (dBm) | Conducted Spurious Emissions (dBc) | Limit (dBc) |
|---|---|---|---|---|
| Low | 2425 | 1.07 | More than 20 dBc | 20 |
| Middle | 2440 | 0.87 | More than 20 dBc | 20 |
| High | 2470 | 0.18 | More than 20 dBc | 20 |

***Notes:***

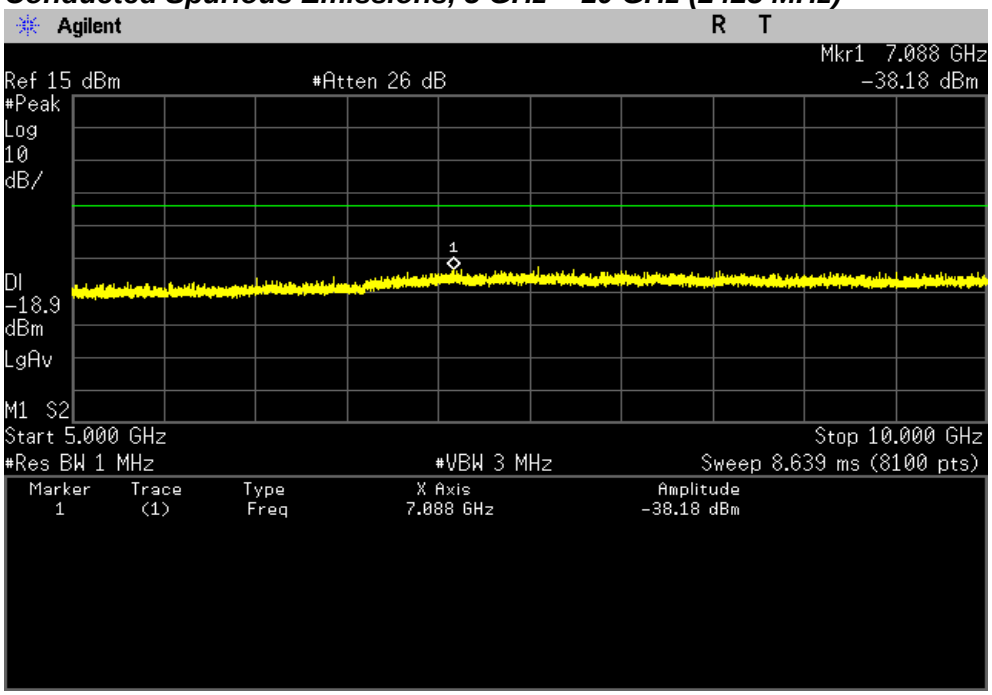
1. *The cable and attenuator loss from 30 MHz to 25 GHz was reflected in spectrum analyzer with correction factor for the spurious emissions test.*
2. *RBW was set to 1 MHz rather than 100 kHz in order to increase the test span.*
3. *The display line shown in the following plots indicates the limit at 20 dB below the fundamental emission level measured in a 100 kHz bandwidth.*
4. *For plots showing conducted spurious emissions near the limit, the frequencies were investigated with a reduced RBW to ensure that no emissions were present.*
5. *During the test, the sweep point was set 8001 for the conducted spurious emissions test and 4001 for the Band Edge test.*

