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Measured Radio Frequency Emissions
From

Siemens/Continental Transmitter
FCC ID: M3N5WY8406
IC: 267F-5WY8406

Report No. 415031-417
March 27, 2008

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For:
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Summary

Tests for compliance with FCC Regulations Part 15, Subpart C, and Industry Canada RSS-210/GEN, were performed on Siemens/Continental model/PN(s) A2C53284422. This device is subject to the Rules and Regulations as a Transmitter.

In testing completed on March 26, 2008, the device tested in the worst case met the allowed FCC specifications for radiated emissions by 6.3 dB (see p. 6). Besides harmonics, there were no other significant spurious emissions found; emissions from digital circuitry were negligible. The conducted emission tests do not apply, since the device is powered from a 3VDC battery.

University of Michigan Radiation Laboratory
FCC Part 15, IC RSS-210/Gen - Test Report No. 415031-417

1. Introduction

Siemens/Continental model/PN(s) A2C53284422 was tested for compliance with FCC Regulations, Part 15, adopted under Docket 87-389, April 18, 1989 as subsequently amended, and with Industry Canada RSS-210/Gen, Issue 7, June 2007. 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". The Site description and attenuation characteristics of the Open Area Test Site are on file with FCC Laboratory, Columbia, Maryland (FCC Reg. No: 91050) and with Industry Canada, Ottawa, ON (File Ref. No: IC 2057A-1).

2. Test Procedure and 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 (0.1-1500 MHz) | | Hewlett-Packard, 182T/8558B |
| 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 | | University of Michigan, NRL design |
| XN-Band Std. Gain Horn | | University of Michigan, NRL design |
| X-Band Std. Gain Horn | | S/A, Model 12-8.2 |
| X-band horn (8.2- 12.4 GHz) | | Narda 640 |
| X-band horn (8.2- 12.4 GHz) | | Scientific Atlanta , 12-8.2, SN: 730 |
| 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 | Avantek, A11-1, A25-1S |
| Amplifier (5-4500 MHz) | X | Avantek |
| Amplifier (4.5-13 GHz) | | Avantek, AFT-12665 |
| Amplifier (6-16 GHz) | | Trek |
| Amplifier (16-26 GHz) | | Avantek |
| LISN Box | | University of Michigan |
| Signal Generator | | Hewlett-Packard 8657B |

3. Device Under Test

3.1 Identification

The DUT is a 315 MHz transmitter, 1 x 0.75 x 1.5 inches in size and the carrier is both ASK and FSK modulated. The carrier is PLL stabilized. The antenna is a trace on the PCB. The DUT was designed and manufactured by Siemens VDO Automotive / Continental, 4685 Investment Drive, Troy, MI 48098. It is identified as:

Siemens/ContinentalTransmitter
Model/PN(s): A2C53284422
FCC ID: M3N5WY8406
IC: 267F-5WY8406

3.2 Variants

There is only a single variant of the device. Both CW and pulsed versions of the device were provided for testing. Measurements determined that the worst case configuration was when the key was removed from the DUT, and that is the configuration reported herein.

3.3 Modes of Operation

The DUT is capable of two operating modes, both at the same power level. In the RKE (Remote Keyless Entry) mode the DUT transmits 1.953Kbp/s ASK data after a button press. In the PEPS (Passive Entry Passive Start) mode the DUT transmits 7.8125Kbp/s FSK data after encoded LF Interrogation. Note: The DUT is manually activated (either by button press or by LF interrogation due to lift of a door handle) and ceases to transmit within 5 seconds of deactivation. Worst case ASK duty is applied to CW measurements. See Figure 6.1.

3.4 EMI/EMC Relevant Modifications

There were no modifications made to the DUT by this laboratory.

4. Emission Limits

The DUT tested falls under the category of an Intentional Radiators and the Digital Devices. For FCC, it is subject to Part 15, Subpart C, (Section 15.231(a-c), 15.209), and Subpart A, (Section 15.33). For Industry Canada it is subject to RSS-210 (Section 2.6 and 2.7). The applicable testing frequencies with corresponding emission limits are given in Tables 4.1 and 4.2 below.

