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Measured Radio Frequency Emissions
From

# Think Wireless SDARS Downconverter-Transceiver Model(s): SIRWRS1

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**Summary**

Tests for compliance with FCC Regulations Part 15, Subpart C, and Industry Canada RSS-210/GEN, were performed on Think Wireless SDARS Downconverter-Transceiver.

In testing completed on March 12, 2007, the device tested met fundamental emission limits by more than 2.5 dB, band edge limits by more than 3.0 dB, and harmonic limits by more than 12.9 dB. Radiated Spurious meet the FCC/IC Class B limit by more than 4.4 dB. AC power line conducted emissions meet the FCC/IC Class B limit by more than 2.3 dB.

## 1. Introduction

Think Wireless SDARS Downconverter-Transceiver was tested for compliance with FCC Regulations, Part 15, adopted under Docket 87-389, April 18, 1989 as amended, and with Industry Canada RSS-210/Gen, Issue 6, September 2005. The tests were performed at the University of Michigan Radiation Laboratory Willow Run Test Range following the procedures described in ANSI C63.4-2003 "Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz" and the document, "FCC Regulatory Requirements for Design and Sale of SDARS In-Home Repeater v.2.3" The Site description and attenuation characteristics of the Open Site facility are on file with FCC Laboratory, Columbia, Maryland (FCC Reg. No: 91050) and with Industry Canada, Ottawa, ON (File Ref. No: IC 2057).

## 2. Test Equipment Used

The pertinent test equipment commonly used in our facility for measurements is listed in Table 2.1 below. The middle column identifies the specific equipment used in these tests.

**Table 2.1 Test Equipment.**

| Test Instrument | Eqpt. Used | Manufacturer/Model |
|---|---|---|
| Spectrum Analyzer (9kHz-22GHz) | X | Hewlett-Packard 8593A SN: 3107A01358 |
| Spectrum Analyzer (9kHz-26GHz) | X | Hewlett-Packard 8593E, SN: 3412A01131 |
| Spectrum Analyzer (9kHz-26GHz) | | Hewlett-Packard 8563E, SN: 3310A01174 |
| Spectrum Analyzer (9kHz-40GHz) | | Hewlett-Packard 8564E, SN: 3745A01031 |
| Power Meter | | Hewlett-Packard, 432A |
| Power Meter | | Anritsu, ML4803A/MP |
| Harmonic Mixer (26-40 GHz) | | Hewlett-Packard 11970A, SN: 3003A08327 |
| Harmonic Mixer (40-60 GHz) | | Hewlett-Packard 11970U, SN: 2332A00500 |
| Harmonic Mixer (75-110 GHz) | | Hewlett-Packard 11970W, SN: 2521A00179 |
| Harmonic Mixer (140-220 GHz) | | Pacific Millimeter Prod., GMA, SN: 26 |
| S-Band Std. Gain Horn | | S/A, Model SGH-2.6 |
| C-Band Std. Gain Horn | X | University of Michigan, NRL design |
| XN-Band Std. Gain Horn | X | University of Michigan, NRL design |
| X-Band Std. Gain Horn | | S/A, Model 12-8.2 |
| X-band horn (8.2- 12.4 GHz) | X | Narda 640 |
| K-band horn (18-26.5 GHz) | | FXR, Inc., K638KF |
| Ka-band horn (26.5-40 GHz) | | FXR, Inc., U638A |
| U-band horn (40-60 GHz) | | Custom Microwave, HO19 |
| W-band horn(75-110 GHz) | | Custom Microwave, HO10 |
| G-band horn (140-220 GHz) | | Custom Microwave, HO5R |
| Bicone Antenna (30-250 MHz) | X | University of Michigan, RLBC-1 |
| Bicone Antenna (200-1000 MHz) | X | University of Michigan, RLBC-2 |
| Dipole Antenna Set (30-1000 MHz) | X | University of Michigan, RLDP-1,-2,-3 |
| Dipole Antenna Set (30-1000 MHz) | | EMCO 2131C, SN: 992 |
| Active Rod Antenna (30 Hz-50 MHz) | | EMCO 3301B, SN: 3223 |
| Active Loop Antenna (30 Hz-50 MHz) | | EMCO 6502, SN:2855 |
| Ridge-horn Antenna (300-5000 MHz) | X | University of Michigan |
| Amplifier (5-1000 MHz) | X | Avantak, A11-1, A25-1S |
| Amplifier (5-4500 MHz) | X | Avantak |
| Amplifier (4.5-13 GHz) | | Avantek, AFT-12665 |
| Amplifier (6-16 GHz) | | Trek |
| Amplifier (16-26 GHz) | | Avantek |
| LISN Box | X | University of Michigan |
| Signal Generator | | Hewlett-Packard 8657B |
| Vector Signal Generator | X | Inovationszentrum GmbH DSG-2000 |

## 3. Configuration and Identification of Device Under Test

The Device Under Test (DUT) is a 902-928 MHz Downconverter-Transceiver. The device directly translates Satellite signals in the SDARS band (centered at 2332.5 MHz) to 921.267 MHz, utilizing the 902-928 MHz ISM band. The size of the DUT is 5(W) x 3.5(H) x 1/2(D) inches. During testing, a signal generator capable of both XM and SIRIUS satellite radio simulation was used to excite the DUT per the specified test procedure (see Section 5 of this report). Nominal operating voltage is 120 VAC.

The DUT was manufactured by Think Wireless, Inc., 6188 NW 62nd Terrace, Parkland, FL 33067. It is identified as:

Think SDARS Downconverter-Transceiver
Model(s): SIRWRS1
FCC ID: UX3TWISIRWRS1

### 3.1 Changes Made to the DUT

No changes where made to the DUT by this test laboratory. However, after the first full round of testing the DUT was returned to the manufacturer due to component supply issues, resulting in a change in pass-band filter sourcing. Additionally, after the first round of testing the manufacturer elected to change the power adapter used. The updated product (with new power adapter) was retested, and is detailed by the data herein.

## 4. Emission Limits

### 4.1 Radiated Emission Limits (FCC 15.249, 15.209; IC RSS-210e:A2.9)

The DUT tested is a 902-928 MHz ISM band transmitter, subject to FCC 15.249, and all other sections referred to therein. The applicable critical testing frequencies with corresponding emission limits are given in Tables 4.1 and 4.2.

Table 4.1. Radiated Emission Limits (Ref: FCC: 15.249; IC: RSS-210e A2.9)

| Frequency (MHz) | Field Strength of Fundamental (mV/m) | Field Strength of Harmonics (μV/m) |
|---|---|---|
| 902 - 928 | 50 | 500 |

1) Field strength limits are specified at a distance of 3 meters.
2) Emissions radiated outside of the specified frequency bands, except for harmonics, shall be attenuated by at least 50 dB below the level of the fundamental or to the general radiated emission limits in Section 15.209 (Class B), whichever is the lesser attenuation.
3) Peak field strength of any emission above 1GHz shall not exceed the maximum permitted average limits specified above by more than 20 dB under any condition of modulation.

Table 4.2. Radiated Emission Limits
(FCC: 15.33, 15.35, 15.109/15.209; IC: RSS-210e, 2.7 Table 2)

| Freq. (MHz) | Class A, $E_{lim}$ dB(μV/m) | Class B, $E_{lim}$ dB(μV/m) |
|---|---|---|
| 30-88 | 49.5 | 40.0 |
| 88-216 | 54.0 | 43.5 |
| 216-960 | 56.9 | 46.0 |
| Above 960 | 60.0 | 54.0 |

Note: Average readings apply above 1000 MHz (1 MHz BW)
Quasi-Peak readings apply up to 1000 MHz (120 kHz BW)

## 4.2 Conducted Emission Limits (FCC 15.107)

Table 4.3. Conducted emission limits (FCC 15.107; IC RSS-Gen 7.2.2 Table 2 (CISPR)).

| Frequency | Class A (dBμV) | | Class B (dBμV) | |
|---|---|---|---|---|
| MHz | μV | dBμV | μV | dBμV |
| 0.150 - 0.50 | 79 | 66 | 66 - 56* | 56 - 46* |
| 0.50 - 5 | 73 | 60 | 56 | 46 |
| 5 - 30 | 73 | 60 | 60 | 50 |

Notes: 1. The lower limit shall apply at the transition frequency
2. The limit decreases linearly with the logarithm of the frequency in the range 0.15-0.50MHz:
*Class B Quasi-peak: dBμV = 50.25 - 19.12*log( f )
*Class B Average: dBμV = 40.25 - 19.12*log( f )
3. 9 kHz RBW

## 4.3 DUT Stimulus

Since the DUT acts as a downconverter - transceiver, the appropriate input stimulus under which the DUT must meet the above emission limits must be well defined. These stimuli have been specified in the document *"[1]FCC Regulatory Requirements For Design and Sale of SDARS In-Home Repeater v.2.3"* for both the XM and SIRIUS bands, and are outlined in this section.

