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# Measured Radio Frequency Emissions From

# Siemens EZ-key LF PASE Transmitter Model 5WY7369

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**Summary**

Tests for compliance with FCC Regulations, Part 15, Subpart C, and for compliance with Industry Canada RSS-210, were performed on Siemens PASE Transmitter. This device is subject to Rules and Regulations as a transmitter. As a digital device it is exempt.

In testing performed May 30 and June 2, 2002, the device tested in the worst case met the allowed specifications for transmitter radiated emissions by 11.6 dB (see p. 6).

The conductive emission tests do not apply, since the device is powered from an automotive 12-volt battery.

## 1. Introduction

Siemens PASE (Passive Start and Entry) was tested for compliance with FCC Regulations, Part 15, adopted under Docket 87-389, April 18, 1989, and with Industry Canada RSS-210, Issue 5, dated February 14, 1998. The tests were performed at the University of Michigan Radiation Laboratory Willow Run Test Range following the procedures described in ANSI C63.4-1992 "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 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 Procedure and Equipment Used

The test equipment commonly used in our facility is listed in Table 2.1 below. The second column identifies the specific equipment used in these tests. The HP 8593E spectrum analyzer is used for primary amplitude and frequency reference.

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 Millimiter 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) | | 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) | X | EMCO 6502, SN: 2855 |
| Ridge-horn Antenna (300-5000 MHz) | | University of Michigan |
| Amplifier (5-1000 MHz) | | Avantak, A11-1, A25-1S |
| Amplifier (5-4500 MHz) | | Avantak |
| Amplifier (4.5-13 GHz) | | Avantek, AFT-12665 |
| Amplifier (6-16 GHz) | | Trek |
| Amplifier (16-26 GHz) | | Avantek |
| LISN (50 µH) | | University of Michigan |
| Signal Generator (0.1-2060 MHz) | | Hewlett-Packard, 8657B |
| Signal Generator (0.01-20 GHz ) | | Hewlett-Packard |

## 3. Configuration and Identification of Device Under Test

The DUT is part the Siemens car security/access system that in this case transmits encoded LF signal to activate 315 MHz RKE transmitter. The LF transmission is initiated by lifting the car door handle, for example. The DUT consisted of an ECU that contains the LF driver and four ferrite loaded coil antennas outside the ECU. Since the antennas are identical and in actual application are switched in as needed, only one antennas was activated for the measurements. This provided more uniform and repeatable data.

The system was powered at 13 volts dc by a laboratory supply. A laptop with a special software was used to control emissions representative of actual operation.

The DUT was designed and manufactured by Siemens. It is identified as:

Siemens EZ-key LF PASE Transmitter
Model: 5WY7369
FCC ID: M3N-65981411
IC: 267F-65981411

As mentioned above, the DUT was controlled by a laptop. In normal operation, the emission consists of three pulses. For emission measurements, the DUT was run in a custom designed repeatedly pulsed mode.

### 3.1 EMI Relevant Modifications

None.

## 4. Emission Limits

### 4.1 Radiated Emission Limits

The DUT tested falls under the category of an Intentional Radiators and the Digital Devices, subject to Subpart C, Section 15.209; and Subpart B, Section 15.109 (transmitter generated signals excluded); and Subpart A, Section 15.33. The applicable testing frequencies with corresponding emission limits are given in Tables 4.1 and 4.2 below. As a digital device, it is exempt.

Table 4.1. Radiated Emission Limits (FCC: 15.205, 15.35; IC: RSS-210 (6.2.2(r), 6.3)). (Transmitter)

| Frequency (MHz) | Fundamental and Spurious* (μV/m) |
|---|---|
| 0.009-0.490<br>0.490-1.705 | 2400/F(kHz), 300m<br>24,000/F(kHz), 30m |
| 0.090-0.110<br>0.49-0.51 | Restricted Bands |

* Harmonics must be below the fundamental.

For extrapolation to other distances, see Section 6.6.