4.1 Radiated Emission Limits

Table 4.1. Radiated Emission Limits (FCC: 15.33, 15.35, 15.209; IC: RSS-210, 2.7 Table 2).
(Digital Class B)

| Freq. (MHz) | E _{lim} (3m) μ V/m | E _{lim} dB(μ V/m) |
|-------------|---------------------------------|---------------------------------|
| 30-88 | 100 | 40.0 |
| 88-216 | 150 | 43.5 |
| 216-960 | 200 | 46.0 |
| 960-2000 | 500 | 54.0 |

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

Table 4.2. Radiated Emission Limits (FCC: 15.231(b), 15.205(a); IC: RSS-210; 2.7 Table 4).
 (Transmitter)

| Frequency (MHz) | Fundamental Ave. E _{lim} (3m) | | Spurious** Ave. E _{lim} (3m) | |
|--------------------|---|-----------------|--|-----------------|
| | (μ V/m) | dB (μ V/m) | (μ V/m) | dB (μ V/m) |
| 260.0-470.0 | 3750-12500* | | 375-1250 | |
| 315 | 6042 | 75.6 | 604.2 | 55.6 |
| 433.9 | 10966 | 80.8 | 1096.6 | 60.8 |
| 322-335.4 | Restricted Bands | | | |
| 399.9-410 | | | 200 | 46.0 |
| 608-614 | | | | |
| 960-1240/1427(IC) | | | | |
| 1300-1427 | | | | |
| 1435-1626.5 | | | | |
| 1645.5-1646.5 (IC) | | | | |
| 1660-1710 | | | 500 | 54.0 |
| 1718.9-1722.2 | | | | |
| 2200-2300 | | | | |

* Linear interpolation, formula: $E = -7083 + 41.67*f$ (MHz)

** Measure up to tenth harmonic; 120 kHz BW up to 1 GHz, 1 MHz BW above 1 GHz

4.3 Exemptions

None.

4.4 Power Line Conducted Emission Limits

The power line conducted emission limits and tests do not apply here, as the DUT is powered by a 3VDC battery.

4.5 Supply Voltage Variation

Measurements of the variation in the fundamental radiated emission shall be performed with the supply voltage varied between 85% and 115% of the nominal rated value. For battery operated equipment, the equipment tests shall be performed using a new battery.

5. Test Procedures

5.1 Semi-Anechoic Chamber Radiated Emission Testing

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

In testing for radiated emissions, a transmitter was provided by the manufacturer that is capable of repeated emissions. It was placed on the test table flat, on its side, and on its end. In the chamber we studied and recorded all the emissions using a Bicone antenna up to 300 MHz and a ridged horn antenna above 200 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 final compliance assessment. We note that for the horn antenna, the antenna pattern is directive and 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.

5.2 Open Area Test Site (OATS) Radiated Emission Testing

After the chamber measurements are complete, emissions are re-measured on the outdoor 3-meter open area test site at the fundamental and harmonics up to 1 GHz using tuned dipoles and/or a high frequency biconical antenna. The DUT is placed on the test table flat, on its side, and on its end, and worst case emissions are recorded. Photographs included in this filing show the DUT on the OATS.

5.3 Field Calculation for Radiated Emission Measurements

To convert the dBm's measured on the spectrum analyzer to dB(μ V/m), we use expression

$$E_3(\text{dB}\mu\text{V/m}) = 107 + P_R + K_A - K_G$$

where P_R = power recorded on spectrum analyzer, dB, measured at 3m

K_A = antenna factor, dB/m

K_G = pre-amplifier gain, including cable loss, dB

When presenting the data, at each frequency the highest measured emission under all of the possible orientations is given. Computations and results are given in Table 5.1. There we see that the DUT meets the limit by 6.3 dB dB.

5.4 Power Line Conducted Emission Testing

These tests do not apply, since the DUT is powered from a 3VDC battery.

6. Test Results

6.1 Correction For Pulse Operation

When the RKE mode of the transmitter is activated by button press, it can, in the worst case, transmit 4 words of Manchester encoded ASK data with transmission period greater than 100 ms. The leading word represents the worst case duty, including one 5.9 ms lead pulse, one 5.438 ms Manchester packet, and one 40.688 ms Manchester data packet. Manchester duty cycle is measured to be 0.265 ms / 0.500 ms. For a manual PEPS FSK activation (via encoded LF interrogation) the DUT transmits a single 14.50 ms (@ 20 dB down) pulse. See Figure 6.1. Computing the duty factor results in:

$$K_E^{\text{ASK}} = (5.900 \text{ ms} + (5.438 \text{ ms} + 40.688 \text{ ms}) \times (0.265 \text{ ms} / 0.500 \text{ ms})) / 100 \text{ ms} = 0.303 \text{ or } -10.4 \text{ dB.}$$

$$K_E^{\text{FSK}} = 14.50 \text{ ms} / 100 \text{ ms} = 0.145 \text{ or } -16.8 \text{ dB.}$$

6.2 Emission Spectrum

Using the ridge-horn antenna and DUT placed in its aperture, emission spectrum was recorded and is shown in Figure 6.2. We note that in scanning from 30 MHz to 4.5 GHz using Bicone and the ridge horn antennas, there were no other significant spurious emissions observed.

