# Certificate of Compliance

| Test Report No.: | SKTTRT-080129-002 | | |
|---|---|---|---|
| Applicant: | KUK JE TONG SHIN CO., LTD. | | |
| Applicant Address: | 476-3 Jakjeon-dong, Kyeyang-ku, Incheon, South Korea | | |
| Manufacturer: | KUK JE TONG SHIN CO., LTD. | | |
| Manufacturer Address: | 476-3 Jakjeon-dong, Kyeyang-ku, Incheon, South Korea | | |
| Device Under Test: | Bluetooth Mono Headset | | |
| FCC ID: | VZE-08021001 | Model Name: | KHM-210 |
| Brand/Trade Name: | - | | |
| Receipt No.: | SKTEU07-1306 | Date of receipt: | December 26, 2007 |
| Date of Issue: | January 29, 2008 | | |
| Location of Testing: | SK TECH CO., LTD.<br>#820-2, Wolmoon-ri, Wabu-up, Namyangju-si, Kyunggi-do, 472-905 South Korea | | |
| Test Procedure: | ANSI C63.4, FCC Public Notice DA 00-705 (March 2000) | | |
| Test Specification: | 47CFR, Part 15 Rules | | |
| FCC Equipment Class: | DSS - Part 15 Spread Spectrum Transmitter | | |
| Test Result: | The above-mentioned device has been tested and passed. | | |

**Tested & Reported by**: *Seung-Taek, Shim* **Approved by**: *Jong-Soo, Yoon*

*2008. 01. 29* *2008. 01. 29*

*Signature* *Date* *Signature* *Date*

| Other Aspects: | - |
|---|---|
| Abbreviations: | · OK, Pass = passed · Fail = failed · N/A = not applicable |

☞
- **This test report is not permitted to copy partly and entirely without our permission.**
- **This test result is dependent on only equipment to be used.**
- **This test result is based on a single evaluation of submitted samples of the above mentioned.**

# >> CONTENTS <<

# 1. GENERAL

These tests were performed using the test procedure outlined in ANSI C63.4, 2003 for intentional radiators, and in accordance with the limits set forth in FCC Part 15.247 for Spread Spectrum Transmitter. The EUT (Equipment Under Test) has been shown to be capable of compliance with the applicable technical standards.

We attest to the accuracy of data. All measurements reported herein were performed by SK TECH CO., LTD. and were made under Chief Engineer's supervision.
We assume full responsibility for the completeness of these measurements and vouch for the qualifications of all persons taking them.

# 2. TEST SITE

SK TECH CO., LTD.

## 2.1 Location

#820-2, Wolmoon-ri, Wabu-up, Namyangju-si, Kyunggi-do, 472-905 South Korea
(FCC Registered Test Site Number: 90752)

This test site is in compliance with ISO/IEC 17025 for general requirements for the competence of testing and calibration laboratories.
This laboratory is recognized as a Conformity Assessment Body (CAB) for CAB's Designation Number: **KR0007** by FCC, is accredited by NVLAP for NVLAP Lab. Code: **200220-0**.

## 2.2 List of Test and Measurement Instruments

| No. | Description | Manufacturer | Model # | Serial # | Calibrated until | Used |
|---|---|---|---|---|---|---|
| 1 | Spectrum Analyzer | Agilent | E4405B | US40520856 | 2008.07.23 | ☐ |
| 2 | EMC Spectrum Analyzer | Agilent | E7405A | US40240203 | 2008.02.02 | ☒ |
| 3 | EMI Test Receiver | Rohde&Schwarz | ESIB40 | 100277 | 2008.07.23 | ☒ |
| 4 | EMI Test Receiver | Rohde&Schwarz | ESVS10 | 825120/008 | 2008.07.24 | ☐ |
| 5 | EMI Test Receiver | Rohde&Schwarz | ESHS10 | 862970/019 | 2008.07.24 | ☒ |
| 6 | Artificial Mains Network | Rohde&Schwarz | ESH3-Z5 | 836679/018 | 2008.07.25 | ☒ |
| 7 | Pre-amplifier | HP | 8447F | 3113A05153 | 2008.02.23 | ☒ |
| 8 | Pre-amplifier | MITEQ | AFS44 | 1116321 | 2008.03.07 | ☒ |
| 9 | Pre-amplifier | MITEQ | AFS44 | 1116322 | 2008.02.06 | ☒ |
| 10 | Power Meter | Agilent | E4417A | MY45100426 | 2008.07.24 | ☐ |
| 11 | Power Sensor | Agilent | E9327A | MY44420696 | 2008.07.24 | ☐ |
| 12 | Attenuator (10dB) | HP | 8491B | 38067 | 2008.07.25 | ☐ |
| 13 | Oscilloscope | Agilent | 54820A | US40240160 | 2008.03.06 | ☐ |
| 14 | Diode detector | Agilent | 8473C | 1882A03173 | 2008.02.06 | ☐ |
| 15 | High Pass Filter | Wainwright | WHKX3.0/18G | 8 | 2008.07.25 | ☒ |
| 16 | VHF Precision Dipole Antenna (TX/RX) | Schwarzbeck | VHAP | 1014 / 1015 | 2008.11.27 | ☐ |
| 17 | UHF Precision Dipole Antenna (TX/RX) | Schwarzbeck | UHAP | 989 / 990 | 2008.11.27 | ☐ |
| 18 | Loop Antenna | Schwarzbeck | HFH2-Z2 | 863048/019 | 2008.12.01 | ☐ |
| 19 | TRILOG Broadband Antenna | Schwarzbeck | VULB9160 | 3141 | 2008.05.29 | ☒ |
| 20 | Horn Antenna | AH Systems | SAS-200/571 | 304 | N/A | ☐ |
| 21 | Horn Antenna | EMCO | 3115 | 00040723 | 2008.03.15 | ☒ |
| 22 | Horn Antenna | EMCO | 3115 | 00056768 | 2008.07.24 | ☒ |
| 23 | Vector Signal Generator | Agilent | E4438C | MY42080359 | 2008.07.25 | ☐ |
| 24 | PSG analog signal generator | Agilent | E8257D-520 | MY45141255 | 2008.07.25 | ☐ |
| 25 | DC Power Supply | HP | 6622A | 3448A03950 | 2008.07.23 | ☐ |
| 26 | DC Power Supply | HP | 6268B | 2542A-07856 | 2008.07.23 | ☐ |
| 27 | Digital Multimeter | HP | HP3458A | 2328A14389 | 2008.03.07 | ☐ |
| 28 | PCS Interface | HP | 83236B | 3711J00881 | 2008.03.09 | ☐ |
| 29 | CDMA Mobile Test Set | HP | 8924C | US35360253 | 2008.03.09 | ☐ |
| 30 | Hygro/Thermo Graph | SATO | PC-5000TRH-II | - | 2008.04.09 | ☒ |
| 31 | Temperature/Humidity Chamber | All Three | ATM-50M | 20030425 | 2008.03.06 | ☐ |
| 32 | Temperature/Humidity Chamber | DAEJIN | DJ-THC02 | 06071 | 2008.03.07 | ☐ |

## 2.3 Test Date

Date of Test: January 23, 2008 ~ January 29, 2008

## 2.4 Test Environment

See each test item's description.

# 3. DESCRIPTION OF THE EQUIPMENT UNDER TEST

The product specification described herein was obtained from the product data sheet or user's manual.

## 3.1 Rating and Physical Characteristics

| | |
|---|---|
| Power source | 3.7VDC Li-ion Polymer battery |
| Transmit Frequency | 2402 ~ 2480 MHz (1 MHz step, 79 channels) |
| X-tal or Oscillator | X-tal: 26 MHz |
| Antenna Type | Integral (chip antenna, Gain: 0.19 dBi) |
| Type of Modulation | FHSS (GFSK) |
| RF Output power | 0 dBm |
| External Ports | USB For battery charging only. |

## 3.2 Equipment Modifications

None

## 3.3 Submitted Documents

Block diagram

Schematic diagram

Antenna Specification

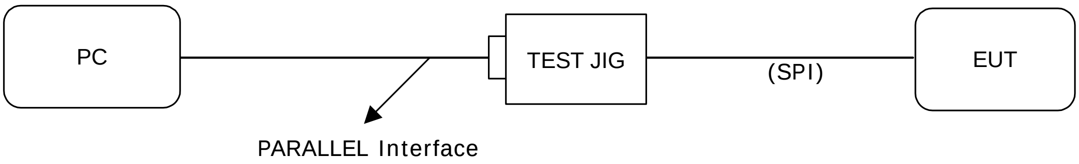
Part List

User manual

# 4. MEASUREMENT CONDITIONS

## 4.1 Description of test configuration

The measurements were taken in continuous transmitting mode using the TEST MODE. For controlling the EUT as TEST MODE, the test program and the TEST JIG were provided by the applicant.




**[ System Block Diagram of Test Configuration ]**

## 4.2 List of Peripherals

| Equipment Type | Manufacturer | Model | S/N |
|---|---|---|---|
| PC ** | DELL INC. | DCNE | 7XH86BX |
| TEST JIG ** | KUK JE TONG SHIN CO., LTD. | - | - |

** For control of the RF module via SPI interface in the EUT.

For radiated spurious emission measurements, the EUT was tested as stand-alone equipment without TEST JIG, setting the EUT to TEST MODE. The AC power line conducted emission measurements were performed while the battery in the EUT was being charged because the EUT is designed not to operate when charging the battery.