Table 4.2. Radiated Emission Limits (FCC: 15.33, 15.35, 15.109; IC: RSS-210, 6.2.2(r)).
(Digital Class B)

| Freq. (MHz) | $E_{lim}$ (3m) µV/m | $E_{lim}$ dB(µV/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)

## 4.2 Conductive Emission Limits

The conductive emission limits and tests do not apply here, since the DUT is powered from an automobile 12VDC system.

# 5. Radiated Emission Tests and Results

## 5.1 Anechonic 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 this case, the receiving antenna was an active loop, placed on a tripod, approximately 1.5 meters above ground.

The DUT was laid on the test table as seen in the Appendix Setup Photos. Using the loop antenna we studied emissions up to 2 MHz. The spectrum analyzer resolution and video bandwidths were usually set to 1 kHz, and sometimes down to 300 Hz. Emissions were studied with the plane of the loop perpendicular and parallel to the direction of propagation from the DUT. Larger emissions were observed when the loop was perpendicular. In the chamber we also recorded the spectrum and modulation characteristics of the carrier. These data are presented in subsequent sections. In scanning from 0.0-2.0 MHz there were no spurious emissions observed other than harmonics. In some instances, it was difficult to separate the DUT emissions from AM band signals.

## 5.2 Outdoor Measurements

After the chamber measurements, the emissions on our outdoor 3-meter site were measured. For transmitter emissions a loop antenna was used; the resolution bandwidth was usually 1 kHz. The measurements were made with loop oriented such that (1) axis of the loop is in direction of propagation (meas. radial magnetic field component), (2) axis of the loop is horizontal and perpendicular to direction of propagation (meas. vertical magnetic field component)., and (3) axis of the loop is vertical (meas. vertical magnetic field component).
See Appendix for measurement set-up. For digital emissions bicone and dipole antennas were used.

See Section 6.6 for field extrapolation of transmitter data from 3 m to 300 m.

## 5.3 Computations and Results

To convert the dBm measured on the spectrum analyzer to dB(µV/m), we use expression

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

where $P_R$ = power recorded on spectrum analyzer, dB, measured at 3 m
$K_A$ = antenna factor, dB/m
$K_G$ = pre-amplifier gain, including cable loss, dB
$K_E$ = pulse operation correction factor, dB (see 6.1)

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 as a transmitter, the DUT meets the limit by 11.6 dB.

Also the 15.209(c) requirement, that the fundamental be greater than other spurious and harmonic emissions, is has been met. See Pr column in Table 5.1.

## 6. Other Measurements and Computations

### 6.1 Correction For Pulse Operation
In normal a operation the transmitter is activated by touching the door/trunk handle. The emission is three pulses (plus a lower level narrow wakeup and a trailing pulse) for about 200 ms. See Figure 6.1. In a 100 ms window there are two main pulses 24.125 ms wide Manchester format (50% duty) ASK modulated The averaging factor for such case is

$$K_E = (2 \times 24.125 \text{ ms}) \times 0.5 / 100 \text{ ms} = 0.24125 \text{ or } -12.4 \text{ dB}$$

### 6.2 Emission Spectrum
Using the loop antenna, the emission spectrum was recorded and is shown in Figure 6.2. Unfortunately, the measurement is contaminated by AM stations.

### 6.3 Bandwidth of the Emission Spectrum
The measured spectrum of the signal is shown in Figure 6.3. From the plot we see that the -20 dB bandwidth is 33.6 kHz and the center frequency is about 125.55 kHz.

### 6.4 Effect of Supply Voltage Variation
The DUT has been designed to be operated from an automobile 12VDC system. For this test, the relative power radiated was measured at the fundamental as the voltage was varied from 10.0 to 18.0 volts. The emission variation is shown in Figure 6.4.

