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# TEST REPORT

| | |
|---|---|
| **Report Number:** | **100659649LEX-001** |
| **Project Number:** | **G100659649** |
| **Report Issue Date:** | **4/26/2012** |
| **Product Name:** | **CAT Module** |
| **Model Number Tested:** | **265D1887G002** |
| **FCCID:** | **ZKJ-DSM04R01** |
| **ICID:** | **10229A-DSM04R01** |
| **FCC Standards:** | **Title 47 CFR Part 15 Subpart B and C** |
| **Industry Canada Standards:** | **RSS-210 Issue 8 & RSS-GEN Issue 3** |

Tested by:
Intertek Testing Services NA, Inc.
731 Enterprise Drive
Lexington, KY 40510

Client:
GE Appliance & Lighting
AP35-1403-02
Louisville, KY 40225

Report prepared by
Bryan Taylor, Team Leader

Report reviewed by
James Sudduth, Assistant Chief Engineer

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## 1 Introduction and Conclusion

The tests indicated in section 2 were performed on the product constructed as described in Section 3. The remaining test sections are the verbatim text from the actual data sheets used during the investigation. These test sections include the test name, the specified test method, a list of the actual test equipment used, documentation photos, results and raw data. No additions, deviations, or exclusions have been made from the standard(s) unless specifically noted.

Based on the results of our investigation, we have concluded the product tested complied with the requirements of the standard(s) indicated. The results obtained in this test report pertain only to the item(s) tested.

All testing was performed at the Intertek office located at 731 Enterprise Drive, Lexington Kentucky, 40510. The radiated emission test site is a 10-meter semi-anechoic chamber. The chamber meets the characteristics of CISPR 16-1 and ANSI C63.4. For measurements, a remotely controlled flush-mount metal-top turntable is used to rotate the EUT a full 360 degrees. A remote controlled non-conductive antenna mast is used to scan the antenna height from one to four meters. The test site is listed with the FCC under Registration Number 485103. The test site is listed with Industry Canada under Site Number IC 2042M-1.

## 2 Test Summary

| Page | Test full name | FCC Reference | IC Reference | Result |
|---|---|---|---|---|
| 6 | Peak Conducted Power | § 15.247(b)(3)(4) | RSS210 A8.4 (4) | Pass |
| 7 | Occupied Bandwidth | § 15.247(a)(2) | RSS210 A8.2(A) | Pass |
| 12 | Conducted Spurious Emissions | § 15.247(d) | RSS210 (A8.5) | Pass |
| 18 | Power Spectral Density | § 15.247(e) | RSS210 A8.2(B) | Pass |
| 22 | Radiated Spurious Emissions (Transmitter) | § 15.247(d), § 15.209, and § 15.205 | RSS-210 (2.2) | Pass |
| 34 | Radiated Spurious Emissions (Receiver) | § 15.109 | RSS-Gen (7.2.3) | Pass |
| 37 | AC Powerline Conducted Emissions | § 15.207 | RSS-Gen (7.2.2) | Pass |
| 40 | Antenna Requirement per FCC Part 15.203 | § 15.203 | RSS-Gen (7.1.4) | Pass |

## 3 Description of Equipment Under Test

| Equipment Under Test | |
|---|---|
| **Manufacturer** | GE Appliance & Lighting |
| **Model Number** | 265D1887G002 |
| **Serial Number** | 007F35 |
| **FCC Identifier** | ZKJ-DSM04R01 |
| **Industry Canada Identifier** | 10229A-DSM04R01 |
| **Receive Date** | 3/1/2012 |
| **Test Start Date** | 3/1/2012 |
| **Test End Date** | 3/9/2012 |
| **Device Received Condition** | Good |
| **Test Sample Type** | Production |
| **Frequency Band** | 2405MHz – 2480MHz |
| **Mode(s) of Operation** | Zigbee |
| **Modulation Type** | QPSK |
| **Transmission Control** | Test Commands via Ember InSight Adapter |
| **Maximum Output Power** | 20.99dBm (conducted output)1 |
| **Test Channels** | 11, 19, 25, and 26 (reduced power band edge) |
| **Antenna Type (15.203)** | Internal PCB Antenna (0.5dBi Peak Gain) |
| **Operating Voltage** | 115VAC/60Hz |
| **Power Supply** | Powered by 5VDC |

| Description of Equipment Under Test |
|---|
| The 265D1887G002 is a communication module which attaches externally to various appliances allowing the user to control certain features wirelessly. |

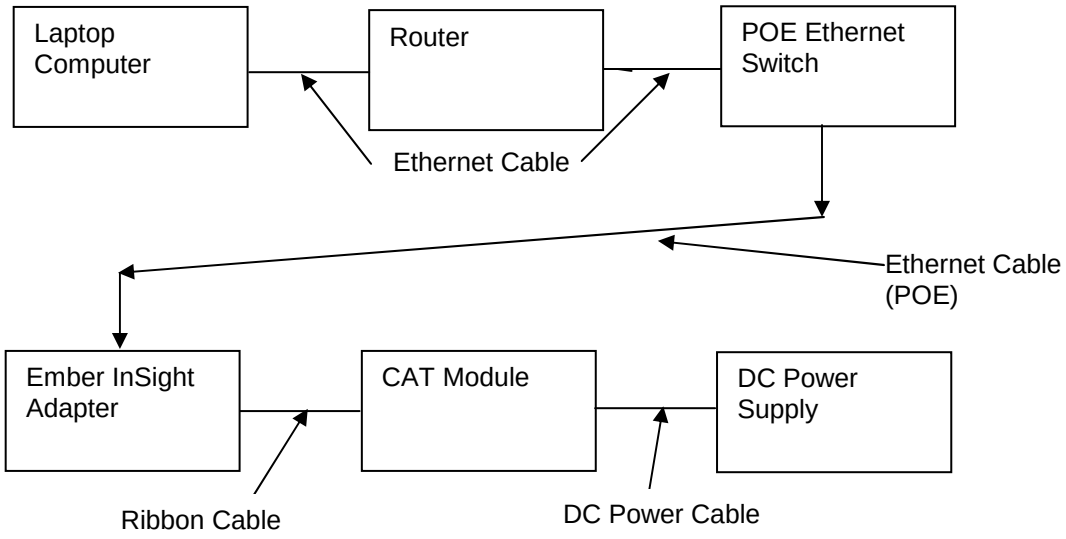
**Operating modes of the EUT:**

| No. | Descriptions of EUT Exercising |
|---|---|
| 1 | Transmitting on channels 11, 19, 25, and 26 (reduced power at band edge). |
| 2 | Receive / idle mode |

1 The maximum output power measured was 21.15dBm on channel 25. However, the output power on channel 25 had to be reduced in order to comply with the band edge radiated emissions for restricted bands. Therefore the maximum output power of the CAT Module is 20.99dBm which occurred on channel 19.

### 3.1 System setup including cable interconnection details, support equipment and simplified block diagram

### 3.2 EUT Block Diagram:




### 3.3 Cables Connected to Test Sample:

| Cables | | | | | |
|---|---|---|---|---|---|
| Description | Length | Shielding | Ferrites | Connection | |
| | | | | From | To |
| Ribbon Cable | 10 in | None | None | Ember InSight Adapter | Test Sample |
| DC Power Cable | 1 meter | None | None | DC Power Supply | Test Sample |

### 3.4 Support Equipment:

| Support Equipment | | | |
|---|---|---|---|
| Description | Manufacturer | Model Number | Serial Number |
| Programming Adapter | Ember | InSight | Not Labeled |
| Laptop Computer | Gateway | LT2802u | 11906695725 |
| Ethernet Switch | Netgear | FS108P | 1DL2013D00C6F |
| Router | Cisco | E1000 | CVN01K670165 |
| DC Power Supply | HP | 6296A | 1036 |

# 4 Peak Conducted Power

## 4.1 Test Limits

**§ 15.247(b)(3):** For systems using digital modulation in the 902–928 MHz, 2400–2483.5 MHz, and 5725–5850 MHz 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.

**§ 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.

## 4.2 Test Procedure

ANSI C63.10: 2009 and KDB Publication No. 558074: Guidance on Measurements for Digital Transmission Systems (47 CFR 15.247)

## 4.3 Test Equipment Used:

| Description | Serial Number | Manufacturer | Model | Cal. Date | Cal. Due |
|---|---|---|---|---|---|
| Spectrum Analyzer | 3099 | Rohde & Schwarz | FSP7 | 9/23/2011 | 9/23/2012 |

## 4.4 Results:

| Channel Number | Frequency (MHz) | Peak Conducted Power (dBm) | Peak Conducted Power Limit (dBm) | Margin (dB) | Result |
|---|---|---|---|---|---|
| 11 | 2405 | 20.79 | 30 | -9.21 | Pass |
| 19 | 2445 | 20.99 | 30 | -9.01 | Pass |
| 25 | 2475 | 21.15 | 30 | -8.85 | Pass |

Note: All results were obtained with a power setting of 5 in the control software.

# 5 Occupied Bandwidth

## 5.1 Test Limits

**§ 15.247(a)(2):** For digital modulation systems, the minimum 6dB bandwidth shall be at least 500kHz.

## 5.2 Test Procedure

ANSI C63.10: 2009 and KDB Publication No. 558074: Guidance on Measurements for Digital Transmission Systems (47 CFR 15.247)

## 5.3 Test Equipment Used:

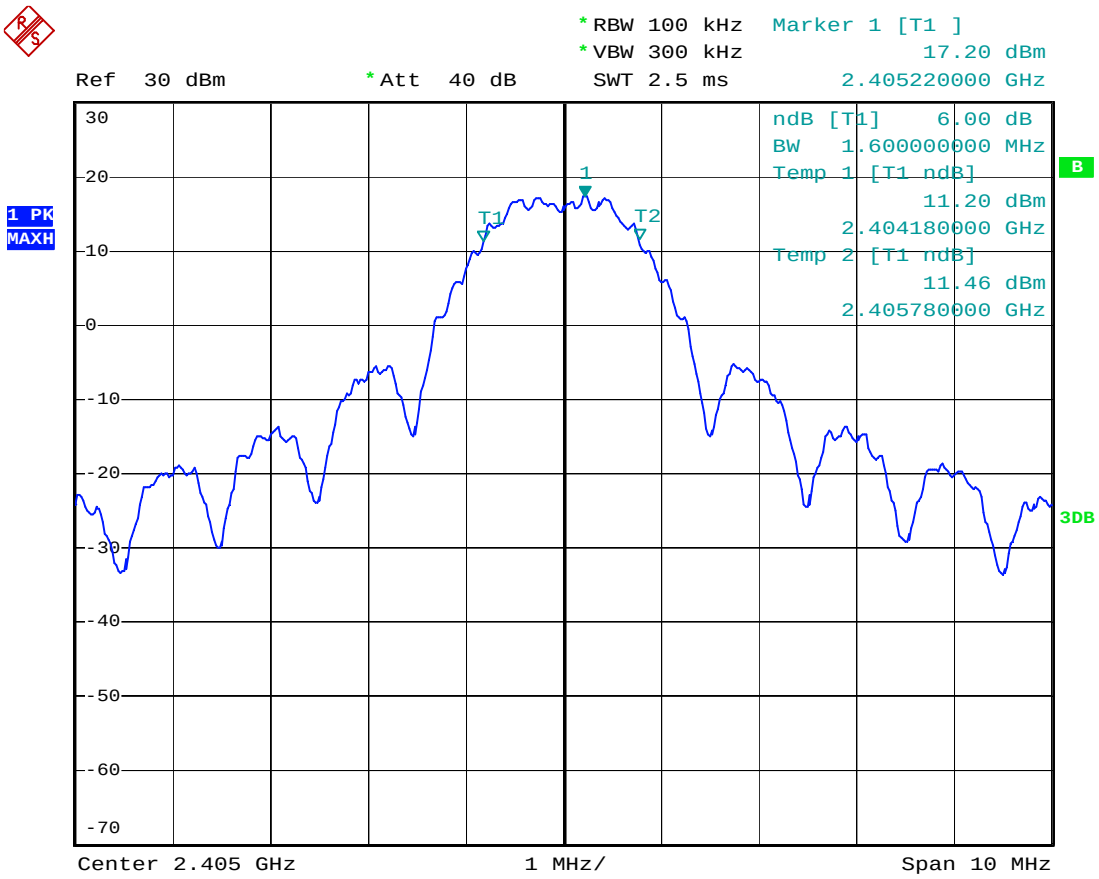
| Description | Serial Number | Manufacturer | Model | Cal. Date | Cal. Due |
|---|---|---|---|---|---|
| Spectrum Analyzer | 3099 | Rohde & Schwarz | FSP7 | 9/23/2011 | 9/23/2012 |

## 5.4 Results:

| Channel Number | Frequency (MHz) | 6dB Bandwidth | 99% Power Bandwidth | Result |
|---|---|---|---|---|
| 11 | 2405 | 1.60MHz | --- | Pass |
| 19 | 2445 | 1.62MHz | 2.42MHz | Pass |
| 25 | 2475 | 1.58MHz | --- | Pass |

Note: All results were obtained with a power setting of 5 in the control software.