## 4.3 Type of Used Cables

| # | START | | END | | CABLE | |
|---|---|---|---|---|---|---|
| | NAME | I/O PORT | NAME | I/O PORT | LENGTH(m) | SHIELDED |
| 1 | EUT | mini-USB | TEST JIG | mini-USB | 0.1 | NO |
| 2 | TEST JIG | SPI | PC | LPT1 | 1.8 | NO |

## 4.4 Uncertainty

| Measurement Item | Combined Standard Uncertainty Uc | Expanded Uncertainty U = $k$Uc ($k$ = 2) |
|---|---|---|
| Conducted RF power | ± 1.49 dB | ± 2.98dB |
| Radiated disturbance | ± 2.30 dB | ± 4.60 dB |
| Conducted disturbance | ± 1.96 dB | ± 3.92 dB |

# 5. TEST AND MEASUREMENTS

**Summary of Test Results**

| **Requirement** | **CFR 47 Section** | **Report Section** | **Test Result** |
|---|---|---|---|
| Antenna Requirement | 15.203, 15.247(b)(4) | 5.1 | PASS |
| Maximum Peak Output Power | 15.247(b)(1), (4) | 5.2 | PASS |
| Carrier Frequency Separation | 15.247(a)(1) | 5.3 | PASS |
| 20dB Channel Bandwidth | 15.247(a)(1) | 5.4 | PASS |
| Number of Hopping Channels | 15.247(a)(iii), 15.247(b)(1) | 5.5 | PASS |
| Time of Occupancy (Dwell Time) | 15.247(a)(iii) | 5.6 | PASS |
| Spurious Emission, Band Edge, and Restricted bands | 15.247(d), 15.205(a), 15.209(a) | 5.7 | PASS |
| Peak Power Spectral Density | 15.247(e) | 5.8 | PASS |
| Conducted Emissions | 15.207(a) | 5.9 | PASS |
| RF Exposure | 15.247(i), 1.1307(b)(1) | 5.10 | PASS |

## 5.1 ANTENNA REQUIREMENT

### 5.1.1 Regulation

According to §15.203, an intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this Section. The manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited.

And 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 dBi. Except as shown in paragraph (c) of this section, if transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced below the stated values in paragraphs (b)(1), (b)(2), and (b)(3) of this section, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

### 5.1.2 Result: PASS

The transmitter has an integral chip antenna. The directional gain of the antenna is 0.19 dBi.

# 5.2 MAXIMUM PEAK OUTPUT POWER

## 5.2.1 Regulation

According to §15.247(b)(1), for frequency hopping systems operating in the 2400-2483.5 MHz band employing at least 75 non-overlapping hopping channels, and all frequency hopping systems in the 5725-5850 MHz band: 1 watt. For all other frequency hopping systems in the 2400-2483.5 MHz band: 0.125 watts.

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 dBi. Except as shown in paragraph (c) of this section, if transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced below the stated values in paragraphs (b)(1), (b)(2), and (b)(3) of this section, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

## 5.2.2 Test Procedure

1. Check the calibration of the measuring instrument (spectrum analyzer) using either an internal calibrator or a known signal from an external generator.
2. Connect the antenna port of the EUT to RF input on the spectrum analyzer via a low loss cable and attenuator.
3. Turn on the EUT and set it to any one measured frequency within its operating range by controlling it via SPI interface and make sure the spectrum analyzer is operated in its linear range.
4. Set the spectrum analyzer as follows:
   Span = approximately 5 times the 20 dB bandwidth, centered on a hopping channel
   RBW > the 20 dB bandwidth of the emission being measured
   VBW ≥ RBW
   Sweep = auto
   Detector function = peak
   Trace = max hold
5. Measure the highest amplitude appearing on spectral display and record the level to calculate results.
6. Repeat above procedures until all frequencies measured were complete.

## 5.2.3 Test Results: PASS

**Table 1: Measured values of the Maximum Peak Output Power (Conducted)**

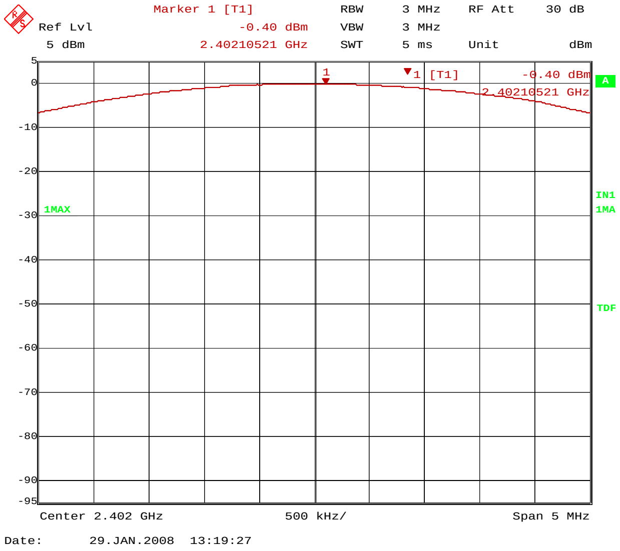
| Operating Frequency | Resolution Bandwidth | Actual | Limit |
|---|---|---|---|
| 2402 MHz | 3 MHz | 0.91 mW(-0.40 dBm) | 1 W (30 dBm) |
| 2441 MHz | 3 MHz | 0.95 mW(-0.22 dBm) | 1 W (30 dBm) |
| 2480 MHz | 3 MHz | 0.90 mW(-0.47 dBm) | 1 W (30 dBm) |

NOTE:

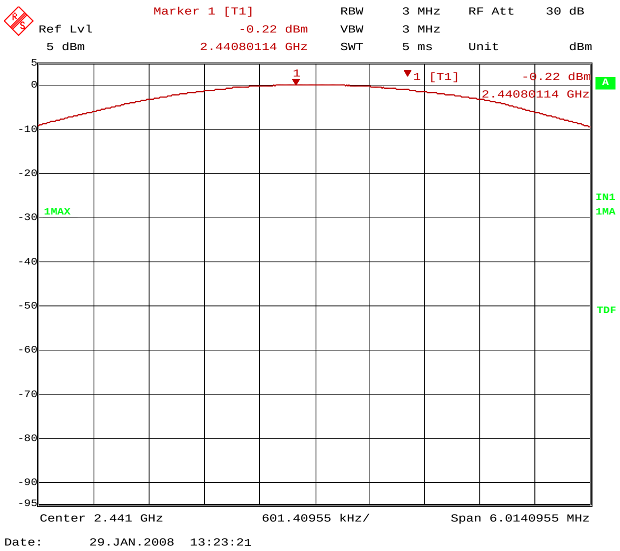
1. Since the directional gain of the integral antenna declared by the manufacturer ($G_{ANT}$ = 0.19 dBi) does not exceed 6.0 dBi, there was no need to reduce the output power.
2. We took the insertion loss of the cable loss into consideration within the measuring instrument.

## Figure 1. Plot of the Maximum Peak Output Power (Conducted)

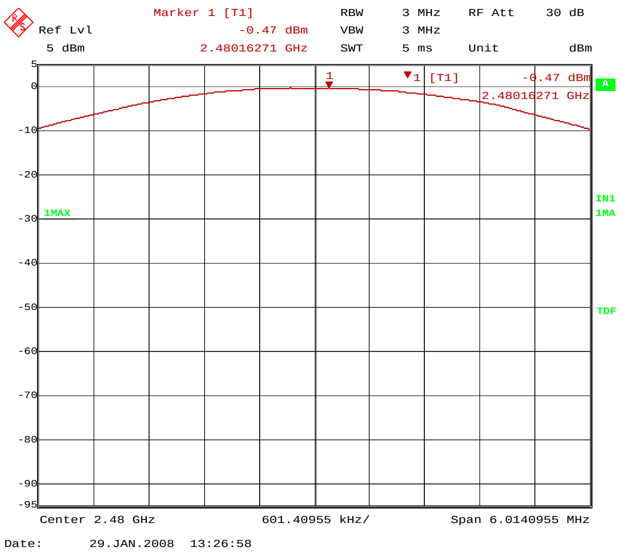
Lowest Channel
(2402 MHz)




Middle Channel
(2441 MHz)




Highest Channel
(2480 MHz)



# 5.3 CARRIER FREQUENCY SEPARATION

## 5.3.1 Regulation

According to §15.247(a)(1), frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, frequency hopping systems operating in the 2400-2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW.

## 5.3.2 Test Procedure

1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Connect the antenna port of the EUT to RF input on the spectrum analyzer via a low loss cable and attenuator.
3. Turn on the EUT and set it to any one measured frequency within its operating range by controlling it via SPI interface.
4. Set the spectrum analyzer as follows:
   Span = wide enough to capture the peaks of two adjacent channels
   Resolution (or IF) Bandwidth (RBW) ≥ 1% of the span
   Video (or Average) Bandwidth (VBW) ≥ RBW
   Sweep = auto
   Detector function = peak
   Trace = max hold
5. Measure the separation between the peaks of the adjacent channels using the marker-delta function.
6. Repeat above procedures until all frequencies measured were complete.

## 5.3.3 Test Results: PASS

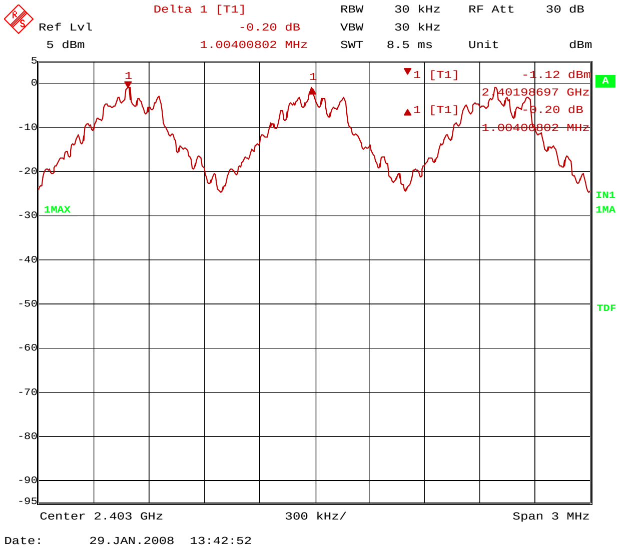
**Table 2: Measured values of the Carrier Frequency Separation**

| Operating frequency | Carrier frequency separation | Limit |
|---|---|---|
| 2402 MHz | 1004 kHz | ≥ 25 kHz or 20 dB bandwidth |
| 2441 MHz | 1004 kHz | ≥ 25 kHz or 20 dB bandwidth |
| 2480 MHz | 1004 kHz | ≥ 25 kHz or 20 dB bandwidth |

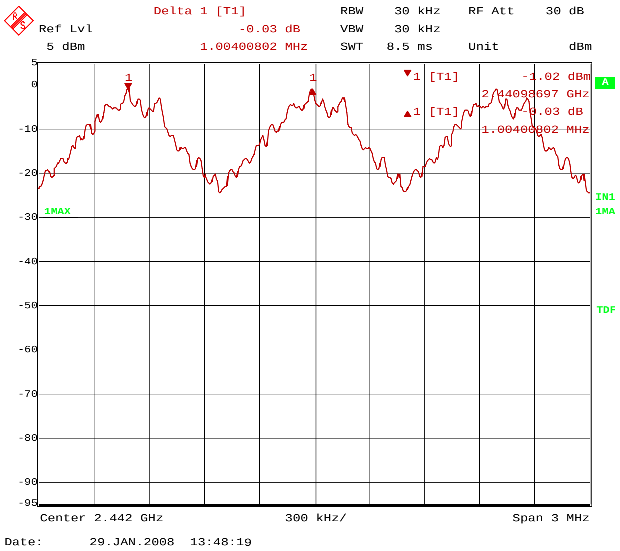
NOTE: We took the insertion loss of the cable loss into consideration within the measuring instrument.

