# TEST REPORT

**of**

FCC Part 15 Subpart C §15.247

FCC ID: 2AU2N-PMM-130

| | | |
|---|---|---|
| Equipment Under Test | : | picohome |
| Model Name | : | PMM-130 |
| Applicant | : | Brilliant and Company Co., Ltd |
| Manufacturer | : | Brilliant and Company Co., Ltd |
| Date of Receipt | : | 2018.09.27 |
| Date of Test(s) | : | 2019.12.03 ~ 2020.01.15 |
| Date of Issue | : | 2020.01.28 |

In the configuration tested, the EUT complied with the standards specified above.

| | | | |
|---|---|---|---|
| **Tested By:** | **Murphy Kim** | **Date:** | **2020.01.28** |
| **Technical Manager:** | **Jungmin Yang** | **Date:** | **2020.01.28** |

*The results of this test report are effective only to the items tested. The SGS Korea is not responsible for the sampling, the results of this test report apply to the sample as received. This test report cannot be reproduced, except in full, without prior written permission of the Company. This test report does not assure KOLAS accreditation.*

# INDEX

Table of contents

1. General Information ---------- 3

2. Transmitter Radiated Spurious Emissions and Conducted Spurious Emission ---------- 8

3. 6 dB Bandwidth ---------- 30

4. Maximum Peak Conducted Output Power ---------- 33

5. Power Spectral Density ---------- 36

6. AC Conducted Power Line Emission ---------- 39

7. Antenna Requirement ---------- 43

*The results of this test report are effective only to the items tested. The SGS Korea is not responsible for the sampling, the results of this test report apply to the sample as received. This test report cannot be reproduced, except in full, without prior written permission of the Company. This test report does not assure KOLAS accreditation.*

# 1. General Information

## 1.1. Testing Laboratory

SGS Korea Co., Ltd. (Gunpo Laboratory)
- 10-2, LS-ro 182beon-gil, Gunpo-si, Gyeonggi-do, Korea, 15807
- 4, LS-ro 182beon-gil, Gunpo-si, Gyeonggi-do, Korea, 15807
- Designation number: KR0150

All SGS services are rendered in accordance with the applicable SGS conditions of service available on request and accessible at http://www.sgs.com/en/Terms-and-Conditions.aspx.

Phone No. : +82 31 688 0901
Fax No. : +82 31 688 0921

## 1.2. Details of Applicant

Applicant : Brilliant and Company Co., Ltd
Address : H-1-912D, 5, Hwarang-ro 14-gil, Seongbuk-gu, Seoul, South Korea, 02792
Contact Person : Han, Cheol-min
Phone No. : +82 2 6959 5538

## 1.3. Details of Manufacturer

Company : Same as applicant
Address : Same as applicant

## 1.4. Description of EUT

| | |
|---|---|
| **Kind of Product** | picohome |
| **Model Name** | PMM-130 |
| **Power Supply** | DC 5.0 V |
| **Frequency Range** | 2 402 ㎒ ~ 2 480 ㎒ (Bluetooth Low Energy) |
| **Modulation Technique** | GFSK |
| **Number of Channels** | 40 channels (Bluetooth Low Energy) |
| **Antenna Type** | PCB pattern antenna |
| **Antenna Gain** | -2.61 ㏈i |

*The results of this test report are effective only to the items tested. The SGS Korea is not responsible for the sampling, the results of this test report apply to the sample as received. This test report cannot be reproduced, except in full, without prior written permission of the Company. This test report does not assure KOLAS accreditation.*

## 1.5. Test Equipment List

| Equipment | Manufacturer | Model | S/N | Cal. Date | Cal. Interval | Cal. Due |
|---|---|---|---|---|---|---|
| Signal Generator | R&S | SMR40 | 100272 | Jun. 07, 2019 | Annual | Jun. 07, 2020 |
| Signal Generator | R&S | SMBV100A | 255834 | Jun. 10, 2019 | Annual | Jun. 10, 2020 |
| Spectrum Analyzer | R&S | FSV30 | 103102 | Jun. 05, 2019 | Annual | Jun. 05, 2020 |
| Spectrum Analyzer | Agilent | N9020A | MY53421758 | Sep. 11, 2019 | Annual | Sep. 11, 2020 |
| Attenuator | AEROFLEX / INMET | 40AH2W-10 | 40G-3 | Jun. 20, 2019 | Annual | Jun. 20, 2020 |
| High Pass Filter | Wainwright Instrument GmbH | WHK3.0/18G-10SS | 344 | May 21, 2019 | Annual | May 21, 2020 |
| High Pass Filter | Wainwright Instrument GmbH | WHNX7.5/26.5G-6SS | 15 | Jun. 05, 2019 | Annual | Jun. 05, 2020 |
| Low Pass Filter | Mini-Circuits | NLP-1200+ | V 8979400903-2 | Feb. 19, 2019 | Annual | Feb. 19, 2020 |
| Power Sensor | R&S | NRP-Z81 | 100748 | Jun. 05, 2019 | Annual | Jun. 05, 2020 |
| DC Power Supply | R&S | HMP2020 | 020089489 | May 21, 2019 | Annual | May 21, 2020 |
| Preamplifier | H.P. | 8447F | 2944A03909 | Aug. 07, 2019 | Annual | Aug. 07, 2020 |
| Signal Conditioning Unit | R&S | SCU-18 | 10117 | Jun. 12, 2019 | Annual | Jun. 12, 2020 |
| Preamplifier | MITEQ Inc. | JS44-18004000-35-8P | 1546891 | May 13, 2019 | Annual | May 13, 2020 |
| Loop Antenna | Schwarzbeck Mess-Elektronik | FMZB 1519 | 1519-039 | Aug. 22 2019 | Biennial | Aug. 22, 2021 |
| Bilog Antenna | Schwarzbeck Mess-Elektronik | VULB 9163 | 396 | Mar. 21, 2019 | Biennial | Mar. 21, 2021 |
| Horn Antenna | R&S | HF906 | 100326 | Feb. 14, 2018 | Biennial | Feb. 14, 2020 |
| Horn Antenna | Schwarzbeck Mess-Elektronik | BBHA 9170 | BBHA9170431 | Sep. 10, 2018 | Biennial | Sep. 10, 2020 |
| Turn Table | Innco systems GmbH | DS 1200 S | N/A | N.C.R. | N/A | N.C.R. |
| Controller | Innco systems GmbH | CONTROLLER CO3000-4P | CO3000/963/383 30516/L | N.C.R. | N/A | N.C.R. |
| Antenna Mast | Innco systems GmbH | MA4640-XP-ET | MA4640/536/383 30516/L | N.C.R. | N/A | N.C.R. |
| Anechoic Chamber | SY Corporation | L × W × H (9.6 m × 6.4 m × 6.6 m) | N/A | N.C.R. | N/A | N.C.R. |
| Test Receiver | R&S | ESU26 | 100109 | Jan. 31, 2019 | Annual | Jan. 31, 2020 |
| Test Receiver | R&S | ESCI 7 | 100911 | Feb. 20, 2019 | Annual | Feb. 20, 2020 |
| Two-Line V-Network | R&S | ENV216 | 100190 | May 14, 2019 | Annual | May 14, 2020 |
| Shield Room | SY Corporation | L × W × H (6.5 m × 3.5 m × 3.5 m) | N/A | N.C.R. | N/A | N.C.R. |
| Coaxial Cable | SUCOFLEX | 104 (3 m) | MY3258414 | Jul. 20, 2019 | Semi-annual | Jan. 20, 2020 |
| Coaxial Cable | SUCOFLEX | 104 (10 m) | MY3145814 | Jul. 20, 2019 | Semi-annual | Jan. 20, 2020 |
| Coaxial Cable | Rosenberger | LA1-C006-1500 | 131014 01/20 | Aug. 23, 2019 | Semi-annual | Feb. 23, 2020 |

*The results of this test report are effective only to the items tested. The SGS Korea is not responsible for the sampling, the results of this test report apply to the sample as received. This test report cannot be reproduced, except in full, without prior written permission of the Company. This test report does not assure KOLAS accreditation.*

## 1.6. Summary of Test Results

The EUT has been tested according to the following specifications:

| APPLIED STANDARD: FCC Part15 Subpart C | | |
|---|---|---|
| **Section** | **Test item(s)** | **Result** |
| 15.205(a)<br>15.209<br>15.247(d) | Transmitter Radiated Spurious Emissions<br>Conducted Spurious Emission | Complied |
| 15.247(a)(2) | 6 dB Bandwidth | Complied |
| 15.247(b)(3) | Maximum Peak Conducted Output Power | Complied |
| 15.247(e) | Power Spectral Density | Complied |
| 15.207 | AC Power Line Conducted Emission | Complied |

## 1.7. Test Procedure(s)

The measurement procedures described in the American National Standard of Procedure for Compliance Testing of unlicensed Wireless Devices (ANSI C63.10-2013) and the guidance provided in KDB 558074 D01 15.247 Meas Guidance v05r02 were used in the measurement of the DUT.

## 1.8. Sample Calculation

Where relevant, the following sample calculation is provided:

### 1.8.1. Conducted Test

Offset value (dB) = Attenuator (dB) + Cable loss (dB)

### 1.8.2. Radiation Test

Field strength level (dBμV/m) = Measured level (dBμV) + Antenna factor (dB) + Cable loss (dB) - Amplifier gain (dB)

*The results of this test report are effective only to the items tested. The SGS Korea is not responsible for the sampling, the results of this test report apply to the sample as received. This test report cannot be reproduced, except in full, without prior written permission of the Company. This test report does not assure KOLAS accreditation.*

## 1.9. Measurement Uncertainty

Where relevant, the following measurement uncertainty levels have been estimated for tests performed on the apparatus:

| Parameter | Uncertainty (dB) |
|---|---|
| RF Output Power | ± 0.52 dB |
| Conducted Spurious Emission | ± 0.76 dB |
| Power Spectral Density | ± 0.41 dB |
| Occupied Bandwidth | ± 9.66 kHz |
| AC Conducted Emission | ± 3.30 dB |
| Radiated Emission, 9 kHz to 30 MHz | ± 3.59 dB |
| Radiated Emission, below 1 GHz | ± 5.88 dB |
| Radiated Emission, above 1 GHz | ± 5.94 dB |

Uncertainty figures are valid to a confidence level of 95 %.

## 1.10. Test Report Revision

| Revision | Report Number | Date of Issue | Description |
|---|---|---|---|
| 0 | F690501/RF-RTL014675 | 2020.01.28 | Initial |

*The results of this test report are effective only to the items tested. The SGS Korea is not responsible for the sampling, the results of this test report apply to the sample as received. This test report cannot be reproduced, except in full, without prior written permission of the Company. This test report does not assure KOLAS accreditation.*

## 1.11. Duty Cycle of EUT

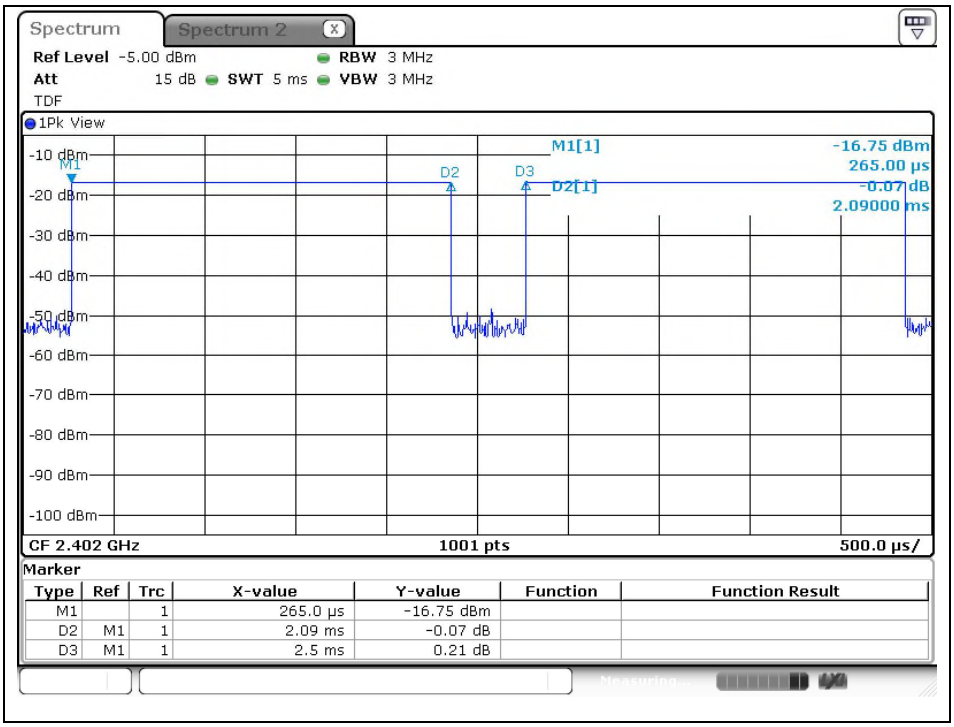
Regarding to KDB 558074 D01 15.247 Meas Guidance v05r02, 6, the maximum duty cycle was investigated and set the spectrum analyzer as below;
Set RBW ≥ OBW if possible; otherwise, set RBW to the largest available value. Set detector = peak or average. The zero-span measurement method shall not be used unless both RBW and VBW are > 50/T and the number of sweep points across duration T exceeds 100.