**6dB Bandwidth Plot (Channel 11)**

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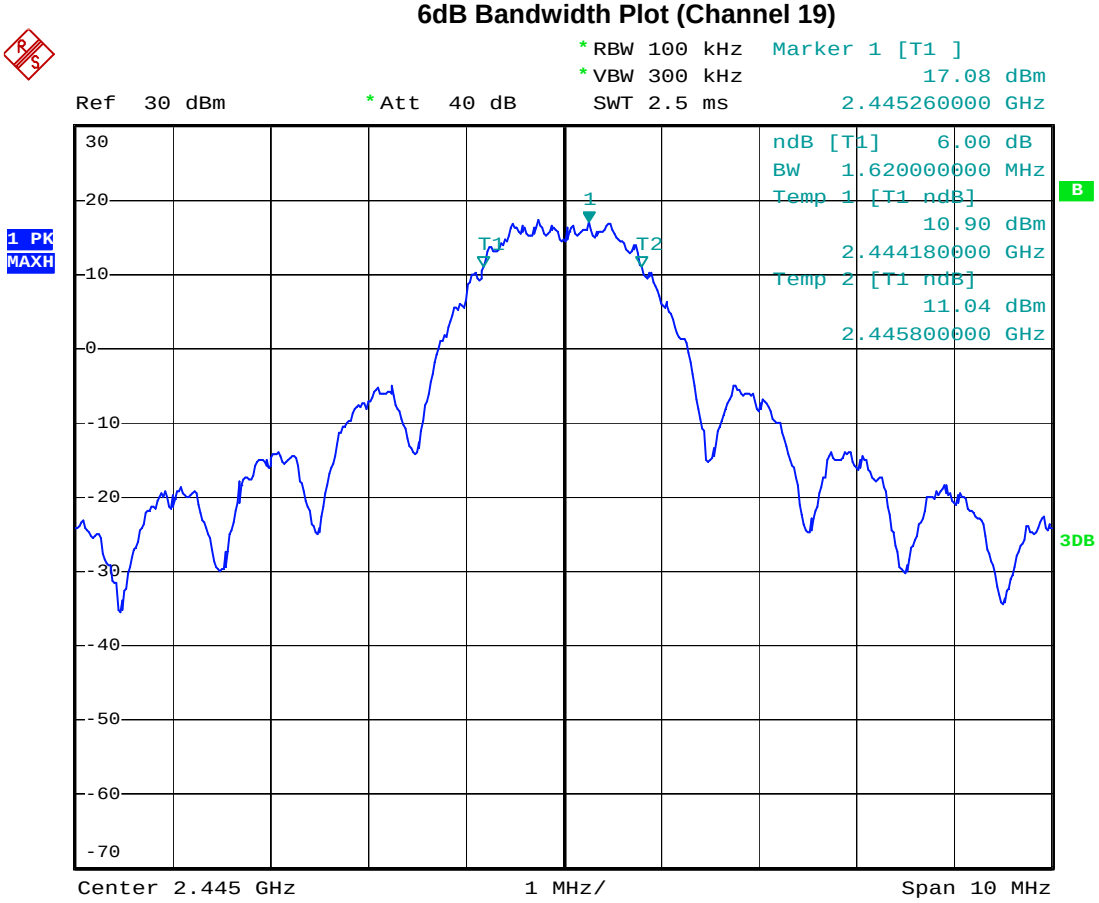
**6dB Bandwidth Plot (Channel 19)**

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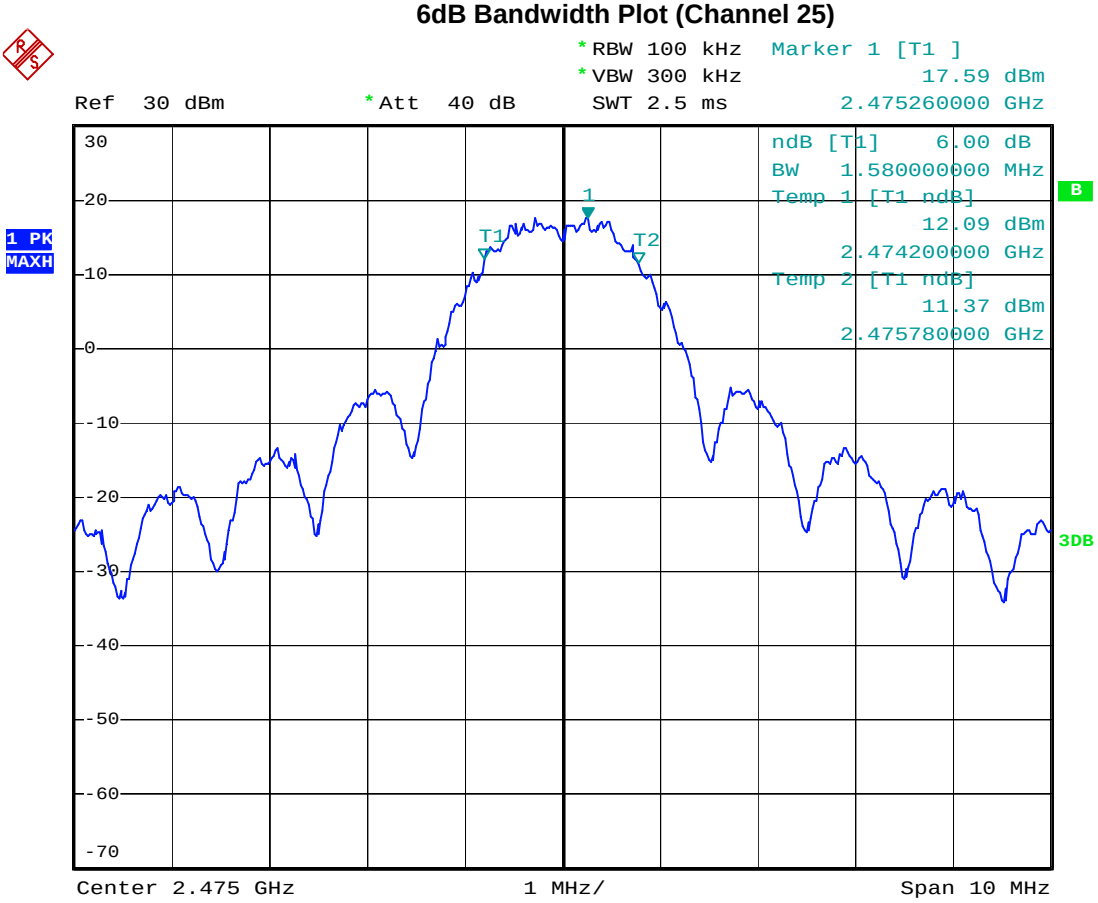
**6dB Bandwidth Plot (Channel 25)**

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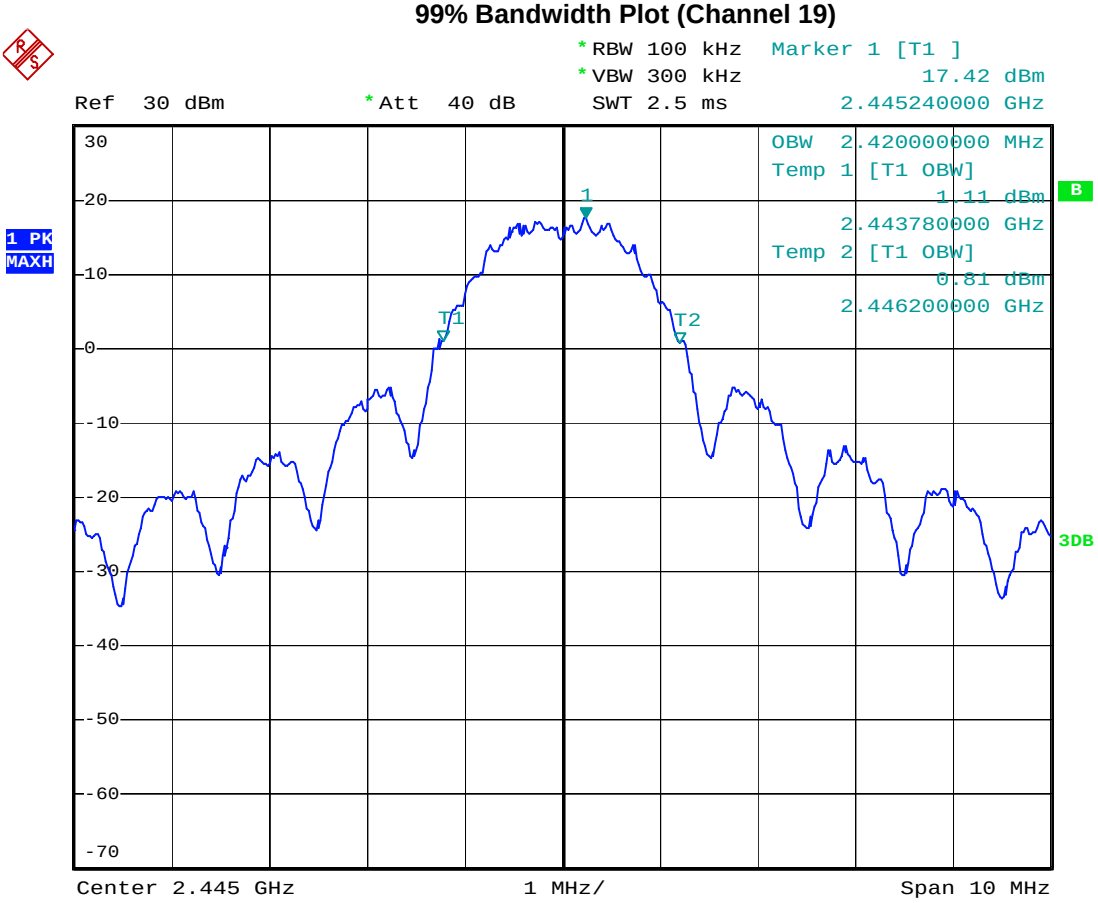
**99% Bandwidth Plot (Channel 19)**

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# 6 Conducted Spurious Emissions

## 6.1 Test Limits

**§ 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.

## 6.2 Test Procedure

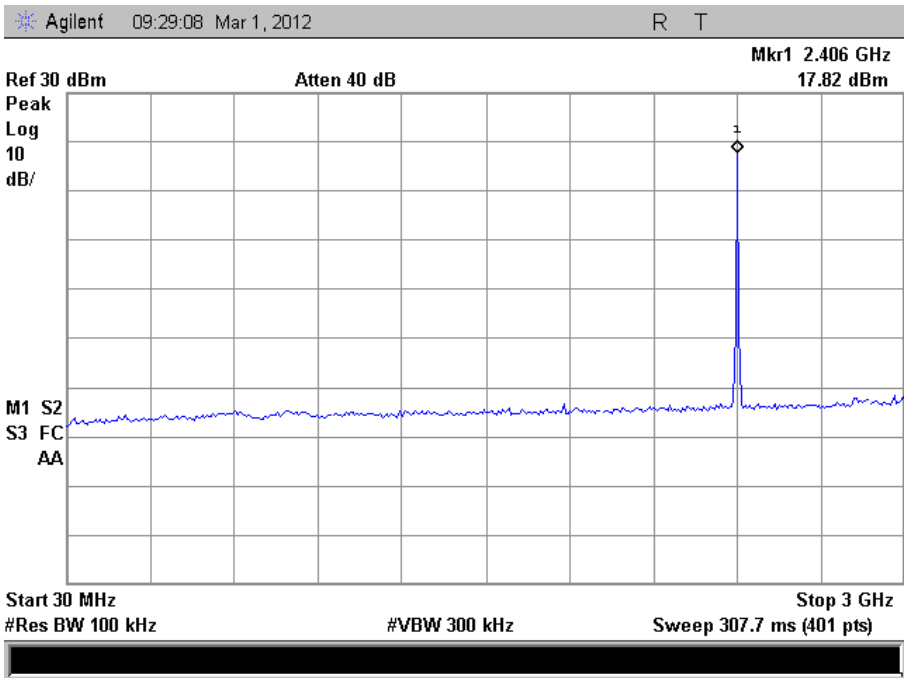
ANSI C63.10: 2009 and KDB Publication No. 558074: Guidance on Measurements for Digital Transmission Systems (47 CFR 15.247)

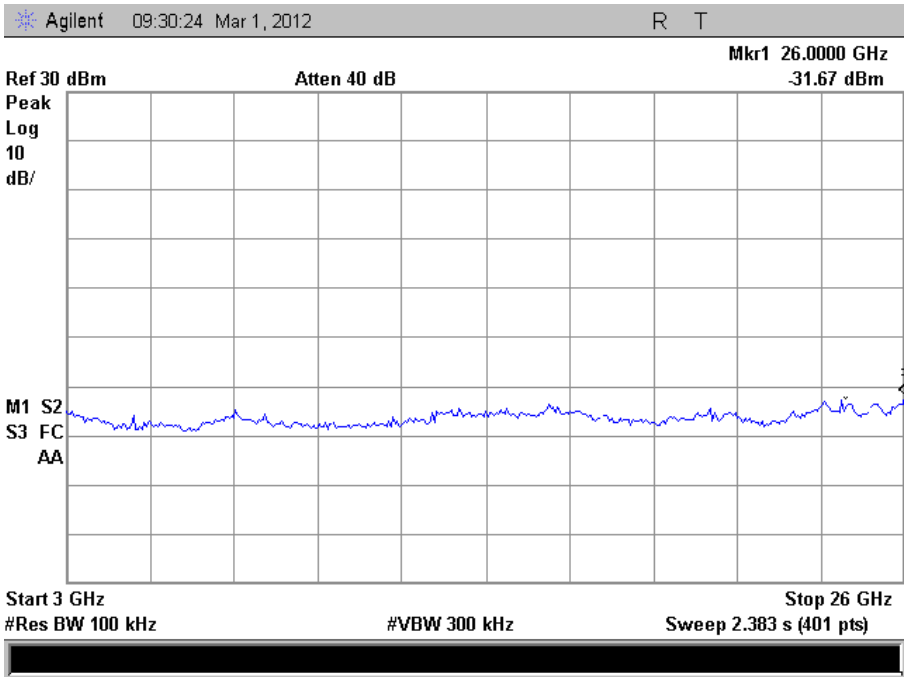
## 6.3 Test Equipment Used:

| Description | Serial Number | Manufacturer | Model | Cal. Date | Cal. Due |
|---|---|---|---|---|---|
| EMC Analyzer | 2142 | HP | E7405 | 9/23/2011 | 9/23/2012 |

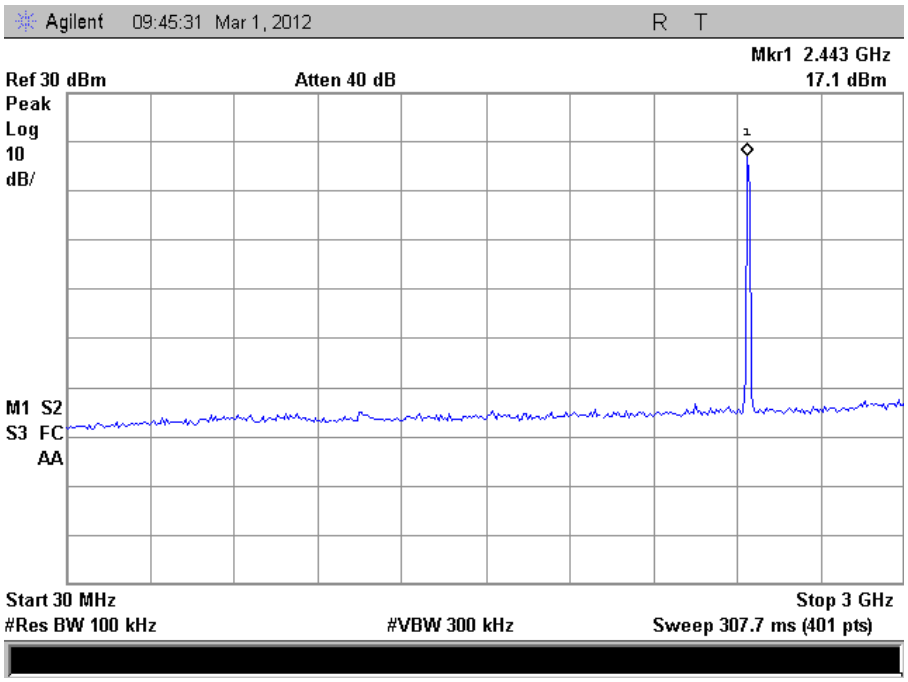
## 6.4 Results:

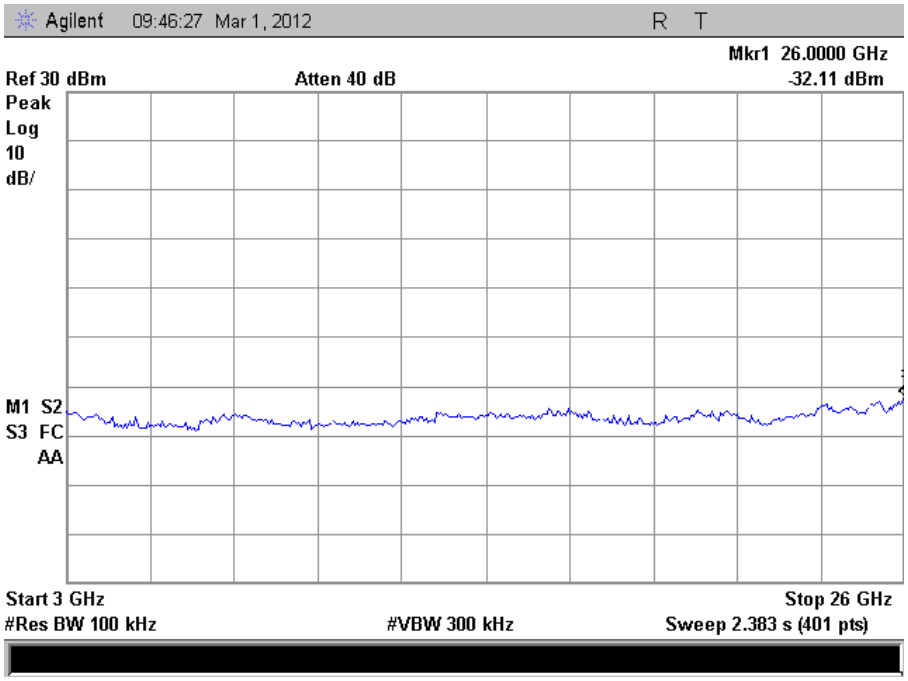
The following plots show that there are no conducted spurious emissions exceeding the 20dB down criteria.