## Figure 2. Plot of the Carrier Frequency Separation

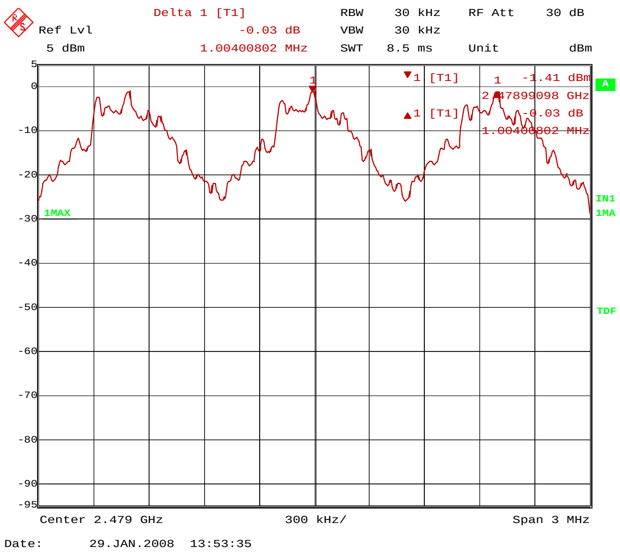
Lowest Channel
(2402 MHz)




Middle Channel
(2441 MHz)




Highest Channel
(2480 MHz)



# 5.4 20 dB CHANNEL BANDWIDTH

## 5.4.1 Regulation

According to §15.247(a)(1), frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, frequency hopping systems operating in the 2400-2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW.

## 5.4.2 Test Procedure

1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Connect the antenna port of the EUT to RF input on the spectrum analyzer via a low loss cable and attenuator.
3. Turn on the EUT and set it to any one measured frequency within its operating range by controlling it via SPI interface and make sure the spectrum analyzer is operated in its linear range.
4. Set the spectrum analyzer as follows:
   Span = approximately 2 to 3 times the 20 dB bandwidth, centered on a hopping channel
   RBW ≥ 1% of the 20 dB bandwidth
   VBW ≥ RBW
   Sweep = auto
   Detector function = peak
   Trace = max hold
5. Set a reference level on it equal to the highest peak value.
6. Measure the frequency difference of two frequencies that were attenuated 20dB from the reference level. Record the frequency difference as the emission bandwidth.
7. Repeat above procedures until all frequencies measured were complete.

## 5.4.3 Test Results: PASS

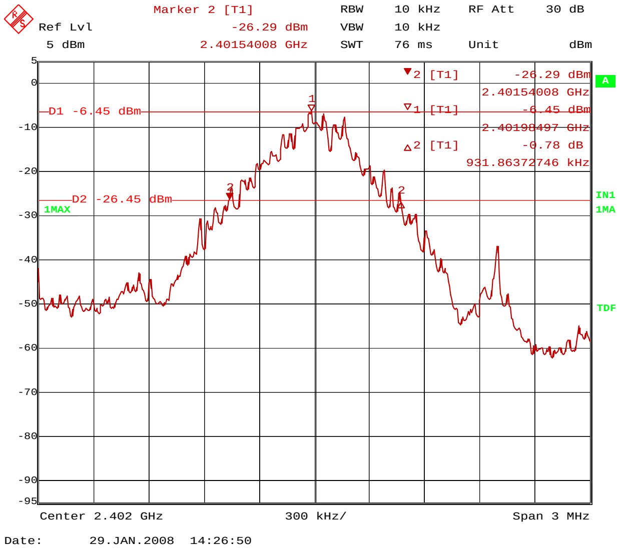
**Table 3: Measured values of the 20dB Channel Bandwidth**

| Operating frequency | 20dB Channel bandwidth | Limit | Carrier frequency separation |
|---|---|---|---|
| 2402 MHz | 932 kHz | < Carrier frequency separation | 1004 kHz |
| 2441 MHz | 938 kHz | < Carrier frequency separation | 1004 kHz |
| 2480 MHz | 932 kHz | < Carrier frequency separation | 1004 kHz |

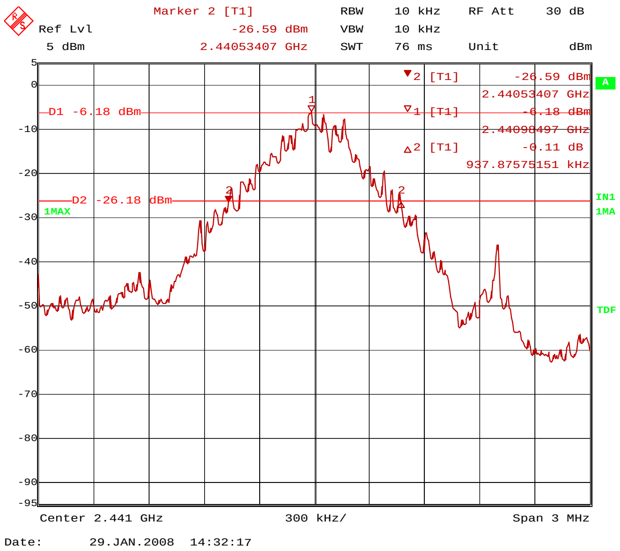
NOTE: We took the insertion loss of the cable loss into consideration within the measuring instrument.

## Figure 3. Plot of the 20dB Channel Bandwidth

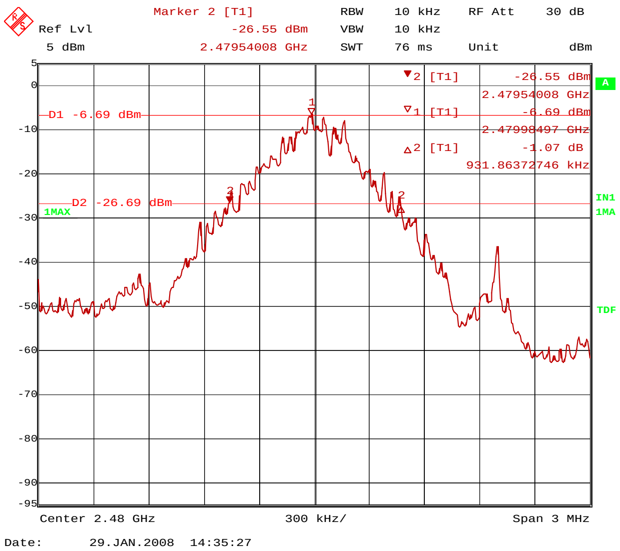
Lowest Channel
(2402 MHz)




Middle Channel
(2441 MHz)




Highest Channel
(2480 MHz)



# 5.5 NUMBER OF HOPPING CHANNELS

## 5.5.1 Regulation

According to §15.247(a)(1)(iii), frequency hopping systems in the 2400-2483.5 MHz band shall use at least 15 channels. The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed. Frequency hopping systems may avoid or suppress transmissions on a particular hopping frequency provided that a minimum of 15 channels are used.

According to §15.247(b)(1), for frequency hopping systems operating in the 2400-2483.5 MHz band employing at least 75 non-overlapping hopping channels, and all frequency hopping systems in the 5725-5850 MHz band: 1 watt. For all other frequency hopping systems in the 2400-2483.5 MHz band: 0.125 watts.

## 5.5.2 Test Procedure

1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Connect the antenna port of the EUT to RF input on the spectrum analyzer via a low loss cable and attenuator.
3. Turn on the EUT and set the hopping function enabled by controlling it via SPI interface.
4. Set the spectrum analyzer as follows:
   Span = the frequency band of operation
   RBW ≥ 1% of the span
   VBW ≥ RBW
   Sweep = auto
   Detector function = peak
   Trace = max hold
5. Record the number of hopping channels.

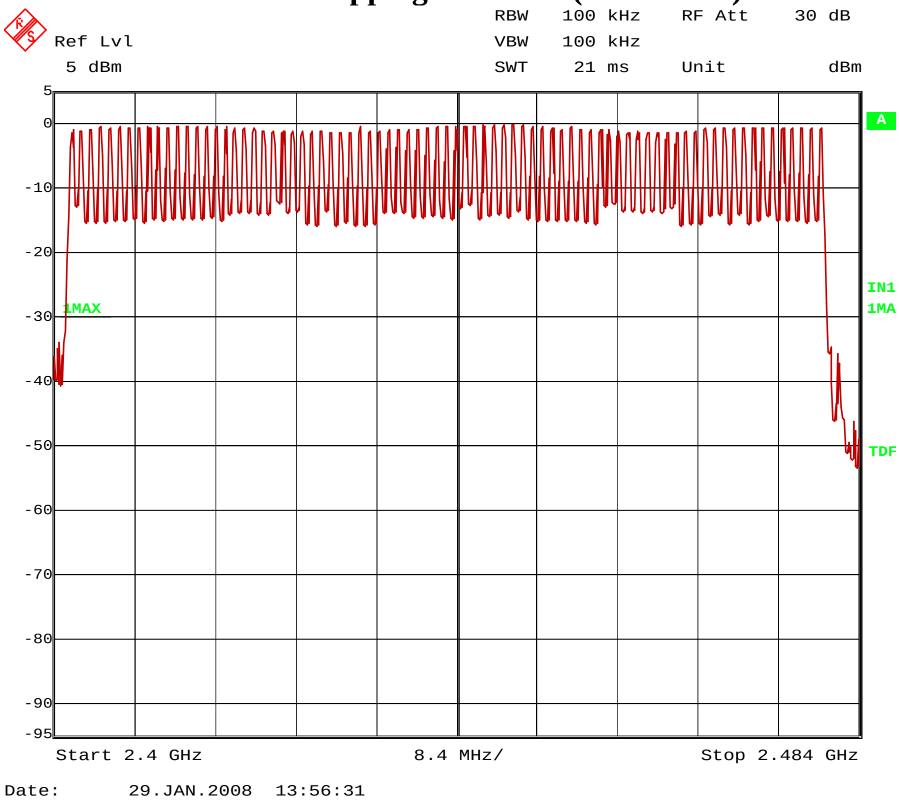
## 5.5.3 Test Results: PASS

**Table 4: Measured values of the Number of Hopping Channels**

| Operating frequency | Number of hopping channels | Limit |
|---|---|---|
| 2402 - 2480 MHz | 79 | ≥ 15 |

NOTE: We took the insertion loss of the attenuator and cable loss into consideration within the measuring instrument.