| Duty Cycle (%) | Correction Factor (dB) |
|---|---|
| 83.60 | 0.78 |

**Remark;**

1. Duty Cycle (%) = (Tx on time / Tx on + off time) x 100
2. Correction Factor (dB) = 10 log (1 / Duty Cycle)

**- Test plot**

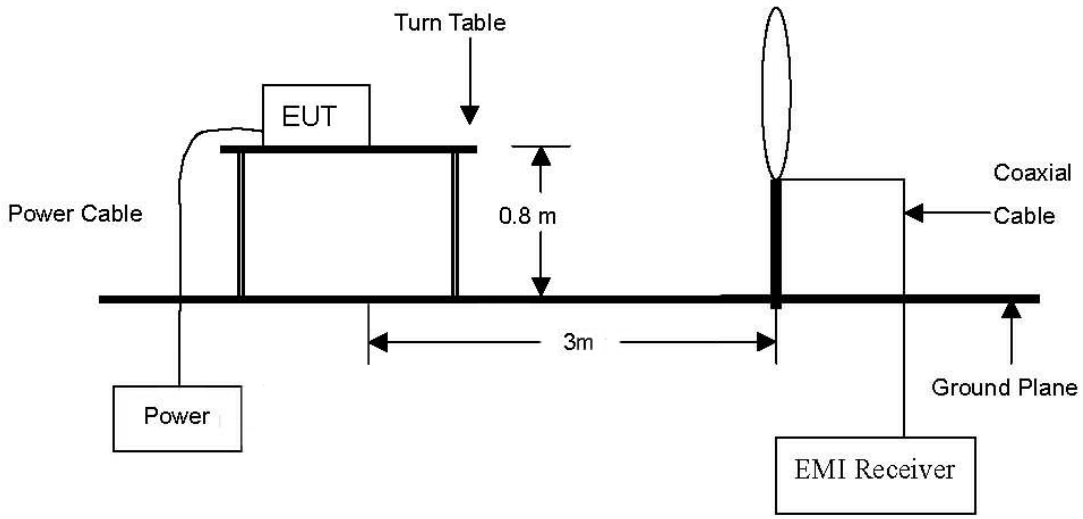


# 2. Transmitter Radiated Spurious Emissions and Conducted Spurious Emission

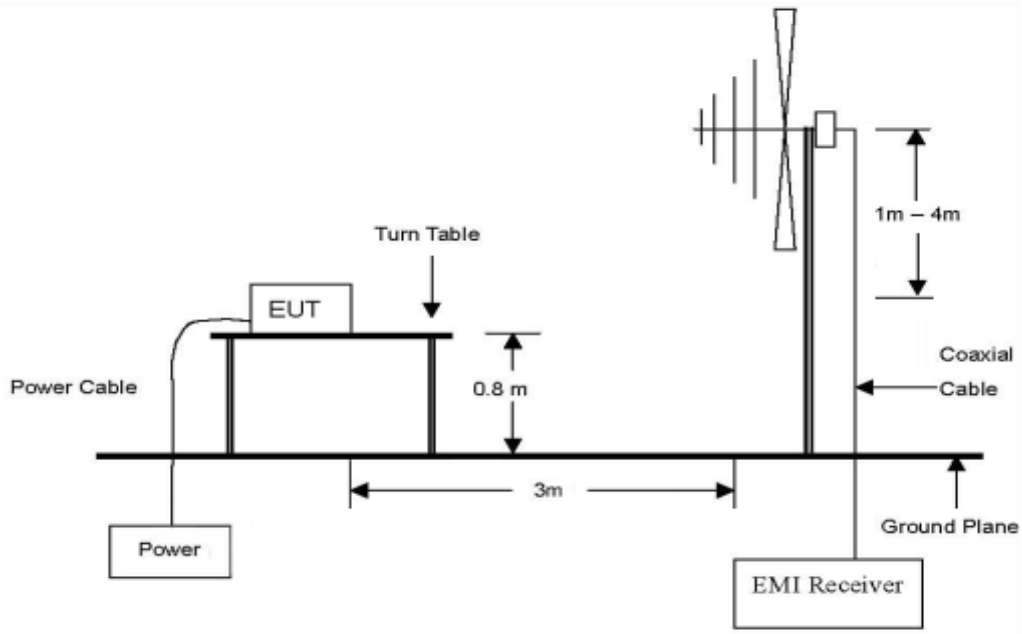
## 2.1. Test Setup

### 2.1.1. Transmitter Radiated Spurious Emissions

The diagram below shows the test setup that is utilized to make the measurements for emission from 9 ㎑ to 30 ㎒.

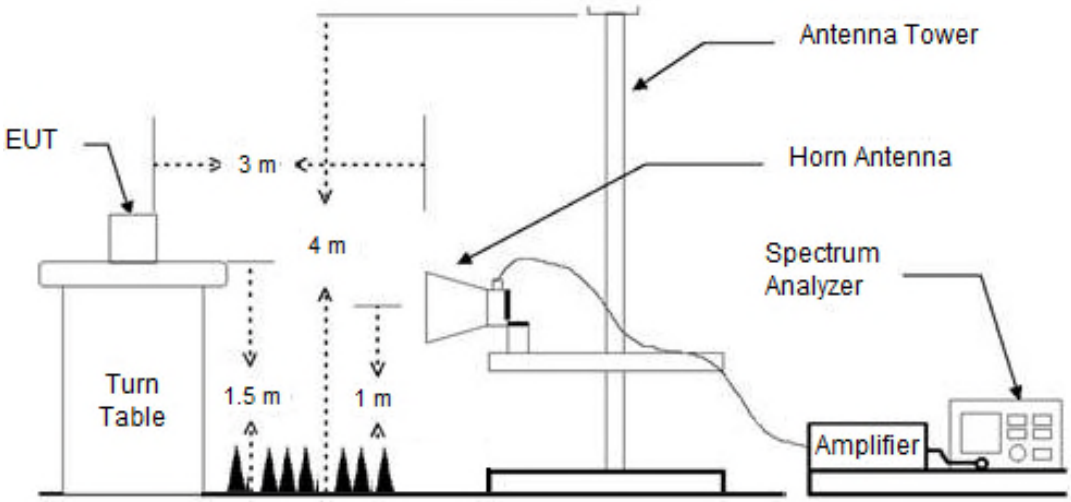



The diagram below shows the test setup that is utilized to make the measurements for emission from 30 ㎒ to 1 ㎓.




*The results of this test report are effective only to the items tested. The SGS Korea is not responsible for the sampling, the results of this test report apply to the sample as received. This test report cannot be reproduced, except in full, without prior written permission of the Company. This test report does not assure KOLAS accreditation.*

The diagram below shows the test setup that is utilized to make the measurements for emission. The spurious emissions were investigated form 1 ㎓ to the 10th harmonic of the highest fundamental frequency or 40 ㎓, whichever is lower.




*The results of this test report are effective only to the items tested. The SGS Korea is not responsible for the sampling, the results of this test report apply to the sample as received. This test report cannot be reproduced, except in full, without prior written permission of the Company. This test report does not assure KOLAS accreditation.*

### 2.1.2. Conducted Spurious Emission

### 2.2. Limit

According to §15.247(d), in any 100 ㎑ bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 ㏈ below that in the 100 ㎑ bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 ㏈ instead of 20 ㏈. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emission which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

According to §15.209(a), except as provided elsewhere in this subpart, the emissions from an intentional radiator shall not exceed the field strength levels specified in the following table:

| Frequency (㎒) | Field Strength (㎶/m) | Measurement Distance (Meters) |
|---|---|---|
| 0.009-0.490 | 2 400/F(㎑) | 300 |
| 0.490-1.705 | 24 000/F(㎑) | 30 |
| 1.705-30.0 | 30 | 30 |
| 30-88 | 100** | 3 |
| 88-216 | 150** | 3 |
| 216-960 | 200** | 3 |
| Above 960 | 500 | 3 |

** Except as provided in paragraph (g), fundamental emissions from intentional radiators operating under this section shall not be located in the frequency bands 54-72 ㎒, 76-88 ㎒, 174-216 ㎒ or 470-806 ㎒. However, operation within these frequency bands is permitted under other sections of this part, e.g., §§15.231 and 15.241.

*The results of this test report are effective only to the items tested. The SGS Korea is not responsible for the sampling, the results of this test report apply to the sample as received. This test report cannot be reproduced, except in full, without prior written permission of the Company. This test report does not assure KOLAS accreditation.*

## 2.3. Test Procedures

Radiated emissions from the EUT were measured according to the dictates in section 11.11 & 11.12 of ANSI C63.10-2013.

### 2.3.1. Test Procedures for emission below 30 ㎒

1. The EUT was placed on the top of a rotating table 0.8 meters above the ground at a 3 meter anechoic chamber test site. The table was rotated 360 degrees to determine the position of the highest radiation.
2. Then antenna is a loop antenna is fixed at one meter above the ground to determine the maximum value of the field strength. Both parallel and perpendicular of the antenna are set to make the measurement.
3. For each suspected emission, the EUT was arranged to its worst case and then the table was turned from 0 degrees to 360 degrees to find the maximum reading.
4. The test-receiver system was set to average or quasi peak detect function and Specified Bandwidth with Maximum Hold Mode.

### 2.3.2. Test Procedures for emission from above 30 ㎒

1. The EUT was placed on the top of a rotating table 0.8 meters above the ground at a 3 meter anechoic chamber test site below 1 ㎓ and 1.5 meters above the ground at a 3 meter anechoic chamber test site above 1 ㎓. The table was rotated 360 degrees to determine the position of the highest radiation.
2. During performing radiated emission below 1 ㎓, the EUT was set 3 meters away from the interference receiving antenna, which was mounted on the top of a variable-height antenna tower. During performing radiated emission above 1 ㎓, the EUT was set 3 meter away from the interference-receiving antenna.
3. The antenna is a bi-log antenna, a horn antenna and its height is varied from one meter to four meters above the ground to determine the maximum value of the field strength. Both horizontal and vertical polarizations of the antenna are set to make the measurement.
4. For each suspected emission, the EUT was arranged to its worst case and then the antenna was tuned to heights from 1 meter to 4 meters and the table was turned from 0 degrees to 360 degrees to find the maximum reading.
5. The test-receiver system was set to Peak Detect Function and Specified Bandwidth with Maximum Hold Mode.

*The results of this test report are effective only to the items tested. The SGS Korea is not responsible for the sampling, the results of this test report apply to the sample as received. This test report cannot be reproduced, except in full, without prior written permission of the Company. This test report does not assure KOLAS accreditation.*

1. Unwanted Emissions into Non-Restricted Frequency Bands

- The Reference Level Measurement refer to section 11.11.2
Set analyzer center frequency to DTS channel center frequency, SPAN ≥ 1.5 times the DTS bandwidth, the RBW = 100 ㎑ and VBW ≥ 3 x RBW, Detector = Peak, Sweep time = Auto couple, Trace = Max hold.

- Unwanted Emissions Level Measurement refer to section 11.11.3
Set the center frequency and span to encompass frequency range to be measured, the RBW = 100 ㎑ and VBW ≥ 3 x RBW, Detector = Peak, Sweep time = Auto couple, Trace = Max hold.

2. Unwanted Emissions into Restricted Frequency Bands

- Peak Power measurement procedure refer to section 11.12.2.4
Set RBW = as specified in Table 9, VBW ≥ 3 x RBW, Detector = Peak, Sweep time = auto, Trace = Max hold.

**Table 9 – RBW as a function of frequency**

| Frequency | RBW |
|---|---|
| 9 ㎑ to 150 ㎑ | 200 ㎐ to 300 ㎐ |
| 0.15 ㎒ to 30 ㎒ | 9 ㎑ to 10 ㎑ |
| 30 ㎒ to 1 000 ㎒ | 100 ㎑ to 120 ㎑ |
| > 1 000 ㎒ | 1 ㎒ |

If the peak – detected amplitude can be shown to comply with the average limit, then it is not necessary to perform a separate average measurement.

- Average Power measurements procedure refer to section 11.12.2.5.2
The EUT shall be configured to operate at the maximum achievable duty cycle.
Measure the duty cycle D of the transmitter output signal as described in section 11.6.
Set RBW = 1 ㎒, VBW ≥ 3 x RBW, Detector = RMS, if span / (# of points in sweep) ≤ (RBW/2).
Satisfying this condition may require increasing the number of points in the sweep or reducing the span. If this condition cannot be satisfied then the detector mode shall be set to peak.

Averaging type = power (i.e., RMS).
As an alternative the detector and averaging type may be set for linear voltage averaging.
Some instruments require linear display mode in order to use linear voltage averaging. Log or ㏈ averaging shall not be used. Sweep time = auto, Perform a trace average of at least 100 traces.

A correction factor shall be added to the measurement results prior to comparing to the emission limit in order to compute the emission level that would have been measured had the test been performed at 100 percent duty cycle. The correction factor is computed as follows:

1) If power averaging (rms) mode was used in step f), then the applicable correction factor is [10 log (1 / D)], where D is the duty cycle.

3. Definition of DUT Axis.
Definition of the test orthogonal plan for EUT was described in the test setup photo.
The test orthogonal plan of EUT is **Y – axis** during radiation test.

*The results of this test report are effective only to the items tested. The SGS Korea is not responsible for the sampling, the results of this test report apply to the sample as received. This test report cannot be reproduced, except in full, without prior written permission of the Company. This test report does not assure KOLAS accreditation.*

### 2.3.3. Test Procedures for Conducted Spurious Emissions

Per the guidance of ANSI C63.10-2013, section 11.11.1 & 11.11.2 & 11.11.3, the reference level for out of band emissions is established from the plots of this section since the band edge emissions are measured with a RBW of 100 ㎑. This reference level is then used as the limit in subsequent plots for out of band spurious emissions shown in section 2.4.3. The limit for out of band spurious emission at the band edge is 20 ㏈ below the fundamental emission level measured in a 100 ㎑ bandwidth.

1. Conducted Emissions at Band Edge
 - The Measurement refer to section 11.11.2
   Set the center frequency and span to encompass frequency range to be measured, the RBW = 100 ㎑ and VBW ≥ 3 x RBW, Detector = Peak, Sweep time = Auto couple, Trace mode = Max hold, The trace was allowed to stabilize.

2. Conducted Spurious Emissions
 - The Measurement refer to section 11.11.3
   Start frequency was set to 9 ㎑ and stop frequency was set to 25 ㎓ (separated into two plots per channel), RBW = 1 ㎒, VBW ≥ 3 x RBW, Detector = Peak, Sweep time = Auto couple, Trace = Max hold, The trace was allowed to stabilize.

3. TDF function
 - For plots showing conducted spurious emissions from 9 ㎑ to 25 ㎓, all path loss of wide frequency range was investigated and compensated to spectrum analyzer as TDF function.
   So, the reading values shown in plots were final result.

*The results of this test report are effective only to the items tested. The SGS Korea is not responsible for the sampling, the results of this test report apply to the sample as received. This test report cannot be reproduced, except in full, without prior written permission of the Company. This test report does not assure KOLAS accreditation.*

## 2.4. Test Results

Ambient temperature : (23 ± 1) ℃
Relative humidity : 47 % R.H.