### 4.3.1 Required Test Stimuli

This section outlines the test stimulus agreed to by the FCC in [1]. The full set of modulation schemes below were tested as proscribed in [1], but are adjusted for the operating specifics of the radio system in question [2]. As in previous filings, it was determined that a reduced test set, using only high, middle, and low input power settings for each mode was sufficient to demonstrate compliance.

*Base Stimulus:*
Base Satellite signal: Input power @ transmitter input: -63 dBm.
Modulation: QPSK
Bandwidth: 4.2 MHz
Frequency: 2322.293 MHz (translates to 911.063 MHz)

*Sirius Satellite Stimulus:*
Satellite signal: Input power @ transmitter input: -57 to –77 dBm in 10 dB increments.
Modulation: QPSK
Bandwidth: 4.2 MHz
Frequencies: Test @ 2322.293 MHz and 2330.207, (translates to 911.063 and 918.977 MHz)

*XM Satellite Stimulus:*
Satellite signal: Input power @ transmitter input: -52 to –72 dBm in 5 dB increments.
Modulation: QPSK
Bandwidth: 3.8 MHz
Frequency: Test @ 2333.465 MHz and 2335.305 MHz (translates to 922.235 and 924.075 MHz)
(NOTE: Base stimulus also present)

*Sirius Terrestrial Stimulus:*
Terrestrial signal: Input @ transmitter input: -17 to –67 dBm in 20 dB increments.
Modulation: OFDM (DQPSK carriers)
Bandwidth: 4.096 MHz
Frequency: Test @ 2326.250 MHz (translates to 915.02 MHz)

*XM Terrestrial Stimulus:*
Terrestrial signal: Input @ transmitter input: -17 dBm.
Modulation: OFDM (DQPSK carriers)
Bandwidth: 4.96 MHz
Frequency: Test @ 2337.490 MHz and 2340.020 MHz (translates to 926.26 and 928.79 MHz)
(NOTE: Base stimulus also present, XM terrestrial signal is no in pass-band of DUT)

*Single-Tone Spur Stimulus:*
Single-Tone Sweep: -75.6 dBm, swept 2312-2352 MHz in 1 MHz increments (trans. to 900-940 MHz)
(Note: Base stimulus also present).

### 4.4 Input Signal Discrimination Requirement

The FCC and IC have agreed [1,3] that the DUT is not required to determine if a signal is valid prior to downconversion and transmission because the input spectrum being repeated resides in the restricted (SDARS) band. However, the design must meet the emissions limits when energy other than the desired signal exists at the input, as dictated in the test procedure.

### 4.5 Supply Voltage Variation

For intentional radiators, measurements of the variation of the input power or the radiated signal level of the fundamental frequency component of the emission, as appropriate, shall be performed with the supply voltage varied between 85% and 115% of the nominal rated supply voltage. For battery operated equipment, the equipment tests shall be performed using a new battery.

## 5. Test Procedure and Computations

The following table summarizes the test scenarios and their respective input test stimuli reported.

Table 5.1 Table of Radiated Test Stimuli [1-2]

| Test Scenario | Stimuli |
|---|---|
| (5.1) | Base Stimulus: -63 dBm @ 2223.293 MHz (SIR Satellite QPSK) |
| (5.2A) | SIR Sat. Stim.: -57 to -77 dBm @ 2223.293 MHz QPSK |
| (5.2B) | SIR Sat. Stim.: -57 to -77 dBm @ 2330.207 MHz QPSK |
| (5.3) | XM Sat. Stim.: -52 to -72 dBm @ 2333.465 MHz & 2335.305 MHz, QPSK (inc. (5.1)) |
| (5.4) | SIR Terr. Stim.: -17 to -67 dBm @ 2326.250 MHz, OFDM |
| (5.5) | XM Terr. Stim.: -17 dBm @ 2337.49 MHz & 2340.020 MHz, OFDM (inc. (5.1)) |
| (5.6) | Single Tone Spur: -81.6 dBm @ 2312 to 2352 MHz (inc. (5.1)) |

### 5.1 Test Procedure: General

Prior to any measurements, all active components of the test setup were allowed a warm-up for a period of approximately one hour, or as recommended by their manufacturers.

### 5.2 Test Procedure: Radiated Emissions

#### 5.2.1 Semi-anechoic Chamber Measurements

To familiarize with the radiated emission behavior of the DUT, the DUT was first studied and measured in a shielded anechoic chamber. In the chamber there is a set-up similar to that of an outdoor 3-meter site, with a turntable, an antenna mast, and a ground plane. Instrumentation includes spectrum analyzers and other equipment as needed.

In testing for radiated emissions, the DUT was stimulated as mentioned in the previous section. It was placed on the test table flat, on its side, or on its end. In the chamber we studied and recorded all the emissions using a Bicone antenna up to 300 MHz and ridged horn and standard gain horn antennas above 300 MHz. The measurements made in the chamber below 1 GHz are used for pre-test evaluation only. The measurements made above 1 GHz are used in pre-test evaluation and in the final compliance assessment. Photographs included in this filing show the indoor testing of the DUT.

Note 1: For the horn antenna, the antenna pattern is more directive and hence the measurement is essentially that of free space (no ground reflection). Consequently it is not essential to measure the DUT for both antenna polarizations, as long as the DUT is measured on all three of its major axis. In the chamber we also recorded the spectrum and modulation characteristics of the carrier. These data are presented in subsequent sections. As a general procedure, emissions are first tested using a peak detector. If the DUT does not meet the quasi-peak (or average) limits via these measurements, quasi-peak (or average) measurements are then made to demonstrate compliance.

Note 2: In order to meet the output power limits for all input signals (from the Sirius home antenna), the repeater transmitter uses active gain control (AGC) to limit the output power to the antenna. Rather than adjusting the bias condition for amplifiers, the AGC feedback loop uses attenuators. Therefore, the bias condition of each amplifier does not depend upon the input signal conditions. It follows that the maximum power (and harmonic levels) from the final amplifier occur when the input signal is maximized nearby the Sirius terrestrial repeaters. This was verified in pretesting, and thus worst case harmonic emissions are reported for testing under the highest level (5.4) Sirius terrestrial stimuli.

#### 5.2.2 Open Area Test Site (OATS) Measurements

After the chamber measurements, emissions were re-measured on the outdoor 3-meter site at fundamental and harmonics up to 1 GHz using tuned dipoles and/or the high frequency Bicone. Photographs included in this filing show the DUT on the Open Area Test Site (OATS).

### 5.2.3 Field Computations

To convert the dBm measured to E(dBμV/m) at the test receiver antenna, E(dBμV/m) is computed from

$$E(dB\mu V/m) = 107\ dB + Pr(R_{meas})(dBm) + K_a - Kg$$

or

$$E(dB\mu V/m) = Pr(R_{meas})(dB\mu V) + K_a - Kg$$

Where $P_r$ = power recorded on spectrum analyzer at the distance $R_{meas}$, dBm or dBμV
$K_a$ = antenna factor, dB/m
$K_g$ = pre-amp gain and/or cable loss, dB

When presenting the data, the highest measured emission at each frequency under all of the possible orientations is given.

### 5.3 Test Procedure: Conducted Emissions

The DUT is powered from a standard 120 VAC line via a transformer. No change in conducted emissions was observed for different operating modes. The results demonstrate emissions from the DUT operating under test stimuli (5.4).

## 6. Measurement Results

### 6.1 Digital Radiated Emissions

Table 6.1. Spurious Radiated Emissions 30 MHz to 1000 MHz. RBW = 120 kHz, VBW>RBW. DUT meets FCC/IC Class B spurious emissions limits by more than 4.2 dB. Note that in indoor pre-testing (up to 2.9 GHz), there were no significant spurious emissions observed. See Figure 6.1

### 6.2 Radiated Emissions – Peak to Average Ratio

Figure 6.2-6.3. Peak to Average Ratio (only worst case plots provided). Measurement distance is 3 m. The DUT demonstrates a quasi-peak to average ratio (f < 1000 MHz) of no less than 4.4 dB and a peak to average emissions ratio (f > 1000 MHz) of no more than 12.9 dB for all modes tested.