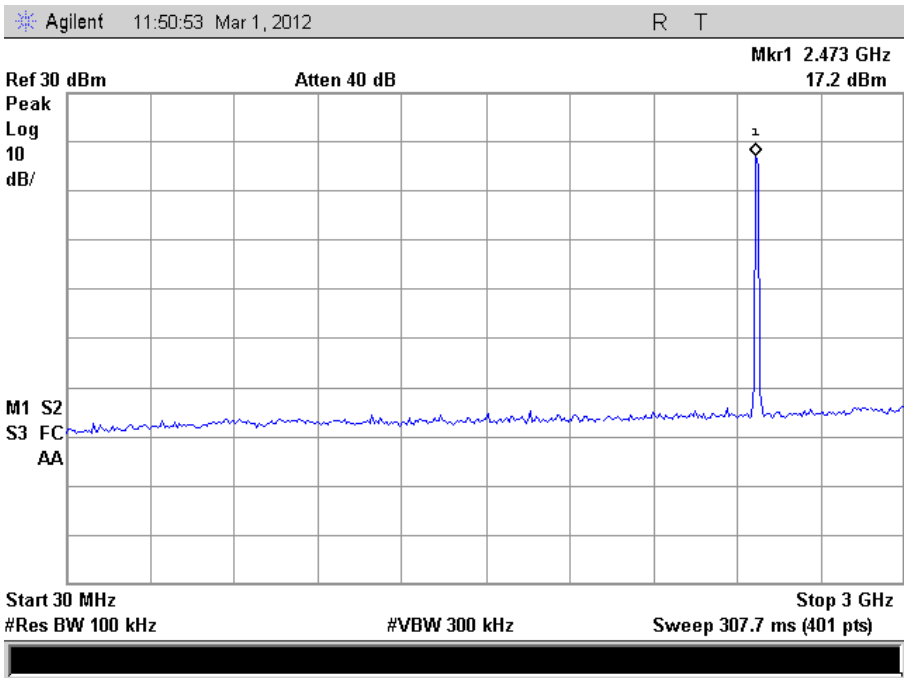



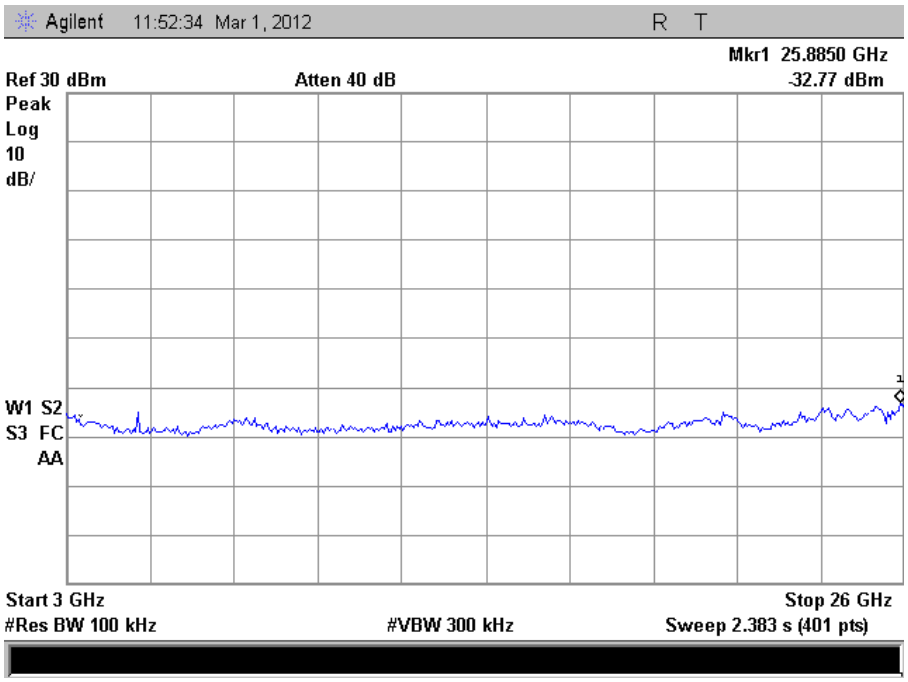

**Conducted Spurious Emissions (Channel 11)**




**Conducted Spurious Emissions (Channel 19)**

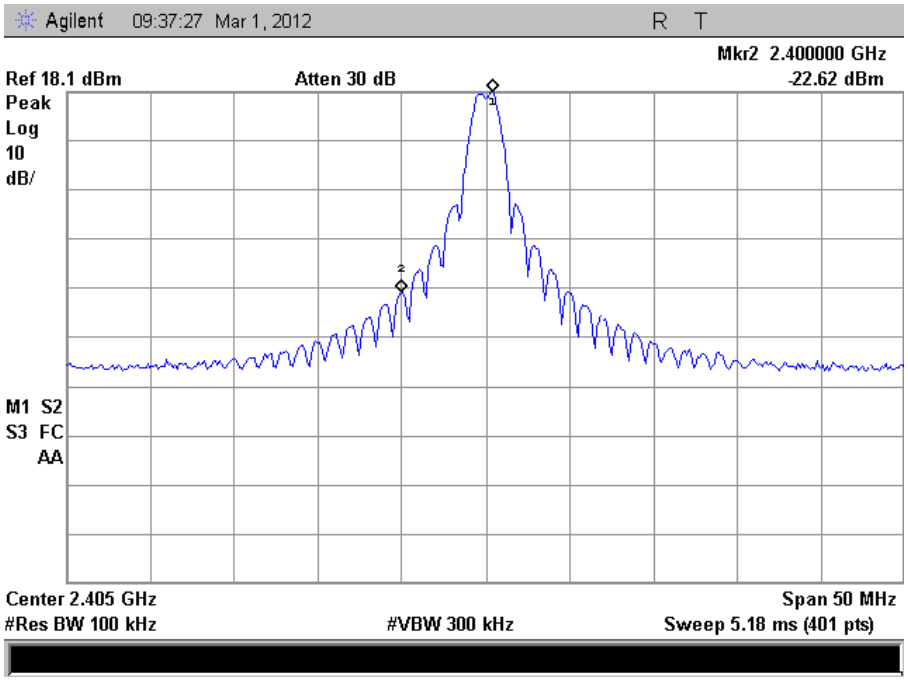


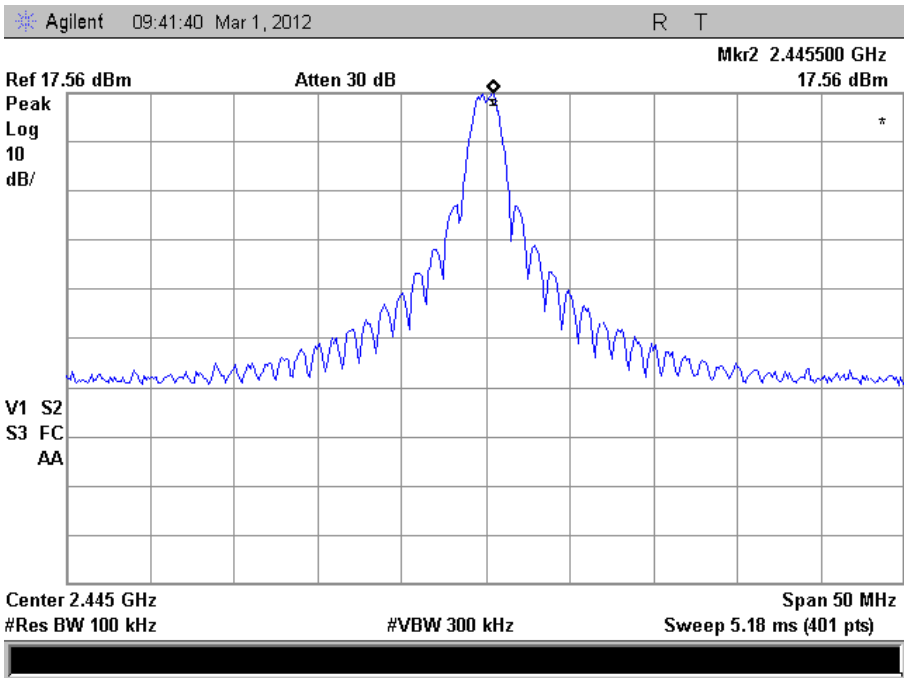

**Conducted Spurious Emissions (Channel 25)**

**Conducted Spurious Emissions Close to Fundamental:**

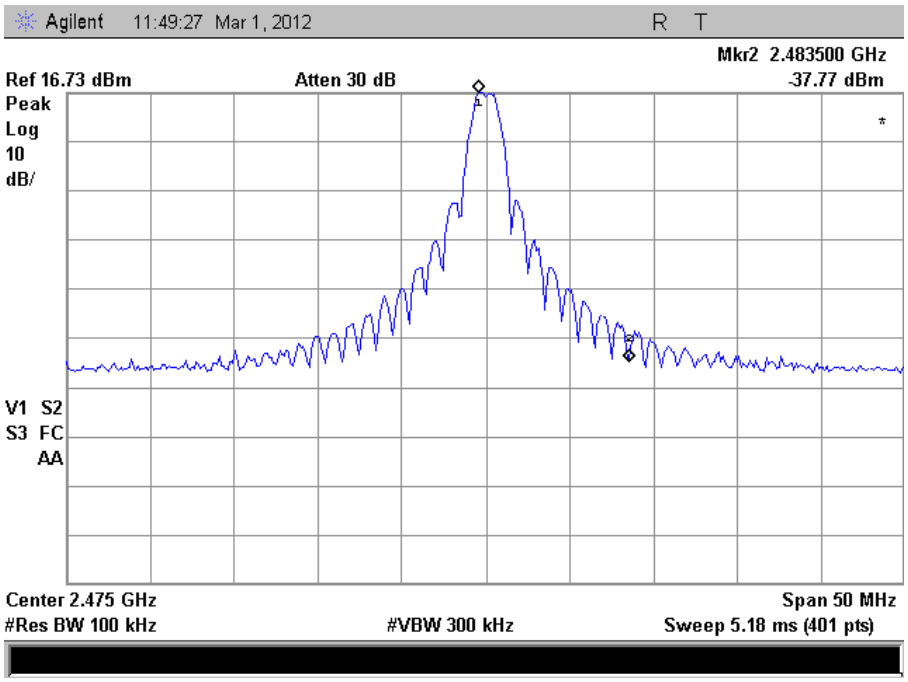
The following plots show that the conducted spurious emissions close to the fundamental signal but outside of the transmit band are at least 20dB down.




**Conducted Spurious Emissions (Channel 11)**




**Conducted Spurious Emissions (Channel 19)**




**Conducted Spurious Emissions (Channel 25)**

# 7 Power Spectral Density

## 7.1 Test Limits

**§ 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.

## 7.2 Test Procedure

ANSI C63.10: 2009 and KDB Publication No. 558074: Guidance on Measurements for Digital Transmission Systems (47 CFR 15.247) PSD Option 1 Method

## 7.3 Test Equipment Used:

| Description | Serial Number | Manufacturer | Model | Cal. Date | Cal. Due |
|---|---|---|---|---|---|
| Spectrum Analyzer | 3099 | Rohde & Schwarz | FSP7 | 9/23/2011 | 9/23/2012 |

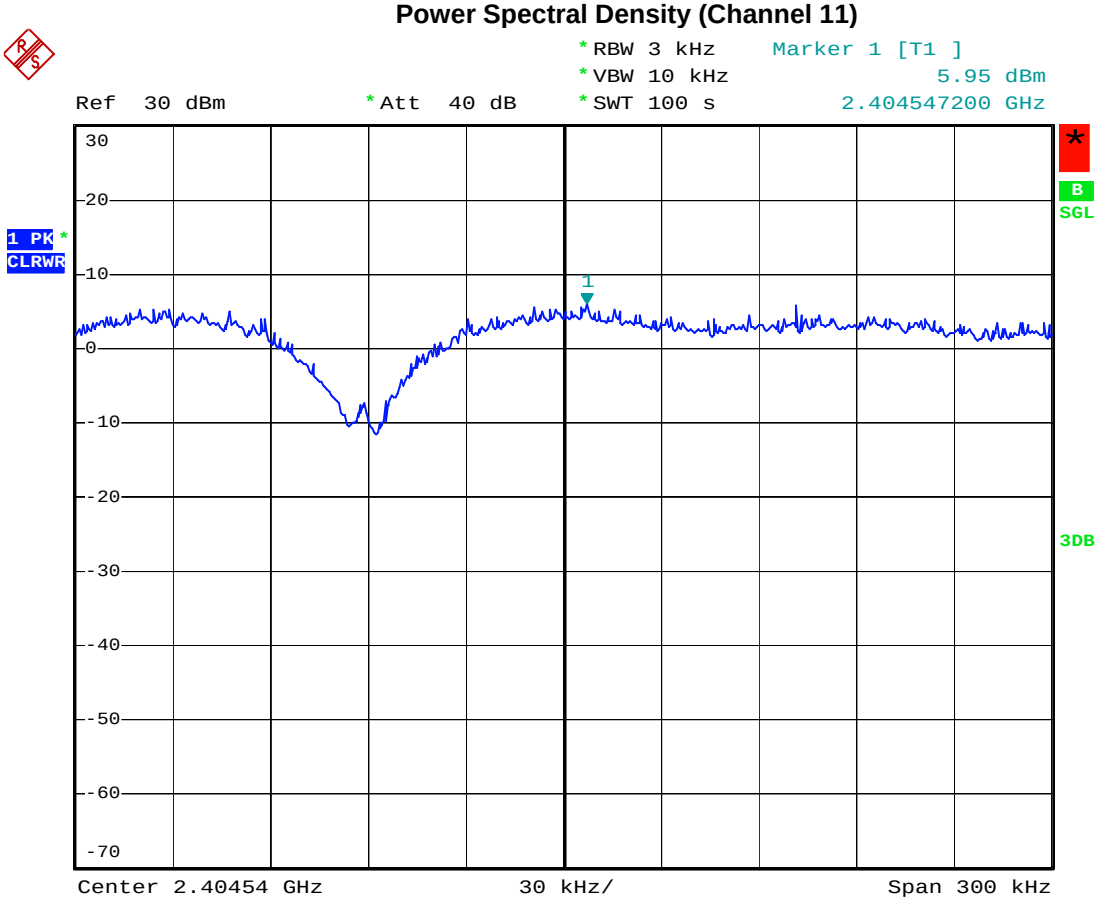
## 7.4 Results:

***PSD Option 1 Method**

| Channel Number | PSD in 3kHz BW (dBm) | Limit (dBm) | Margin (dB) | Result |
|---|---|---|---|---|
| 11 | 5.95 dBm | 8 | -2.05dB | Pass |
| 19 | 6.53 dBm | 8 | -1.47dB | Pass |
| 25 | 6.32 dBm | 8 | -1.68dB | Pass |

Note: All results were obtained with a power setting of 5 in the control software.