# PLOT OF TEST DATA

***Conducted Spurious Emissions, 30 MHz ~ 5 GHz (2425 MHz)***

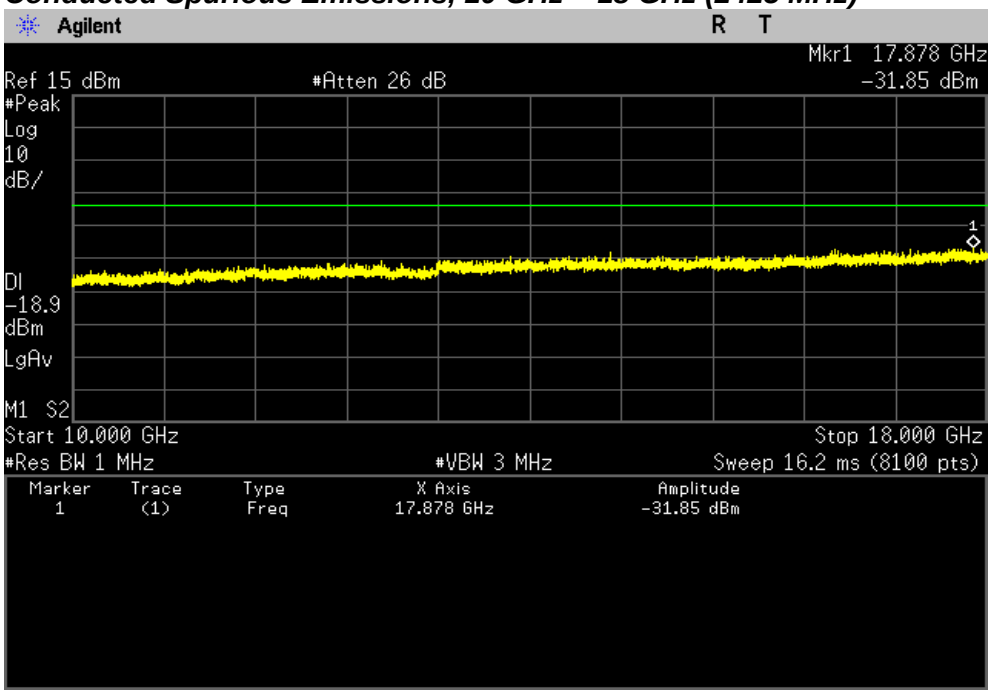



***Conducted Spurious Emissions, 5 GHz ~ 10 GHz (2425 MHz)***

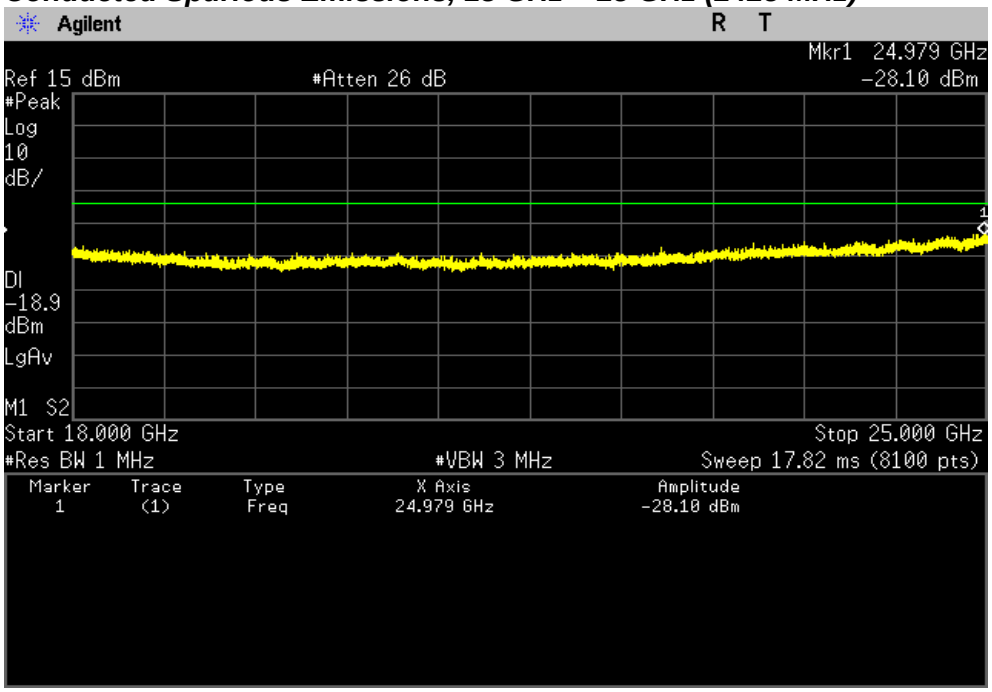


# PLOT OF TEST DATA

***Conducted Spurious Emissions, 10 GHz ~ 18 GHz (2425 MHz)***

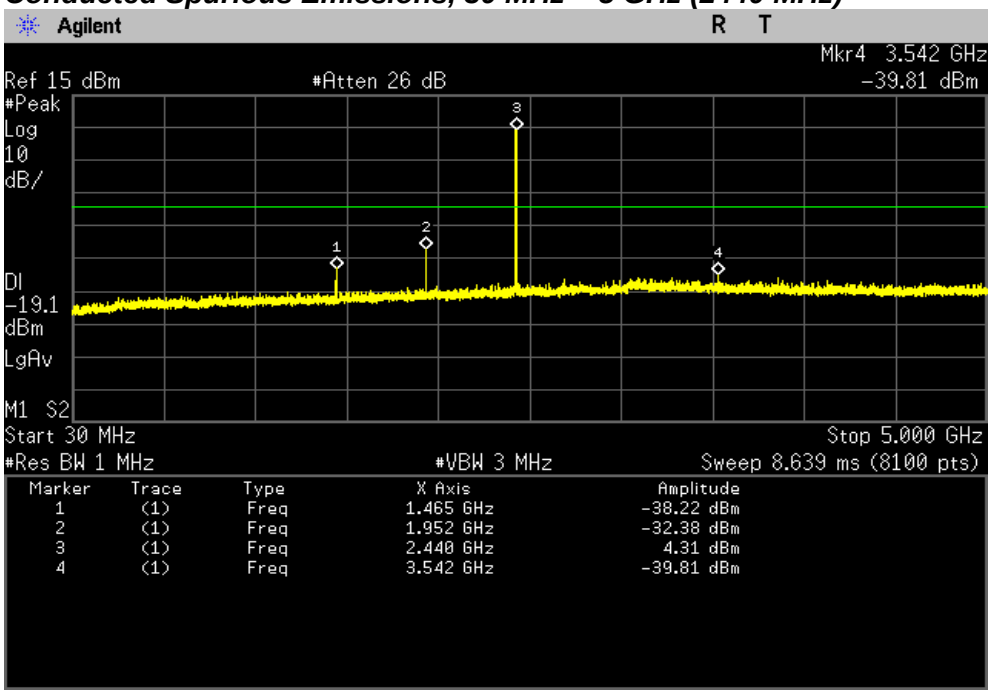



***Conducted Spurious Emissions, 18 GHz ~ 25 GHz (2425 MHz)***

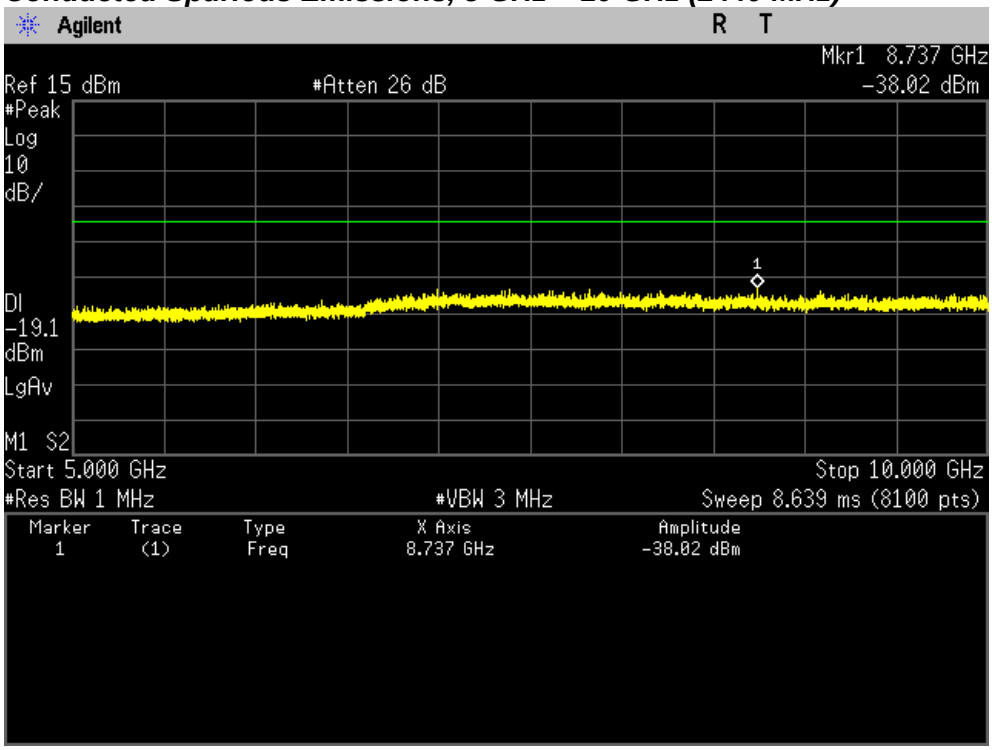


# PLOT OF TEST DATA

***Conducted Spurious Emissions, 30 MHz ~ 5 GHz (2440 MHz)***

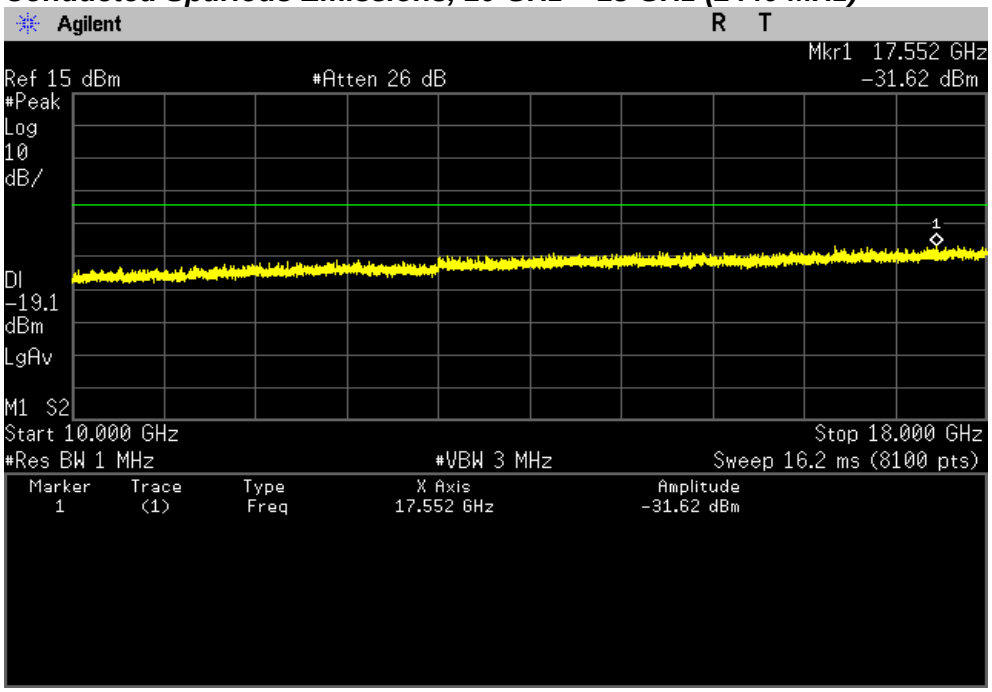



***Conducted Spurious Emissions, 5 GHz ~ 10 GHz (2440 MHz)***

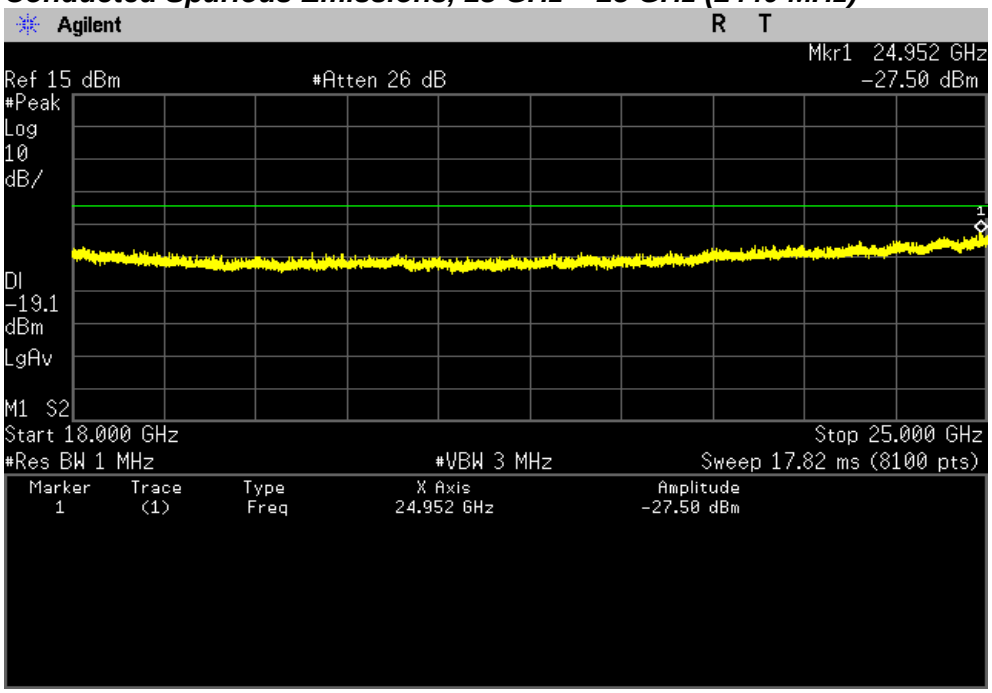


# PLOT OF TEST DATA

***Conducted Spurious Emissions, 10 GHz ~ 18 GHz (2440 MHz)***

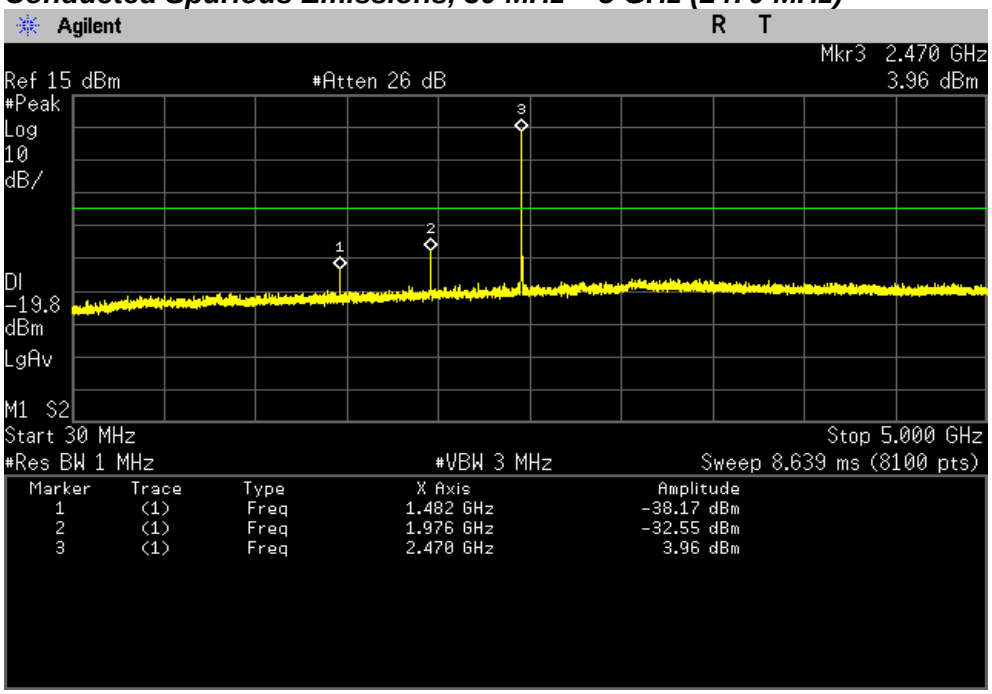