### 2.4.1. Radiated Spurious Emission below 1 000 ㎒

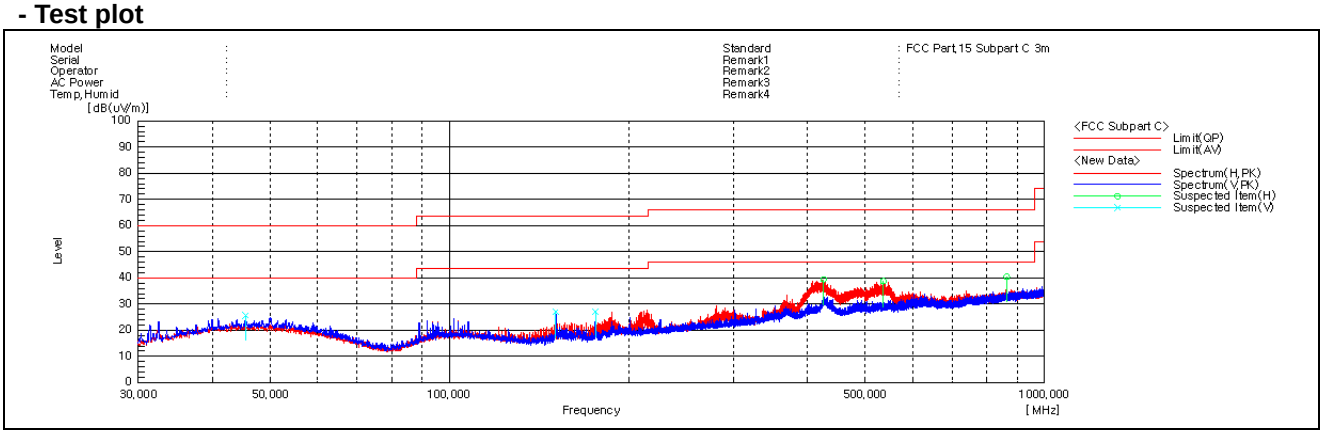
The frequency spectrum from 9 ㎑ to 1 000 ㎒ was investigated. All reading values are peak values.

| Radiated Emissions | | | Ant | Correction Factors | | Total | Limit | |
|---|---|---|---|---|---|---|---|---|
| Frequency (㎒) | Reading (dBμV) | Detect Mode | Pol. | AF (dB/m) | AMP + CL (dB) | Actual (dBμV/m) | Limit (dBμV/m) | Margin (dB) |
| 45.56 | 31.90 | Peak | V | 20.60 | -26.77 | 25.73 | 40.00 | 14.27 |
| 150.97 | 38.60 | Peak | V | 13.90 | -25.59 | 26.91 | 43.50 | 16.59 |
| 176.19 | 37.50 | Peak | V | 14.92 | -25.54 | 26.88 | 43.50 | 16.62 |
| 425.52 | 42.00 | Peak | H | 22.01 | -25.04 | 38.97 | 46.00 | 7.03 |
| 536.26 | 40.00 | Peak | H | 23.53 | -24.83 | 38.70 | 46.00 | 7.30 |
| 863.15 | 36.00 | Peak | H | 27.60 | -23.16 | 40.44 | 46.00 | 5.56 |
| Above 900.00 | Not detected | - | - | - | - | - | - | - |

**Remark;**

1. Spurious emissions for all channels were investigated and almost the same below 1 ㎓.
2. Reported spurious emissions are in **High channel** as worst case among other channels.
3. Radiated spurious emission measurement as below.
   (Actual = Reading + AF + AMP + CL)
4. According to §15.31(o), emission levels are not report much lower than the limits by over 20 ㏈.

**- Test plot**



### 2.4.2. Radiated Spurious Emission above 1 000 ㎒

The frequency spectrum above 1 000 ㎒ was investigated. All reading values are peak and average values.

Low Channel (2 402 ㎒)

| Fundamental | | | Ant. | Correction Factors | | Total |
|---|---|---|---|---|---|---|
| Frequency (㎒) | Reading (dBμV) | Detect Mode | Pol. | AF (dB/m) | CL (dB) | Actual (dBμV/m) |
| 2 402.33 | 48.13 | Peak | V | 28.00 | 8.22 | 84.35 |

| Radiated Emissions | | | Ant. | Correction Factors | | | Total | Limit | |
|---|---|---|---|---|---|---|---|---|---|
| Frequency (㎒) | Reading (dBμV) | Detect Mode | Pol. | AF (dB/m) | CL (dB) | DF (dB) | Actual (dBμV/m) | Limit (dBμV/m) | Margin (dB) |
| *2 310.00 | 14.29 | Peak | V | 27.82 | 8.07 | - | 50.18 | 74.00 | 23.82 |
| *2 310.00 | 3.16 | Average | V | 27.82 | 8.07 | 0.78 | 39.83 | 54.00 | 14.17 |
| *2 356.91 | 16.13 | Peak | V | 27.91 | 8.15 | - | 52.19 | 74.00 | 21.81 |
| *2 345.89 | 4.12 | Average | V | 27.89 | 8.13 | 0.78 | 40.92 | 54.00 | 13.08 |
| *2 390.00 | 13.96 | Peak | V | 27.98 | 8.22 | - | 50.16 | 74.00 | 23.84 |
| *2 390.00 | 3.47 | Average | V | 27.98 | 8.22 | 0.78 | 40.45 | 54.00 | 13.55 |

| Radiated Emissions | | | Ant. | Correction Factors | | | Total | Limit | |
|---|---|---|---|---|---|---|---|---|---|
| Frequency (㎒) | Reading (dBμV) | Detect Mode | Pol. | AF (dB/m) | AMP+CL (dB) | DF (dB) | Actual (dBμV/m) | Limit (dBμV/m) | Margin (dB) |
| 3 202.75 | 56.54 | Peak | H | 30.13 | -36.84 | - | 49.83 | 64.35 | 14.52 |
| 3 282.80 | 54.07 | Peak | H | 30.53 | -36.18 | - | 48.42 | 64.35 | 15.93 |
| Above 3 300.00 | Not detected | - | - | - | - | - | - | - | - |

*The results of this test report are effective only to the items tested. The SGS Korea is not responsible for the sampling, the results of this test report apply to the sample as received. This test report cannot be reproduced, except in full, without prior written permission of the Company. This test report does not assure KOLAS accreditation.*

Middle Channel (2 440 ㎒)

| Fundamental | | | Ant. | Correction Factors | | Total |
|---|---|---|---|---|---|---|
| Frequency (㎒) | Reading (dBμV) | Detect Mode | Pol. | AF (dB/m) | CL (dB) | Actual (dBμV/m) |
| 2 440.07 | 47.47 | Peak | V | 28.00 | 8.34 | 83.81 |

| Radiated Emissions | | | Ant. | Correction Factors | | | Total | Limit | |
|---|---|---|---|---|---|---|---|---|---|
| Frequency (㎒) | Reading (dBμV) | Detect Mode | Pol. | AF (dB/m) | AMP+CL (dB) | DF (dB) | Actual (dBμV/m) | Limit (dBμV/m) | Margin (dB) |
| 3 253.40 | 54.85 | Peak | H | 30.59 | -36.55 | - | 48.89 | 63.81 | 14.92 |
| Above 3 300.00 | Not detected | - | - | - | - | - | - | - | - |

*The results of this test report are effective only to the items tested. The SGS Korea is not responsible for the sampling, the results of this test report apply to the sample as received. This test report cannot be reproduced, except in full, without prior written permission of the Company. This test report does not assure KOLAS accreditation.*

High Channel (2 480 ㎒)

| Fundamental | | | Ant. | Correction Factors | | Total |
|---|---|---|---|---|---|---|
| Frequency (㎒) | Reading (dBμV) | Detect Mode | Pol. | AF (dB/m) | CL (dB) | Actual (dBμV/m) |
| 2 480.08 | 45.94 | Peak | V | 28.00 | 8.37 | 82.31 |

| Radiated Emissions | | | Ant. | Correction Factors | | | Total | Limit | |
|---|---|---|---|---|---|---|---|---|---|
| Frequency (㎒) | Reading (dBμV) | Detect Mode | Pol. | AF (dB/m) | CL (dB) | DF (dB) | Actual (dBμV/m) | Limit (dBμV/m) | Margin (dB) |
| *2 483.50 | 13.46 | Peak | V | 28.00 | 8.37 | - | 49.83 | 74.00 | 24.17 |
| *2 483.50 | 3.93 | Average | V | 28.00 | 8.37 | 0.78 | 41.08 | 54.00 | 12.92 |
| *2 498.59 | 16.31 | Peak | V | 28.00 | 8.38 | - | 52.69 | 74.00 | 21.31 |
| *2 491.65 | 5.14 | Average | V | 28.00 | 8.38 | 0.78 | **42.30** | 54.00 | 11.70 |
| *2 500.00 | 13.83 | Peak | V | 28.00 | 8.38 | - | 50.21 | 74.00 | 23.79 |
| *2 500.00 | 4.34 | Average | V | 28.00 | 8.38 | 0.78 | 41.50 | 54.00 | 12.50 |

| Radiated Emissions | | | Ant. | Correction Factors | | | Total | Limit | |
|---|---|---|---|---|---|---|---|---|---|
| Frequency (㎒) | Reading (dBμV) | Detect Mode | Pol. | AF (dB/m) | AMP+CL (dB) | DF (dB) | Actual (dBμV/m) | Limit (dBμV/m) | Margin (dB) |
| 3 282.80 | 54.31 | Peak | H | 30.53 | -36.18 | - | 48.66 | 62.31 | 13.65 |
| Above 3 300.00 | Not detected | - | - | - | - | - | - | - | - |

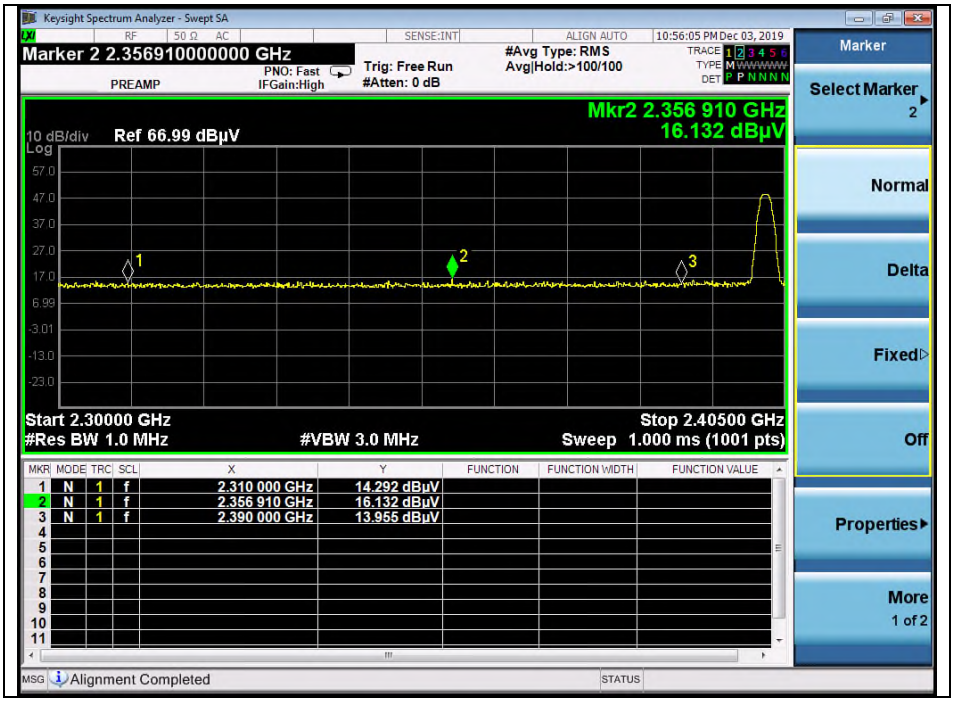
**Remark;**

1. "*" means the restricted band.
2. Measuring frequencies from 1 ㎓ to the 10th harmonic of highest fundamental frequency.
3. Radiated emissions measured in frequency above 1 000 ㎒ were made with an instrument using peak/average detector mode.
4. Actual = Reading + AF + CL + (DF) or Reading + AF + AMP + CL + (DF).
5. According to § 15.31(o), emission levels are not reported much lower than the limits by over 20 ㏈.
6. The maximized peak measured value complies with the average limit, to perform an average measurement is unnecessary.

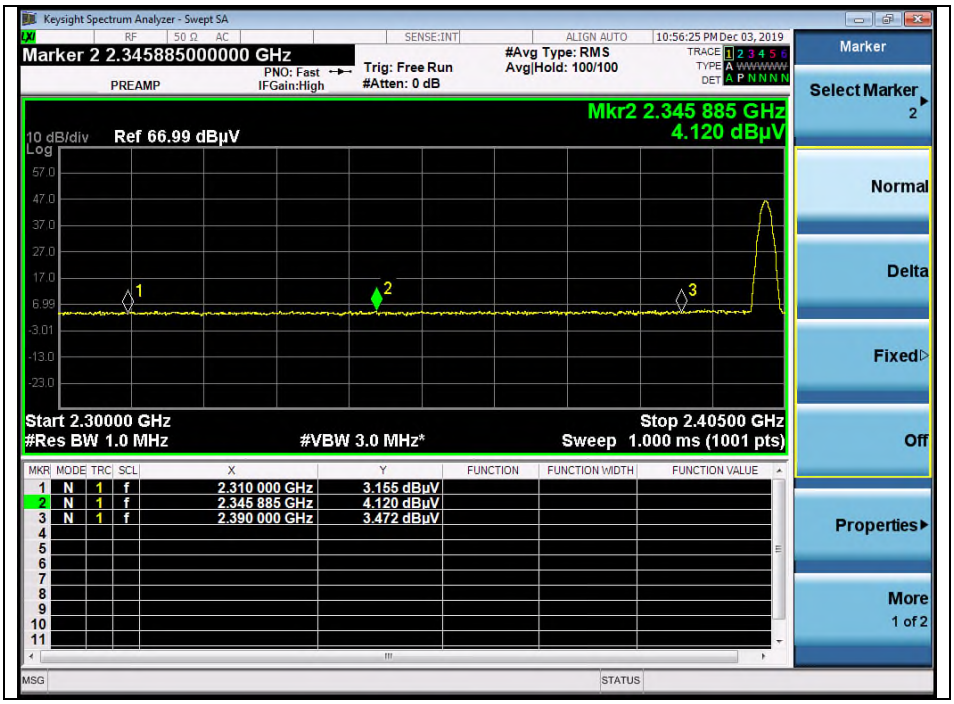
*The results of this test report are effective only to the items tested. The SGS Korea is not responsible for the sampling, the results of this test report apply to the sample as received. This test report cannot be reproduced, except in full, without prior written permission of the Company. This test report does not assure KOLAS accreditation.*

## - Test plots

Low channel Band edge (Peak)

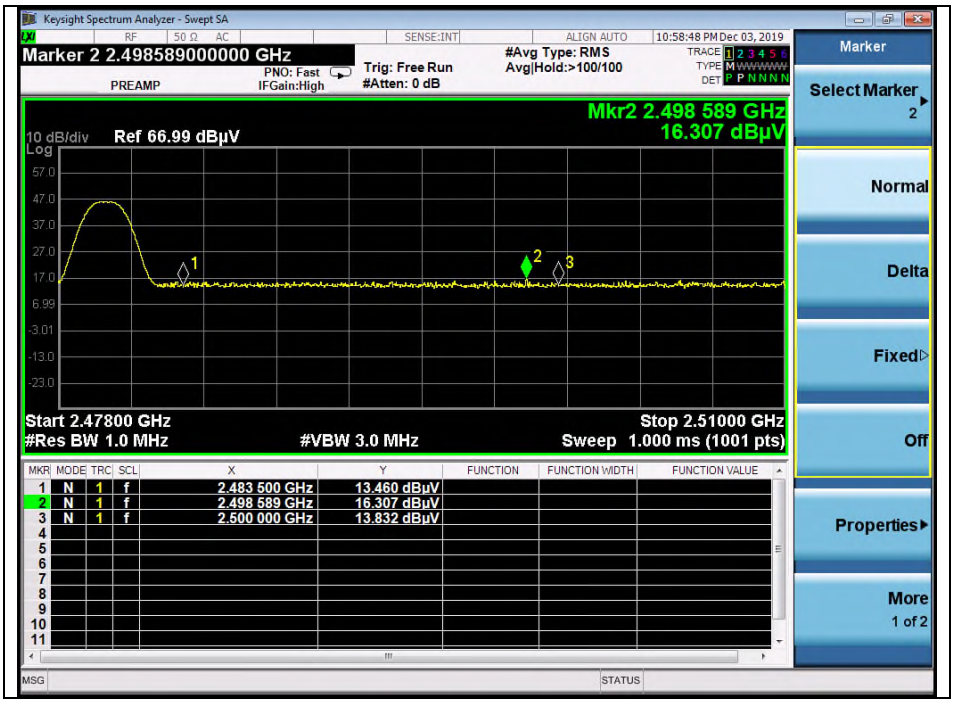



Low channel Band edge (Average)