### 6.5 Input Voltage and Current

V = 12.3 V
I = due to pulsating current, the current could not be easily measured

### 6.6 Field Behavior from 125 kHz to 1.25 MHz
Because at the specified 300/30 m measurement distance the signal is too small to measure, measurements were made at 3 m. To translate the measurement from 3 m to the 300/30 m distance, we computed the field behavior for a Hertzian (small loop) dipole using equations found in most antenna books, such as, Balanis Antenna Theory Analysys and Design, 1997 John Wiley & Sons, 2nd Edition, pg. 207-208. The applicable results that we need are:

| Freq (kHz) | H-component | Extrap positions | Correction (dB) | Notes |
|---|---|---|---|---|
| 125 | Radial | 3m/300m | 117.9 dB | Axial coupling |
| 125 | Transverse | 3m/300m | 121.2 dB | Planar coupling |
| 250 | Radial | 3m/300m | 114.6 dB | Axial coupling |
| 250 | Transverse | 3m/300m | 113.4 dB | Planar coupling |
| 375 | Radial | 3m/300m | 111.9 dB | Axial coupling |
| 375 | Transverse | 3m/300m | 105.6 dB | Planar coupling |
| 500 | Radial | 3m/30m | 59.6 dB | Axial coupling |
| 500 | Transverse | 3m/30m | 60.6 dB | Planar coupling |
| 625 | Radial | 3m/30m | 59.4 dB | Axial coupling |
| 625 | Transverse | 3m/30m | 60.6 dB | Planar coupling |
| 750 | Radial | 3m/30m | 59.1 dB | Axial coupling |
| 750 | Transverse | 3m/30m | 60.8 dB | Planar coupling |
| 875 | Radial | 3m/30m | 58.9 dB | Axial coupling |
| 875 | Transverse | 3m/30m | 61.0 dB | Planar coupling |
| 1000 | Radial | 3m/30m | 58.6 dB | Axial coupling |
| 1000 | Transverse | 3m/30m | 61.2 dB | Planar coupling |
| 1125 | Radial | 3m/30m | 58.3 dB | Axial coupling |
| 1125 | Transverse | 3m/30m | 61.2 dB | Planar coupling |
| 1250 | Radial | 3m/30m | 57.9 dB | Axial coupling |
| 1250 | Transverse | 3m/30m | 61.2 dB | Planar coupling |

In the data table, Table 5.1, the measured field is decreased by the dB values given above to represent the field at 300m or 30m, which ever is applicable.