6.3 Bandwidth of the Emission Spectrum

The measured spectrum of the signal is shown in Figure 6.3. The allowed (-20 dB, 99%) bandwidth is 0.25% of 315 MHz, or 787.25 kHz. From the plot we see that worst case 20 dB bandwidth is 150.0 kHz, and the center frequency is 315 MHz.

6.4 Effect of Supply Voltage Variation and Test Battery Voltages

The DUT has been designed to be powered by a 3VDC battery. For this test, the battery was replaced by a laboratory variable power supply. Relative power radiated was measured at the fundamental as the voltage was varied from 2 to 4 volts. The emission variation is shown in Figure 6.4.

| | | |
|-----------------------------|----------------|---------------------------|
| Batteries: | before testing | $V_{oc} = 3.26 \text{ V}$ |
| | after testing | $V_{oc} = 2.95 \text{ V}$ |
| Ave. current from batteries | | $I = 9.2 \text{ mA (cw)}$ |

Table 5.1 Highest Emissions Measured

| Radiated Emission - RF | | | | | | | | | | Siem./Cont., PEPS; FCC/IC | |
|-------------------------------|--|--------------|--------------|-----------|--------------|------------|----------|---------------------|-----------------------|---------------------------|----------|
| # | Freq. MHz | Ant. Used | Ant. Pol. | Pr dBm | Det. Used | Ka dB/m | Kg dB | E3* dB μ V/m | E3lim dB μ V/m | Pass dB | Comments |
| 1 | DUT w/o Blade(Key) - Worst Case Configuration | | | | | | | | | | |
| 2 | 315.0 | Dip | H | -24.5 | Pk | 18.6 | 22.1 | 68.6 | 75.6 | 7.1 | flat |
| 3 | 315.0 | Dip | V | -28.1 | Pk | 18.6 | 22.1 | 65.0 | 75.6 | 10.7 | end |
| 4 | 630.0 | Dip | H | -78.0 | Pk | 24.4 | 19.0 | 23.9 | 55.6 | 31.7 | flat |
| 5 | 630.0 | Dip | V | -77.7 | Pk | 24.4 | 19.0 | 24.2 | 55.6 | 31.4 | end |
| 6 | 945.0 | Dip | H | -79.7 | Pk | 28.8 | 17.0 | 28.7 | 55.6 | 26.9 | flat |
| 7 | 945.0 | Dip | V | -84.1 | Pk | 28.8 | 17.0 | 24.3 | 55.6 | 31.3 | end |
| 8 | 1260.0 | Horn | H | -56.6 | Pk | 20.6 | 28.1 | 32.5 | 54.0 | 21.5 | side |
| 9 | 1575.0 | Horn | H | -58.5 | Pk | 21.5 | 28.1 | 31.5 | 54.0 | 22.5 | side |
| 10 | 1890.0 | Horn | H | -65.5 | Pk | 22.2 | 28.1 | 25.2 | 55.6 | 30.4 | flat |
| 11 | 2205.0 | Horn | H | -45.4 | Pk | 23.0 | 26.5 | 47.7 | 54.0 | 6.3 | side |
| 12 | 2520.0 | Horn | H | -49.8 | Pk | 23.9 | 26.0 | 44.7 | 55.6 | 11.0 | side |
| 13 | 2835.0 | Horn | H | -62.0 | Pk | 24.8 | 24.7 | 34.7 | 54.0 | 19.3 | end |
| 14 | 3150.0 | Horn | H | -58.7 | Pk | 25.8 | 23.6 | 40.1 | 55.6 | 15.5 | flat |
| 15 | | | | | | | | | | | |
| 16 | | | | | | | | | | | |
| 17 | | | | | | | | | | | |
| 18 | | | | | | | | | | | |
| 19 | | | | | | | | | | | |
| 20 | | | | | | | | | | | |
| 21 | | | | | | | | | | | |
| 22 | | | | | | | | | | | |
| 23 | * Includes 10.4 dB duty factor | | | | | | | | | | |
| 24 | | | | | | | | | | | |
| 25 | | | | | | | | | | | |
| 26 | | | | | | | | | | | |
| 27 | | | | | | | | | | | |

Digital Radiated Emissions*

| # | Freq. kHz | Ant. Used | Ant. Pol. | Pr dBm | Det. Used | Ka dB/m | Kg dB | E3 dB μ V/m | E3lim dB μ V/m | Pass dB | Comments |
|---|---|--------------|--------------|-----------|--------------|------------|----------|--------------------|-----------------------|------------|----------|
| 1 | | | | | | | | | | | |
| 2 | | | | | | | | | | | |
| 3 | | | | | | | | | | | |
| 4 | Digital emissions more than 20 dB below FCC/IC Class B Limit. | | | | | | | | | | |
| 5 | | | | | | | | | | | |
| 6 | | | | | | | | | | | |
| 7 | | | | | | | | | | | |
| 8 | | | | | | | | | | | |
| 9 | | | | | | | | | | | |

Meas. 04/05/2008; U of Mich.