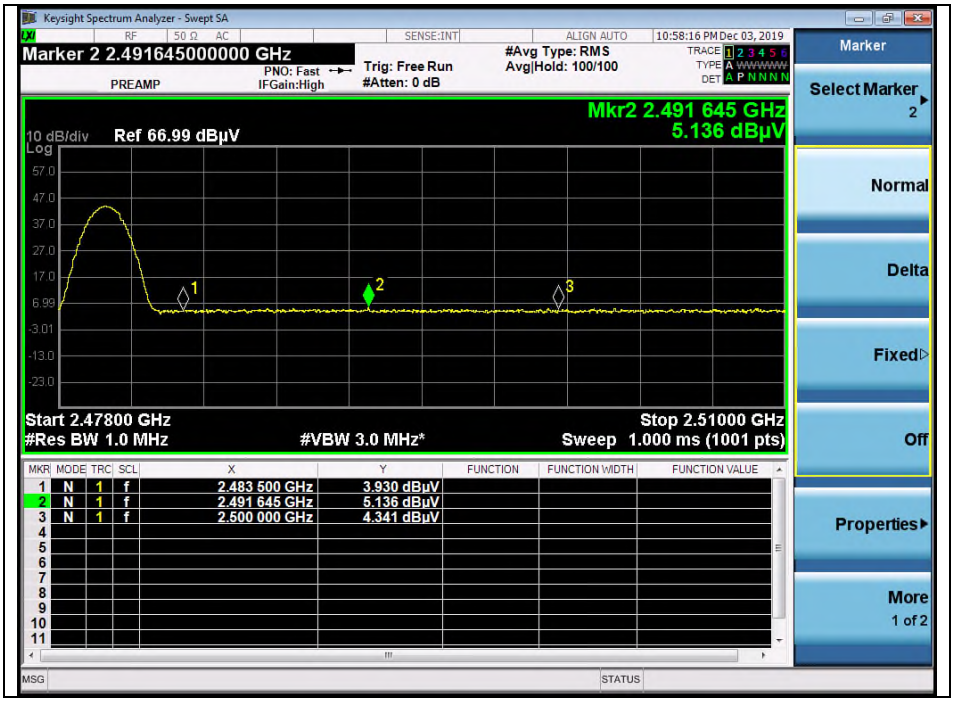



*The results of this test report are effective only to the items tested. The SGS Korea is not responsible for the sampling, the results of this test report apply to the sample as received. This test report cannot be reproduced, except in full, without prior written permission of the Company. This test report does not assure KOLAS accreditation.*

High channel Band edge (Peak)

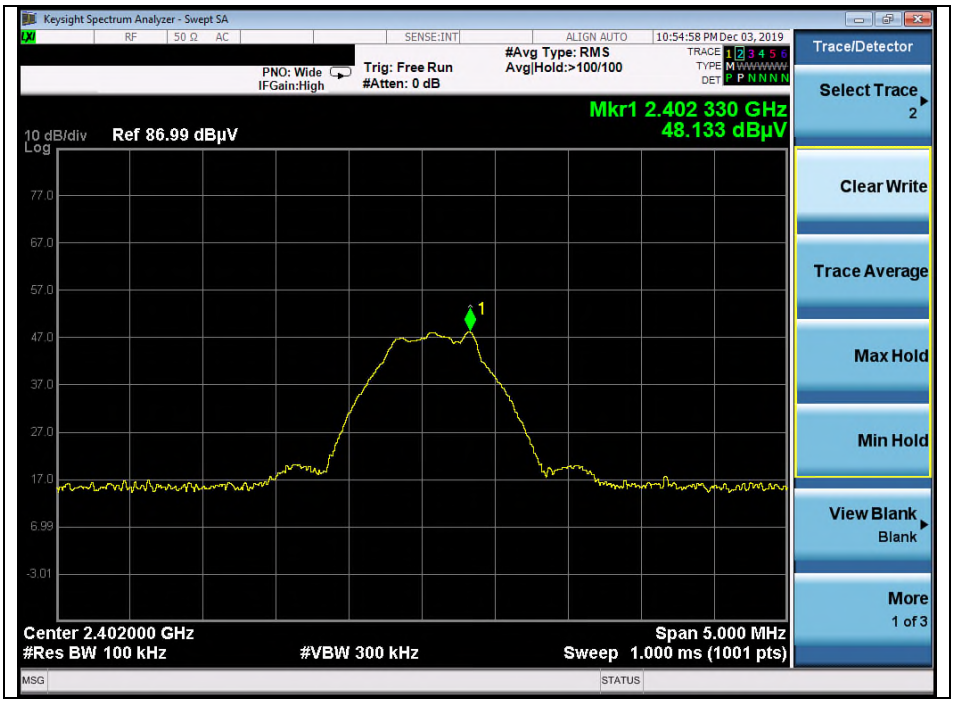



High channel Band edge (Average)




*The results of this test report are effective only to the items tested. The SGS Korea is not responsible for the sampling, the results of this test report apply to the sample as received. This test report cannot be reproduced, except in full, without prior written permission of the Company. This test report does not assure KOLAS accreditation.*

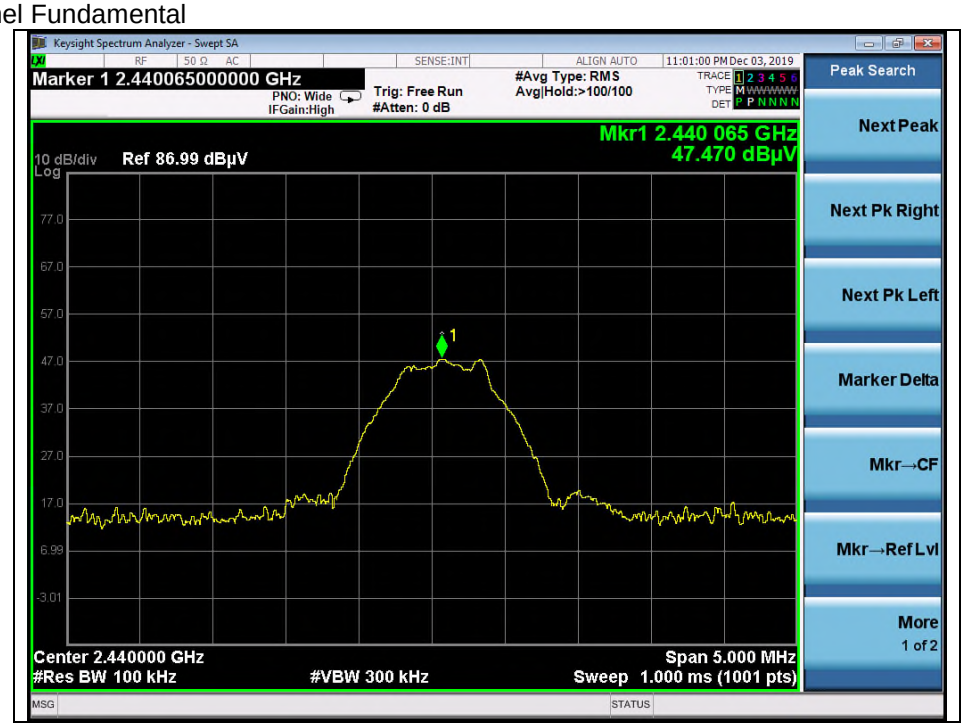
Low channel Fundamental



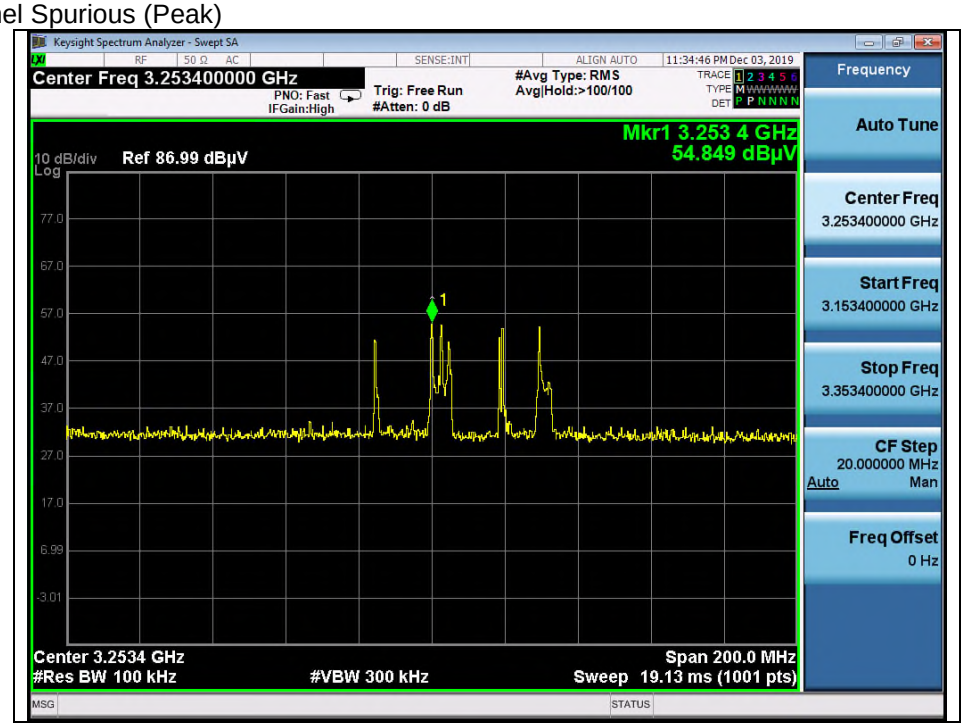

Low channel Spurious (Peak)

Low channel Spurious (Peak)

Middle channel Fundamental

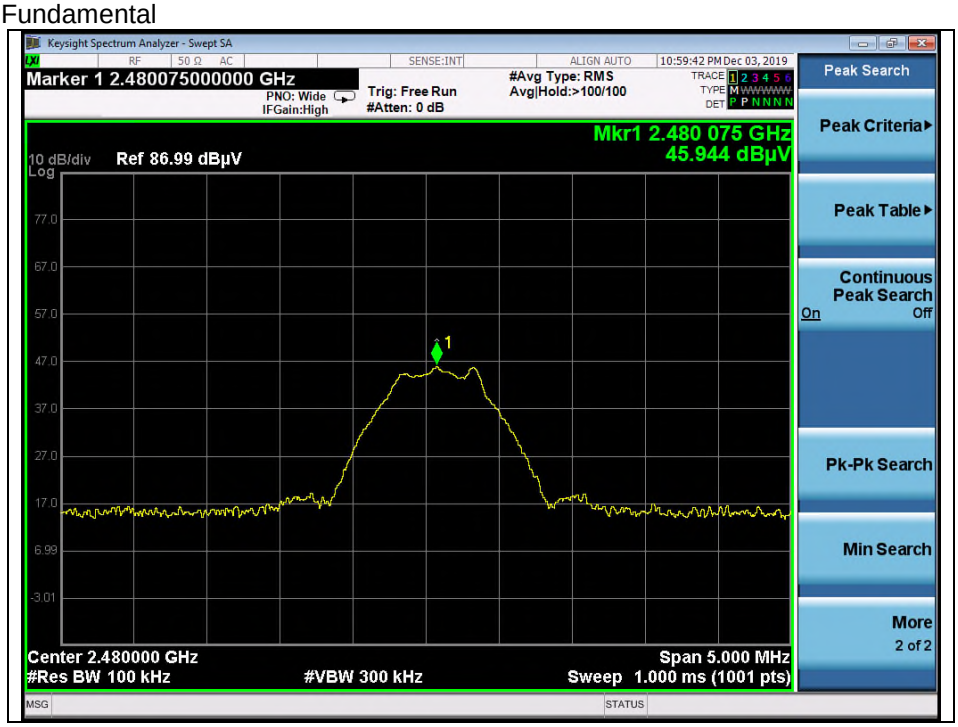



Middle channel Spurious (Peak)

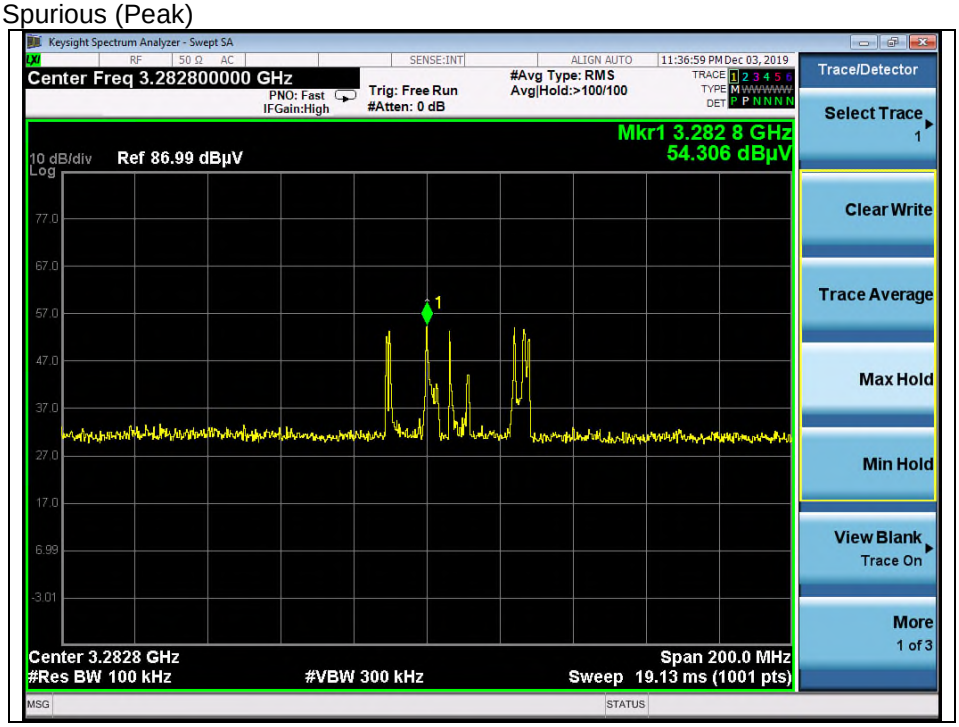



*The results of this test report are effective only to the items tested. The SGS Korea is not responsible for the sampling, the results of this test report apply to the sample as received. This test report cannot be reproduced, except in full, without prior written permission of the Company. This test report does not assure KOLAS accreditation.*