## Figure 4. Plot of the Number of Hopping Channels (Conducted)



## 5.6 TIME OF OCCUPANCY (DWELL TIME)

### 5.6.1 Regulation

According to §15.247(a)(1)(iii), frequency hopping systems in the 2400-2483.5 MHz band shall use at least 15 channels. The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed. Frequency hopping systems may avoid or suppress transmissions on a particular hopping frequency provided that a minimum of 15 channels are used.

### 5.6.2 Test Procedure

1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Connect the antenna port of the EUT to RF input on the spectrum analyzer via a low loss cable.
3. Turn on the EUT and set it to any one measured frequency within its operating range by controlling it via SPI interface.
4. Set the spectrum analyzer as follows:
   Span = zero span, centered on a hopping channel
   RBW = 1 MHz
   VBW ≥ RBW
   Sweep = as necessary to capture the entire dwell time per hopping channel
   Detector function = peak
   Trace = max hold
5. Measure the dwell time using the marker-delta function.
6. Repeat above procedures until all frequencies measured were complete.
7. Repeat this test for different modes of operation (e.g., data rate, modulation format, etc.), if applicable.

### 5.6.3 Test Results: PASS

**Table 5: Measured values of the Time of Occupancy**

| Operating frequency | Reading | Hopping rate | Number of Channels | Actual | Limit |
|---|---|---|---|---|---|
| 2402 MHz | 2.91 ms | 266.667 hops/s | 79 | 0.31 seconds | 0.4 seconds |
| 2441 MHz | 2.91 ms | 266.667 hops/s | 79 | 0.31 seconds | 0.4 seconds |
| 2480 MHz | 2.91 ms | 266.667 hops/s | 79 | 0.31 seconds | 0.4 seconds |

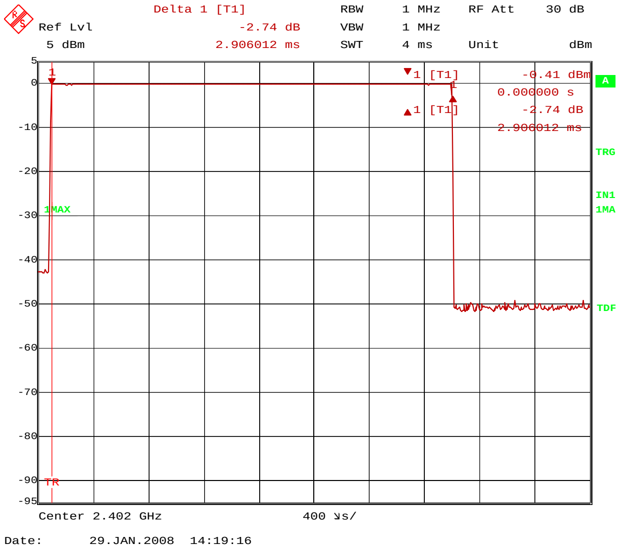
**Actual = Reading × (Hopping rate / Number of channels) × Test period**
**Test period = 0.4 [seconds / channel] × 79 [channel] = 31.6 [seconds]**

NOTE:

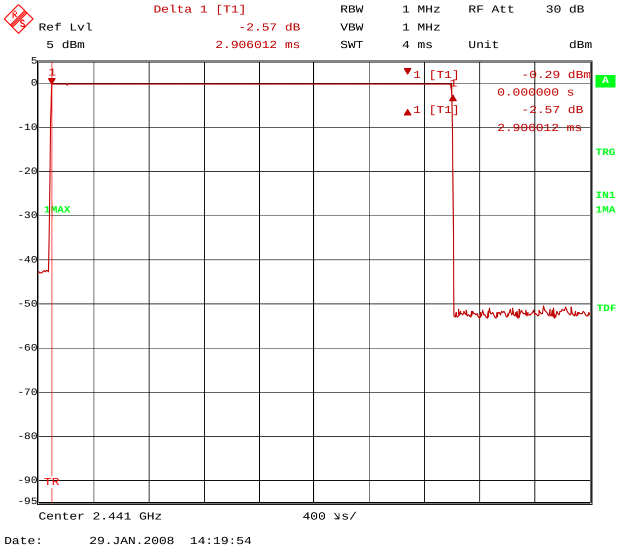
1. The EUT makes worst case 1600 hops per second or 1 time slot has a length of 625µs with 79 channels. A DH5 Packet needs 5 time slot for transmitting and 1 time slot for receiving. Then the EUT makes worst case 266.667 hops per second with 79 channels.
2. We took the insertion loss of the cable loss into consideration within the measuring instrument.

## Figure 5. Plot of the Time of Occupancy (Conducted)

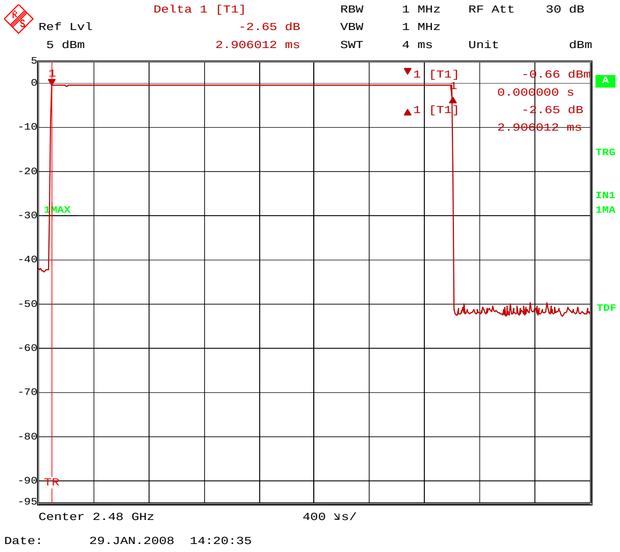
Lowest Channel
(2402 MHz)




Middle Channel
(2441 MHz)




Highest Channel
(2480 MHz)



## 5.7 SPURIOUS EMISSIONS, BAND EDGE, AND RESTRICTED BANDS

### 5.7.1 Regulation

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

According to §15.209(a), for an intentional device, the general requirement of field strength of radiated emissions from intentional radiators at a distance of 3 meters shall not exceed the following values:

| Frequency (MHz) | Field strength (µV/m @ 3m) | Field strength (dBµV/m @ 3m) |
|---|---|---|
| 30–88 | 100 | 40.0 |
| 88–216 | 150 | 43.5 |
| 216–960 | 200 | 46.0 |
| Above 960 | 500 | 54.0 |

According to §15.109(a), for an unintentional device, except for Class A digital devices, the field strength of radiated emissions from unintentional radiators at a distance of 3 meters shall not exceed the above table.

** The emission limits shown in the above table are based on measurement instrumentation employing a CISPR quasi-peak detector and above 1000 MHz are based on the average value of measured emissions.

### 5.7.2 Test Procedure

1) Band-edge Compliance of RF Conducted Emissions

1. Set the spectrum analyzer as follows:
   Span = wide enough to capture the peak level of the emission operating on the channel closest to the bandedge, as well as any modulation products which fall outside of the authorized band of operation
   RBW ≥ 1% of the span
   VBW ≥ RBW
   Sweep = auto
   Detector function = peak
   Trace = max hold
2. Allow the trace to stabilize. Set the marker on the emission at the band-edge, or on the highest modulation product outside of the band, if this level is greater than that at the band-edge. Enable the marker-delta function, and then use the marker-to-peak function to move the marker to the peak of the in-band emission.
3. Now, using the same instrument settings, enable the hopping function of the EUT. Allow the trace to stabilize. Follow the same procedure listed above to determine if any spurious emissions caused by the hopping function also comply with the specified limit.

2) Spurious RF Conducted Emissions:

1. Set the spectrum analyzer as follows:
   Span = wide enough to capture the peak level of the in-band emission and all spurious emissions (e.g., harmonics) from the lowest frequency generated in the EUT up through the 10th harmonic. Typically, several plots are required to cover this entire span.
   RBW = 100 kHz
   VBW ≥ RBW
   Sweep = auto
   Detector function = peak
   Trace = max hold
2. Allow the trace to stabilize. Set the marker on the peak of any spurious emission recorded.

3) Spurious Radiated Emissions:

1. The preliminary radiated measurements were performed to determine the frequency producing the maximum emissions in an anechoic chamber at a distance of 3 meters.
2. The EUT was placed on the top of the 0.8-meter height, 1 × 1.5 meter non-metallic table. To find the maximum emission levels, the height of a measuring antenna was changed and the turntable was rotated 360˚.
3. The antenna polarization was also changed from vertical to horizontal. The spectrum was scanned from 30 to 1000 MHz using the TRILOG broadband antenna, and from 1000 MHz to 18000 MHz using the horn antenna.
4. To obtain the final measurement data, the EUT was arranged on a turntable situated on a 4 × 4 meter at the Open Area Test Site. The EUT was tested at a distance 3 meters.
5. Each frequency found during preliminary measurements was re-examined and investigated. The test-receiver system was set up to average, peak, and quasi-peak detector function with specified bandwidth.

6. The EUT is situated in three orthogonal planes (if appropriate)
7. The presence of ambient signals was verified by turning the EUT off. In case an ambient signal was detected, the measurement bandwidth was reduced temporarily and verification was made that an additional adjacent peak did not exist. This ensures that the ambient signal does not hide any emissions from the EUT.
8. If the emission on which a radiated measurement must be made is located at the edge of the authorized band of operation, then the alternative “marker-delta” method may be employed.