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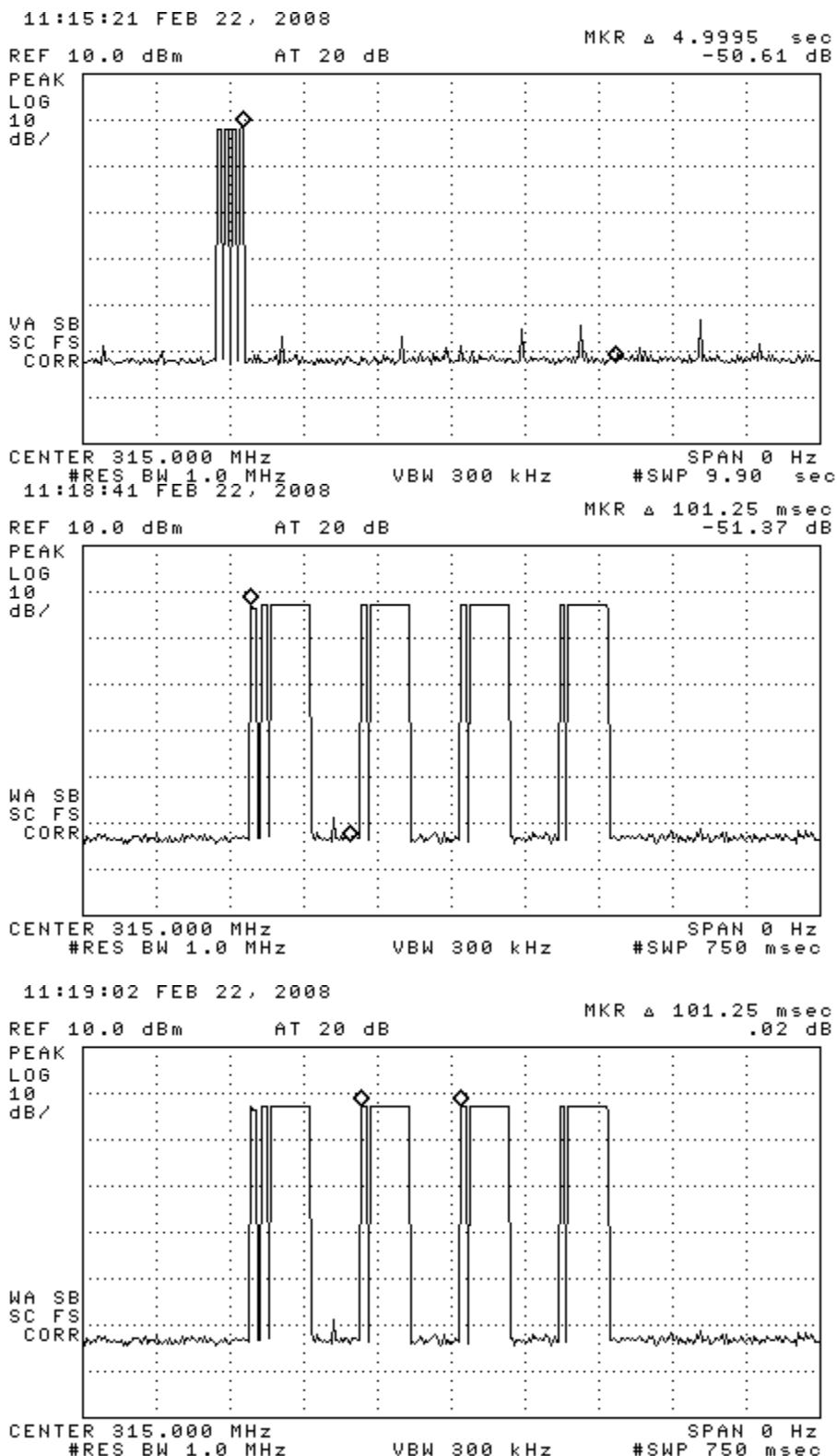


Figure 6.1(a). RKE Transmissions modulation characteristics:
 (top) complete transmission, (center) expanded, (bottom) expanded period.