Table 6.2 Worst Case QPk and Avg. Values Relative to Pk.

| Test Scenario | Quasi-Peak (dB) | Average (dB) |
|---|---|---|
| 5.1 | -4.4 | -10.8 |
| 5.2 A | -5.8 | -12.3 |
| 5.2 B | -5.5 | -12.9 |
| 5.3 | -4.9 | -11.4 |
| 5.4 | -5.3 | -12.0 |
| 5.5 | -5.5 | -11.9 |
| 5.6 | 0.0 (CW Spur) | 0.0 (CW Spur) |

**6.3 Radiated Emissions – Fundamental and Band Edges**
Figures 6.4-6.10. Fundamental and Band Edge Radiated Emissions: 902 – 928 MHz (only the worst case plot for each type of stimuli is provided). 120 kHz RBW, VBW > RBW for f < 1 GHz, 1 MHz RBW, VBW>RBW for f > 1 GHz; measurement distance is 3 m. (Pk > QPk where applicable. Limits are Quasi-Peak Limits) Data is reported in Table 6.2. For Peak field strength measurements, the DUT meets the fundamental emissions limits by more than 2.5 dB, and the band edge emissions limits by more than 3.0 dB in the worst case.

**6.4 Radiated Emissions - Harmonics**
Figure 6.3. Harmonic Radiated Emissions: 1 MHz RBW, VBW>RBW; measurement distance is 3 m. (Pk > QPk > Avg, where applicable. Limits are Average Limits) All emissions reported in Table 6.2(c). The DUT meets the harmonic emissions limits by 12.9 dB in the worst case.

**6.5 Conducted Emissions**
Figures 6.11-6.14. Worst case conducted emissions. 9 kHz RBW, VBW > RBW. The DUT meets conducted emissions limits by more than 2.3 dB in the worst case. All emissions reported in Table 6.3.

**6.6 Effect of Supply Voltage Variation**
The DUT is designed to operate on 120 VAC. The relative radiated emissions and frequency were recorded at the fundamental as the supply voltage was varied from 85 to 135 VAC. Figure 6.15 shows the emission power variation. Current at 120.0 VAC was 24.4 mA.

**Table 6.3(a) 15.249 (902-928 MHz ISM Band)**

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Radiated Emissions** | | | | | | | | | | | Think SDARS; FCC/IC |
| # | Freq. MHz | Ant. Used | Ant. Pol. | Pr. dBm | Det. Used | Ka dB/m | Kg dB | E3 dBμV/m | E3lim dBμV/m | Pass* dB | Comments |
| | **(5.1) Sirius Base Stimulus: -63 dBm @ 2323.293 MHz QPSK** | | | | | | | | | | |
| 1 | 911.9 | Dip | H/V | -28.3 | Pk | 28.4 | 17.0 | 90.1 | 94.0 | **3.8** | |
| 2 | 900.9 | Dip | H/V | -77.4 | Pk | 28.3 | 17.1 | 40.8 | 46.0 | 5.2 | lower band edge |
| 3 | 929.2 | Dip | H/V | -77.7 | Pk | 28.6 | 16.9 | 41.0 | 46.0 | 5.0 | upper band edge |
| 4 | | | | | | | | | | | |
| 5 | | | | | | | | | | | |
| | **(5.2A) Sirius Sat. Stimulus: -57 dBm @ 2323.293 MHz QPSK** | | | | | | | | | | |
| 5 | 911.1 | Dip | H/V | -28.9 | Pk | 28.4 | 17.0 | 89.5 | 94.0 | 4.4 | |
| 6 | 901.4 | Dip | H/V | -77.4 | Pk | 28.3 | 17.1 | 40.8 | 46.0 | 5.2 | lower band edge |
| 7 | 930.1 | Dip | H/V | -77.7 | Pk | 28.7 | 16.9 | 41.0 | 46.0 | 5.0 | upper band edge |
| 8 | | | | | | | | | | | |
| | **(5.2A) Sirius Sat. Stimulus: -67 dBm @ 2323.293 MHz QPSK** | | | | | | | | | | |
| 9 | 910.4 | Dip | H/V | -28.1 | Pk | 28.4 | 17.0 | 90.2 | 94.0 | **3.7** | |
| 10 | 901.6 | Dip | H/V | -77.1 | Pk | 28.3 | 17.1 | 41.1 | 46.0 | 4.9 | lower band edge |
| 11 | 928.7 | Dip | H/V | -77.9 | Pk | 28.6 | 16.9 | 40.8 | 46.0 | 5.2 | upper band edge |
| 12 | | | | | | | | | | | |
| | **(5.2A) Sirius Sat. Stimulus: -77 dBm @ 2323.293 MHz QPSK** | | | | | | | | | | |
| 13 | 910.9 | Dip | H/V | -31.4 | Pk | 28.4 | 17.0 | 87.0 | 94.0 | 6.9 | |
| 14 | 902.0 | Dip | H/V | -77.3 | Pk | 28.3 | 17.1 | 40.9 | 46.0 | 5.1 | lower band edge |
| 15 | 929.0 | Dip | H/V | -77.6 | Pk | 28.6 | 16.9 | 41.1 | 46.0 | 4.9 | upper band edge |
| 16 | | | | | | | | | | | |
| 17 | | | | | | | | | | | |
| 18 | | | | | | | | | | | |
| | **(5.2B) Sirius Sat. Stimulus: -57 dBm @ 2330.207 MHz QPSK** | | | | | | | | | | |
| 19 | 917.9 | Dip | H/V | -30.9 | Pk | 28.5 | 17.0 | 87.6 | 94.0 | 6.4 | |
| 20 | 901.0 | Dip | H/V | -77.4 | Pk | 28.3 | 17.1 | 40.8 | 46.0 | 5.2 | lower band edge |
| 21 | 929.2 | Dip | H/V | -78.0 | Pk | 28.6 | 16.9 | 40.7 | 46.0 | 5.3 | upper band edge |
| 22 | | | | | | | | | | | |
| | **(5.2B) Sirius Sat. Stimulus: -67 dBm @ 2330.207 MHz QPSK** | | | | | | | | | | |
| 23 | 917.2 | Dip | H/V | -29.2 | Pk | 28.5 | 17.0 | 89.3 | 94.0 | **4.7** | |
| 24 | 902.0 | Dip | H/V | -77.3 | Pk | 28.3 | 17.1 | 40.9 | 46.0 | 5.1 | lower band edge |
| 25 | 928.2 | Dip | H/V | -78.0 | Pk | 28.6 | 16.9 | 40.7 | 46.0 | 5.3 | upper band edge |
| 26 | | | | | | | | | | | |
| | **(5.2B) Sirius Sat. Stimulus: -77 dBm @ 2330.207 MHz QPSK** | | | | | | | | | | |
| 27 | 916.9 | Dip | H/V | -30.5 | Pk | 28.5 | 17.0 | 88.0 | 94.0 | 6.0 | |
| 28 | 901.4 | Dip | H/V | -77.0 | Pk | 28.3 | 17.1 | 41.2 | 46.0 | 4.8 | lower band edge |
| 29 | 929.0 | Dip | H/V | -78.4 | Pk | 28.6 | 16.9 | 40.3 | 46.0 | 5.7 | upper band edge |
| 31 | | | | | | | | | | | |
| 32 | | | | | | | | | | | |
| 31 | | | | | | | | | | | |
| 34 | | | | | | | | | | | |
| 35 | | | | | | | | | | | |
| 36 | | | | | | | | | | | |
| 37 | | | | | | | | | | | |