## Table 5.1 Highest Emissions Measured

| Transmitter Radiated Emissions | | | | | | | | | | | Siemens VDO EZ-key LF PASE; FCC/IC |
|---|---|---|---|---|---|---|---|---|---|---|---|
| N | Freq. MHz | Ant. Used | Ant. Orien. | Pr, 3m dBm | Det. Used | Ka dB/m | Kg dB | E* dBµV/m | Elim* dBµV/m | Pass dB | Comments |
| 1 | 0.1253 | Loop | V/perp | -23.6 | Pk | 9.9 | 0.0 | -37.0 | 25.6 | 62.6 | loop perp. (axis in dir. of prop.) |
| 1 | 0.1253 | Loop | V/par | -29.0 | Pk | 9.9 | 0.0 | -42.4 | 25.6 | 68.0 | loop paral (loop in dir. of prop.) |
| 1 | 0.1253 | Loop | H | -30.0 | Pk | 9.9 | 0.0 | -43.4 | 25.6 | 69.0 | loop horiz (loop in horiz. plane) |
| 2 | 0.2506 | Loop | V/perp | -45.3 | Pk | 9.8 | 0.0 | -58.8 | 19.6 | 78.4 | |
| 2 | 0.2506 | Loop | V/par | -49.0 | Pk | 9.8 | 0.0 | -62.5 | 19.6 | 82.1 | |
| 2 | 0.2506 | Loop | H | -50.9 | Pk | 9.8 | 0.0 | -64.4 | 19.6 | 84.0 | |
| 3 | 0.3759 | Loop | V/perp | -63.7 | Pk | 9.8 | 0.0 | -77.2 | 16.1 | 93.3 | |
| 3 | 0.3759 | Loop | V/par | -66.7 | Pk | 9.8 | 0.0 | -80.2 | 16.1 | 96.3 | |
| 3 | 0.3759 | Loop | H | -65.5 | Pk | 9.8 | 0.0 | -79.0 | 16.1 | 95.1 | |
| 4 | 0.5012 | Loop | V/perp | -49.7 | Pk | 9.8 | 0.0 | 7.5 | 33.6 | 26.1 | noise, background rf |
| 4 | 0.5012 | Loop | V/par | -52.9 | Pk | 9.8 | 0.0 | 3.3 | 33.6 | 30.3 | noise, background rf |
| 4 | 0.5012 | Loop | H | -44.2 | Pk | 9.8 | 0.0 | 12.0 | 33.6 | 21.6 | noise, background rf |
| 5 | 0.6265 | Loop | V/perp | -37.3 | Pk | 9.8 | 0.0 | 20.1 | 31.7 | 11.6 | noise, background rf |
| 5 | 0.6265 | Loop | V/par | -47.1 | Pk | 9.8 | 0.0 | 9.1 | 31.7 | 22.6 | noise, background rf |
| 5 | 0.6265 | Loop | H | -63.5 | Pk | 9.8 | 0.0 | - 5.8 | 31.7 | 37.5 | noise, background rf |
| 6 | 0.7518 | Loop | All | -41.4 | Pk | 9.8 | 0.0 | 16.3 | 30.1 | 13.8 | noise, background rf |
| 7 | 0.8771 | Loop | All | -74.6 | Pk | 9.8 | 0.0 | -16.7 | 28.7 | 45.4 | noise, background rf |
| 8 | 1.0024 | Loop | All | -66.7 | Pk | 9.8 | 0.0 | - 8.5 | 27.6 | 36.1 | noise, background rf |
| 9 | 1.1277 | Loop | All | -43.5 | Pk | 9.8 | 0.0 | 15.0 | 26.6 | 11.6 | noise, background rf |
| 10 | 1.2530 | Loop | All | -85.1 | Pk | 9.8 | 0.0 | -26.2 | 25.6 | 51.8 | noise, background rf |
| | | | | | | | | | | | |
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| | | | | | | | | | | | |
| | | * Averaging applies up 490 kHz, 12.35 dB in this case | | | | | | | | | |
| | | | | | | | | | | | |
| | | Measurements made at 3m, see Sec.6.6 for extrapolation values | | | | | | | | | |
| | | Usually 9kHz RBW used, sometimes lower to reduce ambient and instrument noise | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |

| Digital Radiated Emissions, Class 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 |
| | | | | | | | | | | | |
| | | Meets class B limit by more than 20dB | | | | | | | | | |
| | | | | | | | | | | | |

Meas. 06/02/03; U of Mich.