***Conducted Spurious Emissions, 18 GHz ~ 25 GHz (2440 MHz)***

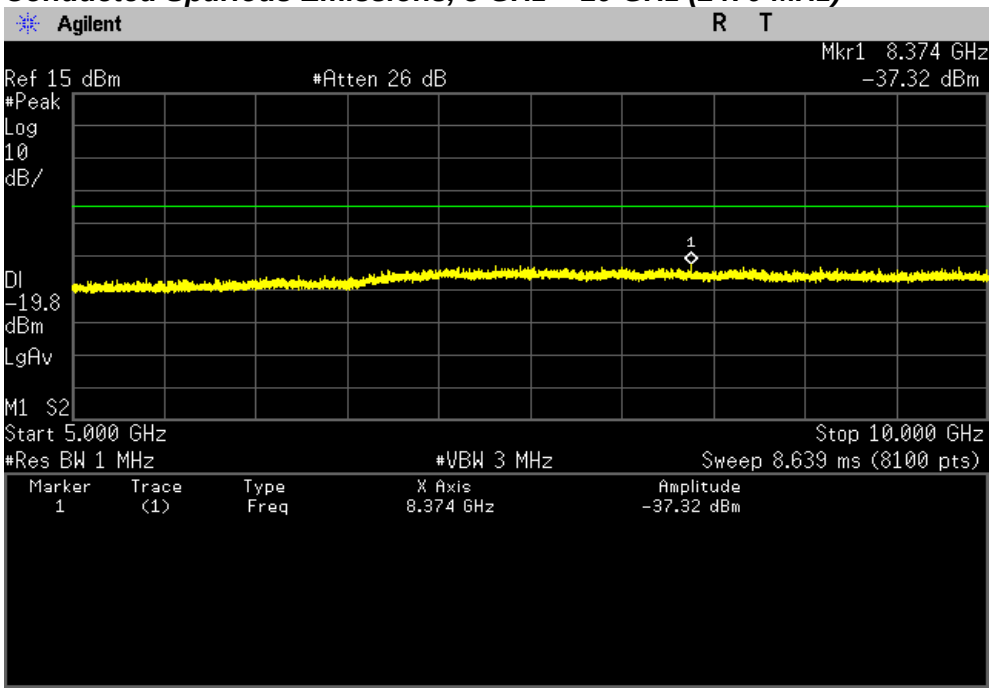


# PLOT OF TEST DATA

***Conducted Spurious Emissions, 30 MHz ~ 5 GHz (2470 MHz)***

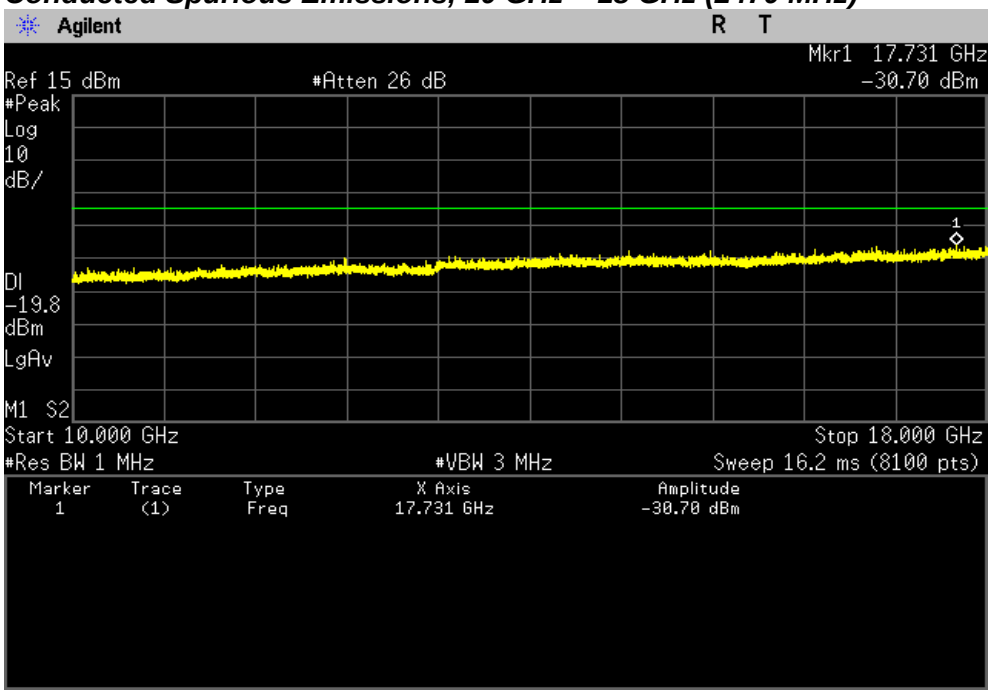



***Conducted Spurious Emissions, 5 GHz ~ 10 GHz (2470 MHz)***

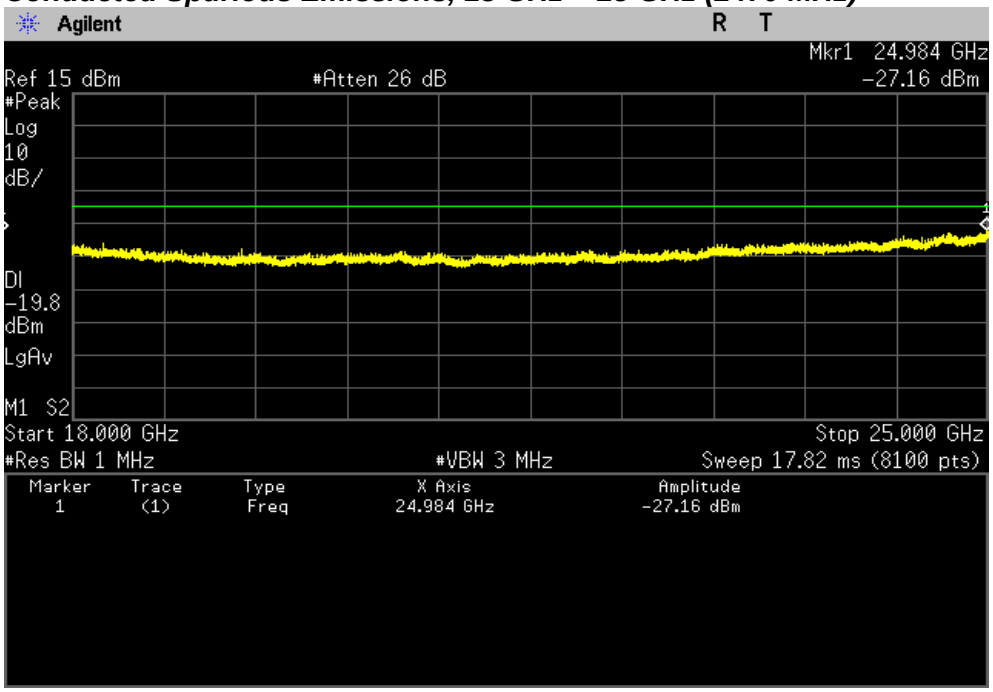


# PLOT OF TEST DATA

***Conducted Spurious Emissions, 10 GHz ~ 18 GHz (2470 MHz)***

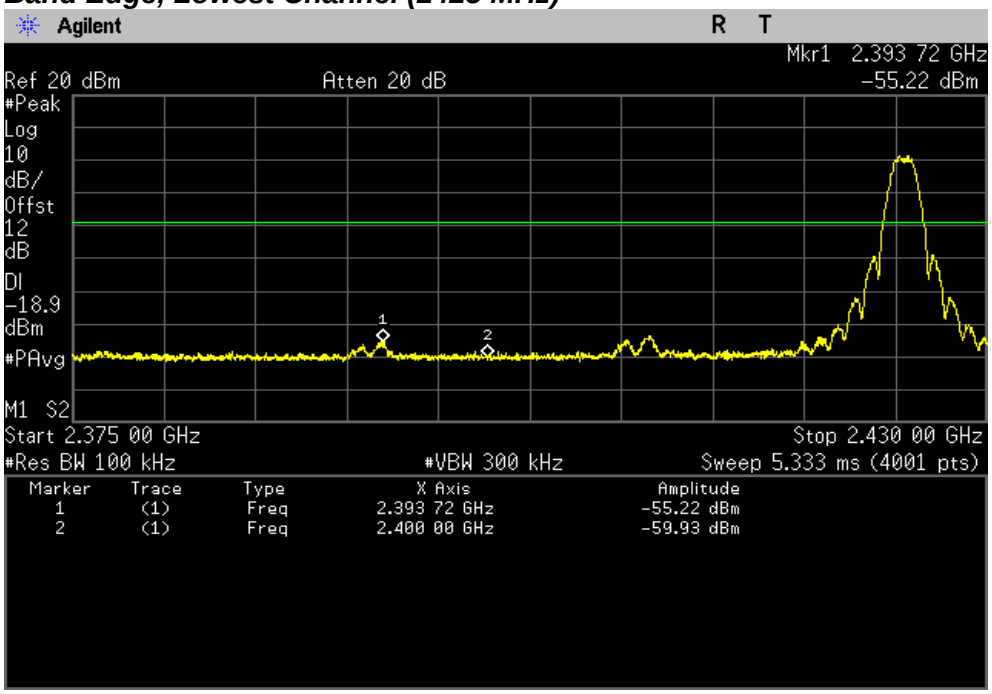



***Conducted Spurious Emissions, 18 GHz ~ 25 GHz (2470 MHz)***

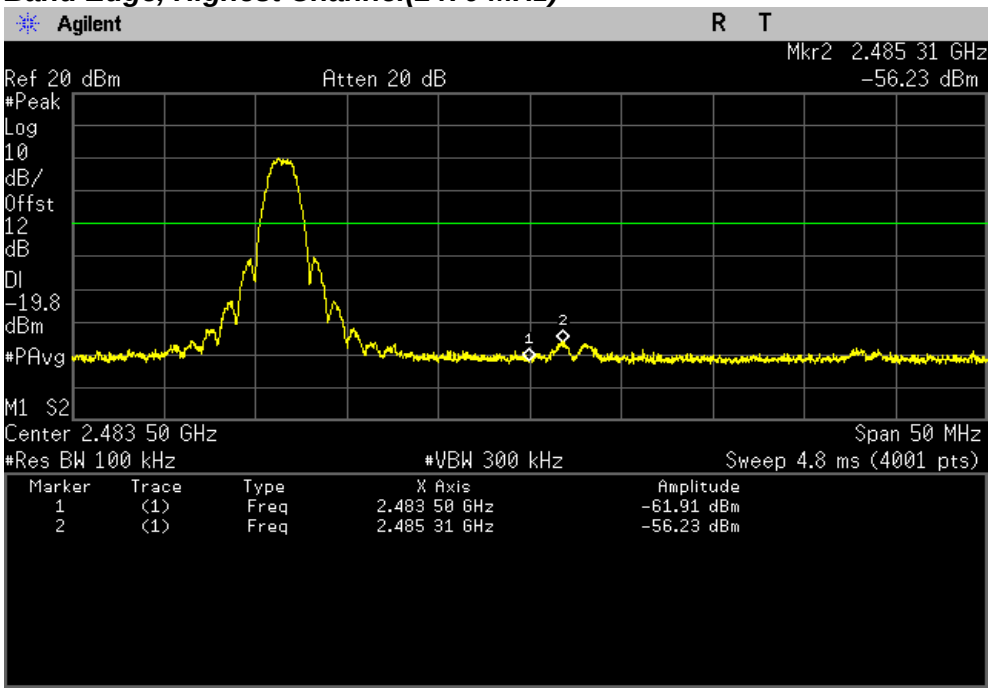


# PLOT OF TEST DATA

***Band Edge, Lowest Channel (2425 MHz)***




***Band Edge, Highest Channel(2470 MHz)***



# TEST DATA

## 8.7 Radiated Spurious Emissions

**FCC §15.247(d)**

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

**Result:**

**Lowest Channel (2425 MHz)**

| Frequency (MHz) | Reading (dBµV/m) | Pol* (H/V) | Detector | AF+CL+Amp (dB)** | Result (dBµV/m) | Limit (dBµV/m) | Margin (dB) |