High channel Fundamental



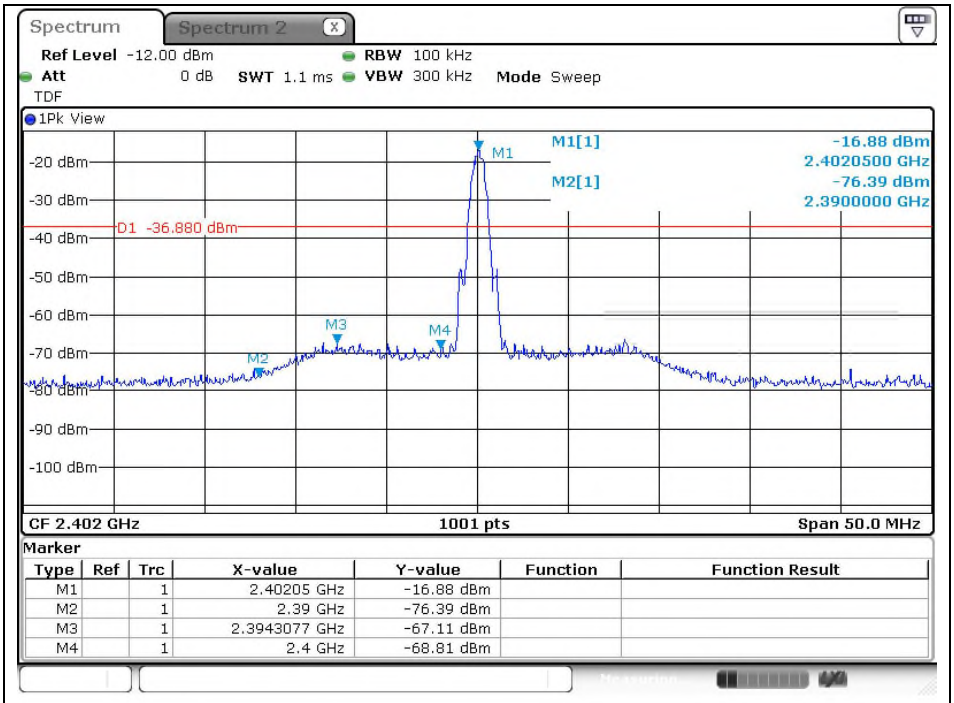

High channel Spurious (Peak)

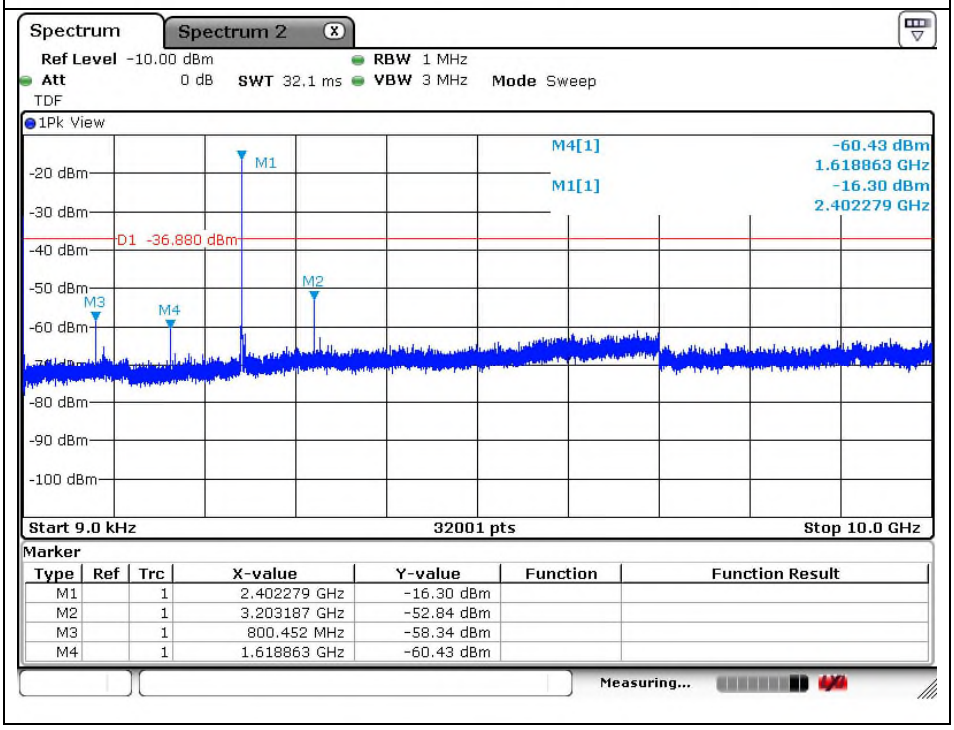



*The results of this test report are effective only to the items tested. The SGS Korea is not responsible for the sampling, the results of this test report apply to the sample as received. This test report cannot be reproduced, except in full, without prior written permission of the Company. This test report does not assure KOLAS accreditation.*

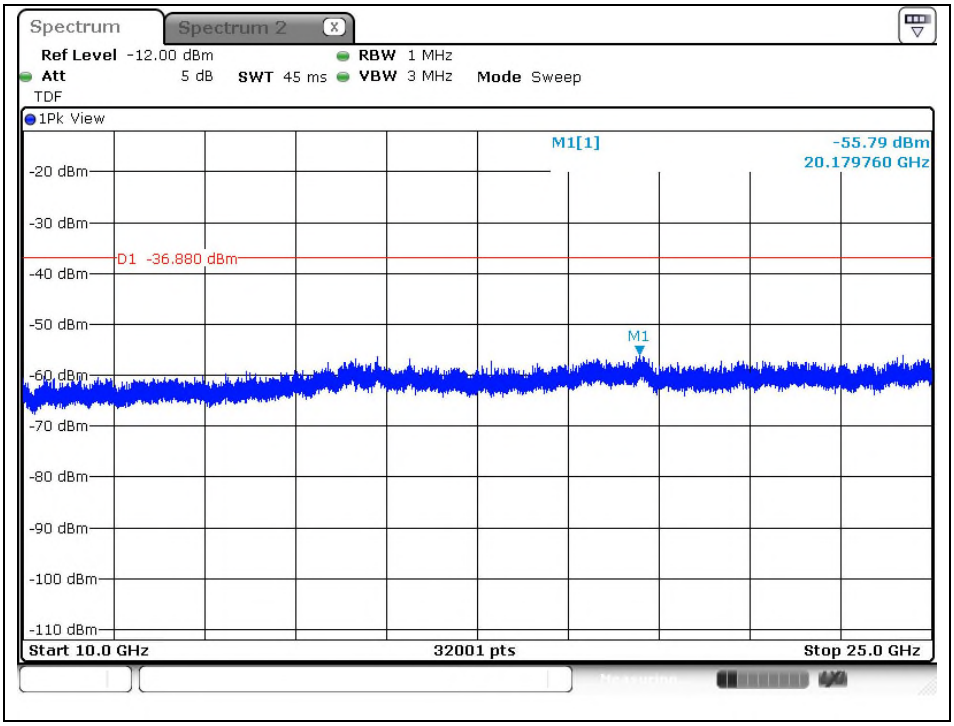
### 2.4.3. Plot of Conducted Spurious Emissions

Low Channel



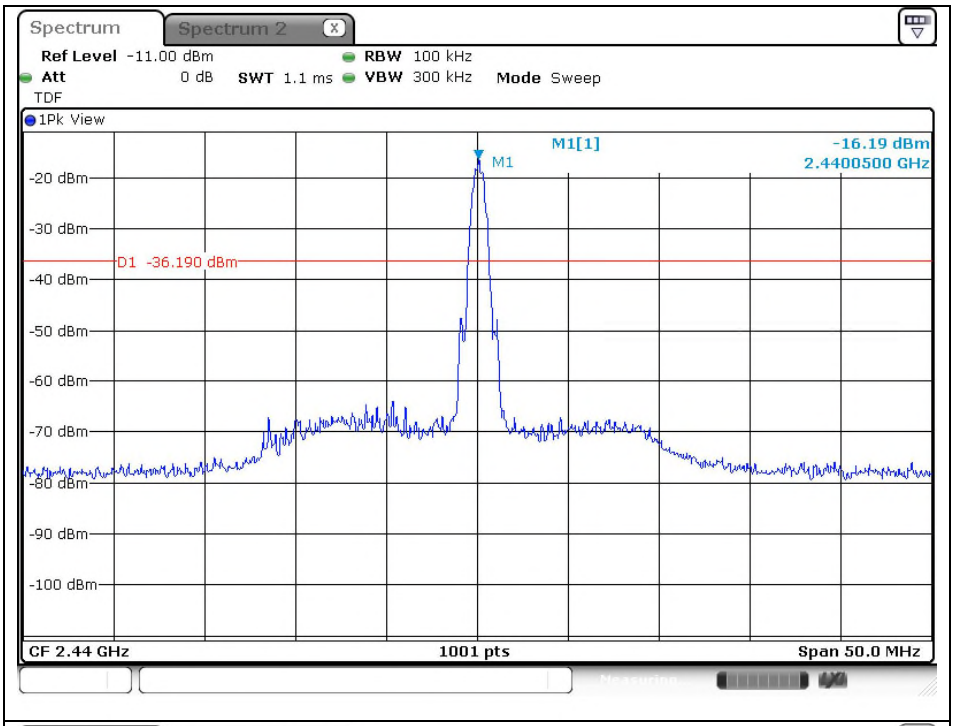



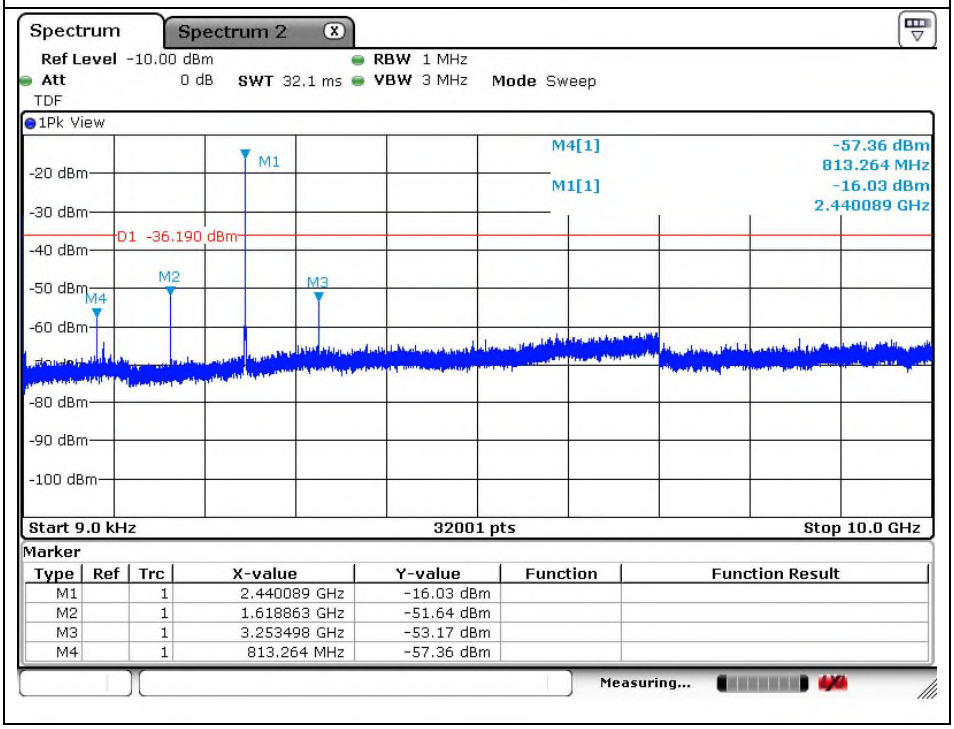

*The results of this test report are effective only to the items tested. The SGS Korea is not responsible for the sampling, the results of this test report apply to the sample as received. This test report cannot be reproduced, except in full, without prior written permission of the Company. This test report does not assure KOLAS accreditation.*



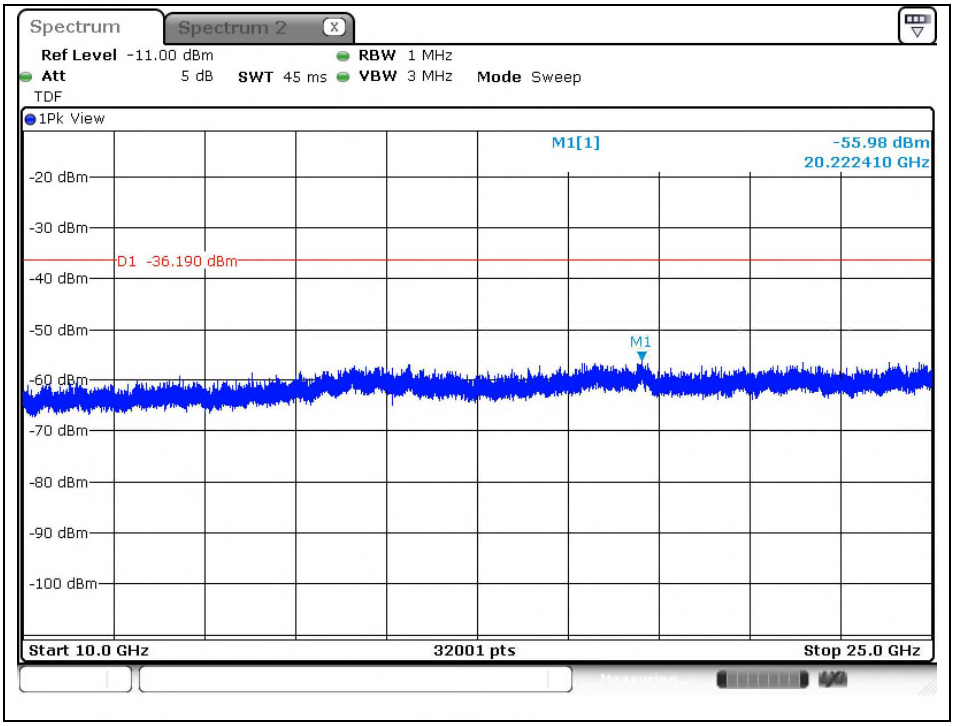

*The results of this test report are effective only to the items tested. The SGS Korea is not responsible for the sampling, the results of this test report apply to the sample as received. This test report cannot be reproduced, except in full, without prior written permission of the Company. This test report does not assure KOLAS accreditation.*