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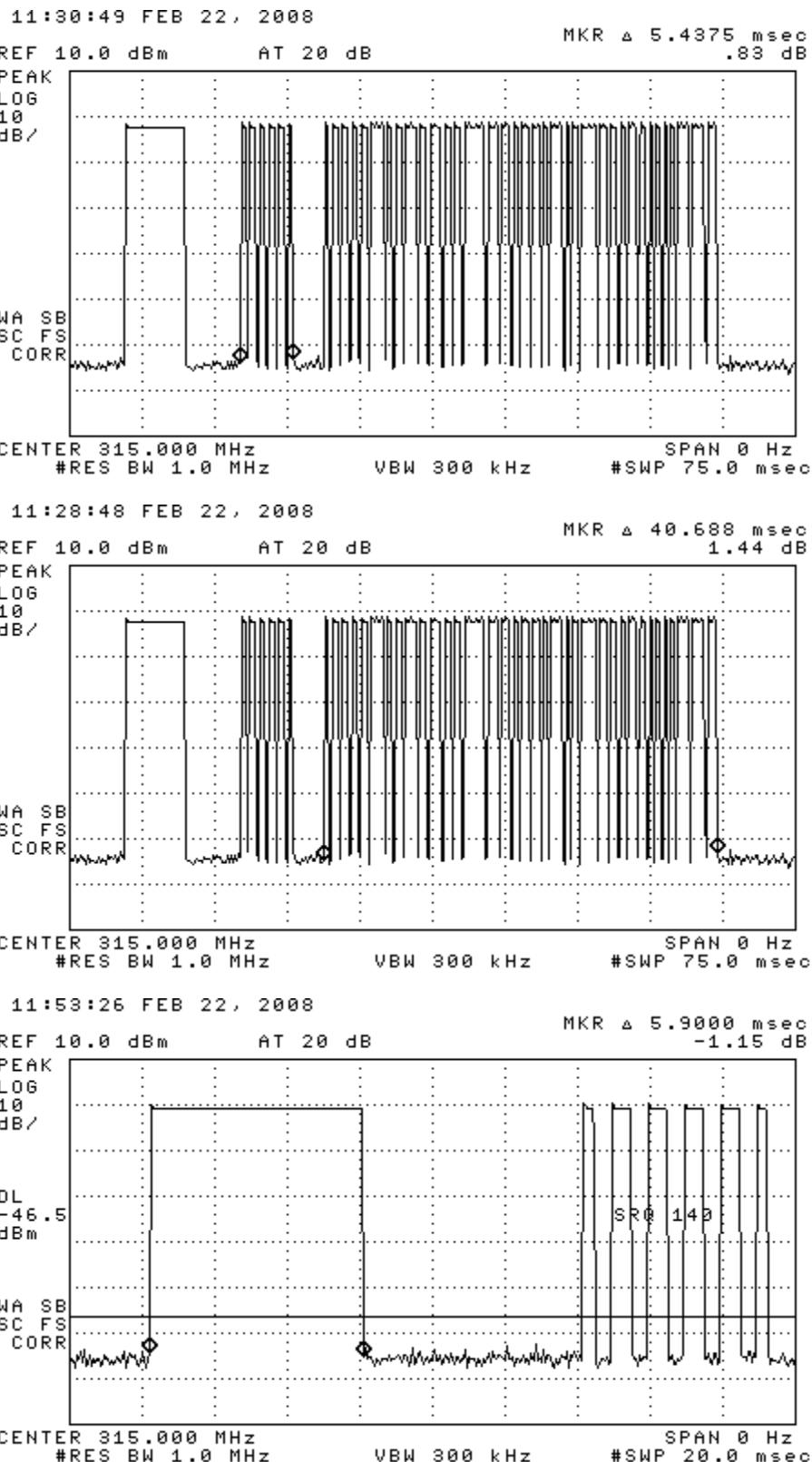


Figure 6.1(b).

RKE modulation characteristics: (top) complete word, (center) second Manchester packet, (bottom) lead pulse.