|---|---|---|---|---|---|---|---|
| 1200.00 | 46.1 | V | Peak | -4.6 | 41.5 | 74.0 | 32.5 |
| 1200.00 | 40.6 | V | Average | -4.6 | 36.0 | 54.0 | 18.0 |
| 1354.00 | 45.4 | H | Peak | -4.0 | 41.4 | 74.0 | 32.6 |
| 1354.00 | 35.8 | H | Average | -4.0 | 31.8 | 54.0 | 22.2 |
| 1500.25 | 43.8 | H | Peak | -3.7 | 40.1 | 74.0 | 33.9 |
| 1500.25 | 35.7 | H | Average | -3.7 | 32.0 | 54.0 | 22.0 |
| 1601.00 | 46.2 | V | Peak | -3.4 | 42.8 | 74.0 | 31.2 |
| 1601.00 | 36.0 | V | Average | -3.4 | 32.6 | 54.0 | 21.4 |
| 3880.00 | 41.6 | H | Peak | 6.1 | 47.7 | 74.0 | 26.3 |
| 3880.00 | 34.4 | H | Average | 6.1 | 40.5 | 54.0 | 13.5 |
| 4849.37 | 42.8 | H | Peak | 9.2 | 52.0 | 74.0 | 22.0 |
| 4849.37 | 31.9 | H | Average | 9.2 | 41.1 | 54.0 | 12.9 |