Middle Channel



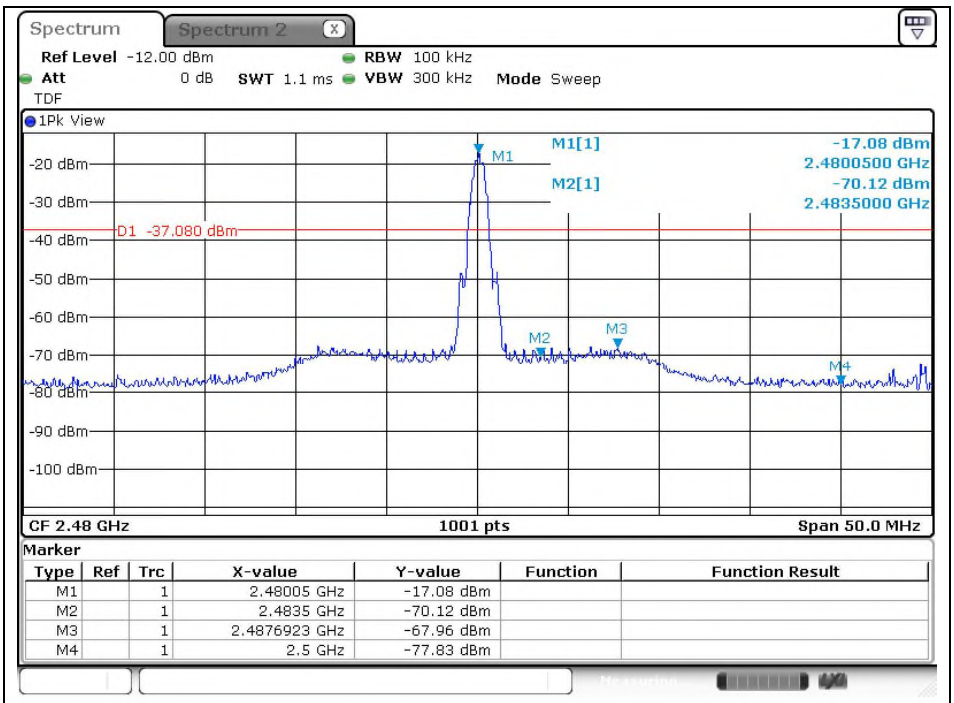



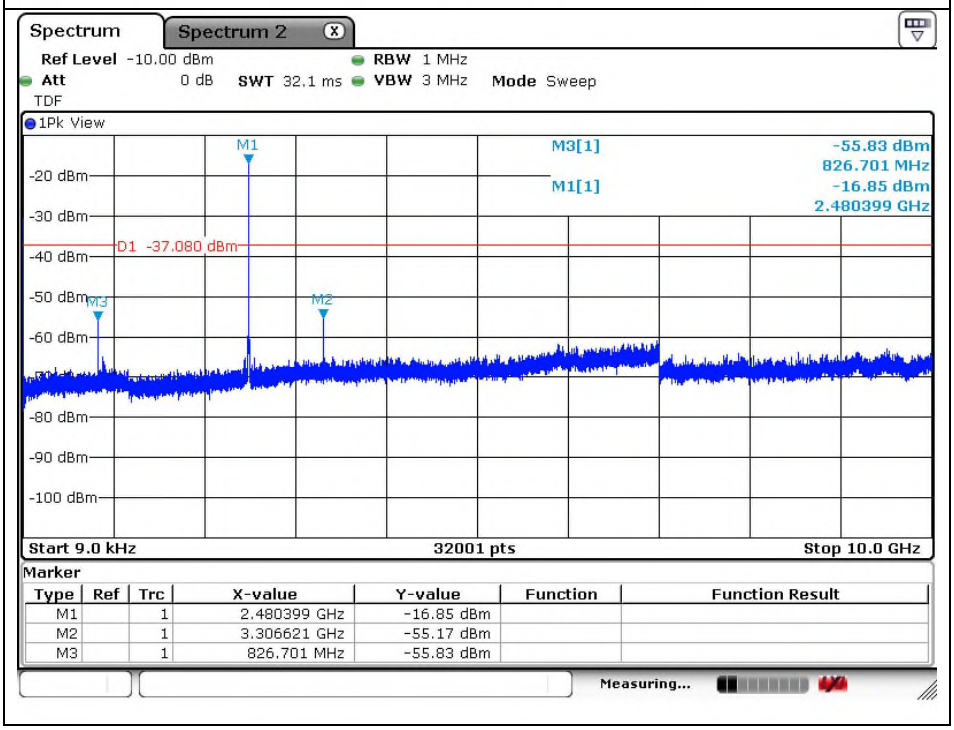

*The results of this test report are effective only to the items tested. The SGS Korea is not responsible for the sampling, the results of this test report apply to the sample as received. This test report cannot be reproduced, except in full, without prior written permission of the Company. This test report does not assure KOLAS accreditation.*



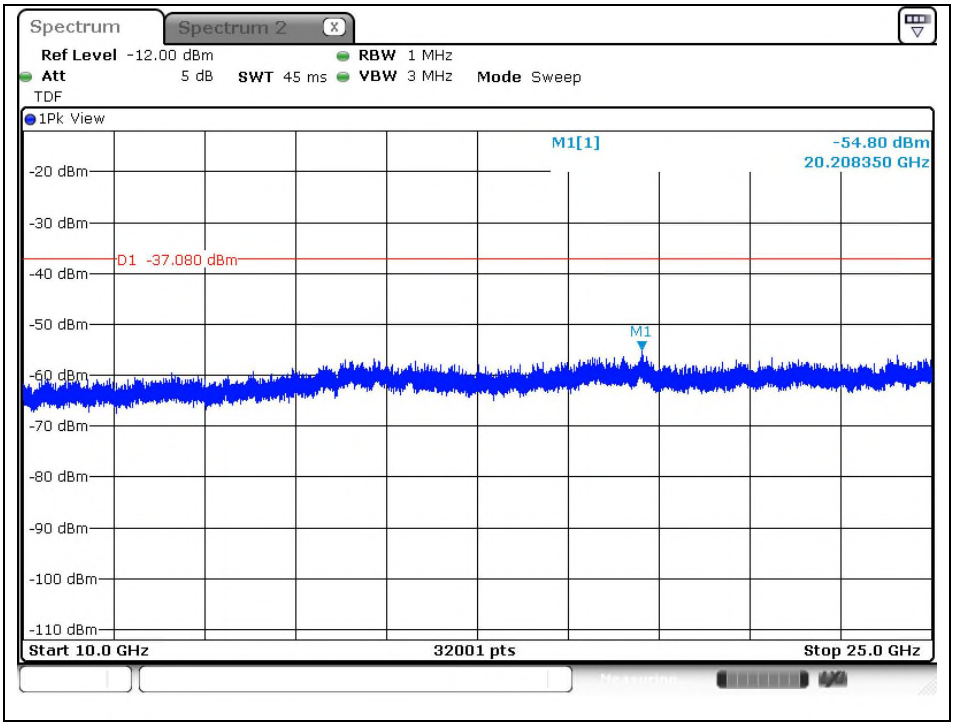

*The results of this test report are effective only to the items tested. The SGS Korea is not responsible for the sampling, the results of this test report apply to the sample as received. This test report cannot be reproduced, except in full, without prior written permission of the Company. This test report does not assure KOLAS accreditation.*

High Channel




*The results of this test report are effective only to the items tested. The SGS Korea is not responsible for the sampling, the results of this test report apply to the sample as received. This test report cannot be reproduced, except in full, without prior written permission of the Company. This test report does not assure KOLAS accreditation.*




*The results of this test report are effective only to the items tested. The SGS Korea is not responsible for the sampling, the results of this test report apply to the sample as received. This test report cannot be reproduced, except in full, without prior written permission of the Company. This test report does not assure KOLAS accreditation.*

# 3. 6 ㏈ Bandwidth

## 3.1. Test Setup

## 3.2. Limit

According to §15.247(a)(2), systems using digital modulation techniques may operate in the 902-928 ㎒, 2 400-2 483.5 ㎒, and 5 725-5 850 ㎒ bands. The minimum 6 ㏈ bandwidth shall be at least 500 ㎑.

## 3.3. Test Procedure

The test follows section 11.8 DTS bandwidth of ANSI C63.10-2013.

Tests performed using section 11.8.1 Option 1.

- Option 1:
1. Set RBW to = 100 ㎑.
2. Set the VBW ≥ 3 x RBW.
3. Detector = peak.
4. Trace mode = max hold.
5. Sweep = auto couple.
6. Allow the trace to stabilize.
7. Measure the maximum width of the emission that is constrained by the frequencies associated with the two outermost amplitude points (upper and lower frequencies) that are attenuated by 6 ㏈ relative to the maximum level measured in the fundamental emission.

*The results of this test report are effective only to the items tested. The SGS Korea is not responsible for the sampling, the results of this test report apply to the sample as received. This test report cannot be reproduced, except in full, without prior written permission of the Company. This test report does not assure KOLAS accreditation.*

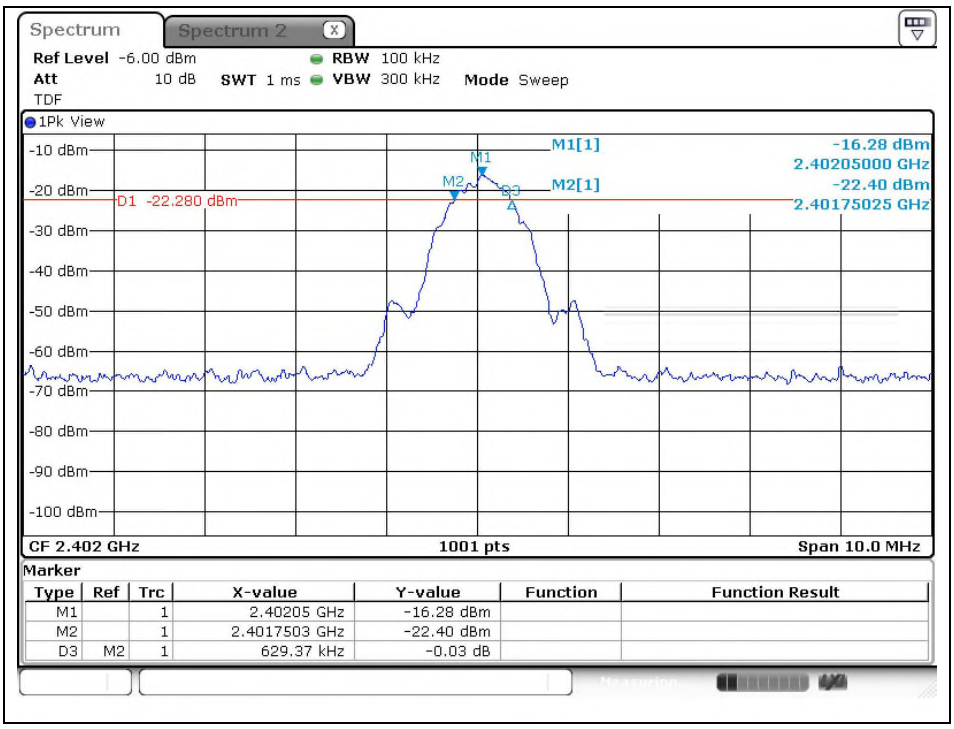
## 3.4. Test Results

Ambient temperature : (23 ± 1) ℃
Relative humidity : 47 % R.H.

| Mode | Channel | Frequency (MHz) | 6 dB Bandwidth (MHz) | Minimum Bandwidth (kHz) |
|---|---|---|---|---|
| GFSK | Low | 2 402 | 0.629 | 500 |
| | Middle | 2 440 | 0.649 | |
| | High | 2 480 | 0.639 | |

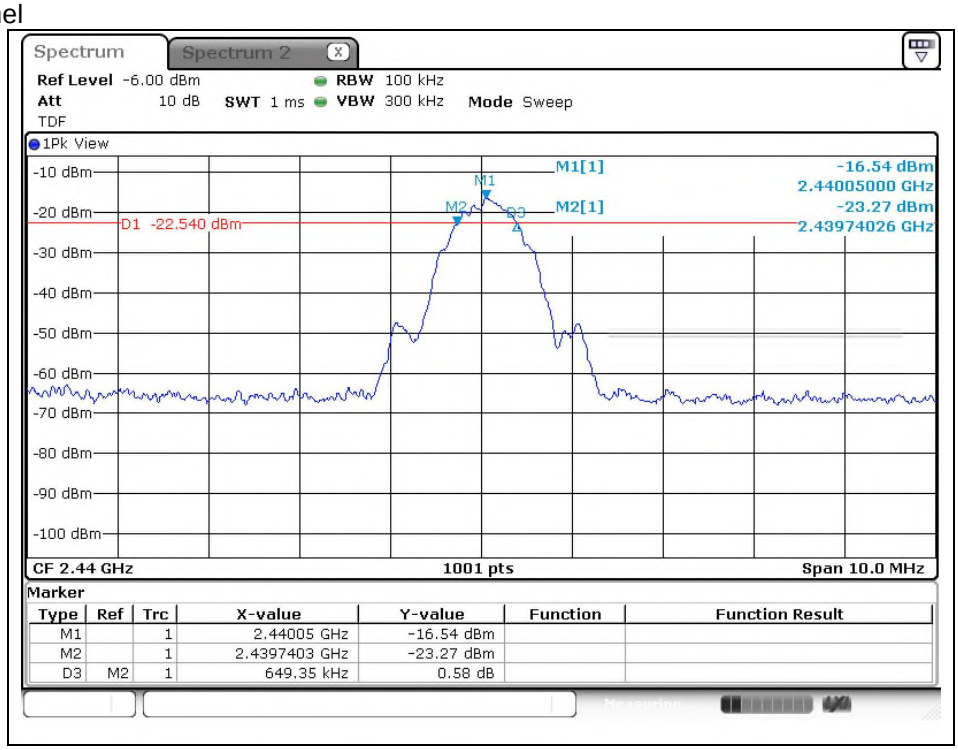
**- Test plots**

Low Channel

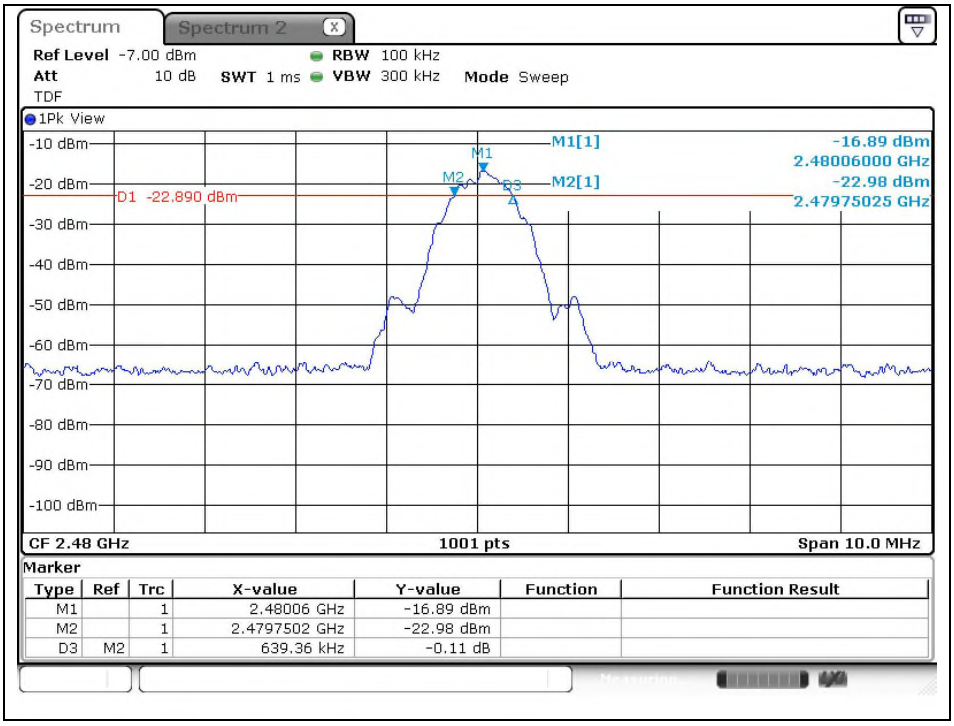



*The results of this test report are effective only to the items tested. The SGS Korea is not responsible for the sampling, the results of this test report apply to the sample as received. This test report cannot be reproduced, except in full, without prior written permission of the Company. This test report does not assure KOLAS accreditation.*