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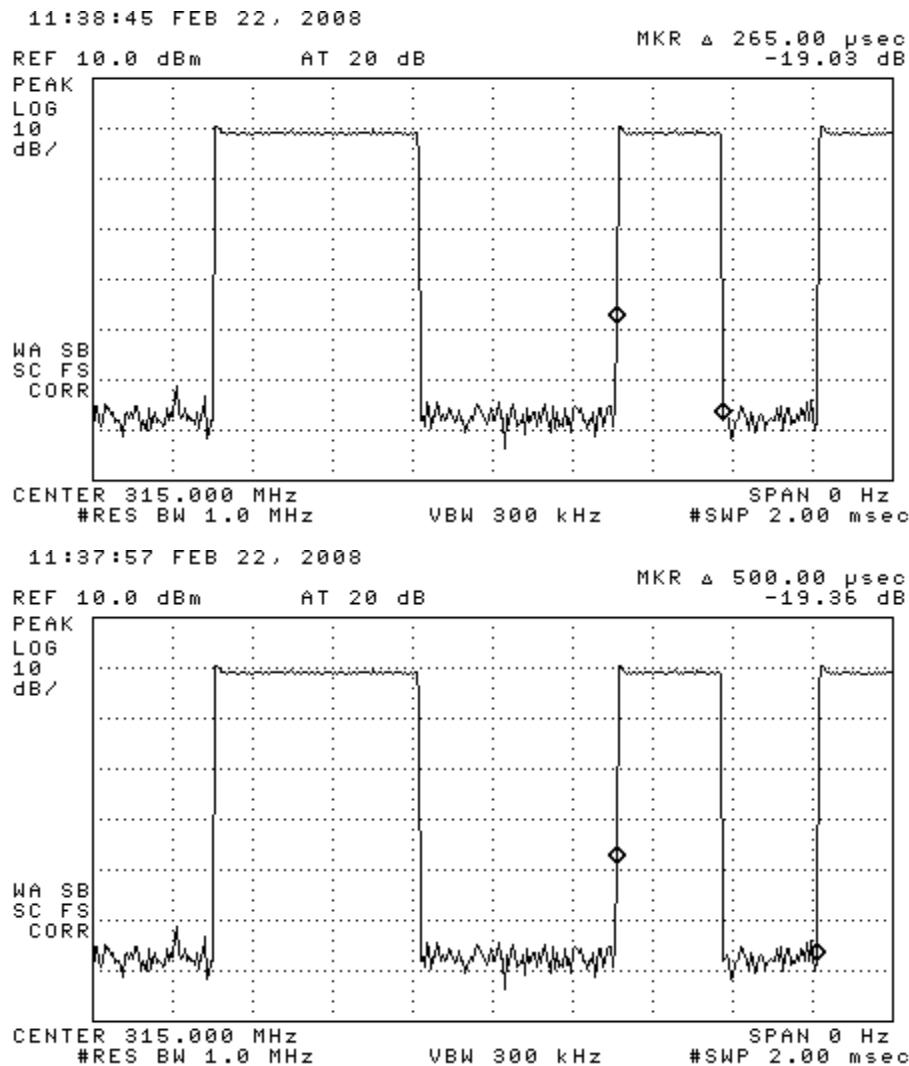


Figure 6.1(c). RKE modulation characteristics: (top) Manchester pulse width, (bottom) Manchester pulse period