**Power Spectral Density (Channel 11)**

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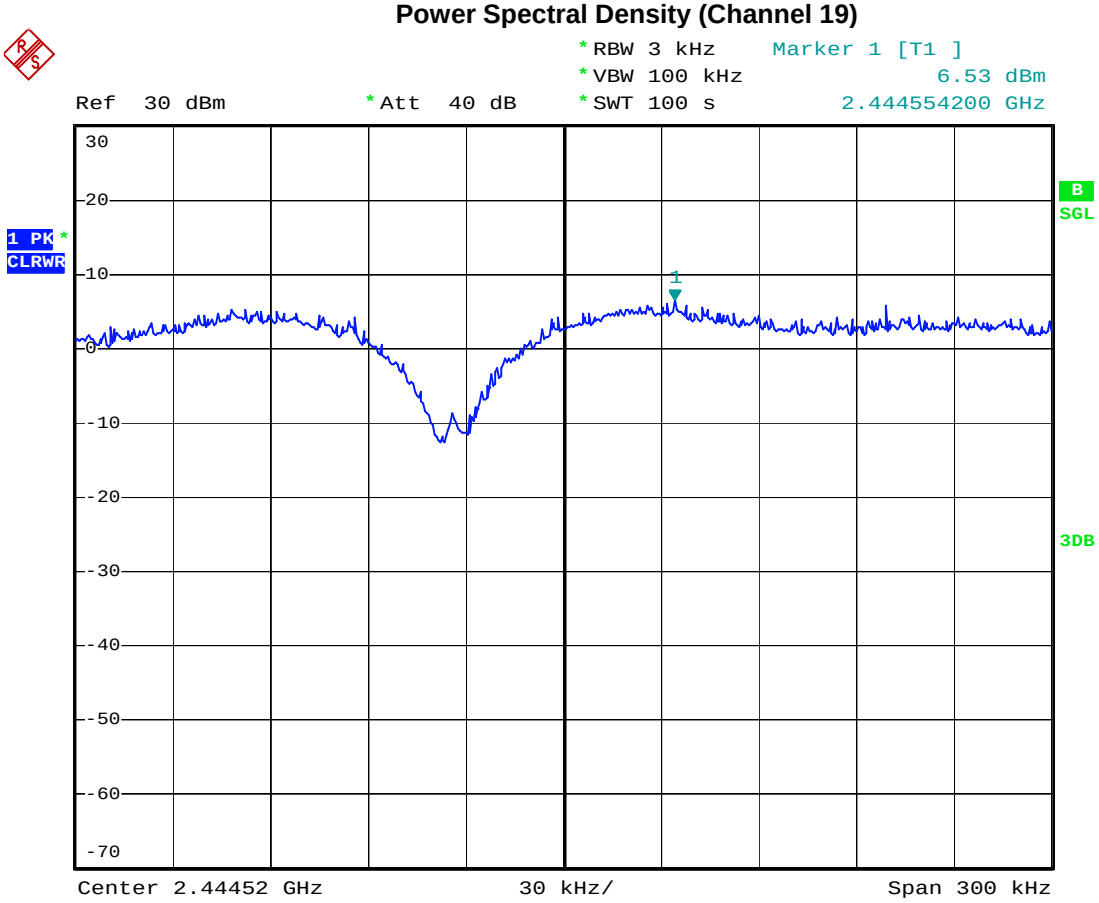
**Power Spectral Density (Channel 19)**

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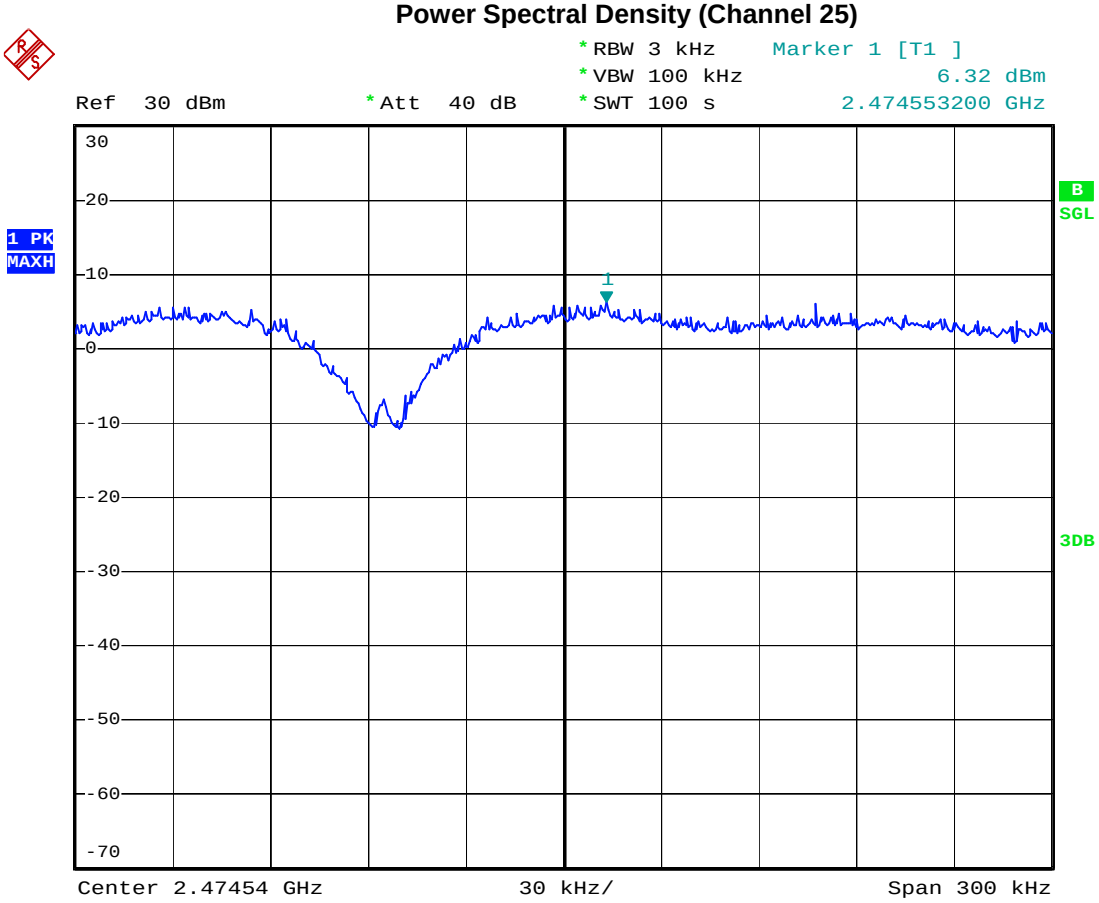
**Power Spectral Density (Channel 25)**

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# 8 Radiated Spurious Emissions (Transmitter)

## 8.1 Test Limits

**§ 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 §15.209(a) is not required. In addition, radiated emissions 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)).

**Part 15.205(a): Restricted Bands of Operations**

| MHz | MHz | MHz | GHz |
|---|---|---|---|
| 0.090–0.110 | 16.42–16.423 | 399.9–410 | 4.5–5.15 |
| [1] 0.495–0.505 | 16.69475–16.69525 | 608–614 | 5.35–5.46 |
| 2.1735–2.1905 | 16.80425–16.80475 | 960–1240 | 7.25–7.75 |
| 4.125–4.128 | 25.5–25.67 | 1300–1427 | 8.025–8.5 |
| 4.17725–4.17775 | 37.5–38.25 | 1435–1626.5 | 9.0–9.2 |
| 4.20725–4.20775 | 73–74.6 | 1645.5–1646.5 | 9.3–9.5 |
| 6.215–6.218 | 74.8–75.2 | 1660–1710 | 10.6–12.7 |
| 6.26775–6.26825 | 108–121.94 | 1718.8–1722.2 | 13.25–13.4 |
| 6.31175–6.31225 | 123–138 | 2200–2300 | 14.47–14.5 |
| 8.291–8.294 | 149.9–150.05 | 2310–2390 | 15.35–16.2 |
| 8.362–8.366 | 156.52475–156.52525 | 2483.5–2500 | 17.7–21.4 |
| 8.37625–8.38675 | 156.7–156.9 | 2655–2900 | 22.01–23.12 |
| 8.41425–8.41475 | 162.0125–167.17 | 3260–3267 | 23.6–24.0 |
| 12.29–12.293 | 167.72–173.2 | 3332–3339 | 31.2–31.8 |
| 12.51975–12.52025 | 240–285 | 3345.8–3358 | 36.43–36.5 |
| 12.57675–12.57725 | 322–335.4 | 3600–4400 | [2] |
| 13.36–13.41. | | | |

[1] Until February 1, 1999, this restricted band shall be 0.490–0.510 MHz.
[2] Above 38.6

**Part 15.209(a): Field Strength Limits for Restricted Bands of Operation**

| Frequency (MHz) | Field Strength (microvolts/meter) | Measurement Distance (meters) |
|---|---|---|
| 0.009 - 0.490 | 2,400 / F (kHz) | 300 |
| 0.490 - 1.705 | 24,000 / F (kHz) | 30 |
| 1.705 - 30.0 | 30 | 30 |
| 30 – 88 | 100 | 3 |
| 88 – 216 | 150 | 3 |
| 216 – 960 | 200 | 3 |
| Above 960 | 500 | 3 |

## 8.2 Test Procedure

ANSI C63.10: 2009 and KDB Publication No. 558074: Guidance on Measurements for Digital Transmission Systems (47 CFR 15.247)

## 8.3 Example of Field Strength Calculation Method:

The measured field strength was calculated by summing the readings taken from the spectrum analyzer with the appropriate correction factors associated with the antenna losses and cable losses. The calculation formula and sample calculations are listed below:

Formula:
FS = RA + AF + CF

FS = Field Strength in dBμV/m
RA = Receiver Amplitude in dBμV
AF = Antenna Factor in dB
CF = Cable Attenuation Factor in dB (Including preamplifier and filter attenuation)

Example Calculation:

RA = 19.48 dBμV
AF = 18.52 dB
CF = 0.78 dB

FS = 19.48 + 18.52 + 0.78 = 38.78 dBμV/m
Level in μV/m = Common Antilogarithm [(38.78 dBμV/m)/20] = 86.89 μV/m

## 8.4 Test Equipment Used:

| Description | Serial Number | Manufacturer | Model | Cal. Date | Cal. Due |
|---|---|---|---|---|---|
| EMI Test Receiver | 10887490.26 | Rohde & Schwarz | ESI26 | 6/29/2011 | 6/29/2012 |
| Preamplifier | 987410 | Miteq | AFS44-00102000-30-10P-44 | 9/12/2011 | 9/12/2012 |
| Preamplifier | SF456200904 | Mini-Circuits | ZX60-3018G-S+ | 9/12/2011 | 9/12/2012 |
| Biconnilog Antenna | 00051864 | ETS | 3142C | 12/20/2011 | 12/20/2012 |
| Horn Antenna | 6556 | ETS | 3115 | 8/24/2011 | 8/24/2012 |
| Horn Antenna | 1096 | Antenna Research | DRG-118/A | 7/20/2011 | 7/20/2012 |
| System Controller | 121701-1 | Sunol Sciences | SC99V | Not Required | Not Required |
| High Pass Filter | 3986-01 DC0408 | Microwave Circuits, Inc. | H3G020G2 | Verify At Time of Use | Verify At Time of Use |

## 8.5 Results:

For each channel it was verified that no change in radiated signal level occurred with the input power varied from 85% to 115% of nominal voltage. All spurious emissions were attenuated by at least 20dB below the level of the fundamental as required by Part 15.247(d). Additionally, all emissions falling within restricted bands of operation and at the band edges were found to be below the limit specified in Part 15.209(a). The spurious emissions listed in the following tables are the worst case emissions. The emissions were measured to 10 times the fundamental with the test sample in three orthogonal positions. The worst case data is reported below.

| TX Channel | Spurious Frequency | Polarity | Corr. Peak Reading. (dBuV/m) | Avg Reading. (dBuV/m) | Duty Cycle Factor (dB) | Corr. Avg Reading. (dBuV/m) | Peak Limit (dBuV/m) | Avg. Limit (dBuV/m) | Results |
|---|---|---|---|---|---|---|---|---|---|
| 11 | 4.8089 GHz | V | 50.471 | 42.431 | 3.6 | 38.831 | 74 | 54 | Compliant |
| 11 | 7.2164 GHz | V | 57.608 | 49.588 | 3.6 | 45.988 | 74 | 54 | Compliant |
| 11 | 9.618 GHz | V | 60.212 | 51.592 | 3.6 | 47.992 | 74 | 54 | Compliant |
| 11 | 12.022 GHz | V | 61.856 | 53.886 | 3.6 | 50.286 | 74 | 54 | Compliant |
| 11 | 14.433 GHz | V | 58.082 | 48.082 | 3.6 | 44.482 | 74 | 54 | Compliant |
| 11 | 16.835 GHz | V | 52.586 | 39.356 | 3.6 | 35.756 | 74 | 54 | Compliant |
| 11 | 4.809 GHz | H | 54.162 | 47.122 | 3.6 | 43.522 | 74 | 54 | Compliant |
| 11 | 7.2164 GHz | H | 53.128 | 44.348 | 3.6 | 40.748 | 74 | 54 | Compliant |
| 11 | 9.6218 GHz | H | 61.048 | 55.218 | 3.6 | 51.618 | 74 | 54 | Compliant |
| 11 | 12.023 GHz | H | 64.916 | 57.036 | 3.6 | 53.436 | 74 | 54 | Compliant |
| 11 | 14.427 GHz | H | 60.957 | 51.017 | 3.6 | 47.417 | 74 | 54 | Compliant |
| 11 | 16.839 GHz | H | 53.26 | 40.07 | 3.6 | 36.47 | 74 | 54 | Compliant |