Middle Channel



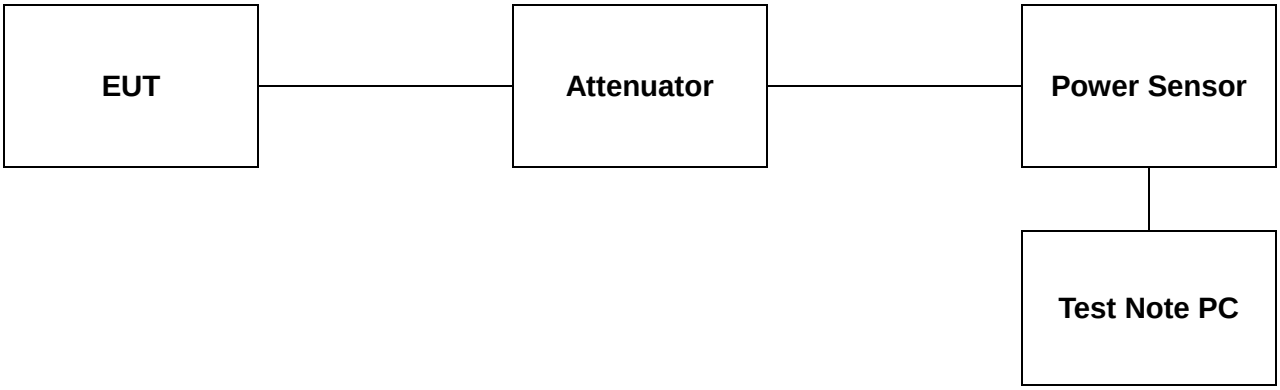

High Channel




*The results of this test report are effective only to the items tested. The SGS Korea is not responsible for the sampling, the results of this test report apply to the sample as received. This test report cannot be reproduced, except in full, without prior written permission of the Company. This test report does not assure KOLAS accreditation.*

# 4. Maximum Peak Conducted Output Power

## 4.1. Test Setup




## 4.2. Limit

According to §15.247(b)(3), for systems using digital modulation in the 902-928 ㎒, 2 400-2 483.5 ㎒, and 5 725-5 850 ㎒ bands: 1 Watt. As an alternative to a peak power measurement, compliance with the one Watt limit can be based on a measurement of the maximum conducted output power. Maximum Conducted Output Power is defined as the total transmit power delivered to all antennas and antenna elements averaged across all symbols in the signaling alphabet when the transmitter is operating at its maximum power control level. Power must be summed across all antennas and antenna elements. The average must not include any time intervals during which the transmitter is off or is transmitting at a reduced power level. If multiple modes of operation are possible (e.g., alternative modulation methods), the maximum conducted output power is the highest total transmit power occurring in any mode.

According to §15.247(b)(4), the conducted output power limit specified in paragraph (b) of this section is based on the use of antennas with directional gains that do not exceed 6 ㏈i. Except as shown in paragraph (c) of this section, if transmitting antennas of directional gain greater than 6 ㏈i are used, the conducted output power from the intentional radiator shall be reduced below the stated values in paragraph (b)(1), (b)(2), and (b)(3) of this section, as appropriate, by the amount in ㏈ that the directional gain of the antenna exceeds 6 ㏈i.

*The results of this test report are effective only to the items tested. The SGS Korea is not responsible for the sampling, the results of this test report apply to the sample as received. This test report cannot be reproduced, except in full, without prior written permission of the Company. This test report does not assure KOLAS accreditation.*

## 4.3. Test Procedure

The test follows section 11.9.1.3 of ANSI C63.10-2013.

**PKPM1 Peak-reading power meter method**
- The maximum peak conducted output power may be measured using a broadband peak RF power meter. The power meter shall have a video bandwidth that is greater than or equal to the DTS bandwidth and shall utilize a fast-responding diode detector.

The test follows section 11.9.2.3.2 of ANSI C63.10-2013.

**Method AVGPM-G (Measurement using a gated RF average-reading power meter)**
- Alternatively, measurements may be performed using a wideband gated RF power meter provided that the gate parameters are adjusted such that the power is measured only when the EUT is transmitting at its maximum power control level. Since this measurement is made only during the ON time of the transmitter, no duty cycle correction is required.

**Test program: (S/W name: R&S Power Viewer, Version: 3.2.0)**

1. Initially overall offset for attenuator and cable loss is measured per frequency.
2. Measured offset is inserted in test program in advance of measurement for output power.
3. Power for each frequency (channel) of device is investigated as final result.
4. Final result reported on this section from R&S power viewer program includes with several factors and test program shows only final result.

*The results of this test report are effective only to the items tested. The SGS Korea is not responsible for the sampling, the results of this test report apply to the sample as received. This test report cannot be reproduced, except in full, without prior written permission of the Company. This test report does not assure KOLAS accreditation.*

## 4.4. Test Results

Ambient temperature : (23 ± 1) ℃
Relative humidity : 47 % R.H.

| Mode | Channel | Frequency (㎒) | Average Power Result (㏈m) | Peak Power Result (㏈m) | Limit (㏈m) |
|---|---|---|---|---|---|
| GFSK | Low | 2 402 | **-14.96** | -10.96 | 30 |
| | Middle | 2 440 | -15.55 | -10.95 | |
| | High | 2 480 | -15.33 | **-10.34** | |

**Remark;**

Attenuator and cable offset was compensated in test program (R&S Power Viewer) before measuring.

*The results of this test report are effective only to the items tested. The SGS Korea is not responsible for the sampling, the results of this test report apply to the sample as received. This test report cannot be reproduced, except in full, without prior written permission of the Company. This test report does not assure KOLAS accreditation.*

# 5. Power Spectral Density

## 5.1. Test Setup

## 5.2. Limit

According to §15.247(e), for digitally modulated systems, the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 �dB m in any 3 ㎑ band during any time interval of continuous transmission. This power spectral density shall be determined in accordance with the provisions of paragraph (b) of this section. The same method of determining the conducted output power shall be used to determine the power spectral density.

## 5.3. Test Procedure

The measurements are recorded using the PKPSD measurement procedure in section 11.10.2 of ANSI C63.10-2013.

- This procedure shall be used if maximum peak conducted output power was used to demonstrate compliance, and is optional if the maximum conducted (average) output power was used to demonstrate compliance.

1. Set analyzer center frequency to DTS channel center frequency.
2. Set the span to 1.5 times the DTS bandwidth.
3. Set the RBW to 3 ㎑ ≤ RBW ≤ 100 ㎑.
4. Set the VBW ≥ 3 x RBW.
5. Detector = peak.
6. Sweep time = auto couple.
7. Trace mode = max hold.
8. Allow trace to fully stabilize.
9. Use the peak marker function to determine the maximum amplitude level within the RBW.
10. If measured value exceeds requirement, then reduce RBW (but no less than 3 ㎑) and repeat.

*The results of this test report are effective only to the items tested. The SGS Korea is not responsible for the sampling, the results of this test report apply to the sample as received. This test report cannot be reproduced, except in full, without prior written permission of the Company. This test report does not assure KOLAS accreditation.*

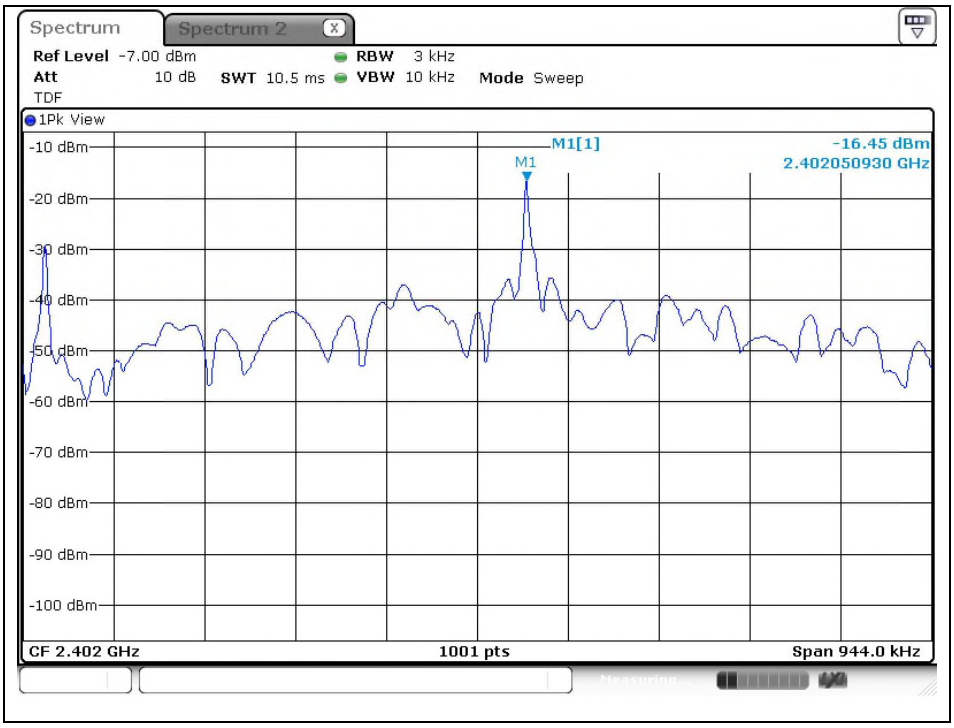
## 5.4. Test Results

Ambient temperature : (23 ± 1) ℃
Relative humidity : 47 % R.H.

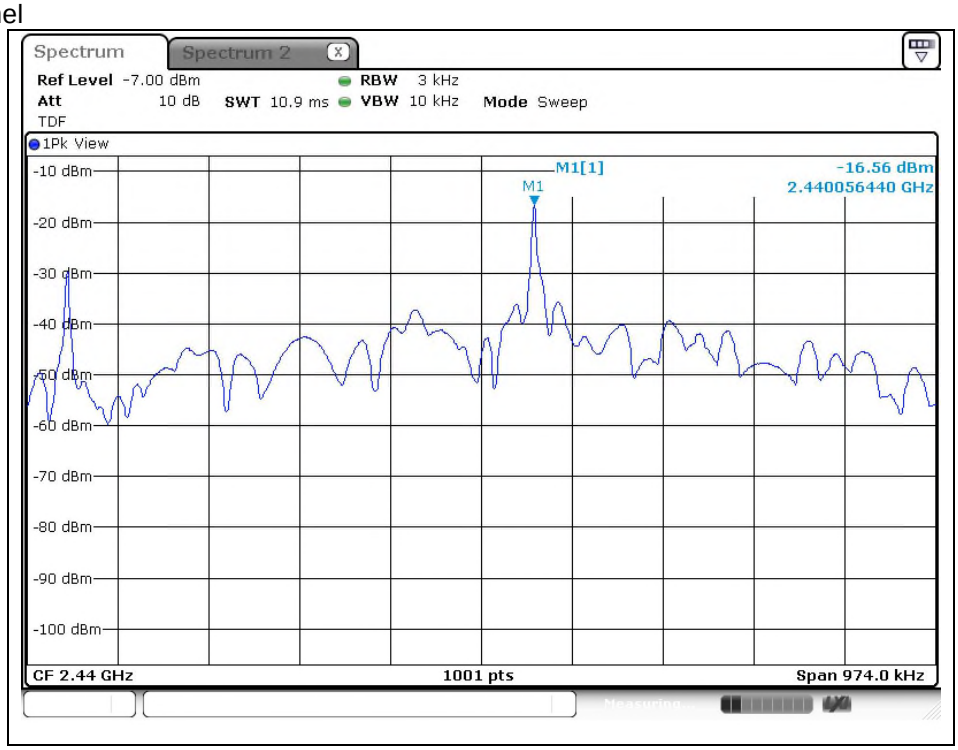
| Mode | Channel | Frequency (㎒) | Measured PSD (㏈ m/3 ㎑) | Limit (㏈ m/3 ㎑) |
|---|---|---|---|---|
| GFSK | Low | 2 402 | -16.45 | 8 |
| | Middle | 2 440 | -16.56 | |
| | High | 2 480 | -17.14 | |