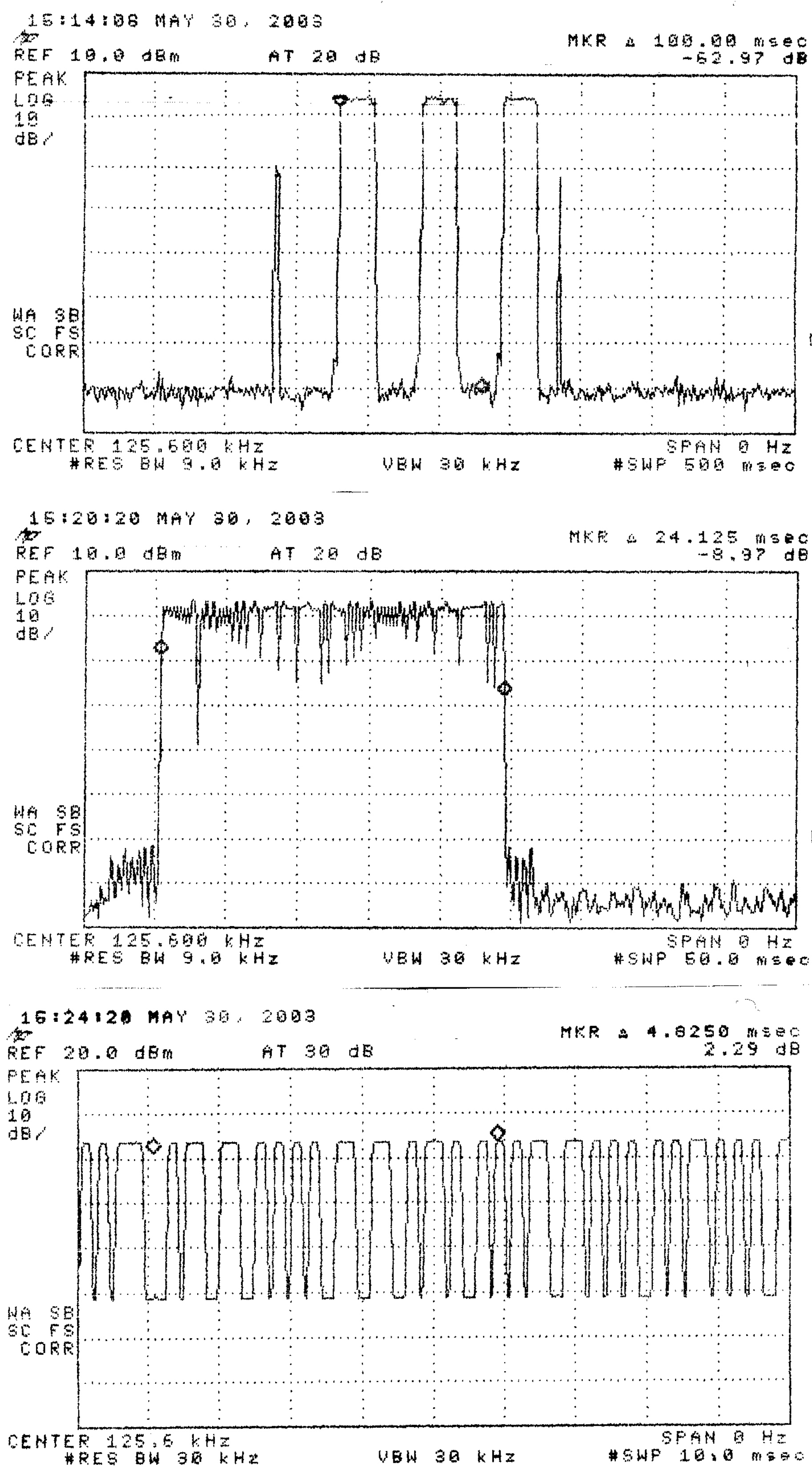


Figure 6.1. Transmissions modulation characteristics: (top) complete transmission, (center) single pulse, (bottom) expanded pulse.

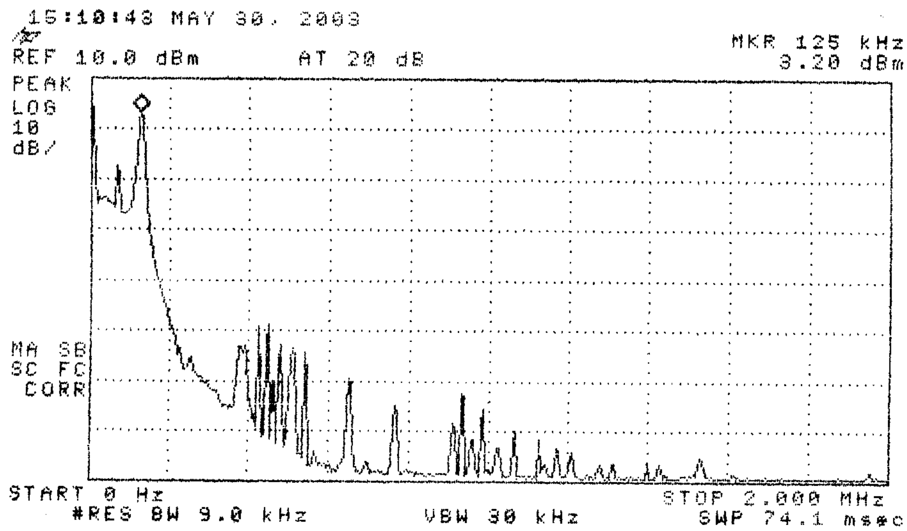


Figure 6.2. Emission spectrum of the DUT.
The amplitudes are only indicative (not calibrated).