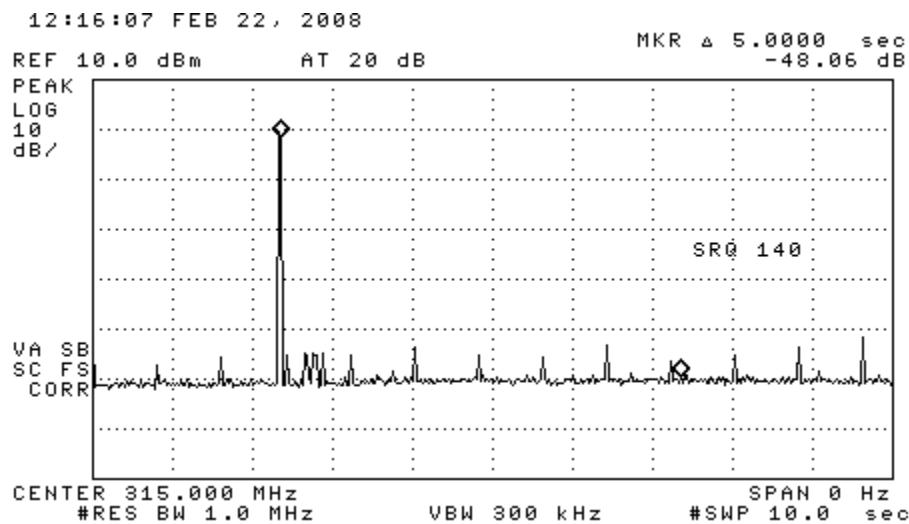


Figure 6.1(d). PEPS modulation characteristics: Response to manual LF Activation

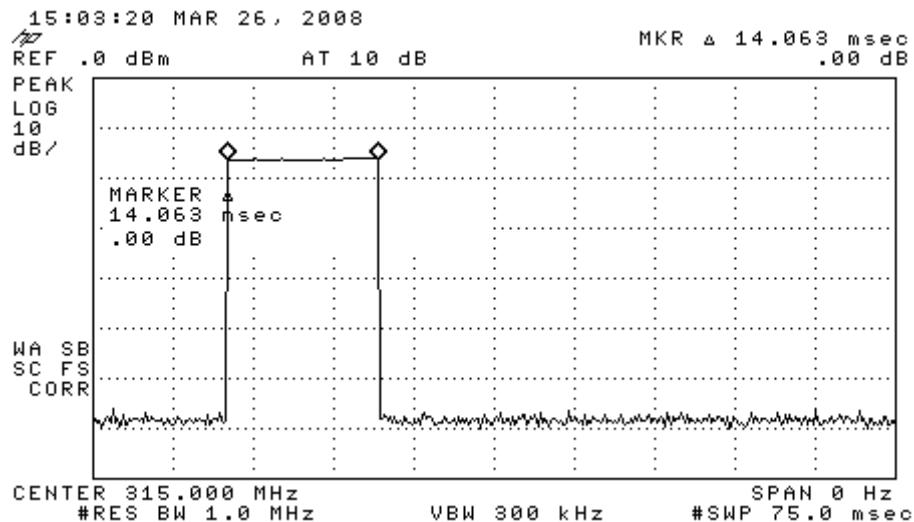


Figure 6.1(e). PEPS modulation characteristics: FSK pulse width.

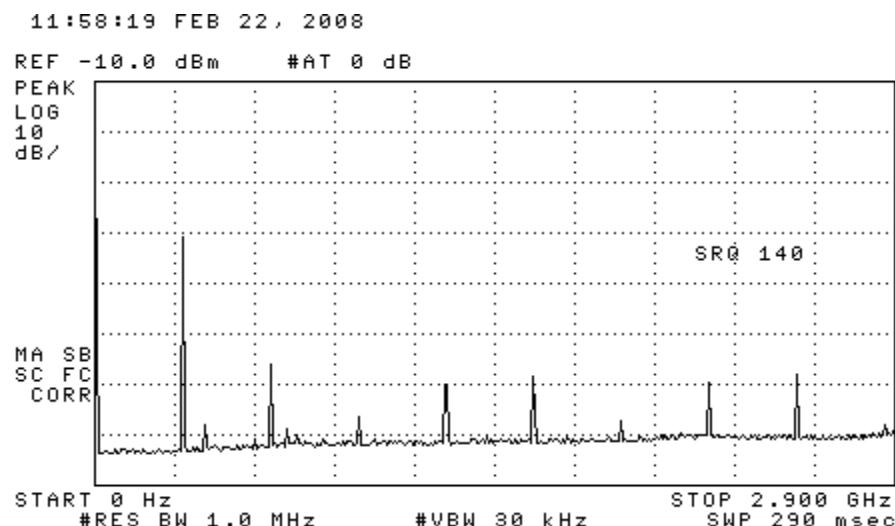


Figure 6.2. Emission spectrum of the DUT (ASK & FSK emission, Max-held). The amplitudes are only indicative (not calibrated).

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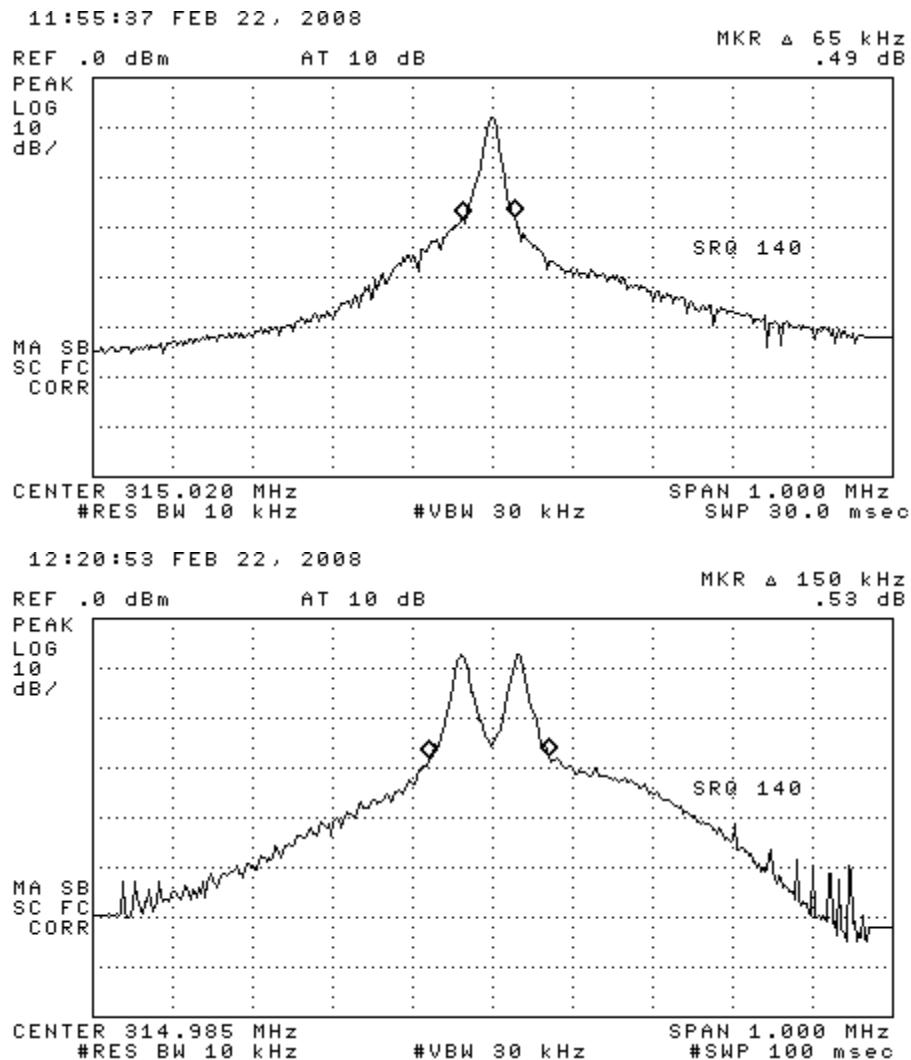