**- Test plots**

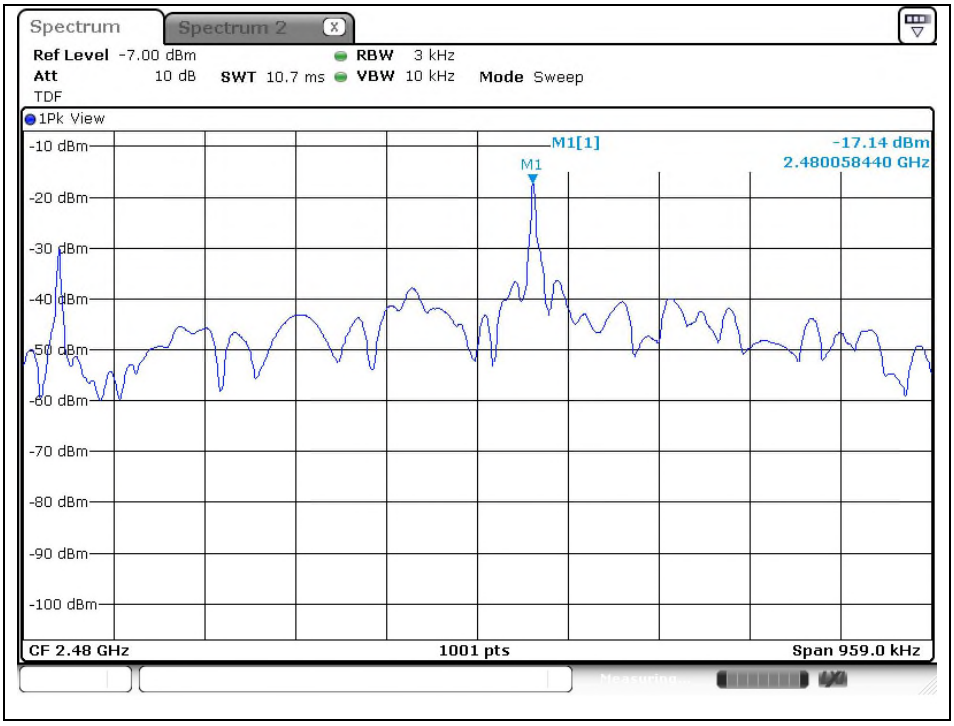
Low Channel



Middle Channel



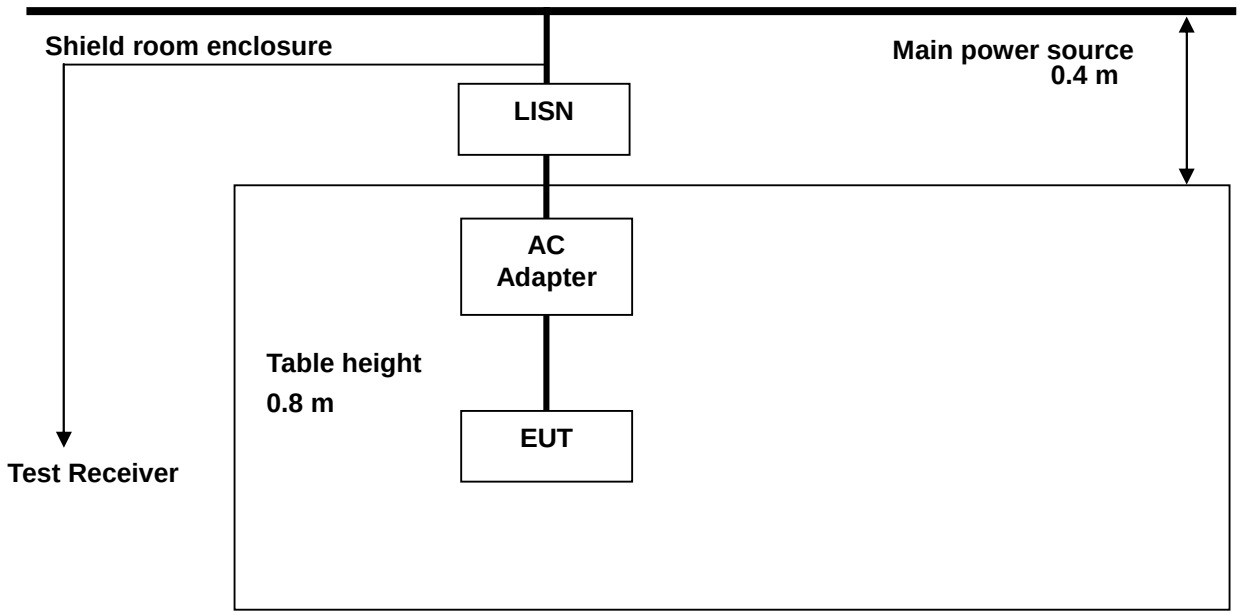

High Channel




*The results of this test report are effective only to the items tested. The SGS Korea is not responsible for the sampling, the results of this test report apply to the sample as received. This test report cannot be reproduced, except in full, without prior written permission of the Company. This test report does not assure KOLAS accreditation.*

# 6. AC Power Line Conducted Emission

## 6.1. Test Setup




## 6.2. Limit

According to §15.207(a), for an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 ㎑ to 30 ㎒, shall not exceed the limits in the following table, as measured using a 50 μH /50 ohms line impedance stabilization network (LISN).
Compliance with the provision of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the boundary between the frequency ranges.

| Frequency of emission (㎒) | Conducted limit (dBμV) | |
|---|---|---|
| | Quasi-peak | Average |
| 0.15-0.5 | 66 to 56* | 56 to 46* |
| 0.5-5 | 56 | 46 |
| 5-30 | 60 | 50 |

* Decreases with the logarithm of the frequency.

*The results of this test report are effective only to the items tested. The SGS Korea is not responsible for the sampling, the results of this test report apply to the sample as received. This test report cannot be reproduced, except in full, without prior written permission of the Company. This test report does not assure KOLAS accreditation.*

## 6.3. Test Procedures

AC conducted emissions from the EUT were measured according to the dictates of ANSI C63.10-2013

1. The test procedure is performed in a 6.5 m × 3.5 m × 3.5 m (L × W × H) shielded room. The EUT along with its peripherals were placed on a 1.0 m (W) × 1.5 m (L) and 0.8 m in height wooden table and the EUT was adjusted to maintain a 0.4 meter space from a vertical reference plane.
2. The EUT was connected to power mains through a line impedance stabilization network (LISN) which provides 50 ohm coupling impedance for measuring instrument and the chassis ground was bounded to the horizontal ground plane of shielded room.
3. All peripherals were connected to the second LISN and the chassis ground also bounded to the horizontal ground plane of shielded room.
4. The excess power cable between the EUT and the LISN was bundled. The power cables of peripherals were unbundled. All connecting cables of EUT and peripherals were moved to find the maximum emission.

*The results of this test report are effective only to the items tested. The SGS Korea is not responsible for the sampling, the results of this test report apply to the sample as received. This test report cannot be reproduced, except in full, without prior written permission of the Company. This test report does not assure KOLAS accreditation.*

## 6.4. Test Results

The following table shows the highest levels of conducted emissions on both phase of Hot and Neutral line.

Ambient temperature : (23 ± 1) ℃
Relative humidity : 47 % R.H.

Frequency range : 0.15 ㎒ - 30 ㎒
Measured Bandwidth : 9 ㎑

| FREQ. | LEVEL (dBμV) | | LINE | LIMIT (dBμV) | | MARGIN (dB) | |
|---|---|---|---|---|---|---|---|
| (㎒) | Q-Peak | Average | | Q-Peak | Average | Q-Peak | Average |
| 0.17 | 34.60 | 20.00 | N | 64.96 | 54.96 | 30.36 | 34.96 |
| 0.25 | 31.40 | 20.10 | N | 61.76 | 51.76 | 30.36 | 31.66 |
| 0.74 | 36.30 | 25.10 | N | 56.00 | 46.00 | 19.70 | 20.90 |
| 2.05 | 28.70 | 17.20 | N | 56.00 | 46.00 | 27.30 | 28.80 |
| 6.42 | 25.70 | 15.70 | N | 60.00 | 50.00 | 34.30 | 34.30 |
| 20.86 | 31.60 | 21.50 | N | 60.00 | 50.00 | 28.40 | 28.50 |
| 0.17 | 34.90 | 16.60 | H | 64.96 | 54.96 | 30.06 | 38.36 |
| 0.25 | 31.10 | 14.00 | H | 61.76 | 51.76 | 30.66 | 37.76 |
| 0.75 | 32.00 | 17.30 | H | 56.00 | 46.00 | 24.00 | 28.70 |
| 2.10 | 22.20 | 10.60 | H | 56.00 | 46.00 | 33.80 | 35.40 |
| 3.72 | 20.60 | 8.70 | H | 56.00 | 46.00 | 35.40 | 37.30 |
| 21.86 | 26.90 | 14.50 | H | 60.00 | 50.00 | 33.10 | 35.50 |

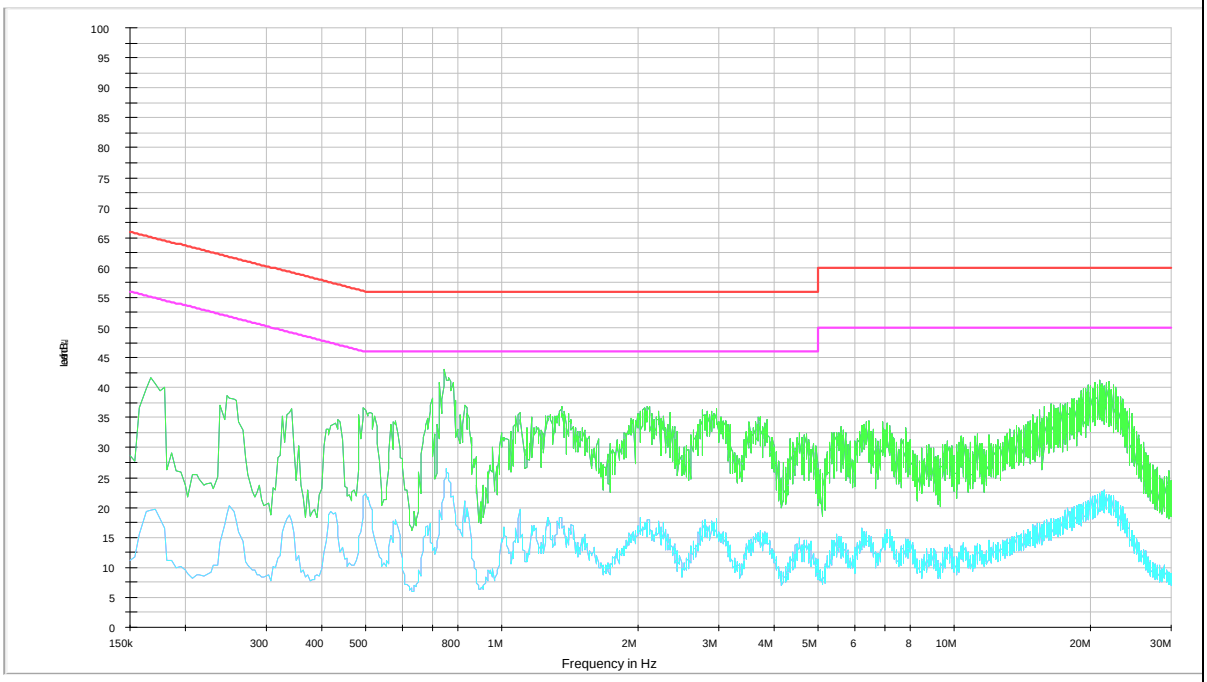
**Remark;**

1. Line (H): Hot, Line (N): Neutral.
2. All channels of operation were investigated and the worst-case emissions were reported using **High channel.**
3. The limit for Class B device(s) from 150 ㎑ to 30 ㎒ are specified in Section of the Title 47 CFR.
4. Traces shown in plot were made by using a peak detector and average detector.
5. Deviations to the Specifications: None.

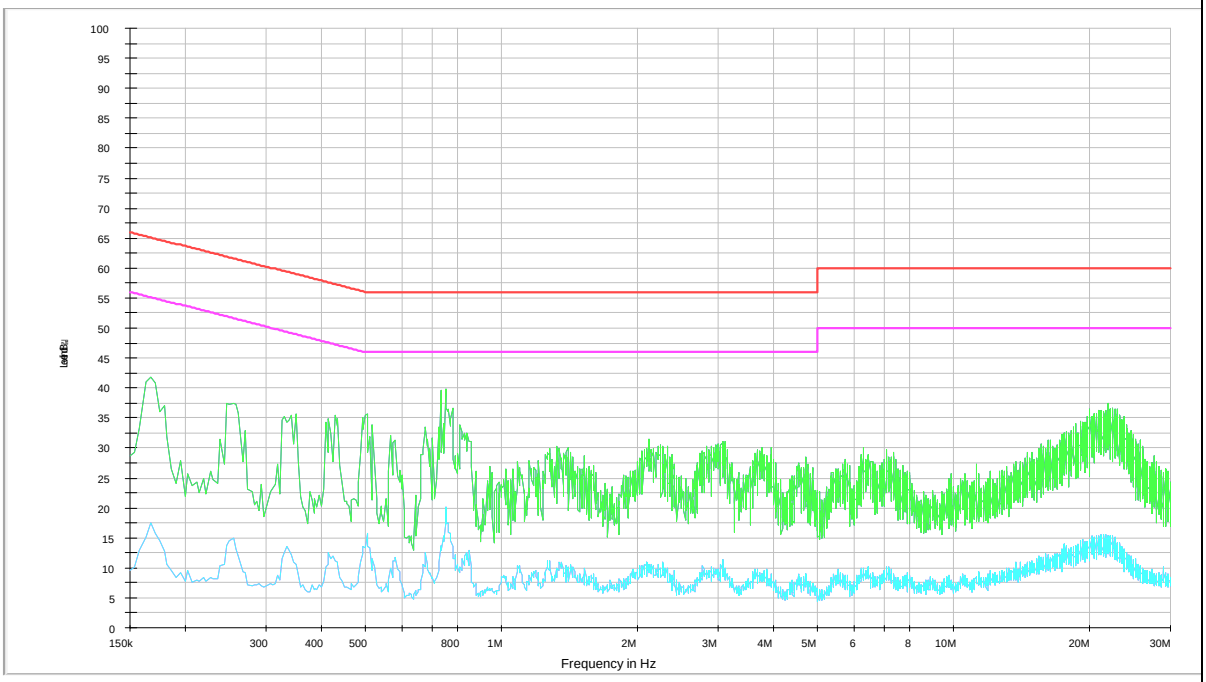
*The results of this test report are effective only to the items tested. The SGS Korea is not responsible for the sampling, the results of this test report apply to the sample as received. This test report cannot be reproduced, except in full, without prior written permission of the Company. This test report does not assure KOLAS accreditation.*

**- Test plots**

Test mode: (Neutral)




Test mode: (Hot)




*The results of this test report are effective only to the items tested. The SGS Korea is not responsible for the sampling, the results of this test report apply to the sample as received. This test report cannot be reproduced, except in full, without prior written permission of the Company. This test report does not assure KOLAS accreditation.*

# 7. Antenna Requirement

## 7.1. Standard Applicable

For intentional device, according to FCC 47 CFR Section §15.203, an intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. And according to FCC 47 CFR Section §15.247(b) if transmitting antennas of directional gain greater than 6 dBi are used, the power shall be reduced by the amount in dB that the gain of the antenna exceeds 6 dBi.

## 7.2. Antenna Connected Construction

Antenna used in this product is PCB pattern antenna with gain of -2.61 dBi.

**- End of the Test Report -**

*The results of this test report are effective only to the items tested. The SGS Korea is not responsible for the sampling, the results of this test report apply to the sample as received. This test report cannot be reproduced, except in full, without prior written permission of the Company. This test report does not assure KOLAS accreditation.*