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**Table 6.3(b) 15.249 (915 MHz ISM Band)**

| Radiated Emissions | | | | | | | | | | | Think SDARS; FCC/IC |
|---|---|---|---|---|---|---|---|---|---|---|---|
| # | Freq. MHz | Ant. Used | Ant. Pol. | Pr. dBuV | Det. Used | Ka dB/m | Kg dB | E3 dBμV/m | E3lim dBμV/m | Pass* dB | Comments |
| **(5.3) XM Sat. Stimulus: -52 dBm @ 2333.465 MHz & 2335.305 MHz (including (5.1))** | | | | | | | | | | | |
| 1 | 921.3 | Dip | H/V | -28.4 | Pk | 28.6 | 17.0 | 90.2 | 94.0 | **3.8** | |
| 2 | 901.5 | Dip | H/V | -78.0 | Pk | 28.3 | 17.1 | 40.2 | 46.0 | 5.8 | lower band edge |
| 3 | 929.4 | Dip | H/V | -77.1 | Pk | 28.6 | 16.9 | 41.6 | 46.0 | 4.4 | upper band edge |
| 4 | | | | | | | | | | | |
| 5 | | | | | | | | | | | |
| **(5.3) XM Sat. Stimulus: -62 dBm @ 2333.465 MHz & 2335.305 MHz (including (5.1))** | | | | | | | | | | | |
| 6 | 921.0 | Dip | H/V | -30.0 | Pk | 28.5 | 17.0 | 88.6 | 94.0 | 5.4 | |
| 7 | 900.1 | Dip | H/V | -76.4 | Pk | 28.3 | 17.1 | 41.8 | 46.0 | 4.2 | lower band edge |
| 8 | 928.2 | Dip | H/V | -77.7 | Pk | 28.6 | 16.9 | 41.0 | 46.0 | 5.0 | upper band edge |
| 9 | | | | | | | | | | | |
| 10 | | | | | | | | | | | |
| **(5.3) XM Sat. Stimulus: -72 dBm @ 2333.465 MHz & 2335.305 MHz (including (5.1))** | | | | | | | | | | | |
| 11 | 920.3 | Dip | H/V | -29.4 | Pk | 28.5 | 17.0 | 89.2 | 94.0 | 4.8 | |
| 12 | 901.2 | Dip | H/V | -76.5 | Pk | 28.3 | 17.1 | 41.7 | 46.0 | 4.3 | lower band edge |
| 13 | 929.1 | Dip | H/V | -77.5 | Pk | 28.6 | 16.9 | 41.2 | 46.0 | 4.8 | upper band edge |
| 14 | | | | | | | | | | | |
| 15 | | | | | | | | | | | |
| **(5.4) SIR Terrestrial: -17 dBm @ 2326.250 MHz OFDM** | | | | | | | | | | | |
| 16 | 917.0 | Dip | H/V | -29.3 | Pk | 28.5 | 17.0 | 89.2 | 94.0 | 4.8 | |
| 17 | 902.0 | Dip | H/V | -77.6 | Pk | 28.3 | 17.1 | 40.6 | 46.0 | 5.4 | lower band edge |
| 18 | 929.5 | Dip | H/V | -77.7 | Pk | 28.6 | 16.9 | 41.0 | 46.0 | 5.0 | upper band edge |
| 19 | | | | | | | | | | | |
| 20 | | | | | | | | | | | |
| **(5.4) SIR Terrestrial: -42 dBm @ 2326.250 MHz OFDM** | | | | | | | | | | | |
| 21 | 915.2 | Dip | H/V | -27.0 | Pk | 28.5 | 17.0 | 91.5 | 94.0 | **2.5** | |
| 22 | 902.0 | Dip | H/V | -77.3 | Pk | 28.3 | 17.1 | 40.9 | 46.0 | 5.1 | lower band edge |
| 23 | 928.5 | Dip | H/V | -78.1 | Pk | 28.6 | 16.9 | 40.6 | 46.0 | 5.4 | upper band edge |
| 24 | | | | | | | | | | | |
| 25 | | | | | | | | | | | |
| **(5.4) SIR Terrestrial: -67 dBm @ 2326.250 MHz OFDM** | | | | | | | | | | | |
| 26 | 915.8 | R-Horn | H/V | -35.9 | Pk | 19.1 | 0.0 | 90.2 | 94.0 | 3.8 | |
| 27 | 901.2 | R-Horn | H/V | -84.9 | Pk | 19.0 | 0.0 | 41.1 | 46.0 | 4.9 | lower band edge |
| 28 | 929.9 | R-Horn | H/V | -85.2 | Pk | 19.1 | 0.0 | 40.9 | 46.0 | 5.1 | upper band edge |
| 29 | | | | | | | | | | | |
| 30 | | | | | | | | | | | |
| 31 | | | | | | | | | | | |
| 32 | | | | | | | | | | | |
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| 36 | | | | | | | | | | | |

U. of Mich; Meas. 02/27/2007

**Table 6.3(c) 15.249 (915 MHz ISM Band)**

| | | | | **Radiated Emissions** | | | | | | | Think SDARS; FCC/IC |
|---|---|---|---|---|---|---|---|---|---|---|---|
| # | Freq. MHz | Ant. Used | Ant. Pol. | Pr. dBuV | Det. Used | Ka dB/m | Kg dB | E3 dBµV/m | E3lim dBµV/m | Pass* dB | Comments |
| | **(5.5) XM Terrestrial: -17 dBm @ 2337.49 MHz & 2340.020 MHz OFDM (including (5.1))** | | | | | | | | | | |
| 1 | 925.2 | Dip | H/V | -27.2 | Pk | 28.6 | 17.0 | 91.4 | 94.0 | **2.6** | |
| 2 | 901.7 | Dip | H/V | -77.8 | Pk | 28.3 | 17.1 | 40.4 | 46.0 | 5.6 | lower band edge |
| 3 | 928.9 | Dip | H/V | -75.7 | Pk | 28.6 | 16.9 | 43.0 | 46.0 | 3.0 | upper band edge |
| 4 | | | | | | | | | | | |
| 5 | | | | | | | | | | | |
| | **(5.6) Single Tone Spur: -75.6 dBm @ 2312 - 2352 MHz x 1MHz (including (5.1))** | | | | | | | | | | |
| 6 | 906.2 | Dip | H/V | -42.4 | Pk | 28.4 | 17.1 | 75.9 | 94.0 | 18.1 | |
| 7 | 907.0 | Dip | H/V | -40.6 | Pk | 28.4 | 17.0 | 77.7 | 94.0 | 16.3 | |
| 8 | 908.1 | Dip | H/V | -39.8 | Pk | 28.4 | 17.0 | 78.5 | 94.0 | 15.5 | |
| 9 | 912.7 | Dip | H/V | -29.5 | Pk | 28.4 | 17.0 | 88.9 | 94.0 | **5.1** | |
| 10 | 913.3 | Dip | H/V | -39.4 | Pk | 28.5 | 17.0 | 79.1 | 94.0 | 14.9 | |
| 11 | 916.0 | Dip | H/V | -39.7 | Pk | 28.5 | 17.0 | 78.8 | 94.0 | 15.2 | |
| 12 | 917.1 | Dip | H/V | -39.9 | Pk | 28.5 | 17.0 | 78.6 | 94.0 | 15.4 | |
| 13 | 918.2 | Dip | H/V | -40.3 | Pk | 28.5 | 17.0 | 78.2 | 94.0 | 15.8 | |
| 14 | 920.0 | Dip | H/V | -40.8 | Pk | 28.5 | 17.0 | 77.8 | 94.0 | 16.2 | |
| 15 | 921.4 | Dip | H/V | -41.5 | Pk | 28.6 | 17.0 | 77.1 | 94.0 | 16.9 | |
| 16 | | | | | | | | | | | |
| 17 | 900.6 | Dip | H/V | -76.2 | Pk | 28.3 | 17.1 | 42.0 | 46.0 | **4.0** | lower band edge |
| 18 | 929.0 | Dip | H/V | -77.7 | Pk | 28.6 | 16.9 | 41.0 | 46.0 | 5.0 | upper band edge |
| 19 | | | | | | | | | | | |
| 20 | | | | | | | | | | | |
| | **Worst Case Harmonics: (5.4) SIR Terrestrial Stimulus @ 2326.250 MHz** | | | | | | | | | | |
| 21 | 1830.0 | Horn RG | H/V | -88.2 | Avg | 22.1 | - 0.2 | 41.1 | 54.0 | **12.9** | noise |
| 22 | 2745.0 | Horn RG | H/V | -71.3 | Avg | 24.8 | 25.8 | 34.7 | 54.0 | 19.3 | noise |
| 23 | 3660.0 | Horn RG | H/V | -71.2 | Avg | 27.5 | 23.8 | 39.5 | 54.0 | 14.5 | noise |
| 24 | 4575.0 | Horn C | H/V | -74.5 | Avg | 24.5 | 34.1 | 23.0 | 54.0 | 31.0 | noise |
| 25 | 5490.0 | Horn C | H/V | -70.5 | Avg | 24.8 | 38.0 | 23.3 | 54.0 | 30.7 | noise |
| 26 | 6405.0 | Horn Xn | H/V | -71.5 | Avg | 24.5 | 38.0 | 22.0 | 54.0 | 32.0 | noise |
| 27 | 7320.0 | Horn Xn | H/V | -70.4 | Avg | 25.2 | 36.8 | 25.0 | 54.0 | 29.0 | noise |
| 28 | 8235.0 | Horn X | H/V | -69.8 | Avg | 27.0 | 36.8 | 27.4 | 54.0 | 26.6 | noise |
| 29 | 9150.0 | Horn X | H/V | -69.1 | Avg | 27.5 | 36.8 | 28.6 | 54.0 | 25.4 | noise |
| 30 | | | | | | | | | | | |
| 31 | Note: | It was determined (as explained in the the test report) that the worst case harmonic emissions | | | | | | | | | |
| 32 | | come during the XM Terrestrial Stimulus (5.4) due to its higher input power level. | | | | | | | | | |
| 33 | | | | | | | | | | | |
| 34 | *AVG measured with RBW = 1 MHz, VBW = 10 kHz. | | | | | | | | | | |
| 35 | | | | | | | | | | | |
| 36 | | | | | | | | | | | |
| 37 | | | | | | | | | | | |
| 38 | | | | | | | | | | | |
| 39 | | | | | | | | | | | |