**Worst Case Spurious Measurements (Channel 11)**

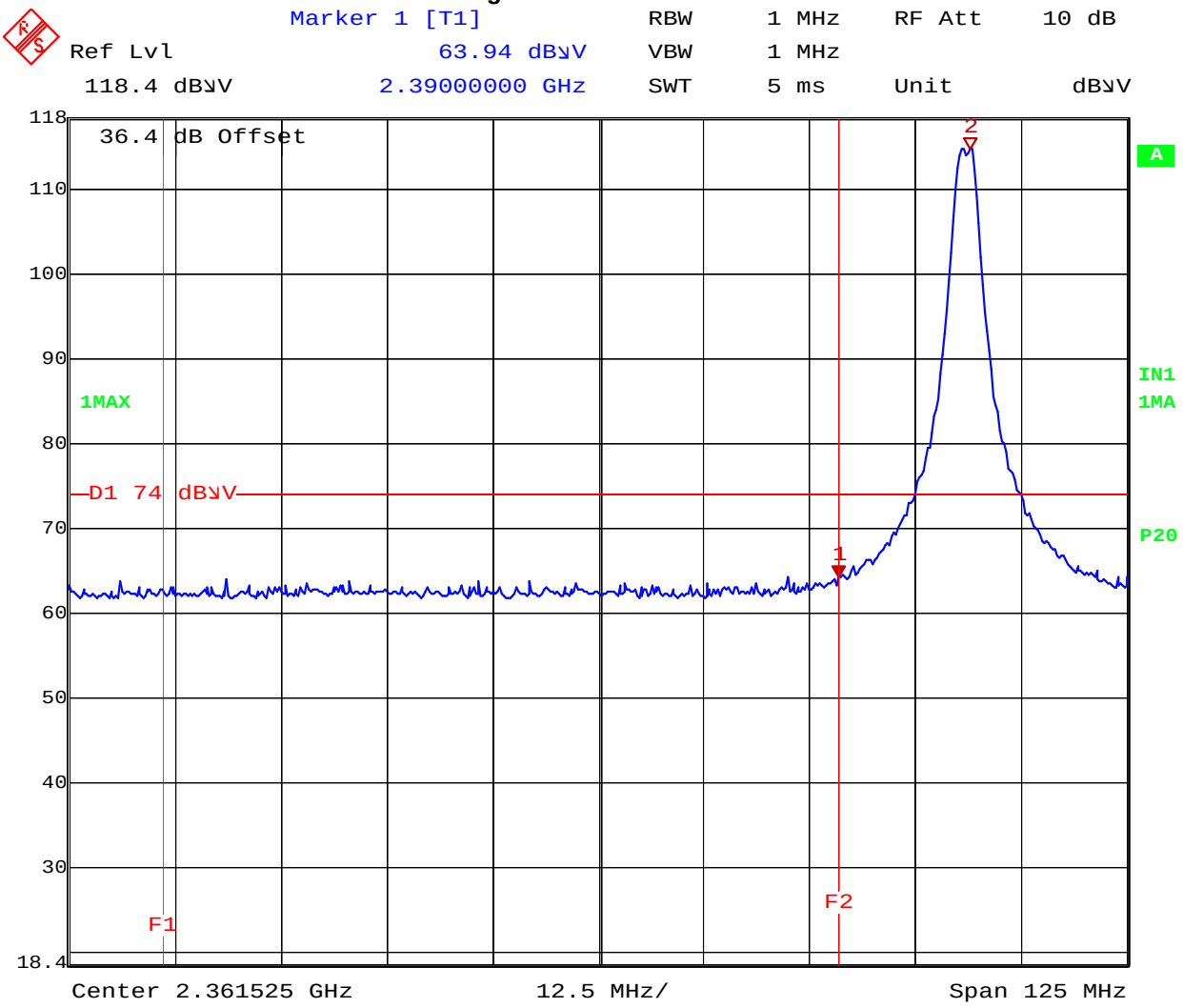
| TX Channel | Spurious Frequency | Polarity | Corr. Peak Reading. (dBuV/m) | Avg Reading. (dBuV/m) | Duty Cycle Factor (dB) | Corr. Avg Reading. (dBuV/m) | Peak Limit (dBuV/m) | Avg. Limit (dBuV/m) | Results |
|---|---|---|---|---|---|---|---|---|---|
| 19 | 4.8889 GHz | V | 55.495 | 48.585 | 3.6 | 44.985 | 74 | 54 | Compliant |
| 19 | 7.3335 GHz | V | 60.644 | 52.684 | 3.6 | 49.084 | 74 | 54 | Compliant |
| 19 | 9.7779 GHz | V | 56.092 | 45.442 | 3.6 | 41.842 | 74 | 54 | Compliant |
| 19 | 12.222 GHz | V | 61.524 | 53.404 | 3.6 | 49.804 | 74 | 54 | Compliant |
| 19 | 14.667 GHz | V | 58.844 | 49.944 | 3.6 | 46.344 | 74 | 54 | Compliant |
| 19 | 17.111 GHz | V | 55.878 | 42.378 | 3.6 | 38.778 | 74 | 54 | Compliant |
| 19 | 4.8909 GHz | H | 57.639 | 50.929 | 3.6 | 47.329 | 74 | 54 | Compliant |
| 19 | 7.3334 GHz | H | 57.013 | 48.863 | 3.6 | 45.263 | 74 | 54 | Compliant |
| 19 | 9.782 GHz | H | 59.015 | 51.415 | 3.6 | 47.815 | 74 | 54 | Compliant |
| 19 | 12.223 GHz | H | 62.525 | 54.115 | 3.6 | 50.515 | 74 | 54 | Compliant |
| 19 | 14.667 GHz | H | 62.114 | 53.904 | 3.6 | 50.304 | 74 | 54 | Compliant |
| 19 | 17.111 GHz | H | 58.97 | 46.66 | 3.6 | 43.06 | 74 | 54 | Compliant |

**Worst Case Spurious Measurements (Channel 19)**

| TX Channel | Spurious Frequency | Polarity | Corr. Peak Reading. (dBuV/m) | Avg Reading. (dBuV/m) | Duty Cycle Factor (dB) | Corr. Avg Reading. (dBuV/m) | Peak Limit (dBuV/m) | Avg. Limit (dBuV/m) | Results |
|---|---|---|---|---|---|---|---|---|---|
| 25 | 4.949 GHz | H | 59.304 | 52.744 | 3.6 | 49.144 | 74 | 54 | Compliant |
| 25 | 7.4264 GHz | H | 52.607 | 43.477 | 3.6 | 39.877 | 74 | 54 | Compliant |
| 25 | 9.8978 GHz | H | 57.976 | 50.016 | 3.6 | 46.416 | 74 | 54 | Compliant |
| 25 | 12.377 GHz | H | 60.672 | 52.342 | 3.6 | 48.742 | 74 | 54 | Compliant |
| 25 | 14.853 GHz | H | 63.823 | 54.533 | 3.6 | 50.933 | 74 | 54 | Compliant |
| 25 | 17.321 GHz | H | 59.618 | 46.528 | 3.6 | 42.928 | 74 | 54 | Compliant |
| 25 | 4.951 GHz | V | 57.704 | 50.984 | 3.6 | 47.384 | 74 | 54 | Compliant |
| 25 | 7.4234 GHz | V | 58.319 | 50.439 | 3.6 | 46.839 | 74 | 54 | Compliant |
| 25 | 9.898 GHz | V | 52.575 | 42.645 | 3.6 | 39.045 | 74 | 54 | Compliant |
| 25 | 12.372 GHz | V | 64.362 | 56.442 | 3.6 | 52.842 | 74 | 54 | Compliant |
| 25 | 14.847 GHz | V | 58.217 | 48.167 | 3.6 | 44.567 | 74 | 54 | Compliant |
| 25 | 17.321 GHz | V | 58.406 | 45.396 | 3.6 | 41.796 | 74 | 54 | Compliant |

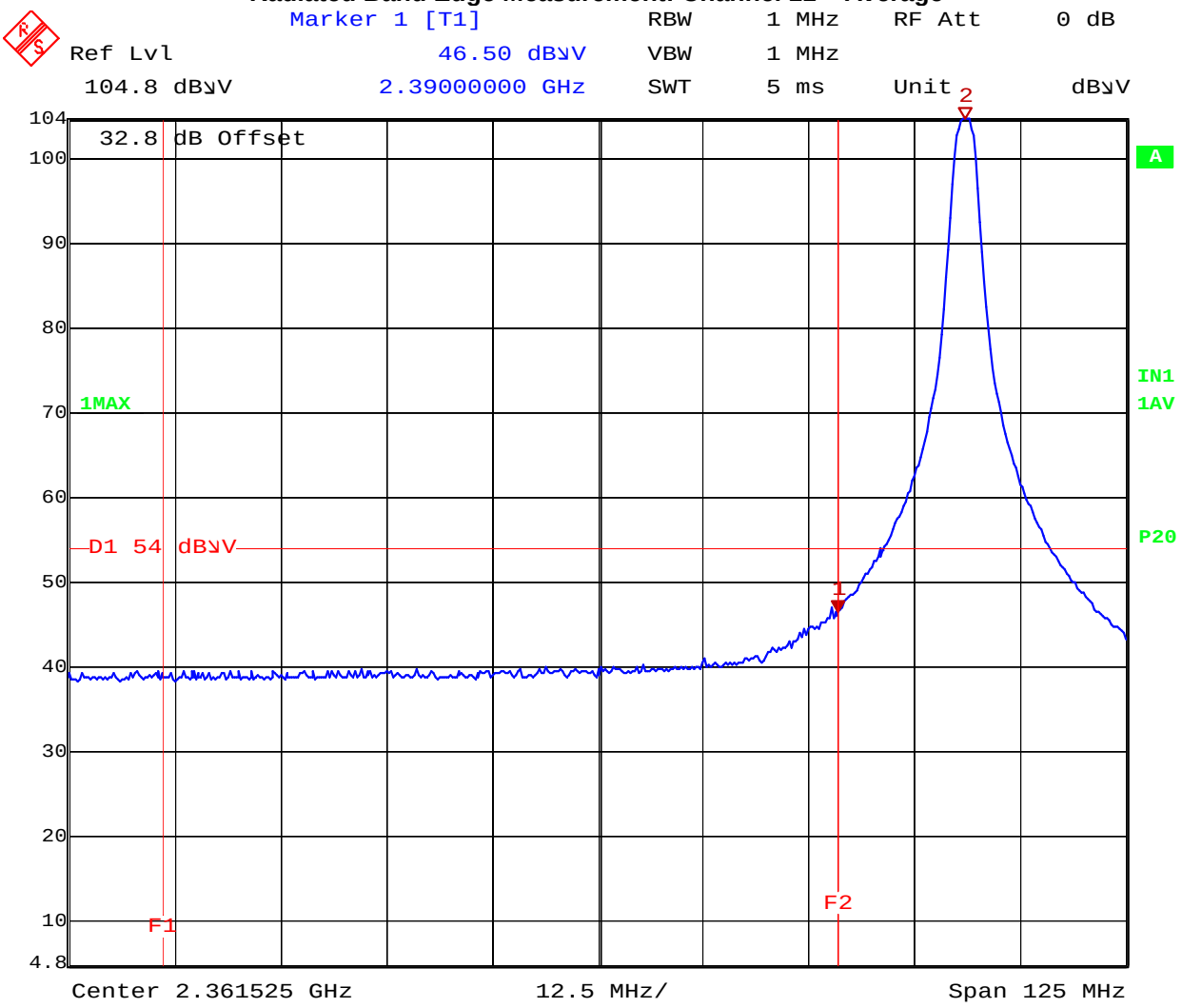
**Worst Case Spurious Measurements (Channel 25)**

**Radiated Band Edge Measurement: Channel 11 – Peak**




Date: 2.MAR.2012 05:56:43

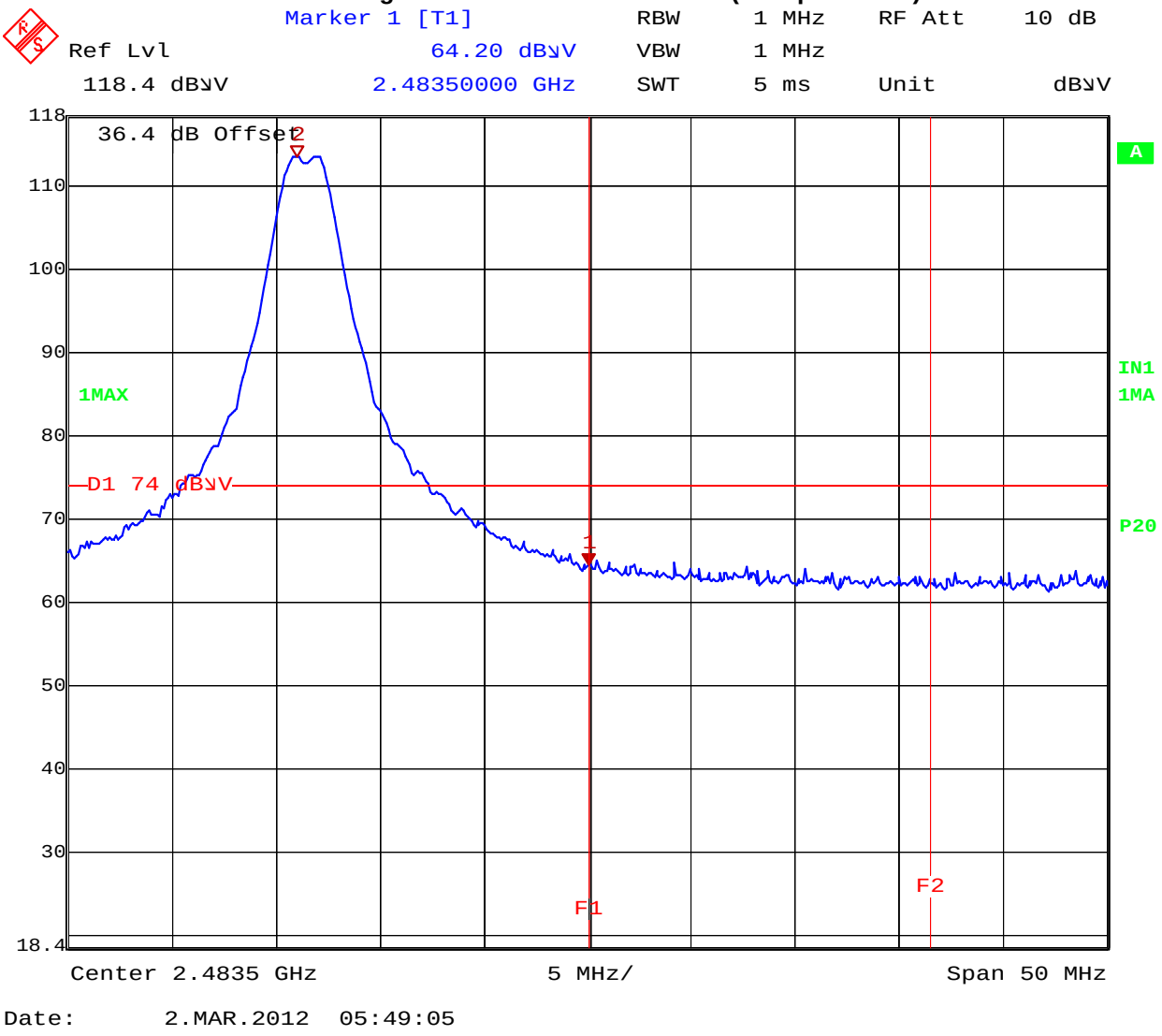
**Radiated Band Edge Measurement: Channel 11 – Average**