# TEST DATA

**Middle Channel (2440 MHz)**

| Frequency (MHz) | Reading (dBµV/m) | Pol* (H/V) | Detector | AF+CL+Amp (dB)** | Result (dBµV/m) | Limit (dBµV/m) | Margin (dB) |
|---|---|---|---|---|---|---|---|
| 1199.75 | 46.7 | V | Peak | -4.6 | 42.1 | 74.0 | 31.9 |
| 1199.75 | 41.5 | V | Average | -4.6 | 36.9 | 54.0 | 17.1 |
| 1348.00 | 45.4 | H | Peak | -4.0 | 41.4 | 74.0 | 32.6 |
| 1348.00 | 38.0 | H | Average | -4.0 | 34.0 | 54.0 | 20.0 |
| 1500.00 | 44.3 | H | Peak | -3.7 | 40.6 | 74.0 | 33.4 |
| 1500.00 | 39.4 | H | Average | -3.7 | 35.7 | 54.0 | 18.3 |
| 1574.00 | 45.3 | V | Peak | -3.5 | 41.8 | 74.0 | 32.2 |
| 1574.00 | 36.5 | V | Average | -3.5 | 33.0 | 54.0 | 21.0 |
| 3903.75 | 41.1 | V | Peak | 6.1 | 47.2 | 74.0 | 26.8 |
| 3903.75 | 33.7 | V | Average | 6.1 | 39.8 | 54.0 | 14.2 |
| 4879.08 | 42.2 | V | Peak | 9.4 | 51.6 | 74.0 | 22.4 |
| 4879.08 | 31.8 | V | Average | 9.4 | 41.2 | 54.0 | 12.8 |