U. of Mich; Meas. 12/28/2006, 02/27/2007

**Table 6.1  Highest Digital Radiated Emissions Measured**

| | | | | | | | | | | | Think SDARS; FCC/IC B |
|---|---|---|---|---|---|---|---|---|---|---|---|
| # | Freq. MHz | Ant. Used | Ant. Pol. | Pr dBm | Det. Used | Ka dB/m | Kg dB | E3 dBμV/m | E3lim dBμV/m | Pass dB | Comments |
| 1 | 31.7 | Bic | V | -69.4 | Pk | 12.8 | 26.0 | 24.4 | 40.0 | 15.6 | background |
| 2 | 33.3 | Bic | H | -80.6 | Pk | 12.3 | 26.0 | 12.8 | 40.0 | 27.2 | noise |
| 3 | 50.1 | Bic | H | -79.3 | Pk | 9.1 | 25.7 | 11.0 | 40.0 | 29.0 | noise |
| 4 | 80.0 | Bic | H | -71.9 | Pk | 7.6 | 25.3 | 17.4 | 40.0 | 22.6 | noise |
| 5 | 80.0 | Bic | V | -65.4 | Pk | 7.6 | 25.3 | 23.9 | 40.0 | 16.1 | background |
| 6 | 117.6 | Bic | V | -74.9 | Pk | 9.8 | 24.7 | 17.2 | 43.5 | 26.3 | noise |
| 7 | 131.4 | Bic | H | -79.6 | Pk | 11.0 | 24.5 | 13.9 | 43.5 | 29.6 | noise |
| 8 | 172.1 | Bic | V | -78.7 | Pk | 13.8 | 23.9 | 18.3 | 43.5 | 25.2 | noise |
| 9 | 217.4 | Bic | H | -74.9 | Pk | 14.8 | 23.3 | 23.6 | 46.0 | 22.4 | noise |
| 10 | 240.1 | Bic | H | -75.8 | Pk | 14.7 | 23.1 | 22.8 | 46.0 | 23.2 | noise |
| 11 | 250.6 | SBic | H | -80.4 | Pk | 15.6 | 23.0 | 19.2 | 46.0 | 26.8 | noise |
| 12 | 358.1 | SBic | V | -80.1 | Pk | 20.0 | 21.8 | 25.1 | 46.0 | 20.9 | noise |
| 13 | 375.9 | SBic | H | -80.4 | Pk | 20.5 | 21.6 | 25.5 | 46.0 | 20.5 | noise |
| 14 | 442.5 | SBic | V | -81.7 | Pk | 22.1 | 20.9 | 26.5 | 46.0 | 19.5 | noise |
| 15 | 442.5 | SBic | V | -84.6 | Pk | 22.1 | 20.9 | 23.6 | 46.0 | 22.4 | noise |
| 16 | 564.0 | SBic | H | -76.1 | Pk | 24.2 | 19.8 | 35.3 | 46.0 | 10.7 | background |
| 17 | 564.0 | SBic | V | -75.0 | Pk | 24.2 | 19.8 | 36.4 | 46.0 | 9.6 | background |
| 18 | 624.3 | SBic | H | -75.0 | Pk | 25.0 | 19.3 | 37.7 | 46.0 | 8.3 | background |
| 19 | 773.9 | SBic | H | -81.5 | Pk | 27.0 | 18.2 | 34.3 | 46.0 | 11.7 | noise |
| 20 | 787.8 | SBic | V | -78.3 | Pk | 27.2 | 18.1 | 37.8 | 46.0 | 8.2 | background |
| 21 | 1411.0 | Horn RG | H/V | -69.0 | Avg | 39.6 | 28.0 | 49.6 | 54.0 | **4.4** | LO |
| 22 | 1830.0 | Horn RG | H/V | -88.2 | Avg | 22.1 | - 0.2 | 41.1 | 54.0 | 12.9 | noise |
| 23 | 2745.0 | Horn RG | H/V | -71.3 | Avg | 24.8 | 25.8 | 34.7 | 54.0 | 19.3 | noise |
| 24 | 3660.0 | Horn RG | H/V | -71.2 | Avg | 27.5 | 23.8 | 39.5 | 54.0 | 14.5 | noise |
| 25 | 4575.0 | Horn C | H/V | -74.5 | Avg | 24.5 | 34.1 | 23.0 | 54.0 | 31.0 | noise |
| 26 | 5490.0 | Horn C | H/V | -70.5 | Avg | 24.8 | 38.0 | 23.3 | 54.0 | 30.7 | noise |
| 27 | 6405.0 | Horn Xn | H/V | -71.5 | Avg | 24.5 | 38.0 | 22.0 | 54.0 | 32.0 | noise |
| 28 | 7320.0 | Horn Xn | H/V | -70.4 | Avg | 25.2 | 36.8 | 25.0 | 54.0 | 29.0 | noise |
| 29 | 8235.0 | Horn X | H/V | -69.8 | Avg | 27.0 | 36.8 | 27.4 | 54.0 | 26.6 | noise |
| 30 | 9150.0 | Horn X | H/V | -69.1 | Avg | 27.5 | 36.8 | 28.6 | 54.0 | 25.4 | noise |
| 31 | | | | | | | | | | | |
| 32 | | | | | | | | | | | |
| 33 | | | | | | | | | | | |
| 34 | Note: | Worst case emissions measured. No observed change to digital or LO emission | | | | | | | | | |
| 35 | | for different modes of operation. | | | | | | | | | |
| 36 | | | | | | | | | | | |
| 37 | | | | | | | | | | | |
| 38 | | | | | | | | | | | |
| 39 | | | | | | | | | | | |
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| 43 | | | | | | | | | | | |

Meas. 01/03/2007, 3/03/2007; U of Mich.