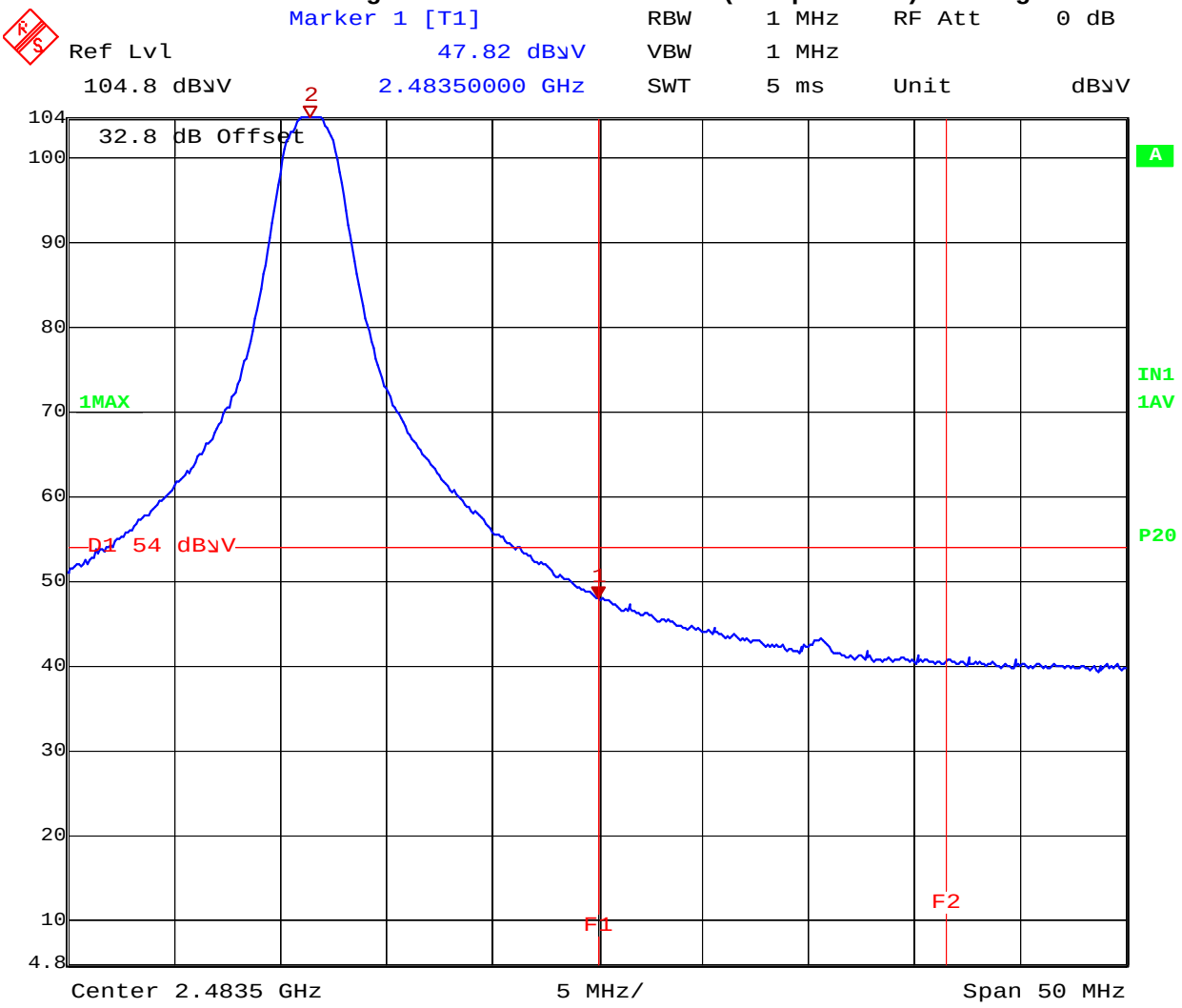

Date: 2.MAR.2012 05:58:11

**Note:** A 3.6dB duty cycle correction factor was also applied to this measurement. See section 12 of this report for calculation of the duty cycle correction factor.

**Radiated Band Edge Measurement: Channel 24 (settxpower = 5) – Peak**



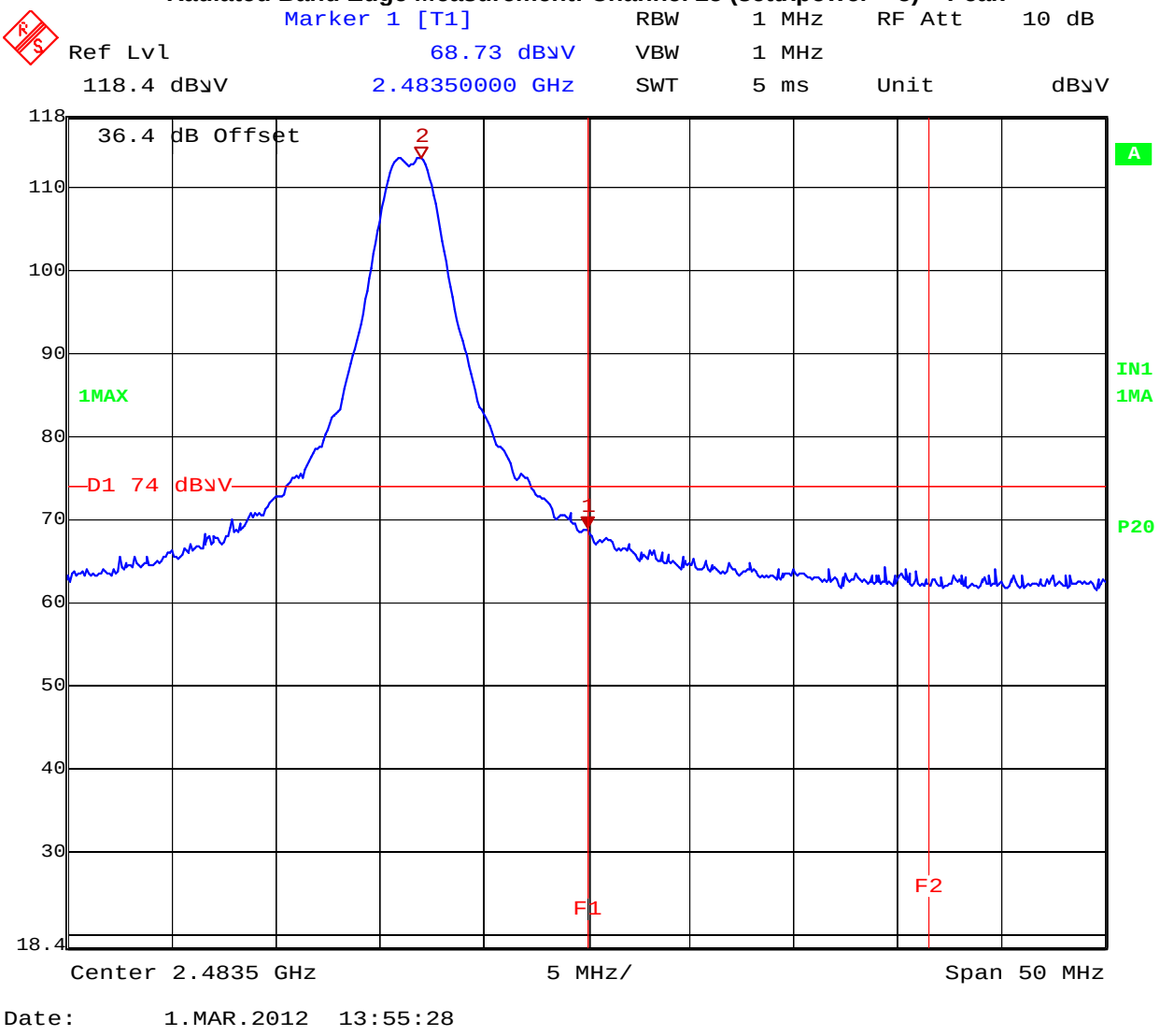
**Radiated Band Edge Measurement: Channel 24 (settxpower = 5) – Average**



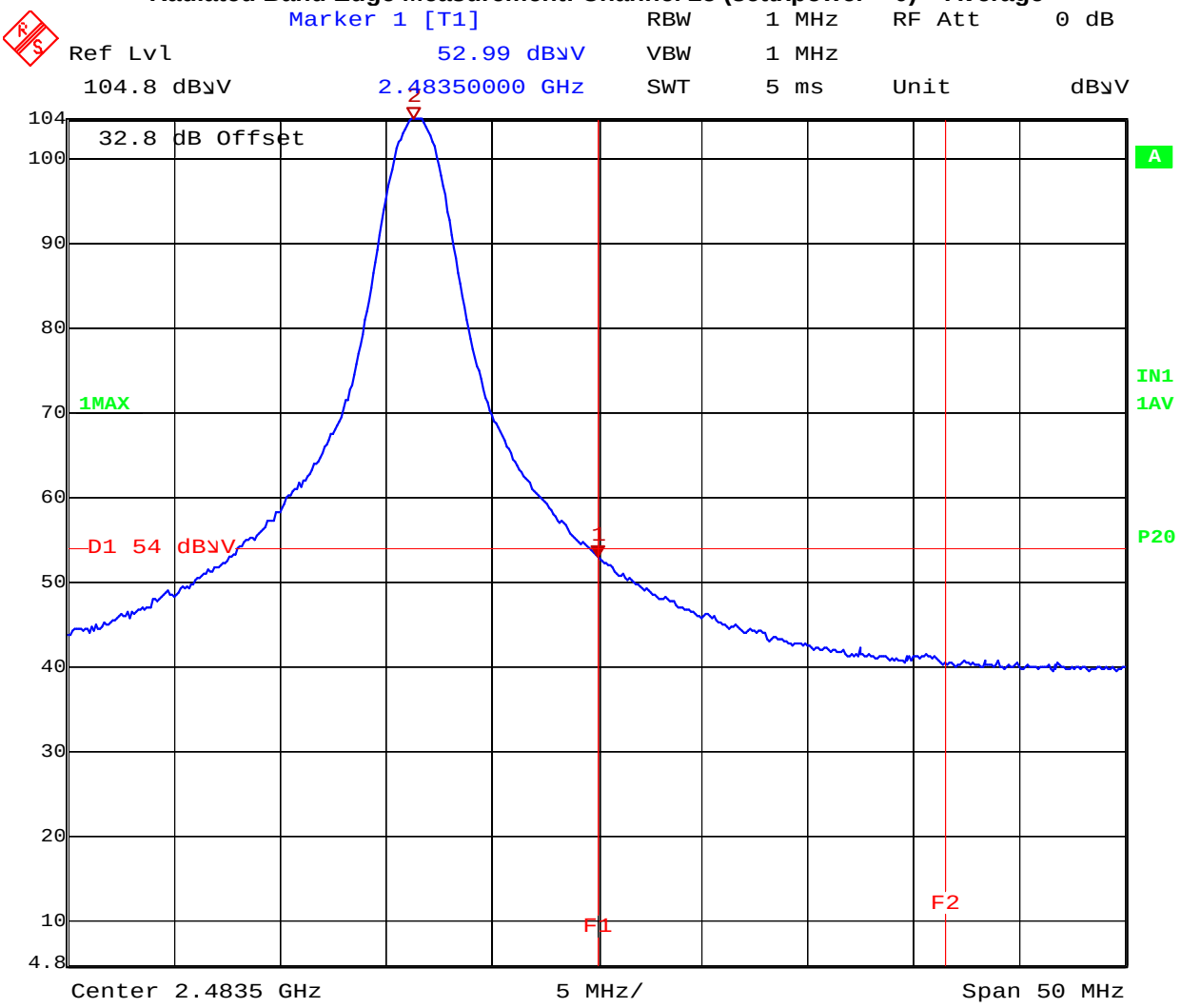

Date: 2.MAR.2012 05:46:47

**Note:** A 3.6dB duty cycle correction factor was also applied to this measurement. See section 12 of this report for calculation of the duty cycle correction factor.