**Highest Channel (2470 MHz)**

| Frequency (MHz) | Reading (dBµV/m) | Pol* (H/V) | Detector | AF+CL+Amp (dB)** | Result (dBµV/m) | Limit (dBµV/m) | Margin (dB) |
|---|---|---|---|---|---|---|---|
| 1200.00 | 47.7 | V | Peak | -4.6 | 43.1 | 74.0 | 30.9 |
| 1200.00 | 41.6 | V | Average | -4.6 | 37.0 | 54.0 | 17.0 |
| 1500.00 | 45.0 | V | Peak | -3.7 | 41.3 | 74.0 | 32.7 |
| 1500.00 | 39.4 | V | Average | -3.7 | 35.7 | 54.0 | 18.3 |
| 2374.00 | 43.2 | V | Peak | -1.0 | 42.2 | 74.0 | 31.8 |
| 2374.00 | 35.9 | V | Average | -1.0 | 34.9 | 54.0 | 19.1 |
| 3951.87 | 41.8 | H | Peak | 6.1 | 47.9 | 74.0 | 26.1 |
| 3951.87 | 35.2 | H | Average | 6.1 | 41.3 | 54.0 | 12.7 |
| 4940.39 | 46.6 | H | Peak | 9.6 | 56.2 | 74.0 | 17.8 |
| 4940.39 | 38.3 | H | Average | 9.6 | 47.9 | 54.0 | 6.1 |

***Note(s):***

1. *Pol. H = Horizontal V = Vertical
2. **AF + CL + Amp. = Antenna Factor + Cable Loss + Amplifier.
3. 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.
4. Peak emissions were measured using RBW = 1 MHz, VBW = 3 MHz, Detector = Peak
5. For average measurements, "12.2.5.2 Average Power Measurement Procedures" at "558074 D01 DTS Meas Guidance v03r01" was used.
6. The spectrum was measured from 9 kHz to 10$^{th}$ harmonic and the worst-case emissions were reported. No significant emissions were found beyond the 2$^{nd}$ harmonic for this device.

# TEST DATA

## 8.8 Radiated Band Edge

**FCC §15.247(d)**

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

**Result:**

| Frequency (MHz) | Reading (dBµV/m) | Pol* (H/V) | Detector | AF+CL+Amp (dB)** | Result (dBµV/m) | Limit (dBµV/m) | Margin (dB) |
|---|---|---|---|---|---|---|---|
| 2360.98 | 44.0 | V | Peak | -1.0 | 43.0 | 74.0 | 31.0 |
| 2360.98 | 32.9 | V | Average | -1.0 | 31.9 | 54.0 | 22.1 |
| 2486.60 | 45.1 | V | Peak | -0.5 | 44.6 | 74.0 | 29.4 |
| 2486.60 | 34.2 | V | Average | -0.5 | 33.7 | 54.0 | 20.3 |

***Note(s):***

*1. *Pol. H = Horizontal V = Vertical*

*2. **AF + CL + Amp. = Antenna Factor + Cable Loss + Amplifier.*

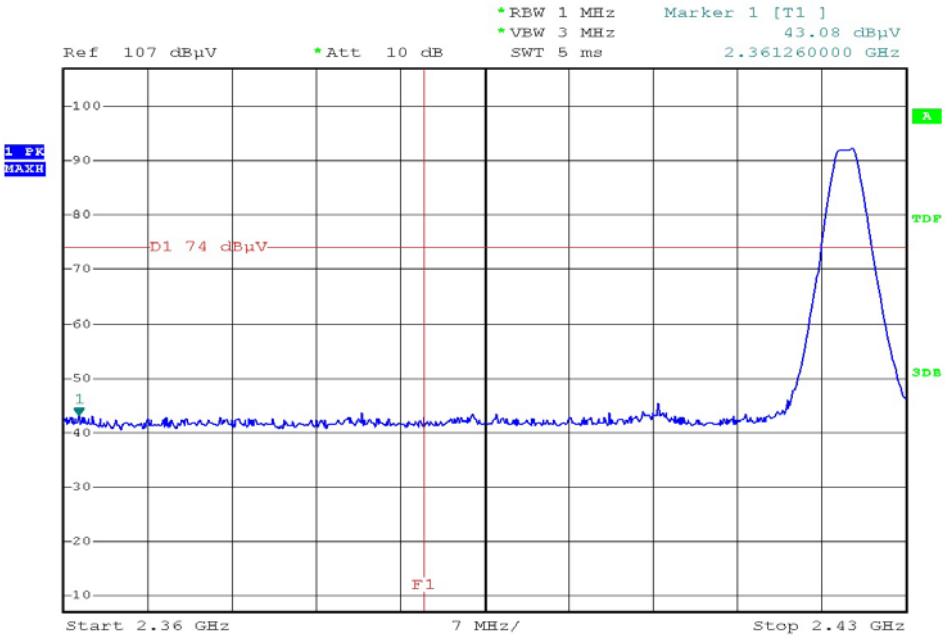
*3. Measurement of the radiated emissions is performed in vertical and horizontal polarizations. The worst data were recorded*

*4. For peak measurements, the resolution bandwidth was set to 1 MHz and the video bandwidth was set to 3 MHz.*

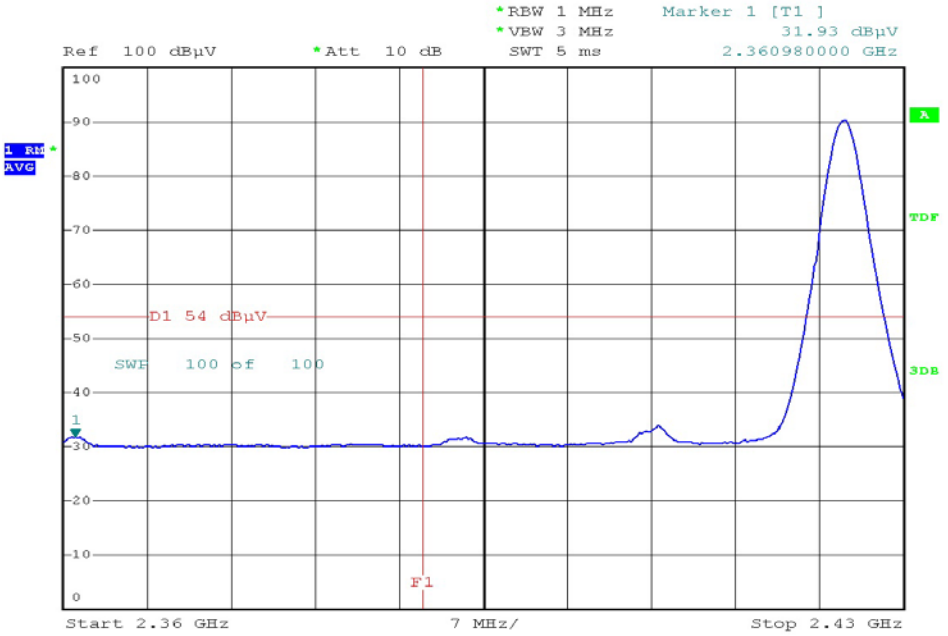
*5. For average measurements, "12.2.5.1 Average Power Measurement Procedures" at "558074 D01 DTS Meas Guidance v03r01" was used.*