**Table 6.5 Highest Conducted Emissions Measured**

| | | | | | | | | | | | | Think SDARS; FCC/IC/CISPR B |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Freq. | Line | Peak Det., dBµV | | Pass | QP Det., dBµV | | Pass | Ave. Det., dBµV | | Pass | |
| # | MHz | Side | Vtest | Vlim* | dB* | Vtest | Vlim | dB | Vtest | Vlim | dB | Comments |
| 1 | 0.18 | Lo | 52.3 | 54.6 | **2.3** | | 64.6 | | | 54.6 | | |
| 2 | 0.41 | Lo | 44.6 | 47.6 | 3.0 | | 57.6 | | | 47.6 | | |
| 3 | 0.47 | Lo | 43.5 | 46.5 | 3.0 | | 56.5 | | | 46.5 | | |
| 4 | 0.53 | Lo | 45.4 | 46.0 | 0.6 | 44.1 | 56.0 | 11.9 | 36.9 | 46.0 | 9.1 | |
| 5 | 0.59 | Lo | 43.4 | 46.0 | 2.6 | | 56.0 | | | 46.0 | | |
| 6 | 0.71 | Lo | 44.3 | 46.0 | 1.7 | 42.8 | 56.0 | 13.2 | 35.4 | 46.0 | 10.6 | |
| 7 | 0.71 | Lo | 44.5 | 46.0 | 1.5 | 42.8 | 56.0 | 13.2 | 35.3 | 46.0 | 10.7 | |
| 8 | 0.76 | Lo | 44.7 | 46.0 | 1.3 | 42.8 | 56.0 | 13.2 | 36 | 46.0 | 10.0 | |
| 9 | 0.88 | Lo | 42.4 | 46.0 | 3.6 | | 56.0 | | | 46.0 | | |
| 10 | 1.41 | Lo | 44.3 | 46.0 | 1.7 | 42.1 | 56.0 | 13.9 | 34.8 | 46.0 | 11.2 | |
| 11 | 1.41 | Lo | 44.2 | 46.0 | 1.8 | 41.2 | 56.0 | 14.8 | 33.2 | 46.0 | 12.8 | |
| 12 | 1.47 | Lo | 44.5 | 46.0 | 1.5 | 42.7 | 56.0 | 13.3 | 33.5 | 46.0 | 12.5 | |
| 13 | 3.12 | Lo | 42.1 | 46.0 | 3.9 | | 56.0 | | | 46.0 | | |
| 14 | 4.59 | Lo | 36.5 | 46.0 | 9.5 | | 56.0 | | | 46.0 | | |
| 15 | 14.53 | Lo | 43.6 | 50.0 | 6.4 | | 60.0 | | | 50.0 | | |
| 16 | 25.59 | Lo | 36.9 | 50.0 | 13.1 | | 60.0 | | | 50.0 | | |
| 17 | 25.94 | Lo | 35.7 | 50.0 | 14.3 | | 60.0 | | | 50.0 | | |
| 18 | 27.48 | Lo | 32.9 | 50.0 | 17.1 | | 60.0 | | | 50.0 | | |
| 19 | | | | | | | | | | | | |
| 20 | 0.24 | Hi | 47.4 | 52.2 | 4.8 | | 62.3 | | | 52.2 | | |
| 21 | 0.41 | Hi | 46.0 | 47.6 | 1.6 | 44.6 | 57.6 | 13.0 | 37.5 | 47.6 | 10.1 | |
| 22 | 0.53 | Hi | 46.2 | 46.0 | - 0.2 | 44.5 | 56.0 | 11.5 | 37.5 | 46.0 | 8.5 | |
| 23 | 0.53 | Hi | 46.3 | 46.0 | - 0.3 | 44.7 | 56.0 | 11.3 | 38.1 | 46.0 | 7.9 | |
| 24 | 0.71 | Hi | 45.0 | 46.0 | 1.0 | 42.9 | 56.0 | 13.1 | 35.6 | 46.0 | 10.4 | |
| 25 | 0.77 | Hi | 44.6 | 46.0 | 1.4 | 42.6 | 56.0 | 13.4 | 36.2 | 46.0 | 9.8 | |
| 26 | 0.82 | Hi | 44.0 | 46.0 | 2.0 | 42.2 | 56.0 | 13.8 | 35.2 | 46.0 | 10.8 | |
| 27 | 1.35 | Hi | 44.7 | 46.0 | 1.3 | 42.4 | 56.0 | 13.6 | 34.4 | 46.0 | 11.6 | |
| 28 | 1.41 | Hi | 44.5 | 46.0 | 1.5 | 42.3 | 56.0 | 13.7 | 33.6 | 46.0 | 12.4 | |
| 29 | 1.47 | Hi | 44.7 | 46.0 | 1.3 | 42.2 | 56.0 | 13.8 | 32.6 | 46.0 | 13.4 | |
| 30 | 2.42 | Hi | 40.8 | 46.0 | 5.2 | | 56.0 | | | 46.0 | | |
| 31 | 3.05 | Hi | 42.1 | 46.0 | 3.9 | | 56.0 | | | 46.0 | | |
| 32 | 3.54 | Hi | 39.7 | 46.0 | 6.4 | | 56.0 | | | 46.0 | | |
| 33 | 4.45 | Hi | 36.6 | 46.0 | 9.4 | | 56.0 | | | 46.0 | | |
| 34 | 5.29 | Hi | 35.6 | 50.0 | 14.4 | | 60.0 | | | 50.0 | | |
| 35 | 14.53 | Hi | 42.8 | 50.0 | 7.2 | | 60.0 | | | 50.0 | | |
| 36 | 24.19 | Hi | 36.1 | 50.0 | 13.9 | | 60.0 | | | 50.0 | | |
| 37 | 25.10 | Hi | 36.3 | 50.0 | 13.7 | | 60.0 | | | 50.0 | | |
| 38 | | | | | | | | | | | | |
| 39 | | | | | | | | | | | | |
| 40 | Note: | Worst case emissions measured. No observed change to digital emissions | | | | | | | | | | |
| 41 | | for different modes of operation. | | | | | | | | | | |
| 42 | | | | | | | | | | | | |
| 40 | | | | | | | | | | | | |

**Average limit* Meas. 03/12/2007; U of Mich.

*Since Vpeak >= Vqp >= Vave and if Vtestpeak < Vavelim, then Vqplim and Vavelim are met.*

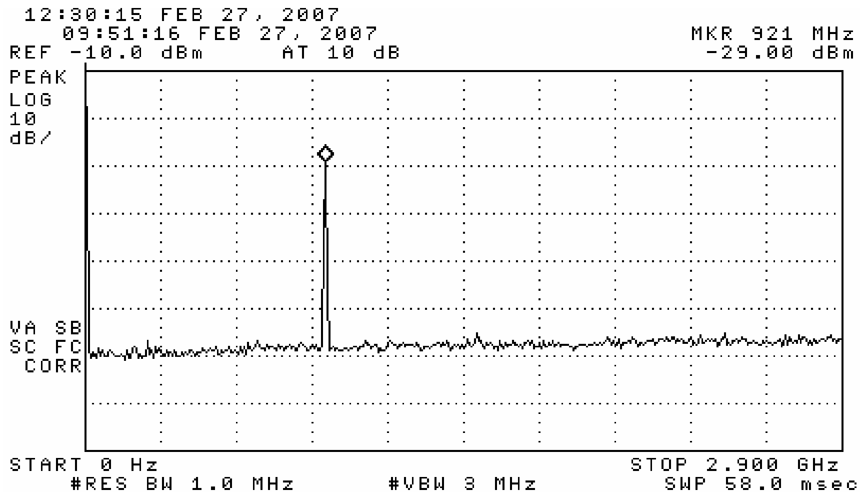
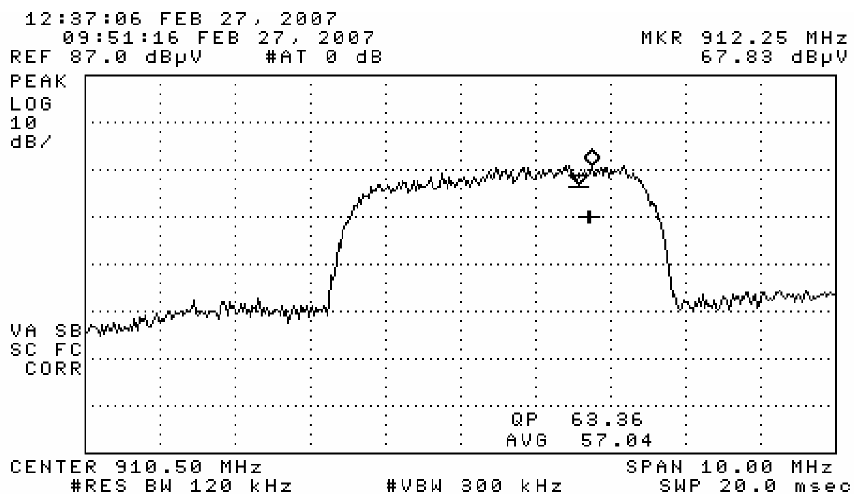



Figure 6.1. Emission spectrum of the DUT. The amplitudes are only indicative (not calibrated).