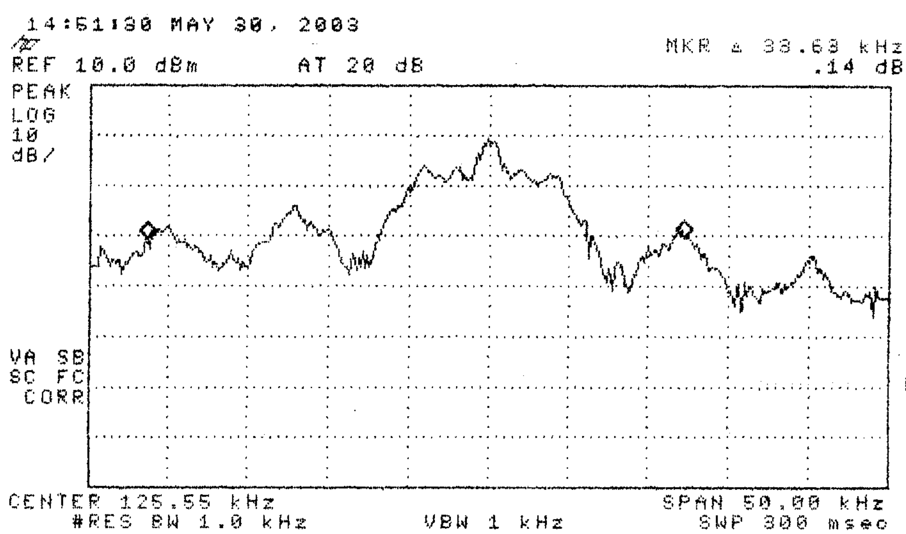


Figure 6.3. Measured bandwidth of the DUT. (repeated pulses)

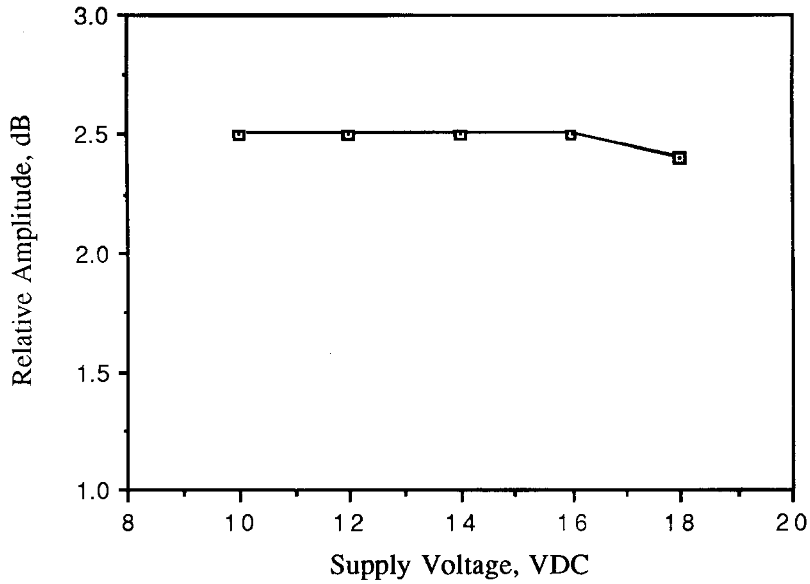


Figure 6.4. Relative emission at 125 kHz vs. supply voltage.

DUT on OATS

Close-up on the DUT on OATS