# PLOT OF TEST DATA

## Restricted Band Spurious Emissions, Lowest channel Peak

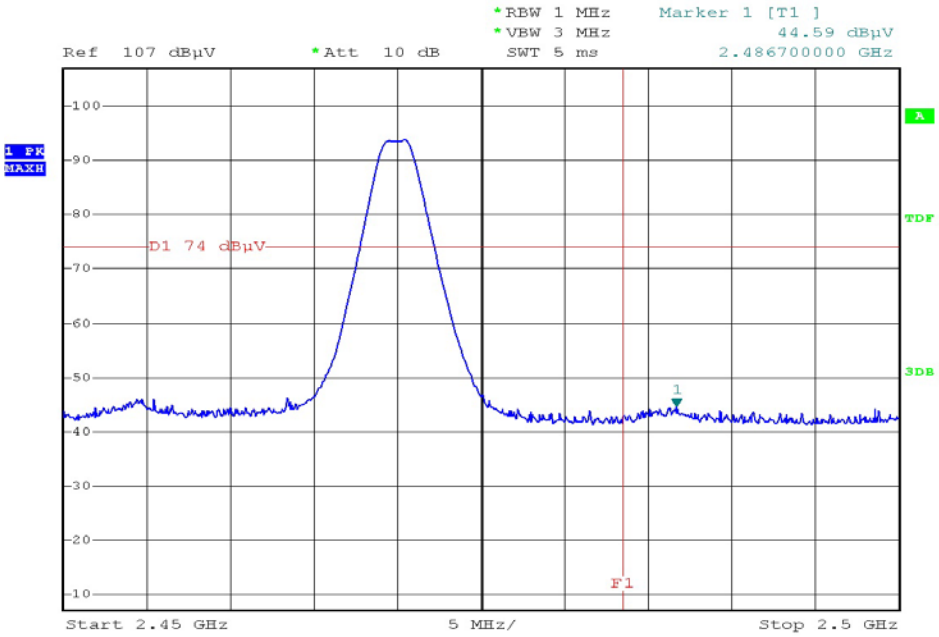



## Restricted Band Spurious Emissions, Lowest channel Average

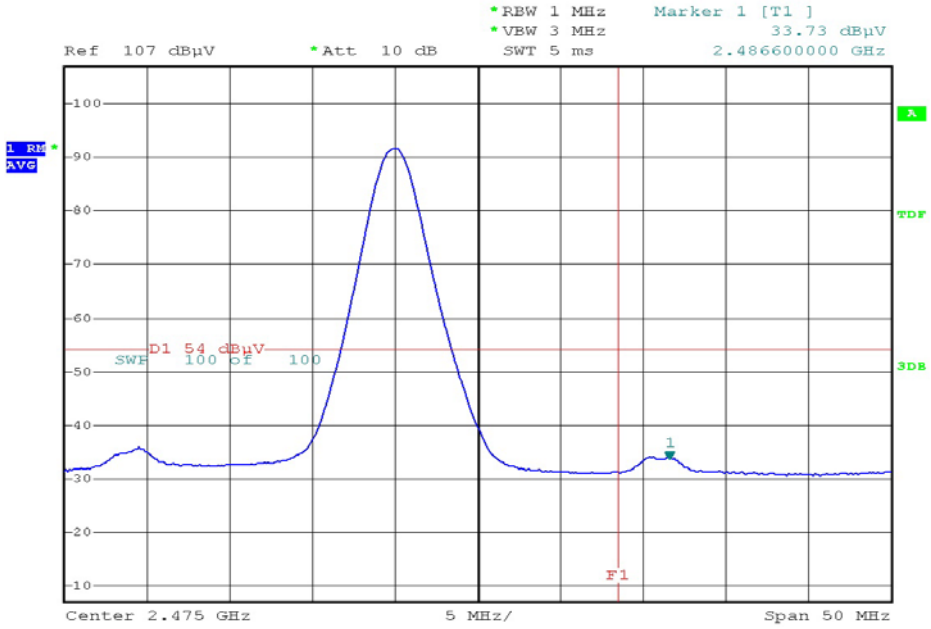


# PLOT OF TEST DATA

## Restricted Band Spurious Emissions, Highest channel Peak




## Restricted Band Spurious Emissions, Highest channel Average



# 9. TEST EQUIPMENT

| No. | Instrument | Manufacturer | Model | Serial No. | Calibration Date | Calibration Interval |
|---|---|---|---|---|---|---|
| 1 | *Test Receiver | R & S | ESCS 30 | 833364/020 | Jan. 09 2013 | 1 year |
| 2 | *Test Receiver | R & S | ESCS 30 | 100302 | Oct. 08 2013 | 1 year |
| 3 | *Amplifier | R & S | SCU 01 | 10029 | Apr. 05 2013 | 1 year |
| 4 | *Amplifier | Sonoma Instrument | 310N | 291916 | Jul. 16 2013 | 1 year |
| 5 | *Amplifier | R & S | SCU18 | 10065 | Apr. 05 2013 | 1 year |
| 6 | *Amplifier | R & S | SCU26 | 10011 | Jul. 08 2013 | 1 year |
| 7 | Amplifier | R & S | SCU40 | 10008 | Jul. 08 2013 | 1 year |
| 8 | *Pre Amplifier | HP | 8449B | 3008A00107 | Jan. 09 2014 | 1 year |
| 9 | *Spectrum Analyzer | Agilent | E4440A | MY44303257 | Jul. 16 2013 | 1 year |
| 10 | *Spectrum Analyzer | Agilent | E4440A | MY44022567 | Apr. 05 2013 | 1 year |
| 11 | *Spectrum Analyzer | R & S | FSP40 | 100361 | Jul. 16 2013 | 1 year |
| 12 | *Loop Antenna | R & S | HFH2-Z2 | 100279 | Feb. 21 2012 | 2 year |
| 13 | Wideband Power Sensor | R & S | NRP-Z81 | 100634 | Jul. 16 2013 | 1 year |
| 14 | *Biconical Log Antenna | ARA | LPB-2520/A | 1180 | Apr. 26 2012 | 2 year |
| 15 | *Horn Antenna | SCHWARZBECK | BBHA9120D | 9120D-474 | Aug. 13 2012 | 2 year |
| 16 | *Horn Antenna | Q-par Angus | QSH20S20 | 8179 | Mar. 20 2013 | 2 year |
| 17 | Horn Antenna | Q-par Angus | QSH22K20 | 8180 | Mar. 20 2013 | 2 year |
| 18 | Trilog-Broadband Antenna | SCHWARZBECK | VULB 9163 | 9163-454 | Feb. 24 2012 | 2 year |
| 19 | *Trilog-Broadband Antenna | SCHWARZBECK | VULB 9168 | 9168-257 | Mar. 06 2013 | 2 year |
| 20 | *LISN | R & S | ESH3-Z5 | 833874/006 | Oct. 08 2013 | 1 year |
| 21 | *LISN | R & S | ESH2-Z5 | 100227 | Apr. 04 2013 | 1 year |
| 22 | *Position Controller | DAEIL EMC | N/A | N/A | N/A | N/A |
| 23 | *Turn Table | DAEIL EMC | N/A | N/A | N/A | N/A |
| 24 | *Antenna Mast | DAEIL EMC | N/A | N/A | N/A | N/A |
| 25 | *Shielded Room | EM Eng. | N/A | N/A | N/A | N/A |
| 26 | *Position Controller | INNCO | CO2000 | 1480406/L | N/A | N/A |
| 27 | *Turn Table | INNCO | DS1200S | N/A | N/A | N/A |
| 28 | *Antenna Mast | INNCO | MA4000 | N/A | N/A | N/A |
| 29 | *Anechoic Chamber | Seo-Young EMC | N/A | N/A | N/A | N/A |
| 30 | *Shielded Room | Seo-Young EMC | N/A | N/A | N/A | N/A |