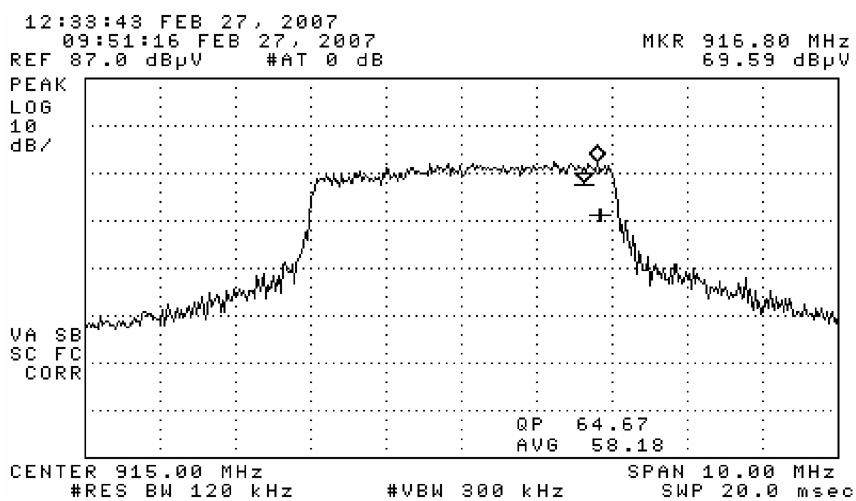
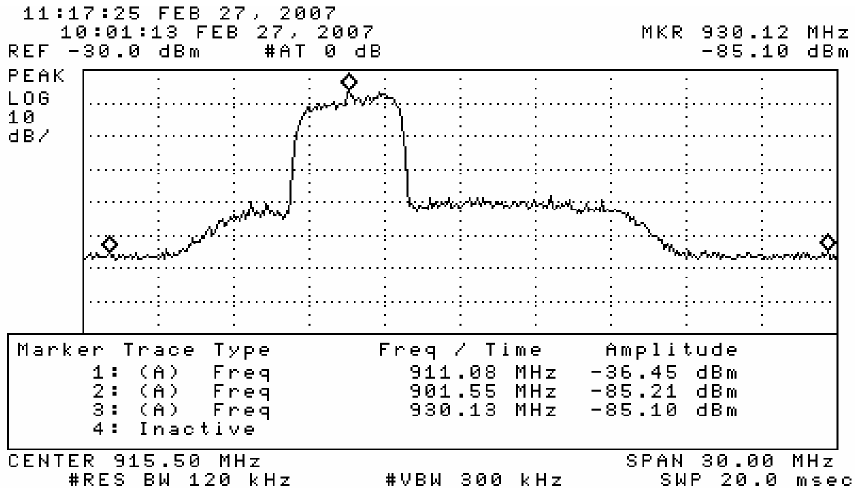
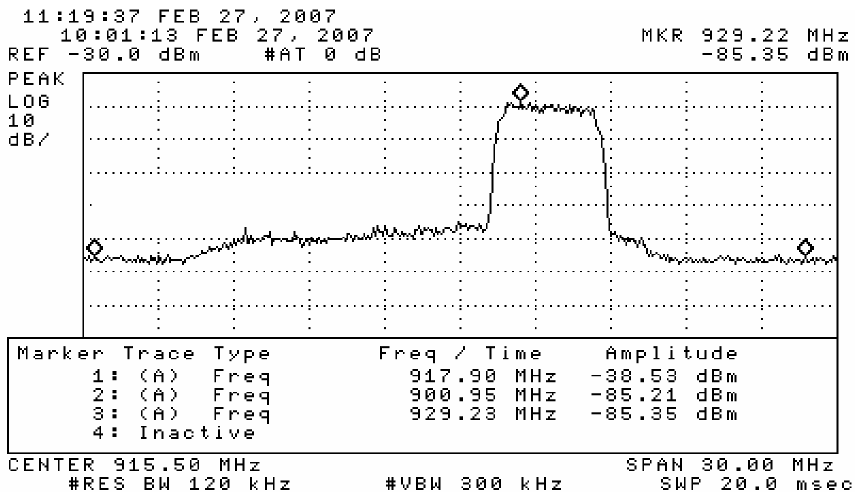
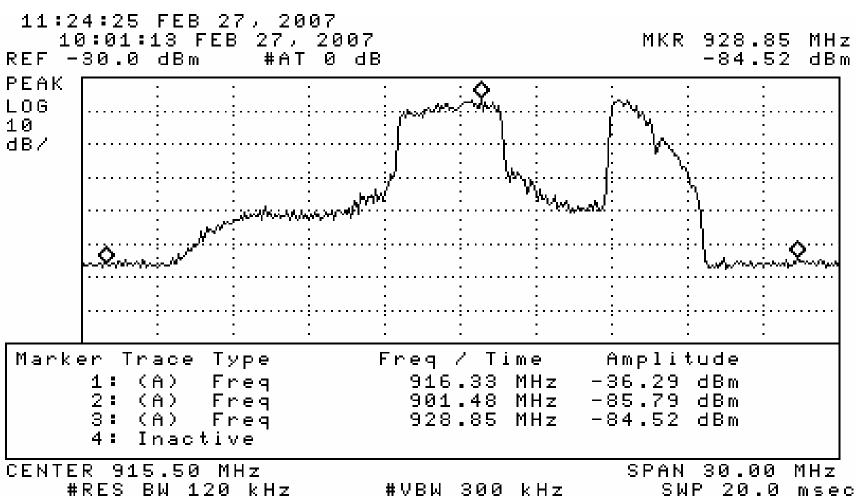



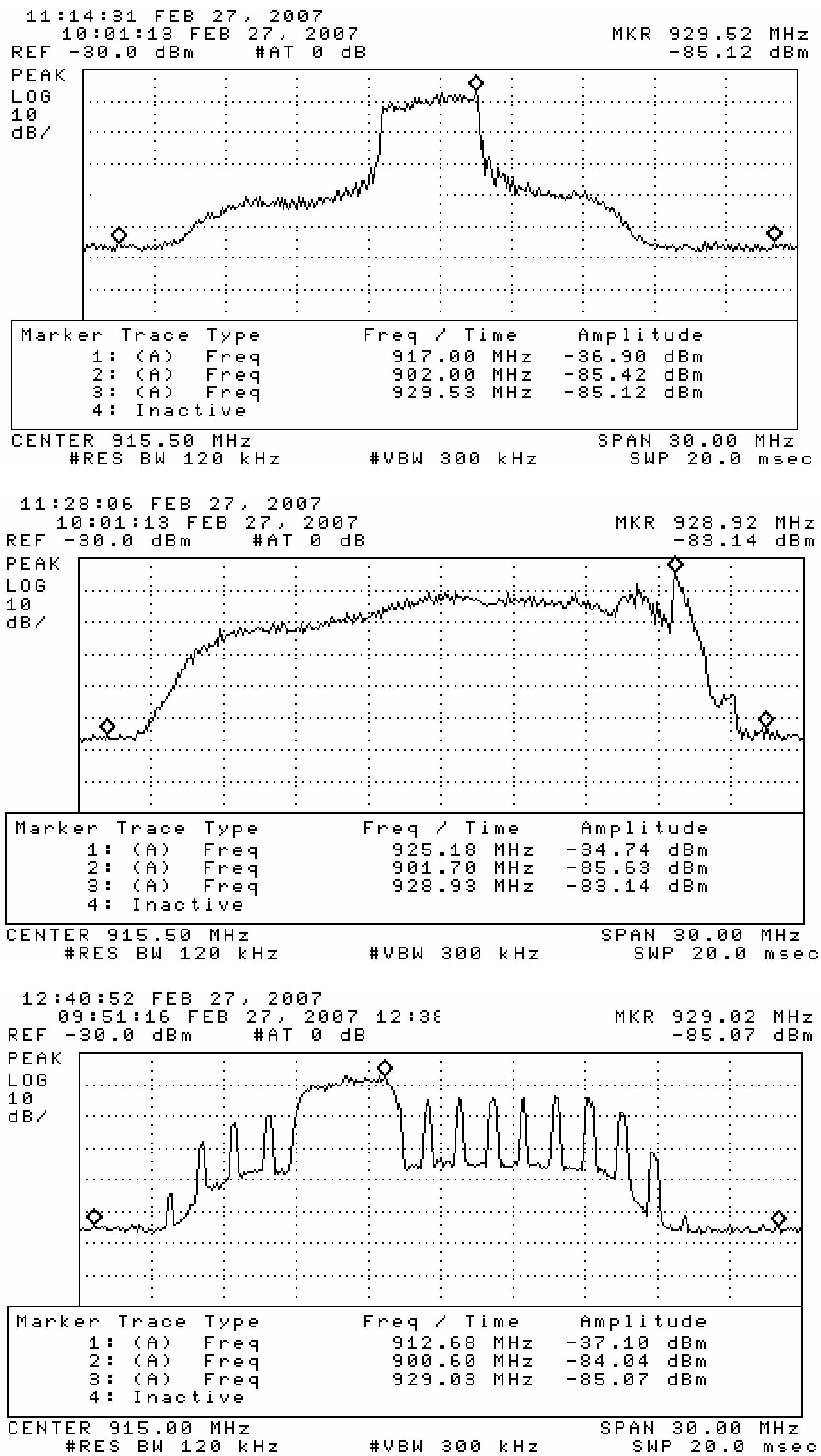

Figure 6.2-6.3. Peak to QPk to Avg. Ratio examples (top) Scenario (5.1) -63 dBm stimuli, (bottom) Scenario (5.4), -17 dBm stimuli.