4) Marker-Delta Method at the edge of the authorized band of operation:

1. Perform an in-band field strength measurement of the fundamental emission using the RBW and detector function as the above Spurious Radiated Emissions test procedure.
2. Choose a spectrum analyzer span that encompasses both the peak of the fundamental emission and the band-edge emission under investigation. Set the analyzer RBW to 1% of the total span (but never less than 30 kHz) with a video bandwidth equal to or greater than the RBW. Record the peak levels of the fundamental emission and the relevant band-edge emission (i.e., run several sweeps in peak hold mode). Observe the stored trace and measure the amplitude delta between the peak of the fundamental and the peak of the band-edge emission. This is not a field strength measurement; it is only a relative measurement to determine the amount by which the emission drops at the band-edge relative to the highest fundamental emission level.
3. Subtract the delta measured in step (2) from the field strengths measured in step (1). The resultant field strengths (CISPR QP, average, or peak, as appropriate) are then used to determine band-edge compliance as required by Section 15.205.
4. The above "delta" measurement technique may be used for measuring emissions that are up to two "standard" bandwidths away from the band-edge, where a "standard" bandwidth is the bandwidth specified by C63.4 for the frequency being measured. For example, for band-edge measurements in the restricted band that begins at 2483.5 MHz, C63.4 specifies a measurement bandwidth of at least 1 MHz. Therefore you may use the "delta" technique for measuring emissions up to 2 MHz removed from the band-edge. Radiated emissions that are removed by more than two “standard” bandwidths must be measured as the above Spurious Radiated Emissions test procedure.

### 5.7.3 Test Results: PASS

Band-edge compliance of RF conducted/radiated emissions was shown in the Figure 6 and 7.
Spurious RF conducted emissions were shown in the Figure 8.

NOTE: We took the insertion loss of the cable loss into consideration within the measuring instrument.

**Table 6: Measured values of the Field strength of spurious emission (Radiated)**

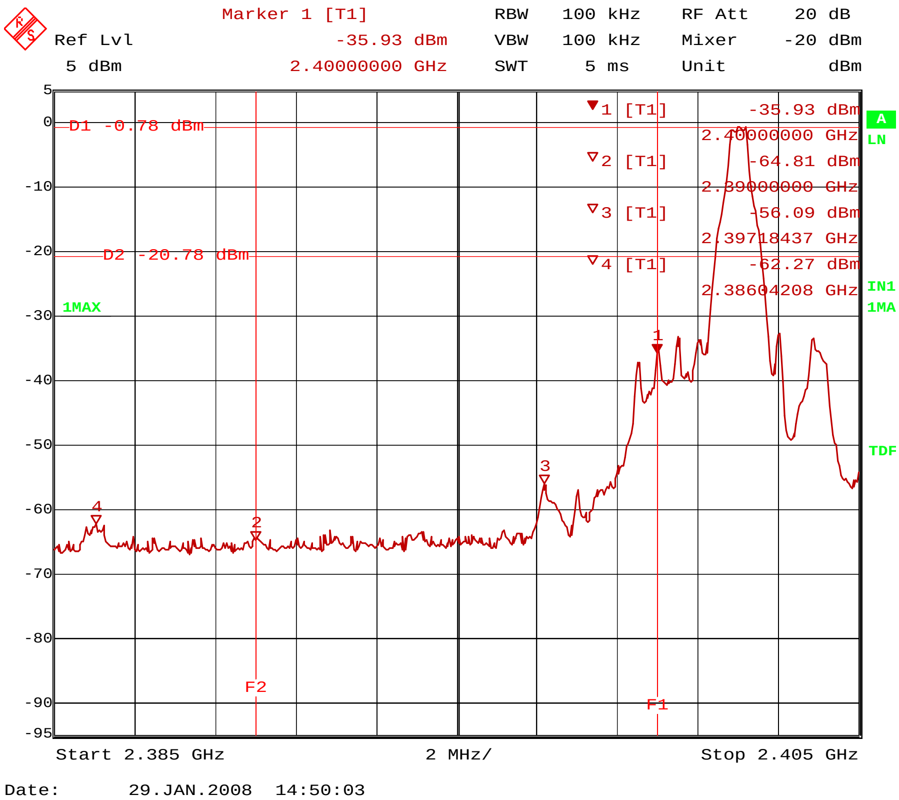
| Frequency [MHz] | Receiver Bandwidth [kHz] | Pol. [V/H] | Antenna Height [m] | Turn Table [degree] | Reading [dB(μV)] | Amp Gain [dB] | ATT [dB] | AF [dB(1/m)] | CL [dB] | Actual [dB(μV/m)] | Limit [dB(μV/m)] | Margin [dB] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Quasi-peak data, emissions below 1000 MHz** | | | | | | | | | | | | |
| | | | No Spurious Radiated Emissions Found | | | | | | | | | |
| **AVERAGE data, emissions above 1000 MHz** | | | | | | | | | | | | |
| 2402.0 | 1000 | V | 1.11 | 343 | 93.95 | 43.7 | 10.1 | 28.3 | 4.9 | 93.6 | - | - |
| 1602.0 | 1000 | V | 1.00 | 123 | 52.62 | 43.3 | 0.0 | 25.9 | 4.0 | 39.2 | 54.0 | 14.8 |
| 3204.0* | 1000 | --- | --- | --- | --- | 44.2 | 1.4 | 30.5 | 5.8 | --- | 54.0 | --- |
| 4804.0 | 1000 | V | 1.55 | 220 | 45.24 | 44.6 | 0.8 | 32.6 | 7.2 | 41.2 | 54.0 | 12.8 |
| | | | | | | | | | | | | |
| 2441.0 | 1000 | V | 1.10 | 346 | 94.07 | 43.7 | 10.1 | 28.3 | 4.9 | 93.7 | - | - |
| 1628.0* | 1000 | V | 1.03 | 315 | 50.52 | 43.3 | 0.0 | 25.9 | 4.0 | 37.1 | 54.0 | 16.9 |
| 3256.0 | 1000 | --- | --- | --- | --- | 44.2 | 1.4 | 30.5 | 5.8 | --- | 54.0 | --- |
| 4882.0 | 1000 | V | 1.31 | 181 | 44.13 | 44.6 | 0.8 | 32.8 | 7.3 | 40.1 | 54.0 | 13.9 |
| | | | | | | | | | | | | |
| 2480.0 | 1000 | V | 1.11 | 343 | 93.91 | 43.8 | 10.1 | 28.6 | 5.0 | 93.8 | - | - |
| 1654.0* | 1000 | V | 1.12 | 42 | 51.05 | 43.3 | 0.0 | 26.2 | 4.1 | 38.1 | 54.0 | 16.0 |
| 3308.0* | 1000 | --- | --- | --- | --- | 44.2 | 1.4 | 30.5 | 5.8 | --- | 54.0 | --- |
| 4960.0 | 1000 | V | 1.57 | 194 | 44.82 | 44.6 | 0.8 | 32.5 | 7.3 | 40.8 | 54.0 | 13.2 |
| | | | | | | | | | | | | |
| **PEAK data, emissions above 1000 MHz** | | | | | | | | | | | | |
| 2402.0 | 1000 | V | 1.11 | 343 | 96.74 | 43.7 | 10.1 | 28.3 | 4.9 | 96.3 | - | - |
| 1602.0 | 1000 | V | 1.00 | 123 | 59.99 | 43.3 | 0.0 | 25.9 | 4.0 | 46.6 | 74.0 | 27.4 |
| 3204.0* | 1000 | --- | --- | --- | --- | 44.2 | 1.4 | 30.5 | 5.8 | --- | 74.0 | --- |
| 4804.0 | 1000 | V | 1.55 | 220 | 53.50 | 44.6 | 0.8 | 32.6 | 7.2 | 49.5 | 74.0 | 24.5 |
| | | | | | | | | | | | | |
| 2441.0 | 1000 | V | 1.10 | 346 | 97.04 | 43.7 | 10.1 | 28.3 | 4.9 | 96.6 | - | - |
| 1628.0* | 1000 | V | 1.03 | 315 | 56.59 | 43.3 | 0.0 | 25.9 | 4.0 | 43.2 | 74.0 | 30.8 |
| 3256.0 | 1000 | --- | --- | --- | --- | 44.2 | 1.4 | 30.5 | 5.8 | --- | 74.0 | --- |
| 4882.0 | 1000 | V | 1.31 | 181 | 52.30 | 44.6 | 0.8 | 32.5 | 7.3 | 48.3 | 74.0 | 25.7 |
| | | | | | | | | | | | | |
| 2480.0 | 1000 | V | 1.11 | 343 | 96.74 | 43.8 | 10.1 | 28.6 | 5.0 | 96.6 | - | - |
| 1654.0* | 1000 | V | 1.12 | 42 | 59.84 | 43.3 | 0.0 | 26.2 | 4.1 | 46.8 | 74.0 | 27.2 |
| 3308.0* | 1000 | --- | --- | --- | --- | 44.2 | 1.4 | 30.5 | 5.8 | --- | 74.0 | --- |
| 4960.0 | 1000 | V | 1.56 | 236 | 53.50 | 44.6 | 0.8 | 32.5 | 7.3 | 49.5 | 74.0 | 24.5 |
| | | | | | | | | | | | | |

**Margin (dB) = Limit – Actual**
**[Actual = Reading – Amp Gain + Attenuator + AF + CL]**
1. H = Horizontal, V = Vertical Polarization
2. ATT = Attenuation (10dB pad and/or Insertion Loss of HPF), AF/CL = Antenna Factor and Cable Loss
* The spurious emission at the frequency does not fall in the restricted bands.
Remark "---" means the emission level was too low to be measured or in the noise floor.

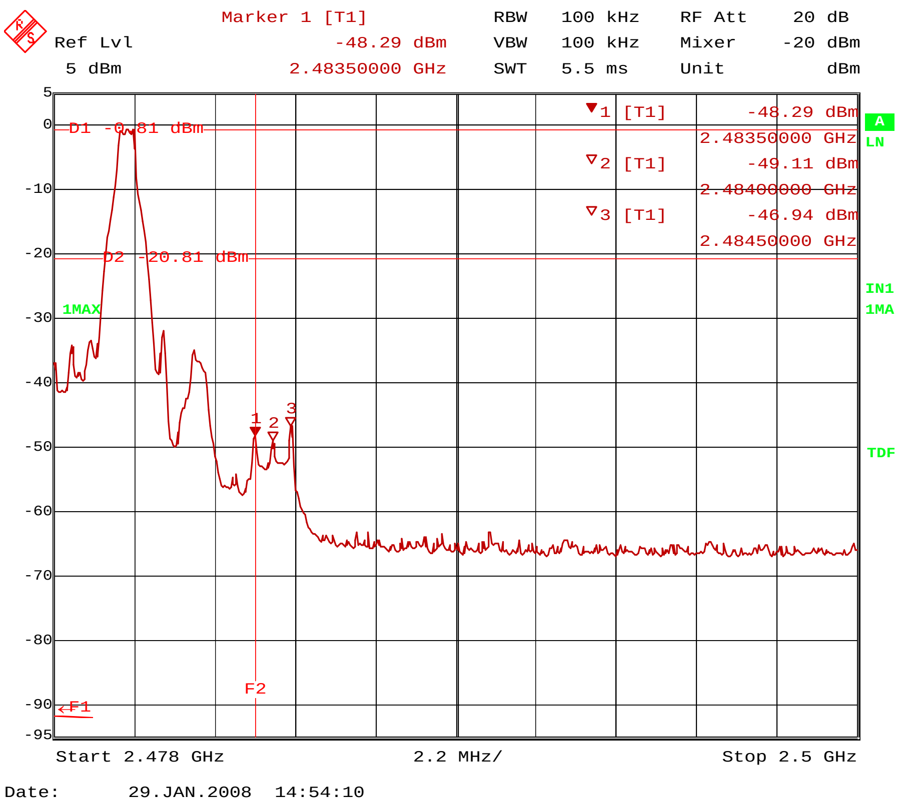
NOTE: All emissions not reported were more than 20 dB below the specified limit or in the noise floor.

## Figure 6. Plot of the Band Edge (Conducted)

Lower band-edge
Hopping disenabled

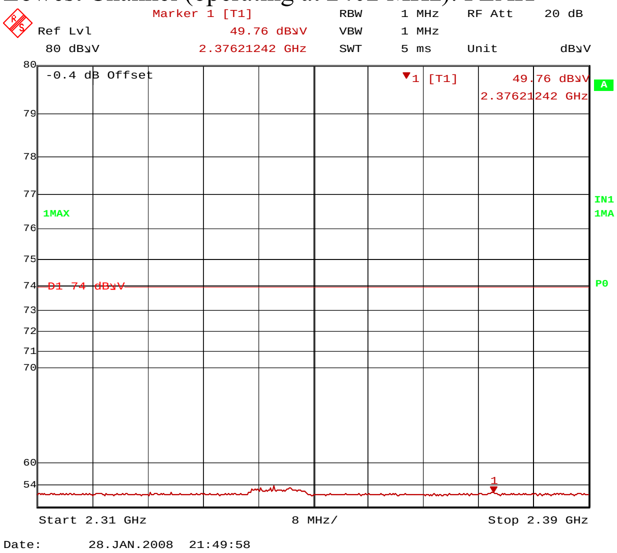



Upper band-edge
Hopping disenabled

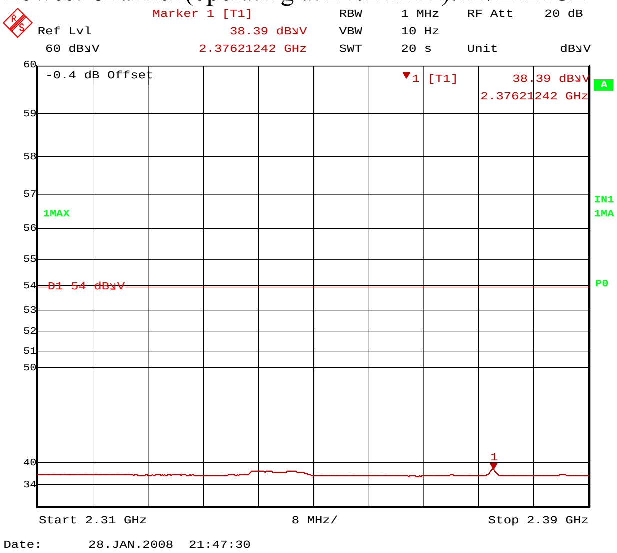


## Figure 7. Plot of the Band Edge (Radiated)

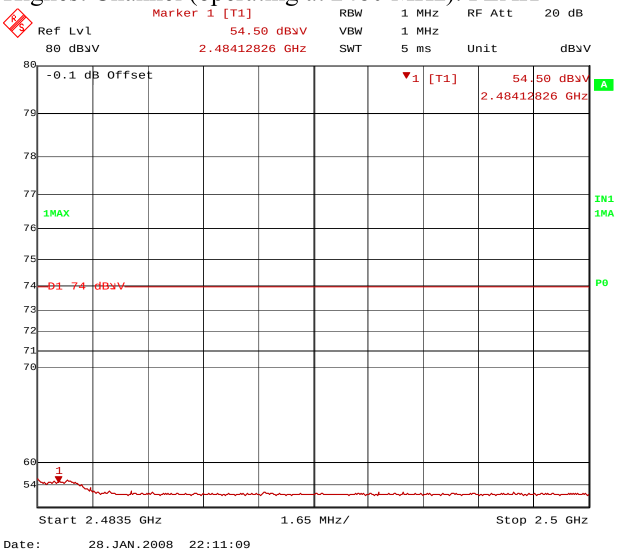
Lowest Channel (operating at 2402 MHz): PEAK



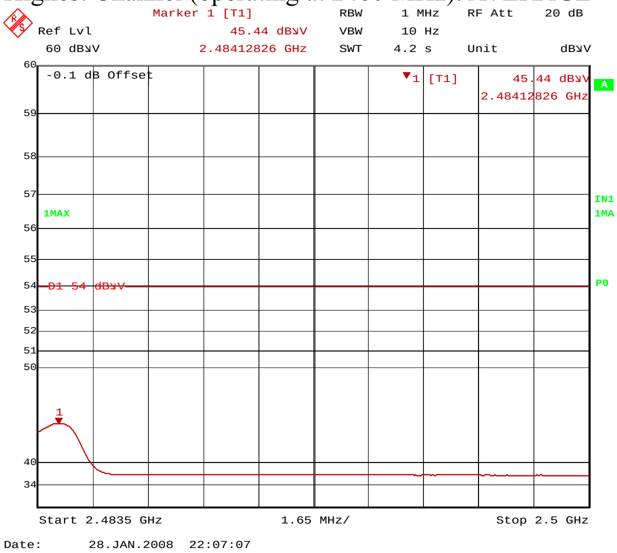

Lowest Channel (operating at 2402 MHz): AVERAGE




Highest Channel (operating at 2480 MHz): PEAK

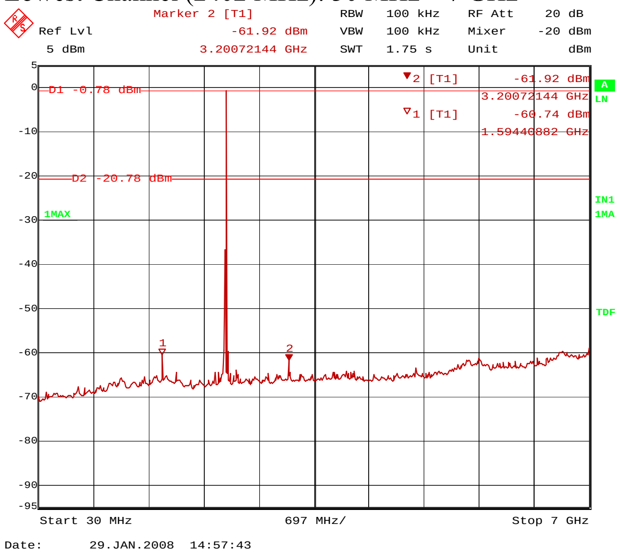



Highest Channel (operating at 2480 MHz): AVERAGE

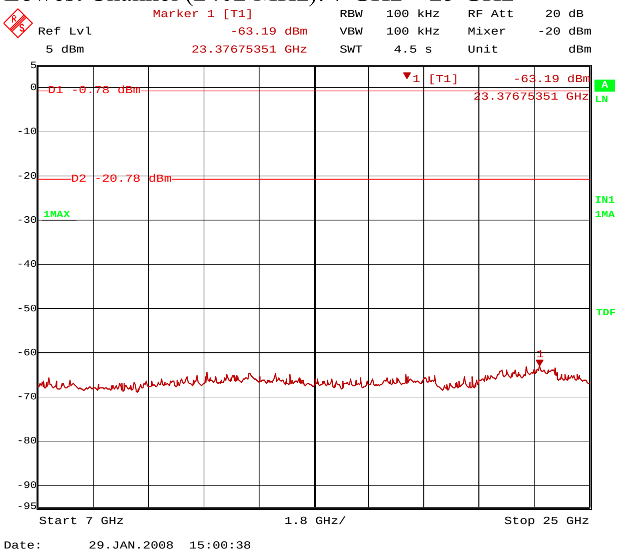


## Figure 8: Spurious RF conducted emissions

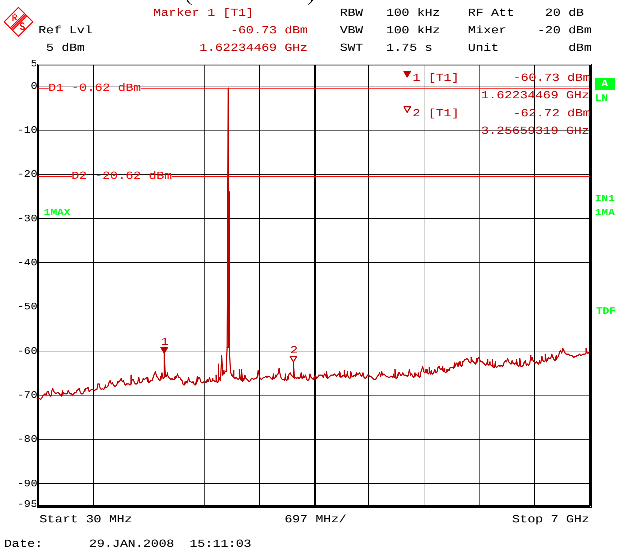
Lowest Channel (2402 MHz): 30 MHz ~ 7 GHz