***Note(s)***

1. ** Test equipment used during the test.*

# 10. ACCURACY OF MEASUREMENT

The Measurement Uncertainties stated were calculated in accordance with the requirements of measurement uncertainty contained in CISPR 16-4-2 with the confidence level of 95%

## 1. Conducted Uncertainty Calculation

| Source of Uncertainty | Xi | Uncertainty of Xi | | Coverage factor k | u(Xi) (dB) | Ci | Ci u(Xi) (dB) |
|---|---|---|---|---|---|---|---|
| | | Value (dB) | Probability Distribution | | | | |
| Receiver reading | RI | ± 0.1 | normal 1 | 1.000 | 0.1 | 1 | 0.1 |
| Attenuation AMN-Receiver | LC | ± 0.08 | normal 2 | 2.000 | 0.04 | 1 | 0.04 |
| AMN Voltage division factor | LAMN | ± 0.8 | normal 2 | 2.000 | 0.4 | 1 | 0.4 |
| Sine wave voltage | dVSW | ± 2.00 | normal 2 | 2.000 | 1.00 | 1 | 1.00 |
| Pulse amplitude response | dVPA | ± 1.50 | rectangular | 1.732 | 0.87 | 1 | 0.87 |
| Pulse repetition rate response | dVPR | ± 1.50 | rectangular | 1.732 | 0.87 | 1 | 0.87 |
| Noise floor proximity | dVNF | ± 0.00 | - | - | 0.00 | 1 | 0.00 |
| AMN Impedance | dZ | ± 1.80 | triangular | 2.449 | 0.73 | 1 | 0.73 |
| ⓐ Mismatch | M | + 0.70 | U-Shaped | 1.414 | 0.49 | 1 | 0.49 |
| ⓑ Mismatch | M | - 0.80 | U-Shaped | 1.414 | - 0.56 | 1 | - 0.56 |
| Measurement System Repeatability | RS | 0.05 | normal 1 | 1.000 | 0.05 | 1 | 0.05 |
| Remark | ⓐ: AMN-Receiver Mismatch : +<br>ⓑ: AMN-Receiver Mismatch : - | | | | | | |
| Combined Standard Uncertainty | Normal | | | ± 1.88 | | | |
| Expended Uncertainty U | Normal ($k$ = 2) | | | ± 3.76 | | | |

## 2. Radiation Uncertainty Calculation

| Source of Uncertainty | Xi | Uncertainty of Xi | | Coverage factor k | u(Xi) (dB) | Ci | Ci u(Xi) (dB) |
|---|---|---|---|---|---|---|---|
| | | Value (dB) | Probability Distribution | | | | |
| Receiver reading | ***RI*** | ± 0.10 | normal 1 | 1.000 | 0.10 | 1 | 0.10 |
| Sine wave voltage | ***dVsw*** | ± 2.00 | normal 2 | 2.000 | 1.00 | 1 | 1.00 |
| Pulse amplitude response | ***dVpa*** | ± 1.50 | rectangular | 1.732 | 0.87 | 1 | 0.87 |
| Pulse repetition rate response | ***dVpr*** | ± 1.50 | rectangular | 1.732 | 0.87 | 1 | 0.87 |
| Noise floor proximity | ***dVnf*** | ± 0.50 | normal 2 | 2.000 | 0.25 | 1 | 0.25 |
| Antenna Factor Calibration | ***AF*** | ± 1.50 | normal 2 | 2.000 | 0.75 | 1 | 0.75 |
| Attenuation Antenna-receiver | ***CL*** | ± 0.52 | normal 2 | 2.000 | 0.26 | 1 | 0.26 |
| Antenna Directivity | ***AD*** | ± 1.00 | rectangular | 1.732 | 0.58 | 1 | 0.58 |
| Antenna Factor Height Dependence | ***AH*** | ± 0.50 | rectangular | 1.732 | 0.29 | 1 | 0.29 |
| Antenna Phase Centre Variation | ***AP*** | ± 0.30 | rectangular | 1.732 | 0.17 | 1 | 0.17 |
| Antenna Factor Frequency Interpolation | ***AI*** | ± 0.30 | rectangular | 1.732 | 0.17 | 1 | 0.17 |
| Site Imperfections | ***SI*** | ± 4.00 | triangular | 2.449 | 1.63 | 1 | 1.63 |
| Measurement Distance Variation | ***DV*** | ± 0.10 | rectangular | 1.732 | 0.06 | 1 | 0.06 |
| Antenna Balance | ***Dbal*** | ± 0.90 | rectangular | 1.732 | 0.52 | 1 | 0.52 |
| Cross Polarisation | ***DCross*** | ± 0.90 | rectangular | 1.732 | 0.52 | 1 | 0.52 |
| ⓐ Mismatch | ***M*** | + 0.25 | U-Shaped | 1.414 | 0.18 | 1 | 0.18 |
| ⓑ Mismatch | ***M*** | - 0.26 | U-Shaped | 1.414 | - 0.18 | 1 | - 0.18 |
| ⓒ Mismatch | ***M*** | + 0.98 | U-Shaped | 1.414 | 0.69 | 1 | 0.69 |
| ⓓ Mismatch | ***M*** | - 1.11 | U-Shaped | 1.414 | - 0.79 | 1 | - 0.79 |
| Measurement System Repeatability | ***RS*** | 0.09 | normal 1 | 1.000 | 0.09 | 1 | 0.09 |
| Remark | ⓐ: Biconical Antenna-receiver Mismatch : + (< 200 MHz)<br>ⓑ: Biconical Antenna-receiver Mismatch : - (< 200 MHz)<br>ⓒ: Log Periodic Antenna-receiver Mismatch : + (≧ 200 MHz)<br>ⓓ: Log Periodic Antenna-receiver Mismatch : - (≧ 200 MHz) | | | | | | |
| Combined Standard Uncertainty | Normal | | | ± 2.63 (< 200 MHz)<br>± 2.74 (≧200 MHz) | | | |
| Expended Uncertainty U | Normal (*k* = 2) | | | ± 5.26 (< 200 MHz)<br>± 5.48 (≧200 MHz) | | | |