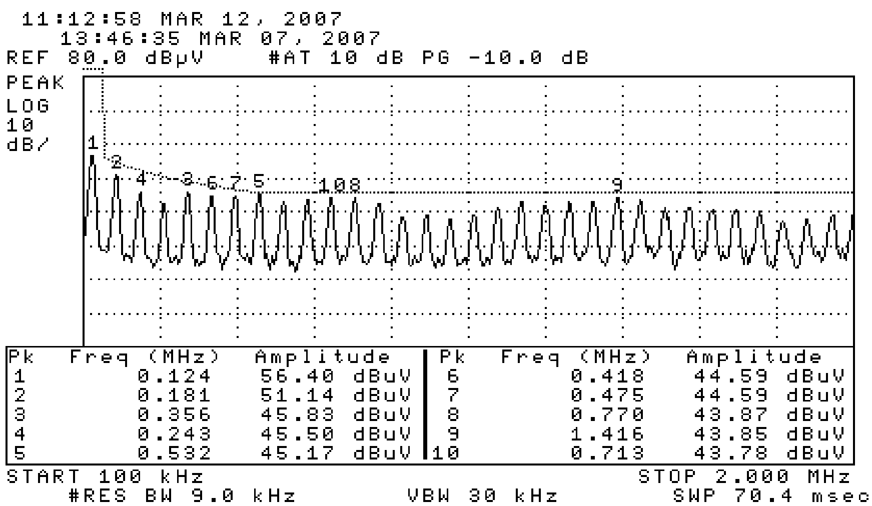




Figures 6.4-6.6. Relative band edge emissions from Semi-anechoic Chamber measurements. (top) Scenario (5.1) & (5.2A) Max Held, (middle) Scenario (5.2B), (bottom) Scenario (5.3) Plot with base stimuli was corrupted, representative plot with terrestrial stimuli show here. Data reported in data table is recorded with proper base stimuli applied.




Figures 6.10. Relative band edge emissions from Semi-anechoic Chamber measurements. (top) Scenario (5.4), (middle) Scenario (5.5), (bottom) Scenario (5.6) Max Held.



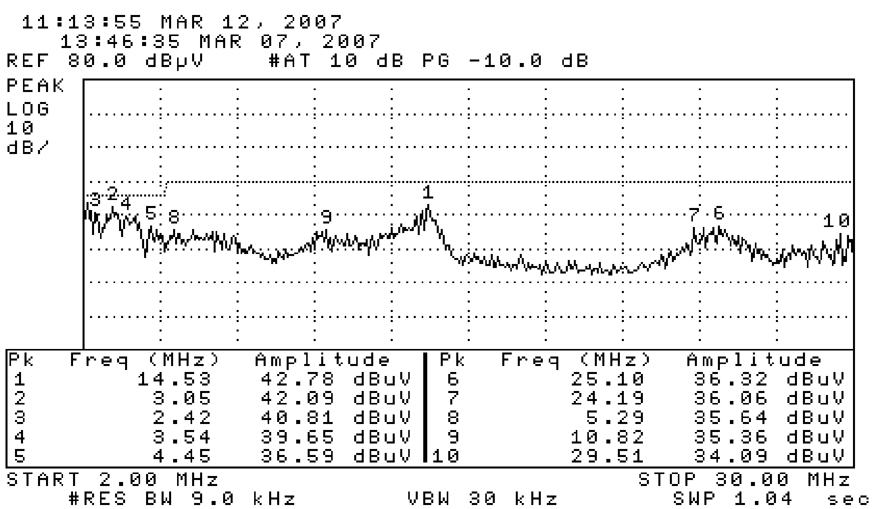
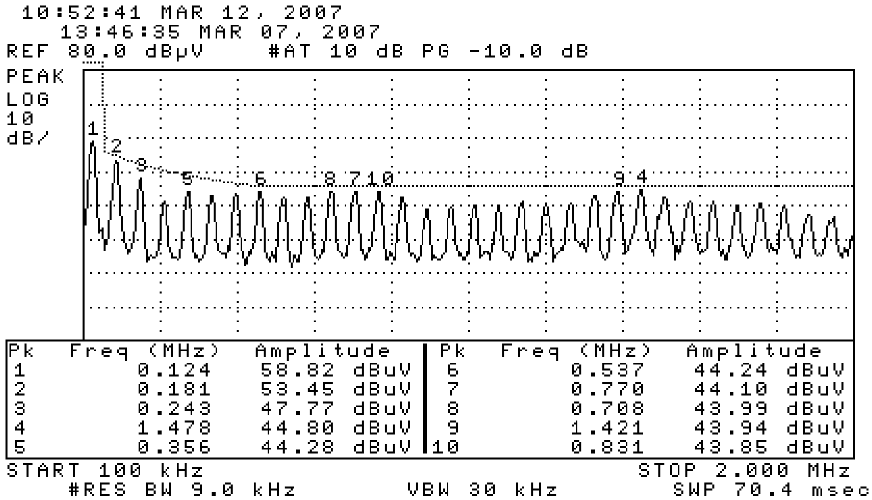




Figure 6.11-6.12. Conducted Emissions (5.4), HI line – (0-2 MHz) (0-30 MHz)



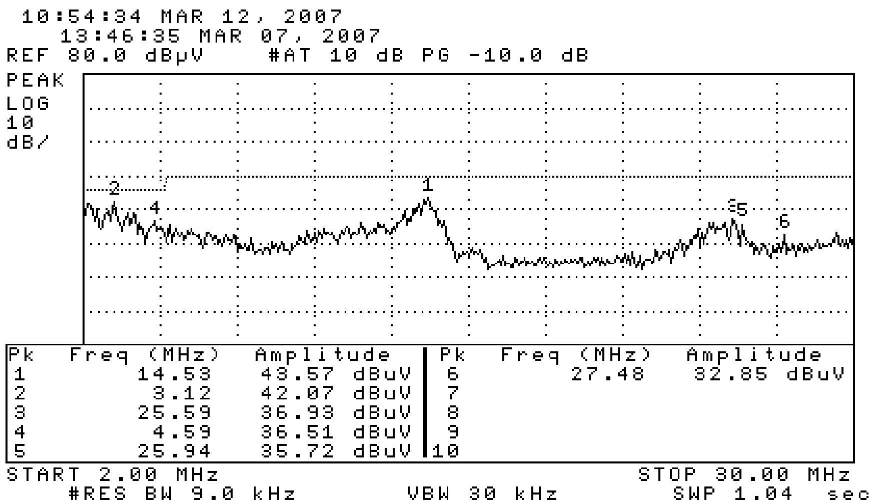




Figure 6.13-6.14. Conducted Emissions (5.4) LO line – (0-2 MHz) (0-30 MHz)

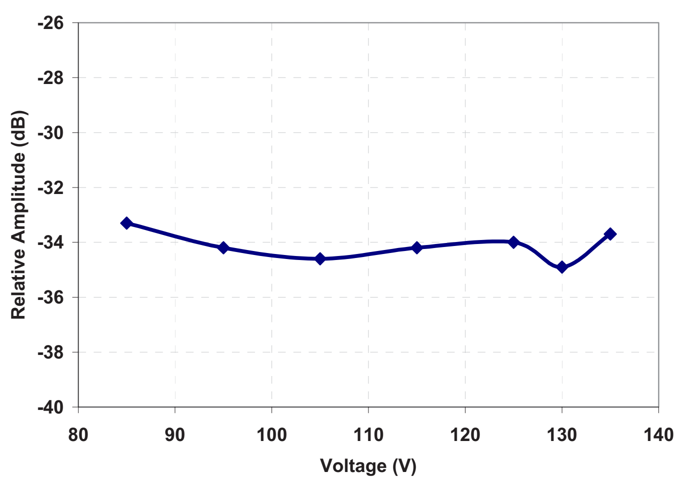



Figure 6.15. Relative emission at fundamental ($f_M$) vs. supply voltage (5.4).

DUT on OATS

DUT on OATS (Close-up)