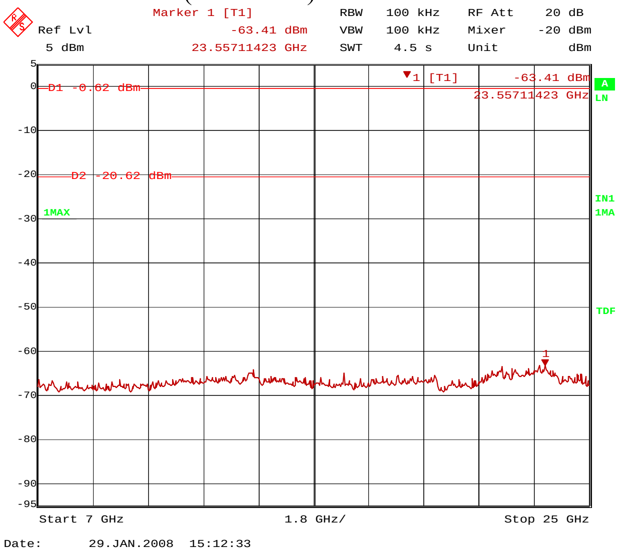

Lowest Channel (2402 MHz): 7 GHz ~ 25 GHz



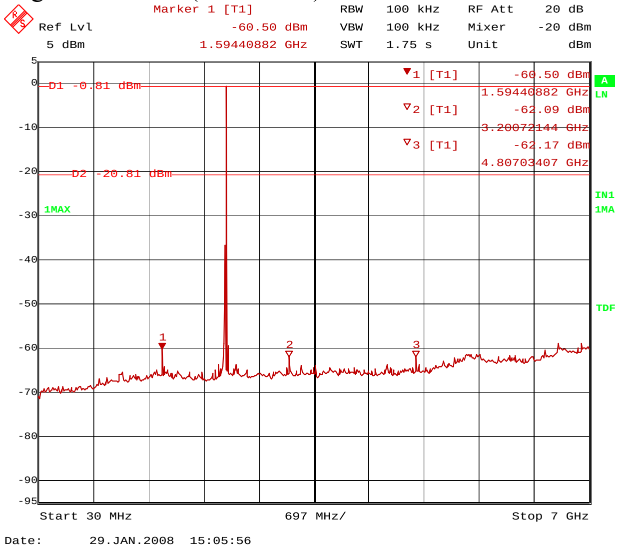

Middle Channel (2441 MHz): 30 MHz ~ 7 GHz



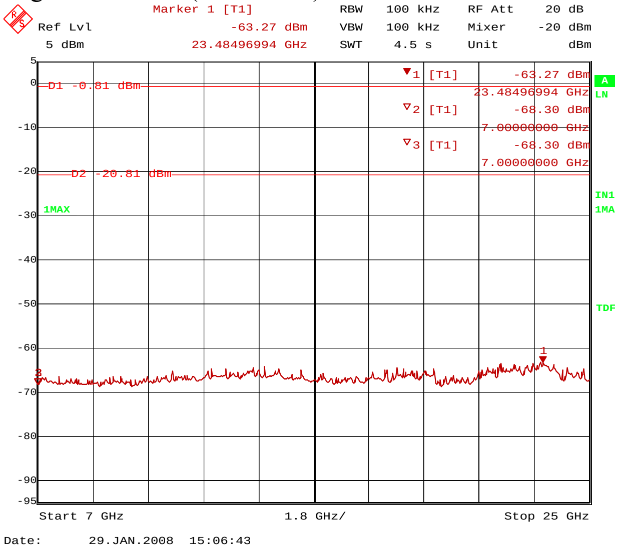

Middle Channel (2441 MHz): 7 GHz ~ 25 GHz




Highest Channel (2480 MHz): 30 MHz ~ 7 GHz




Highest Channel (2480 MHz): 7 GHz ~ 25 GHz



# 5.8 PEAK POWER SPECTRAL DENSITY

## 5.8.1 Regulation

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 dBm in any 3 kHz 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.

## 5.8.2 Test Procedure

1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Connect the antenna port of the EUT to RF input on the spectrum analyzer via a low loss cable and attenuator.
3. Turn on the EUT and set it to any one measured frequency within its operating range by controlling it via SPI interface and make sure the spectrum analyzer is operated in its linear range.
4. Set the spectrum analyzer to MAX HOLD mode with RBW = 3kHz.
5. Measure the highest amplitude appearing on spectral display and record the level to calculate results.
6. Repeat above procedures until all frequencies measured were complete.

## 5.8.3 Test Results: PASS

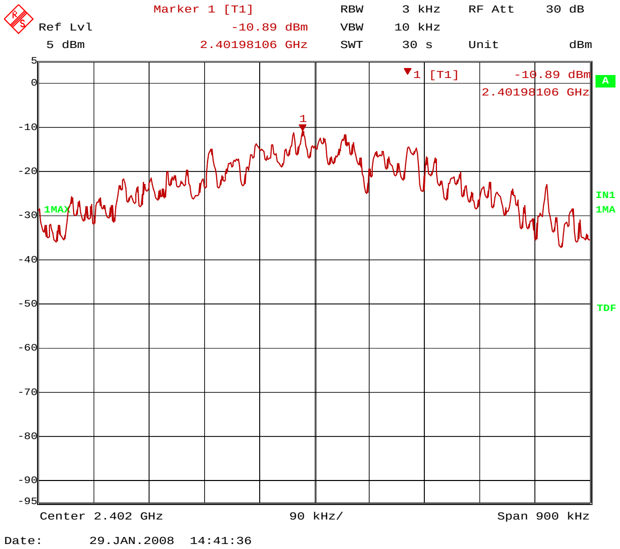
**Table 7: Measured values of the Peak Power Spectral Density**

| Operating frequency | Actual | Limit |
|---|---|---|
| 2402 MHz | -10.89 dBm | 8.0 dBm |
| 2441 MHz | -10.72 dBm | 8.0 dBm |
| 2480 MHz | -11.23 dBm | 8.0 dBm |

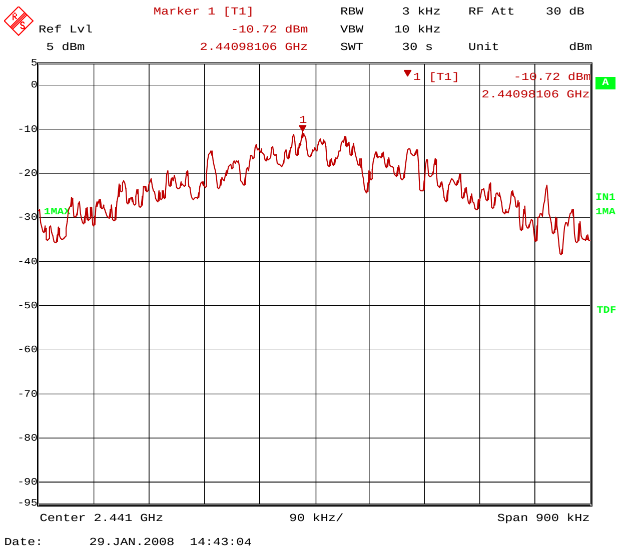
NOTE: We took the insertion loss of the cable loss into consideration within the measuring instrument.

## Figure 9. Plot of the Peak Power Spectral Density

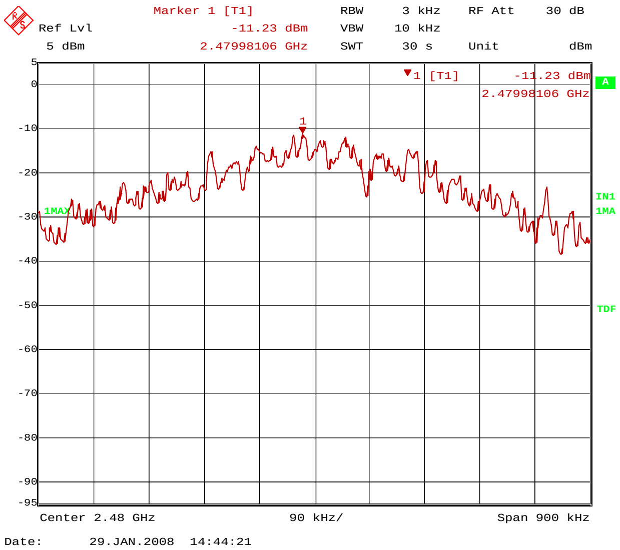
Lowest Channel
(2402 MHz)




Middle Channel
(2441 MHz)




Highest Channel
(2480 MHz)



# 5.9 AC POWER LINE CONDUCTED EMISSIONS

## 5.9.1 Regulation

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 kHz to 30 MHz, shall not exceed the limits in the following table, as measured using a 50μH/50Ω line impedance stabilization network (LISN). Compliance with the provisions 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 (MHz) | Conducted limit (dBμV) | |
|---|---|---|
| | Qausi-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.

According to §15.107(a), for unintentional device, except for Class A digital devices, line conducted emission limits are the same as the above table.

## 5.9.2 Test Procedure

1. The EUT was placed on a wooden table of size, 1 m by 1.5 m, raised 80 cm in which is located 40 cm away from the vertical wall and 1.5m away from the side wall of the shielded room.
2. Each current-carrying conductor of the EUT power cord was individually connected through a 50Ω/50μH LISN, which is an input transducer to a Spectrum Analyzer or an EMI/Field Intensity Meter, to the input power source.
3. Exploratory measurements were made to identify the frequency of the emission that had the highest amplitude relative to the limit by operating the EUT in a range of typical modes of operation, cable position, and with a typical system equipment configuration and arrangement. Based on the exploratory tests of the EUT, the one EUT cable configuration and arrangement and mode of operation that had produced the emission with the highest amplitude relative to the limit was selected for the final measurement.
4. The final test on all current-carrying conductors of all of the power cords to the equipment that comprises the EUT (but not the cords associated with other non-EUT equipment is the system) was then performed over the frequency range of 0.15 MHz to 30 MHz.
5. The measurements were made with the detector set to PEAK amplitude within a bandwidth of 10 kHz or to QUASI-PEAK and AVERAGE within a bandwidth of 9 kHz. The EUT was in transmitting mode during the measurements.