**Radiated Band Edge Measurement: Channel 25 (settxpower = 5) – Peak**



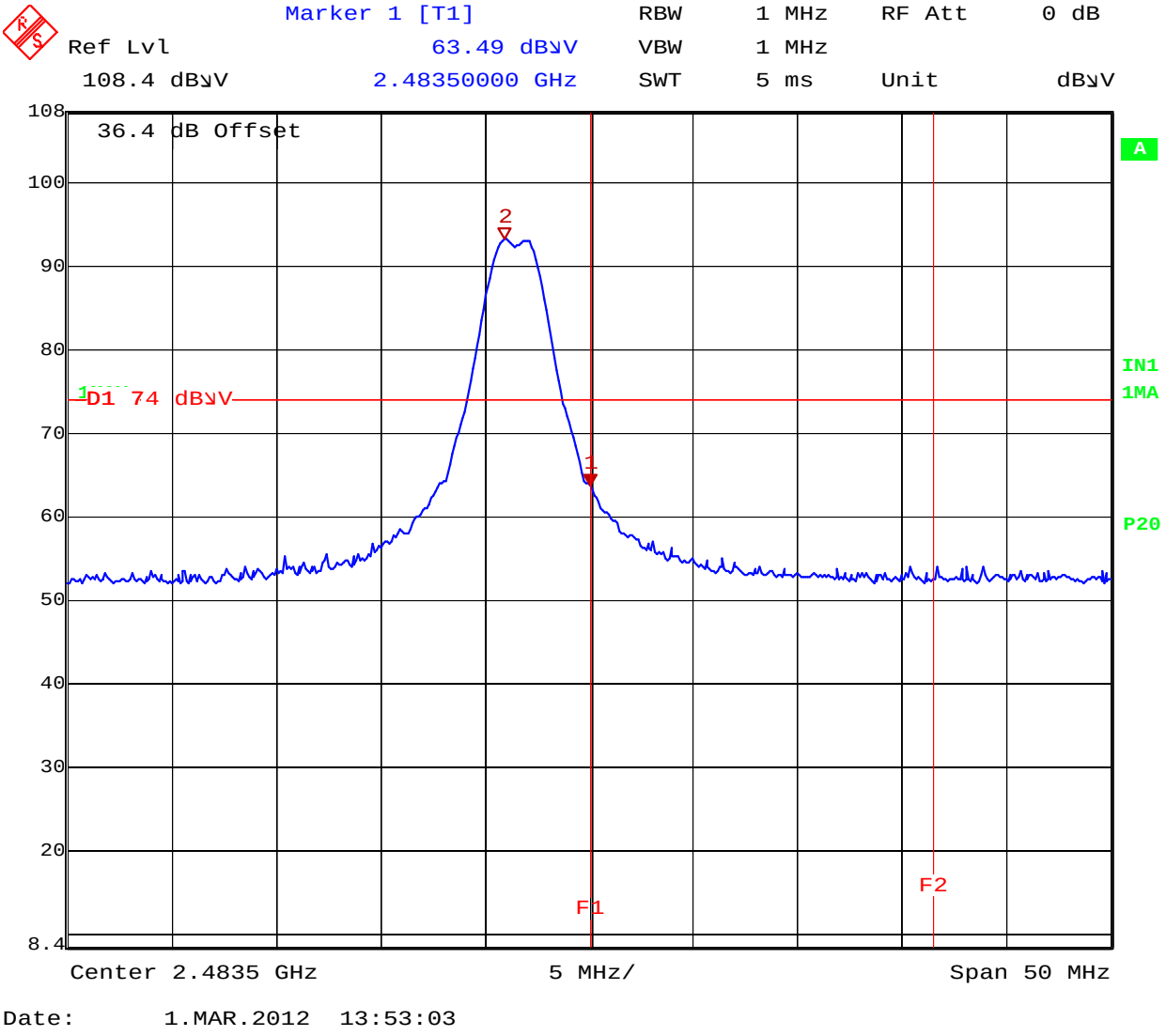
**Radiated Band Edge Measurement: Channel 25 (settxpower = 0) – Average**



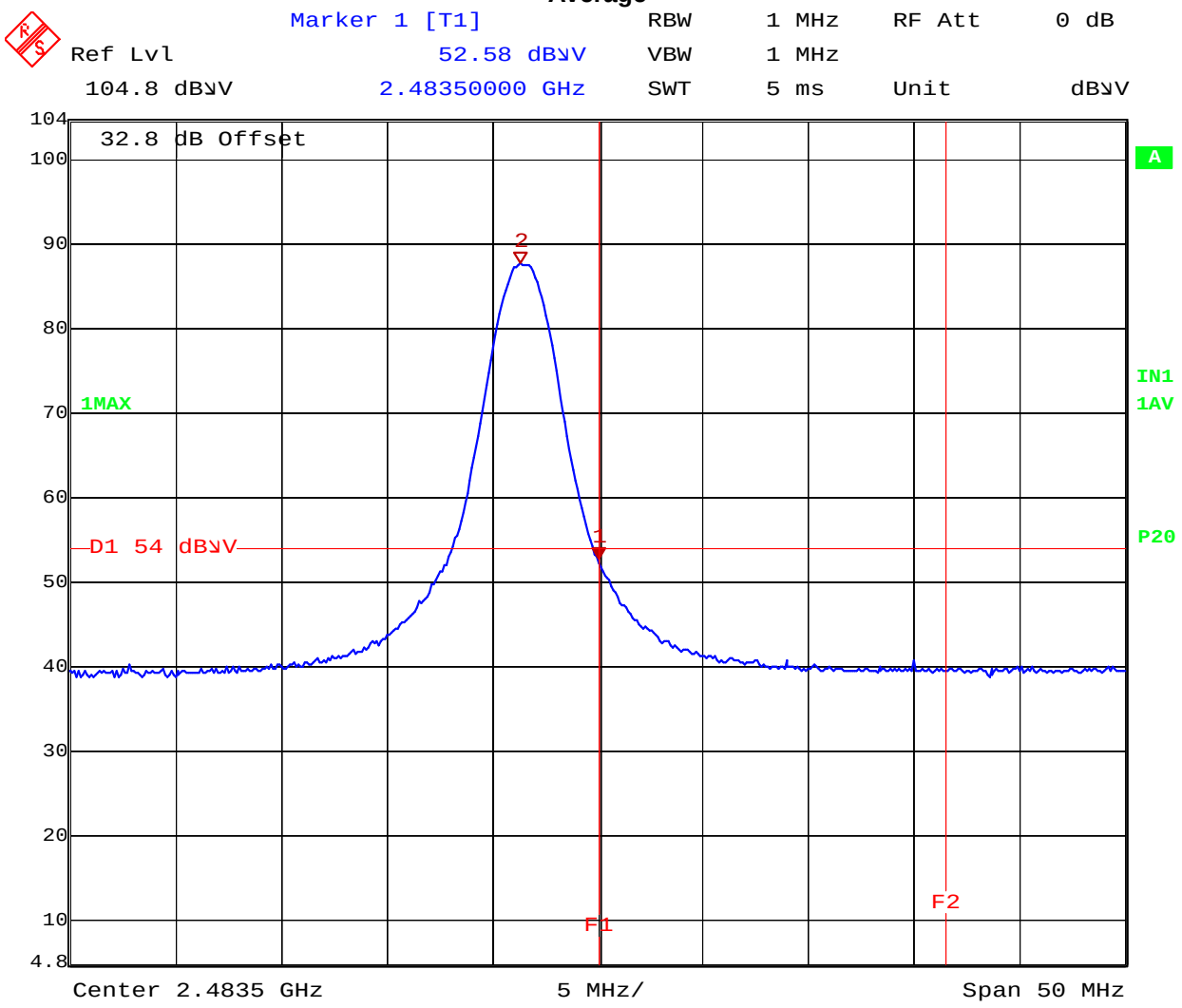

Date: 1.MAR.2012 13:59:38

**Note:** A 3.6dB duty cycle correction factor was also applied to this measurement. See section 12 of this report for calculation of the duty cycle correction factor.

**Radiated Band Edge Measurement: Channel 26 (Reduced Power Level, settxpower = -13) – Peak**



**Radiated Band Edge Measurement: Channel 26 (Reduced Power Level, settxpower = -13) – Average**




Date: 1.MAR.2012 13:50:57

**Note:** A 3.6dB duty cycle correction factor was also applied to this measurement. See section 12 of this report for calculation of the duty cycle correction factor.

# 9 Radiated Spurious Emissions (Receiver)

## 9.1 Test Limits

**§ 15.109:** 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 following values:

| Frequency of emission (MHz) | Field strength (microvolts/meter) | Field strength (dBuV/m) |
|---|---|---|
| 30–88 | 100 | 40 |
| 88–216 | 150 | 43.5 |
| 216–960 | 200 | 46 |
| Above 960 | 500 | 54 |

## 9.2 Test Procedure

ANSI C63.4: 2009

## 9.3 Example of Field Strength Calculation Method:

The measured field strength was calculated by summing the readings taken from the spectrum analyzer with the appropriate correction factors associated with the antenna losses and cable losses. The calculation formula and sample calculations are listed below:

Formula:
FS = RA + AF + CF

FS = Field Strength in dBμV/m
RA = Receiver Amplitude in dBμV
AF = Antenna Factor in dB
CF = Cable Attenuation Factor in dB (Including preamplifier and filter attenuation)

Example Calculation:

RA = 19.48 dBμV
AF = 18.52 dB
CF = 0.78 dB

FS = 19.48 + 18.52 + 0.78 = 38.78 dBμV/m
Level in μV/m = Common Antilogarithm [(38.78 dBμV/m)/20] = 86.89 μV/m

### 9.4 Test Equipment Used:

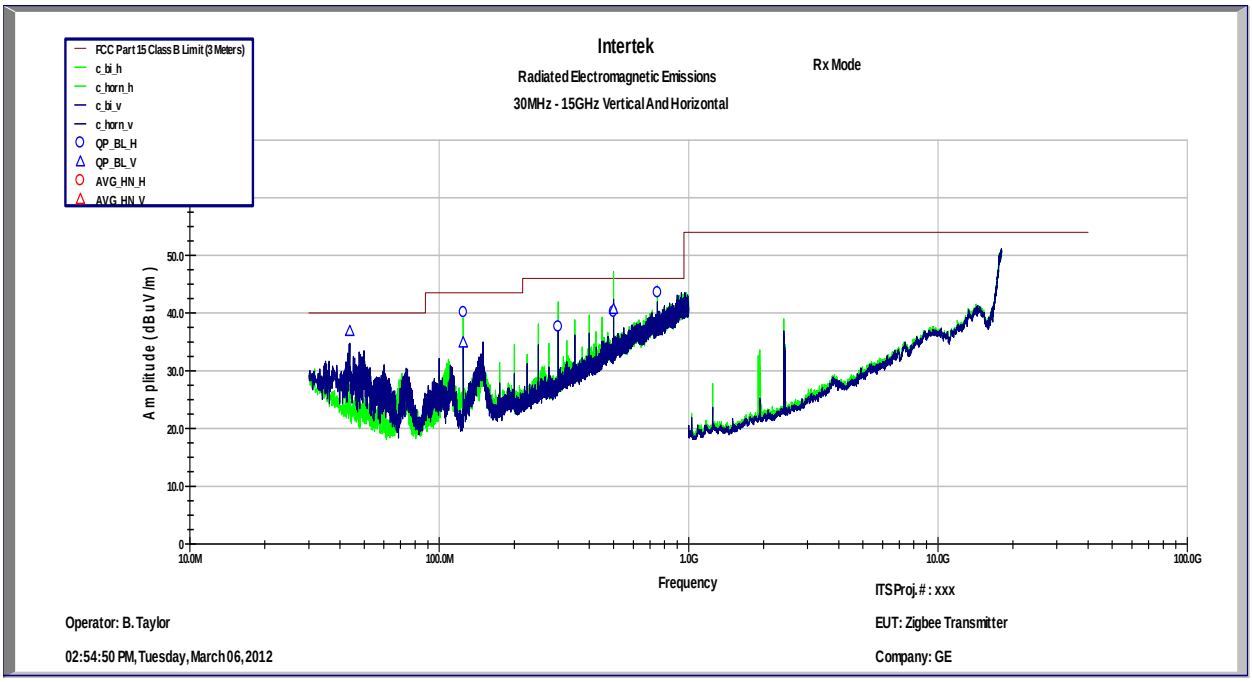
| Description | Serial Number | Manufacturer | Model | Cal. Date | Cal. Due |
|---|---|---|---|---|---|
| EMI Test Receiver | 10887490.26 | Rohde & Schwarz | ESI26 | 6/29/2011 | 6/29/2012 |
| Preamplifier | 987410 | Miteq | AFS44-00102000-30-10P-44 | 9/12/2011 | 9/12/2012 |
| Preamplifier | SF456200904 | Mini-Circuits | ZX60-3018G-S+ | 9/12/2011 | 9/12/2012 |
| Biconnilog Antenna | 00051864 | ETS | 3142C | 12/20/2011 | 12/20/2012 |
| Horn Antenna | 6556 | ETS | 3115 | 8/24/2011 | 8/24/2012 |
| Horn Antenna | 1096 | Antenna Research | DRG-118/A | 7/20/2011 | 7/20/2012 |
| System Controller | 121701-1 | Sunol Sciences | SC99V | Not Required | Not Required |
| High Pass Filter | 3986-01 DC0408 | Microwave Circuits, Inc. | H3G020G2 | Verify At Time of Use | Verify At Time of Use |

## 9.5 Results:

All spurious emissions with the test sample in receive mode were below the limits specified in Part 15.109 for a class B digital device.

| Radiated Emissions | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Test Engineer:** | Bryan Taylor | **Start Date:** | 3/6/2012 | | **End Date:** | 3/6/2012 | | | | |
| **Temperature:** | 25.1C | **Humidity:** | 17.20% | | **Pressure:** | 998.98mbar | | | | |
| **Specification:** | FCC Part 15B | **Test Limit:** | Class B | | | | | | | |
| **Notes:** | RX Mode | | | | | | | | | |
| **A** | **B** | **C** | **D** | **E** | **F** | **G** | **H** | **I** | **J** | **K** |
| **Frequency** | **Polarity (H/V)** | **Raw Reading (dBuV)** | **Cab. (dB)** | **Ant. (dB)** | **Corr. Reading. (dBuV/m)** | **Limit (dBuV/m)** | **Delta (dB)** | **RBW / Detector** | **Test Distance** | **Results** |
| 125.0 MHz | H | 31.11 | 1.61 | 7.4 | 40.12 | 43.52 | -3.4 | 120kHz / QP | 3m | **Compliant** |
| 300.0 MHz | H | 21.3 | 2.43 | 13.9 | 37.63 | 46.02 | -8.39 | 120kHz / QP | 3m | **Compliant** |
| 500.02 MHz | H | 18.89 | 3.11 | 18.2 | 40.2 | 46.02 | -5.82 | 120kHz / QP | 3m | **Compliant** |
| 750.01 MHz | H | 18.08 | 3.78 | 21.7 | 43.56 | 46.02 | -2.46 | 120kHz / QP | 3m | **Compliant** |
| 43.798 MHz | V | 25.28 | 0.86 | 10.7 | 36.84 | 40 | -3.16 | 120kHz / QP | 3m | **Compliant** |
| 125.0 MHz | V | 25.87 | 1.61 | 7.4 | 34.88 | 43.52 | -8.64 | 120kHz / QP | 3m | **Compliant** |
| 500.0 MHz | V | 19.36 | 3.11 | 18.2 | 40.67 | 46.02 | -5.35 | 120kHz / QP | 3m | **Compliant** |
| Calculations: | | | | | F = C + D + E | | H = F - G | | | |

Maximized Quasi Peak Emissions




Peak Scan (Receive Mode)

# 10 AC Powerline Conducted Emissions

## 10.1 Test Limits

**§ 15.107(e):** Except as shown in paragraphs (b) and (c) of this section, 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 50 μH/50 ohms 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) | |
|---|---|---|
| | 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.