Figure 6.3. Measured bandwidth of the DUT : (top) RKE ASK (pulsed emission), (bottom) PEPS FSK (pulsed emission)

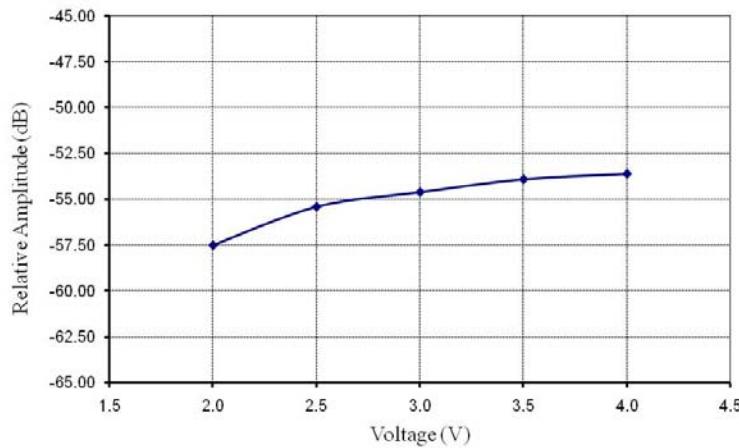
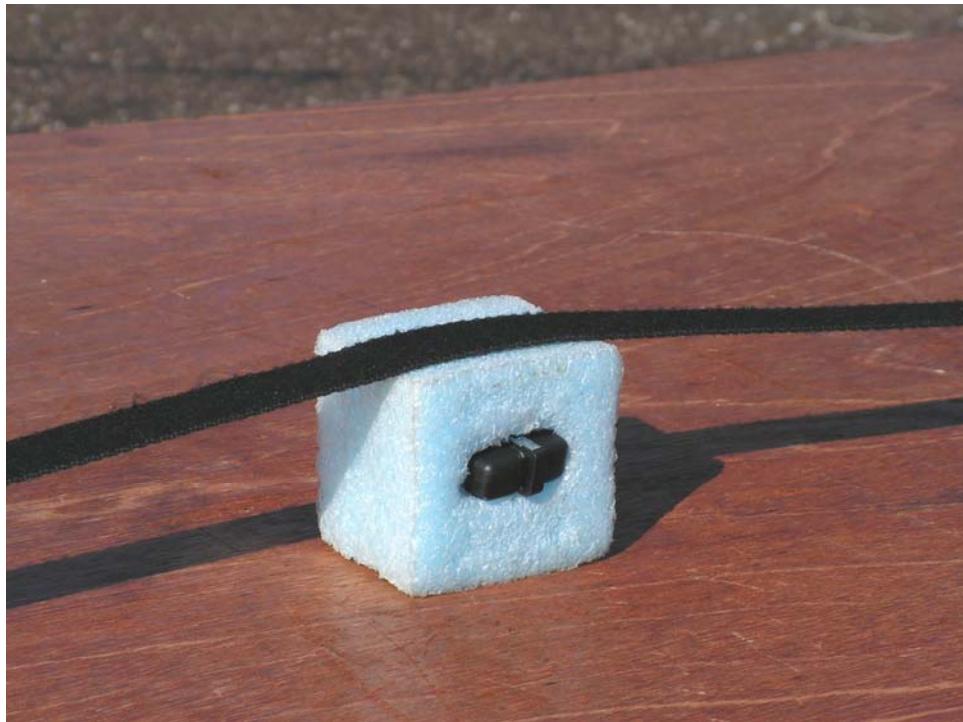


Figure 6.4. Relative emission at 315 MHz vs. supply voltage (cw emission).



DUT on OATS



DUT on OATS (close-up)