### 5.9.3 Test Results: PASS

**Table 8: Measured values of the AC Power Line Conducted Emissions**

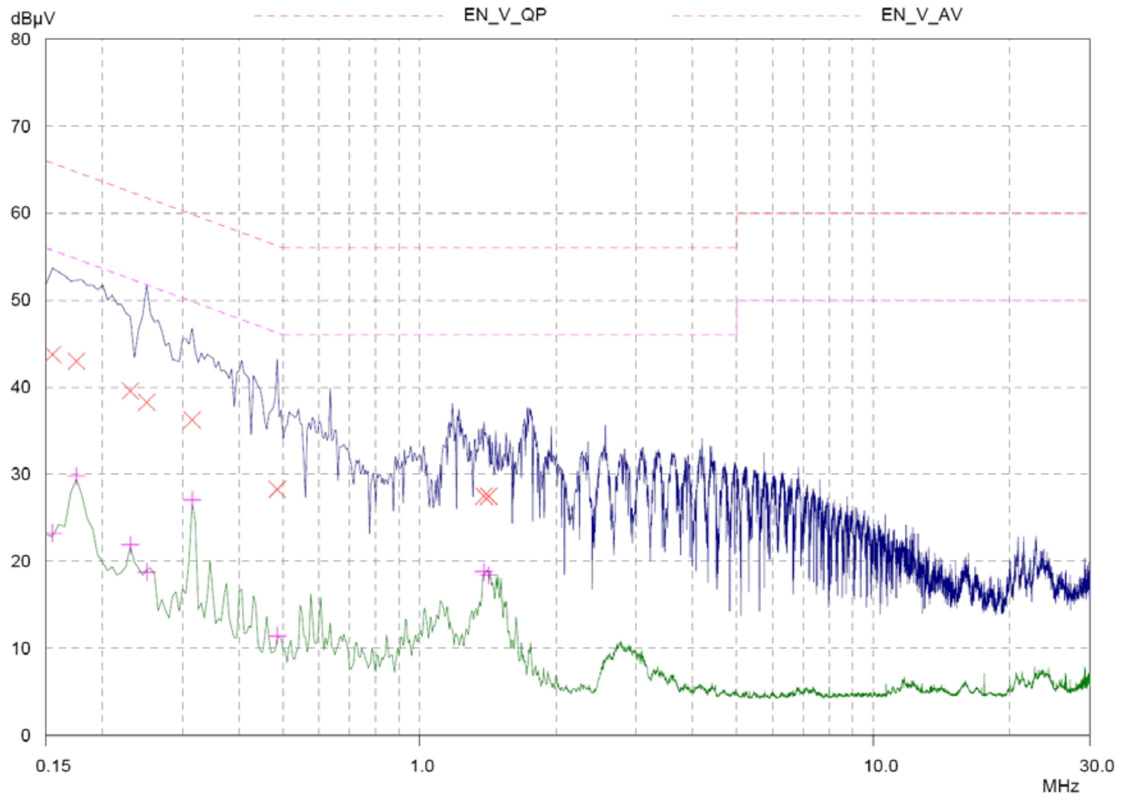
| Frequency [MHz] | Reading [dBμV] | L / N | CF [dB] | CL [dB] | Actual [dBμV] | Limit [dBμV] | Margin [dB] |
|---|---|---|---|---|---|---|---|
| **QUASI-PEAK DATA** | | | | | | | |
| 0.150 | 44.45 | N | 0.06 | 0.01 | 44.52 | 66.00 | 21.48 |
| 0.155 | 43.74 | L | 0.06 | 0.01 | 43.81 | 65.73 | 21.92 |
| 0.175 | 42.95 | L | 0.06 | 0.01 | 43.02 | 64.72 | 21.70 |
| 0.230 | 39.55 | L | 0.12 | 0.02 | 39.69 | 62.45 | 22.76 |
| 0.250 | 38.25 | L | 0.12 | 0.02 | 38.39 | 61.76 | 23.37 |
| 0.315 | 36.22 | L | 0.12 | 0.02 | 36.36 | 59.84 | 23.48 |
| 1.385 | 27.47 | L | 0.14 | 0.07 | 27.68 | 56.00 | 28.32 |
| 1.420 | 27.45 | L | 0.14 | 0.07 | 27.66 | 56.00 | 28.34 |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| **AVERAGE DATA** | | | | | | | |
| 0.150 | 20.60 | N | 0.05 | 0.01 | 20.66 | 56.00 | 35.34 |
| 0.155 | 23.21 | L | 0.05 | 0.01 | 23.27 | 55.73 | 32.46 |
| 0.175 | 29.76 | L | 0.05 | 0.01 | 29.82 | 54.72 | 24.90 |
| 0.230 | 21.88 | L | 0.14 | 0.02 | 22.04 | 52.45 | 30.41 |
| 0.250 | 18.77 | L | 0.14 | 0.02 | 18.93 | 51.76 | 32.83 |
| 0.315 | 27.02 | L | 0.14 | 0.02 | 27.18 | 49.84 | 22.66 |
| 1.385 | 18.83 | L | 0.14 | 0.07 | 19.04 | 46.00 | 26.96 |
| 1.420 | 18.36 | L | 0.14 | 0.07 | 18.57 | 46.00 | 27.43 |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |

**Margin (dB) = Limit – Actual**
**[Actual = Reading + CF + CL]**
L/N = LINE / NEUTRAL
CF/CL = Correction Factor and Cable Loss

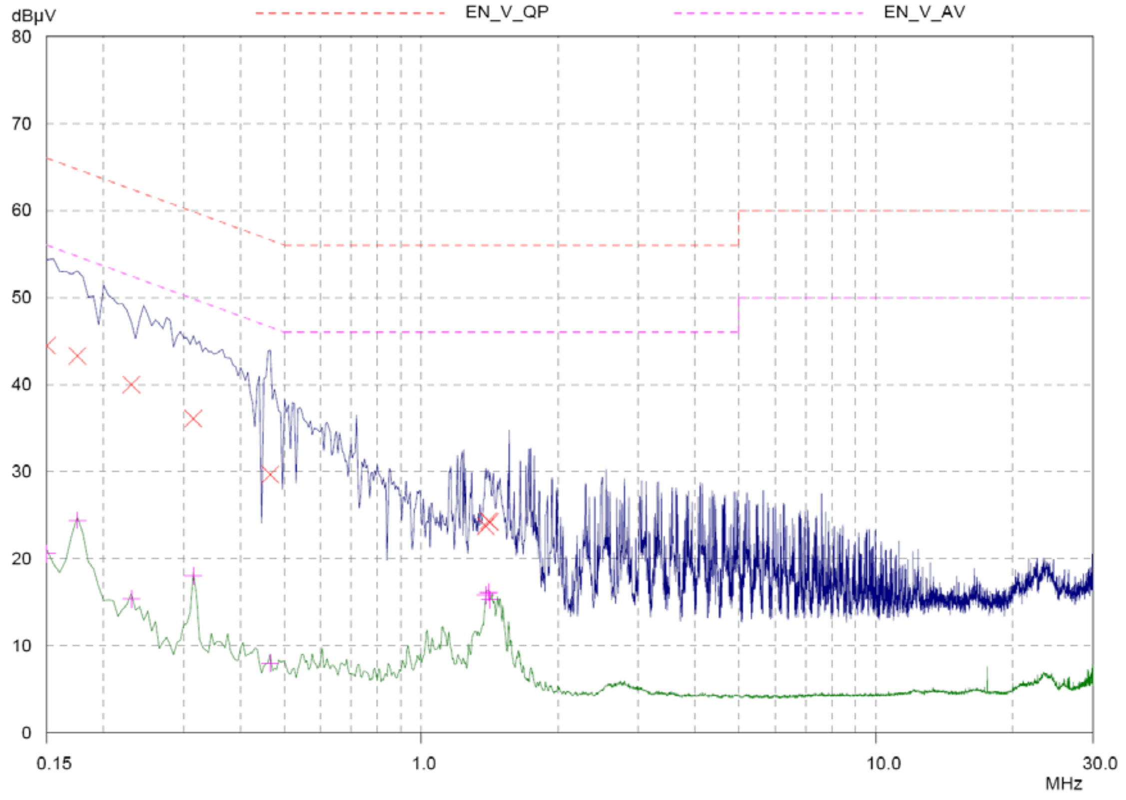
NOTE: The frequency range was scanned from 150 kHz to 30 MHz. All emissions not reported were more than 20 dB below the specified limit.

# Figure 10. Plot of the AC Power Line Conducted Emissions

**Line – PE(Peak and Average detector used)**




**Neutral – PE(Peak and Average detector used)**



## 5.10 RF Exposure

### 5.10.1 Regulation

According to §15.247(i), systems operating under the provisions of this section shall be operated in a manner that ensures that the public is not exposed to radio frequency energy levels in excess of the Commission's guidelines. See § 1.1307(b)(1) of this Chapter.

Limits for Maximum Permissive Exposure: RF exposure is calculated.

| Frequency Range | Electric Field Strength [V/m] | Magnetic Field Strength [A/m] | Power Density [mW/cm$^2$] | Averaging Time [minute] |
|---|---|---|---|---|
| Limits for General Population/Uncontrolled Exposure | | | | |
| 0.3 ~ 1.34<br>1.34 ~ 30<br>30 ~ 300<br>300 ~ 1500<br>1500 ~ 15000 | 614<br>824/f<br>27.5<br>/<br>/ | 1.63<br>2.19/f<br>0.073<br>/<br>/ | *(100)<br>*(180/f$^2$)<br>0.2<br>f/1500<br>1.0 | 30<br>30<br>30<br>30<br>30 |

f = frequency in MHz, * = Plane-wave equivalent power density

**MPE (Maximum Permissive Exposure) Prediction**

Predication of MPE limit at a given distance: Equation from page 18 of OET Bulletin 65, Edition 97-01

$S = PG/4\pi R^2$

$\left(\Rightarrow R = \sqrt{PG/4\pi S}\right)$

S = power density [mW/cm$^2$]
P = power input to antenna [mW]
G = power gain of the antenna in the direction of interest relative to an isotropic radiator
R = distance to the center of radiation of the antenna [cm]

| EUT: Maximum peak output power =0.95 [mW](= -0.22 dBm) & Antenna gain =1.04 (= 0.19 [dBi]) | |
|---|---|
| 100 mW, at 20 cm from an antenna 6 [dBi] | S = PG/4πR² = 100 × 3.98 / (4 × π × 400)<br>= 0.0792 [mW/cm2] < 1.0 [mW/cm2] |
| 0.95 mW, at 20 cm from the antenna 0.19 [dBi] | S = PG/4πR² = 0.0002 [mW/cm2] < 1.0 [mW/cm2] |
| 0.95 mW, at 2.5 cm from the antenna 0.19 [dBi] | S = PG/4πR² = 0.0126 [mW/cm2] < 1.0 [mW/cm2] |

### 5.10.2 RF Exposure Compliance Issue

The EUT is categorically excluded from routine environmental because it operates at very low power level. The equipment is deemed to comply with the SAR or MPE limits without testing due to this very low power level. SAR data was not submitted because the output power of the EUT was below the low thresholds in the July 02 TCB Exclusion List: for portable transmitters,

Low threshold [($60/f_{GHZ} \approx 25$) mW, $d < 2.5$ cm, ($120/f_{GHZ} \approx 50$) mW, $d \geq 2.5$ cm], and

High threshold [($900/f_{GHZ} \approx 370$) mW, $d < 20$ cm], where $f_{GHz}$: 2.44, d: distance to a person's body