## 10.2 Test Procedure

ANSI C63.4: 2009

## 10.3 Test Equipment Used:

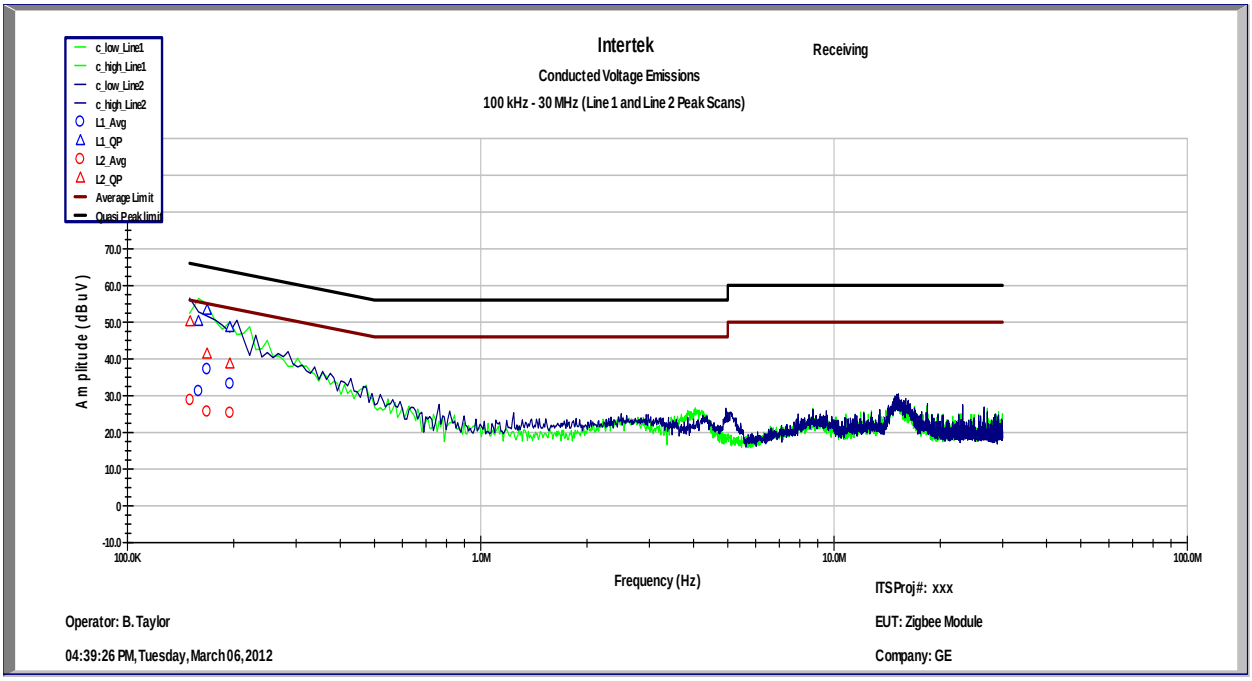
| Description | Serial Number | Manufacturer | Model | Cal. Date | Cal. Due |
|---|---|---|---|---|---|
| EMI Test Receiver | 10887490.26 | Rohde & Schwarz | ESI26 | 6/29/2011 | 6/29/2012 |
| LISN | 1026 | Fischer Custom Communication | FCC-LISN-50-50-2M | 6/16/2011 | 6/16/2012 |

## 10.4 Results:

| Conducted Voltage Emissions on Power Lines | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Test Engineer:** | B. Taylor | **Start Date:** | 3/6/2012 | **End Date:** | 3/6/2012 | | | |
| **Temperature:** | 25.1C | **Humidity:** | 17.20% | **Pressure:** | 998.98mbar | | | |
| **Specification:** | FCC Part 15 | **Test Limit:** | Class B | **RBW:** | 9kHz | | | |
| **Notes:** | Receive Mode | | | | | | | |

| Line | Frequency (MHz) | Quasi-Peak (dBuV) | Quasi-Peak Limit (dBuV) | Quasi-Peak Delta (dB) | Average (dBuV) | Average Limit (dBuV) | Average Delta (dB) | Results |
|---|---|---|---|---|---|---|---|---|
| Line 1 | 159.0 KHz | 50.23 | 65.52 | -15.28 | 31.19 | 55.52 | -24.32 | **Compliant** |
| Line 1 | 168.0 KHz | 53.3 | 65.06 | -11.76 | 37.16 | 55.06 | -17.9 | **Compliant** |
| Line 1 | 195.0 KHz | 48.58 | 63.82 | -15.24 | 33.15 | 53.82 | -20.67 | **Compliant** |
| Line 2 | 150.4 KHz | 50.15 | 65.98 | -15.82 | 28.76 | 55.98 | -27.21 | **Compliant** |
| Line 2 | 168.0 KHz | 41.36 | 65.06 | -23.7 | 25.64 | 55.06 | -29.42 | **Compliant** |
| Line 2 | 195.0 KHz | 38.65 | 63.82 | -25.17 | 25.27 | 53.82 | -28.55 | **Compliant** |

RX Mode
Quasi-Peak and Average Measurements

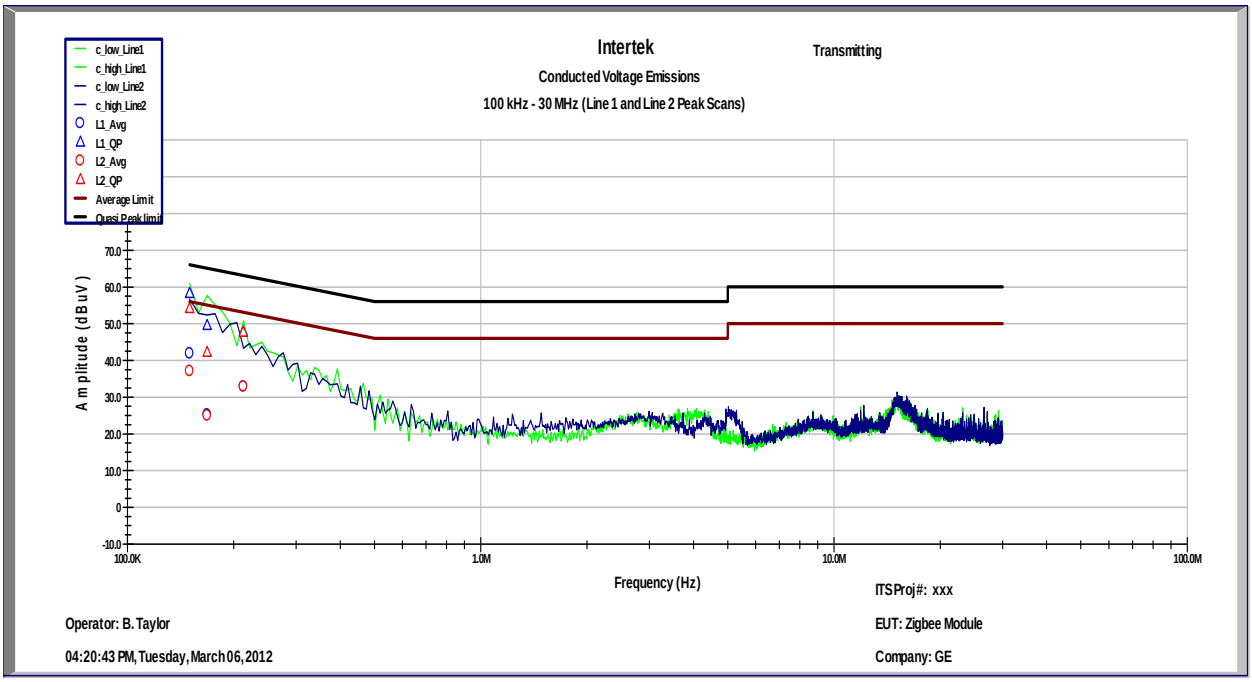



RX Mode
Peak Scan (Line 1 and 2)

| Conducted Voltage Emissions on Power Lines | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Test Engineer:** | Bryan Taylor | **Start Date:** | 3/6/2012 | **End Date:** | 3/6/2012 | | |
| **Temperature:** | 25.1C | **Humidity:** | 17.20% | **Pressure:** | 998.98mbar | | |
| **Specification:** | FCC Part 15 | **Test Limit:** | Class B | **RBW:** | 9kHz | | |
| **Notes:** | Transmitting on Middle Channel | | | | | | |

| Line | Frequency (MHz) | Quasi-Peak (dBuV) | Quasi-Peak Limit (dBuV) | Quasi-Peak Delta (dB) | Average (dBuV) | Average Limit (dBuV) | Average Delta (dB) | Results |
|---|---|---|---|---|---|---|---|---|
| Line 1 | 150.0 KHz | 58.23 | 66 | -7.77 | 41.85 | 56 | -14.15 | **Compliant** |
| Line 1 | 168.2 KHz | 49.54 | 65.05 | -15.51 | 25.25 | 55.05 | -29.8 | **Compliant** |
| Line 1 | 212.8 KHz | 47.75 | 63.1 | -15.35 | 32.88 | 53.1 | -20.22 | **Compliant** |
| Line 2 | 150.0 KHz | 54.13 | 66 | -11.87 | 37.08 | 56 | -18.92 | **Compliant** |
| Line 2 | 168.2 KHz | 42.21 | 65.05 | -22.84 | 24.92 | 55.05 | -30.13 | **Compliant** |
| Line 2 | 212.8 KHz | 47.75 | 63.1 | -15.35 | 32.88 | 53.1 | -20.22 | **Compliant** |

Transmitting on Middle Channel
Quasi-Peak and Average Measurements




Transmitting on Middle Channel
Peak Scan (Line 1 and 2)

# 11 Antenna Requirement per FCC Part 15.203

## 11.1 Test Limits

**§ 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. This requirement does not apply to carrier current devices or to devices operated under the provisions of §15.211, §15.213, §15.217, §15.219, or §15.221. Further, this requirement does not apply to intentional radiators that must be professionally installed, such as perimeter protection systems and some field disturbance sensors, or to other intentional radiators which, in accordance with §15.31(d), must be measured at the installation site. However, the installer shall be responsible for ensuring that the proper antenna is employed so that the limits in this part are not exceeded.

## 11.2 Results:

The sample tested met the antenna requirement. The antenna utilized a PCB antenna that was not detachable.

## 12 Duty Cycle Correction Factor Determination

The worst case duty cycle over a 100ms windows was calculated by the manufacture to determine the duty cycle factor.

Goal: Calculate the worse case time a ZigBee Node will be in TX Mode in any 100ms Time Window.
Correction Factor is: 20*Log10(Duty Cycle)

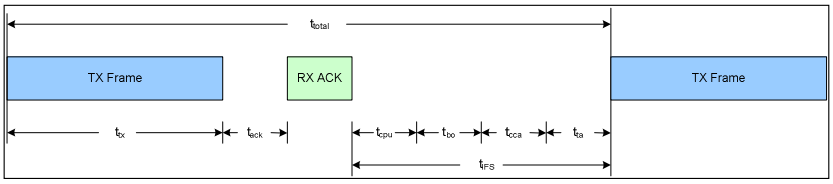
Procedure: In order to calculate the worse case TX on time, Ember started by reviewing the IEEE 802.15.4 MAC and PHY constants. In addition, Ember used the slotted ACK LIFS and SIFS scenarios. Each scenario is described below.

Worst Case Scenario: The worst case scenario utilizes LIFS, and a TX, RX ACK, TX, RX ACK… from a single node. It has been proven through calculation, this scenario keeps the node in TX Mode for the longest

***Summary:*** ***If you are using EmberZNet Stack SW, the TX duty cycle: 66%***

***IEEE 802.15.4-2003 2.4 GHz PHY Constants***

| | | | |
|---|---|---|---|
| Data Rate | 250000 | bits / sec | |
| | 31250 | bytes / sec | |
| Symbols/byte | 2 | sym / bytes | |
| Symbol Timing | 62500 | sym / sec | |
| | 0.000016 | sec / sym | |
| Byte Timing | 0.000032 | sec / byte | |
| | | | |
| PHY PSDU | 6 | bytes | 4 Pramble, SPD, Length |
| Max Length | 127 | bytes | |
| Total Packet Length | 133 | bytes | |
| Maximum Time TX PKT | 0.004256 | sec | |




***Long Frame Scenario:***
1) TX Frame — Assume Frame is Data Frame
2) Wait for ACK
3) RX ACK
4) CPU Processing of ACK
5) Wait for Backoff
6) Repeat 1)

**MAC-Level Calculation (LIFS)**

| **Long InterFrame Spacing (Slotted w/ ACK)** | | | |
|---|---|---|---|
| Long Frame | 127 | bytes | |
| Data Frame Payload | 102 | bytes | |
| ACK Frame | 5 | bytes | |
| tack | 12 | sym | |
| LIFS | 40 | sym | |
| Backoff Period | 20 | sym | |
| Maximum Backoff | 7 | | Random between 0 and 7 |
| Backoff Required | 2 | | |
| Backoff Time | 70 | sym | Average at 3.5 |

| ***Transmit Time*** | |
|---|---|
| TX Time (Packet) | 0.004256 |
| Total TX Time (sec) | 0.004256 |

| ***NOT Transmit time (RX or Idle)*** | | |
|---|---|---|
| Wait for ACK (tack) | 0.000192 | |
| RX Time (ACK) | 0.000352 | |
| Backoff Time (tbo) | 0.00112 | (Backoff Time * Backoff Period) |
| CPU Processing (tcpu) | 0.0002 | (0.2ms average on EM2xx running EmberZNet) |
| CCA Assessment (tcca) | 0.000128 | (averaged over 8 symbols in RX Mode) |
| Turn Around Time (RX to TX) | 0.000192 | (After CCA, Radio turns over to TX in 12 symbols) |
| Total Off Time (sec) | 0.002184 | |

| | |
|---|---|
| Total Time (ttotal) | 0.00644 |
| Number of RX / TX cycles in 100ms | 15.5279503 |

Worse Case (100ms window)

| | |
|---|---|
| TX Frame 10 times | 0.04256 |
| RX or IDLE 10 Times | 0.02184 |
| Sum | 0.0644 |

| | | | |
|---|---|---|---|
| **MAC TX Duty Cycle (On /total)** | 66.09% | | Represents theoretical ZigBee / MAC performance |
| | 3.59768496 | dB | |

## 13 Measurement Uncertainty

The measured value related to the corresponding limit will be used to decide whether the equipment meets the requirements.

The measurement uncertainty figures were calculated and correspond to a coverage factor of k = 2, providing a confidence level of respectively 95.45 % in the case where the distributions characterizing the actual measurement uncertainties are normal (Gaussian).

Measurement uncertainty Table

| Parameter | Uncertainty | Notes |
|---|---|---|
| Radiated emissions, 30 to 1000 MHz | ±3.9dB | |
| Radiated emissions, 1 to 18 GHz | ±4.2dB | |
| Radiated emissions, 18 to 40 GHz | ±4.3dB | |
| Power Port Conducted emissions, 150kHz to 30 MHz | ±2.8dB | |

## 14 Revision History

| Revision Level | Date | Report Number | Notes |
|---|---|---|---|
| 0 | 4/26/2012 | 100659649LEX-001 | Original Issue |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |