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Measured Radio Frequency Emissions  
From

**Motorola GTM800 RKE Receiver  
Model LHJ012**

Report No. 415031-110  
January 16, 2002

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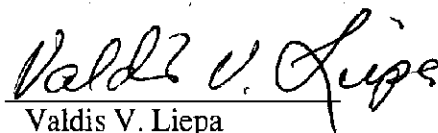
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**Summary**

Tests for compliance with FCC Regulations Part 15, Subpart B, and with Industry Canada Regulations, RSS-210, were performed on Motorola RKE Receiver. The device is subject to the Rules and Regulations as a Receiver. As a Digital Device it is exempt, but such measurements were made to assess the receiver's overall emissions.

In testing performed on November 28, 2001 and January 16, 2002, the device tested in the worst case met the specifications for radiated emissions by 3.1 dB (see p. 6). Since the device is powered from an automotive 12 VDC system, the line conductive emission tests do not apply.

## 1. Introduction

Motorola GTM800 RKE Receiver, Model LHJ012, was tested for compliance with FCC Regulations, Part 15, adopted under Docket 87-389, April 18, 1989, and with Industry Canada RSS-210, Issue 2, 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 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)  |           | 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 (50 $\mu$ H)                  |           | University of Michigan                 |
| Signal Generator (0.1-2060 MHz)    | X         | Hewlett-Packard, 8657B                 |
| Signal Generator (0.01-20 GHz )    |           | Hewlett-Packard                        |

### 3. Configuration and Identification of Device Under Test

The DUT is a 315.0 MHz superheterodyne receiver, designed for onboard automobile security/convenience applications, and as such, it is powered from an automotive 12 VDC source. The IF is 10.7 MHz, and the LO is at 304.3 MHz. It is housed in a plastic case along with doorlock and window controls and electronics. In the digital section of the receiver, decoding, signal processing, etc. are performed by a micro timed by a 4.03 MHz resonator. The case is approximately 2 by 2 by 7 inches and the antenna is internal to the case. For testing, a 3-meter long section of generic harness was used, with power wires separated from the control/signal wires.

The DUT was designed and manufactured by Motorola, Inc., Automotive and Industrial Electronics Group, 4000 Commercial Ave., Northbrook, IL 60062-1840. It is identified as:

Motorola GTM800 RKE Receiver  
Model: LHJ012  
S/N: 112701  
FCC ID: LHJ012  
CANADA:

#### 3.1 Modifications Made

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

### 4. Emission Limits

For FCC the DUT falls under Part 15, Subpart B, "Unintentional Radiators". For Industry Canada the DUT falls under Receiver category and is subject to technical requirement of sections 7.1 to 7.4 in RSS-210. The pertinent test 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, 15.109; IC: RSS-210, 7.3).

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

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

## 4.2 Conducted Emission Limits

Table 4.2. Conducted Emission Limits (FCC: 15.107; IC: RSS-210, 6.6).

| Freq. (MHz)   | $\mu\text{V}$ | $\text{dB}(\mu\text{V})$ |
|---------------|---------------|--------------------------|
| 0.450 - 1.705 | 250           | 48.0                     |
| 1.705 - 30.0  | 250           | 48.0                     |

Note: Quasi-Peak readings apply here

## 4.3 Antenna Power Conduction Limits

(FCC: 15.111(a); IC: RSS-210, 7.2).  $P_{\text{max}} = 2 \text{ nW}$ ; for frequency range see Table 4.1.

## 5. Emission Tests and Results

**NOTE:** Even though the FCC and/or Industry Canada specify that both the radiated and conductive emissions be measured using the Quasi-Peak and/or average detection schemes, we normally use peak detection since especially the Quasi-Peak is cumbersome to use with our instrumentation. In case the measurement fails to meet the limits, or the measurement is near the limit, it is remeasured using appropriate detection. We note, that since the peak detected signal is always higher or equal to the Quasi-Peak or average detected signal, the margin of compliance may be better, but not worse, than indicated in this report. The type of detection used is indicated in the data table, Table 5.1.

### 5.1 Anechoic Chamber Radiated Emission Tests

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

To study and test for radiated emissions, the DUT was powered by a laboratory power supply. A 315 MHz CW signal was injected (radiated) from a nearby signal generator using a short wire antenna. The DUT was placed on the test table on each of its three axis. For each placement, the table was rotated to obtain maximum signal for vertical and horizontal emission polarizations. This sequence was repeated throughout the required frequency range.

In the chamber we studied and recorded all the emissions using a ridge-horn antenna, which covers 200 MHz to 5000 MHz, up to 2 GHz. In scanning from 30 MHz to 2.0 GHz, there were no spurious emissions observed other than the LO, the injection signal, and the LO harmonics. Figures 5.1 and 5.2 show emissions measured 0-1000 MHz and 1000-2000 MHz, respectively. These measurements are made with a ridge-horn antenna at 3m, with spectrum analyzer in peak hold mode and the receiver rotated in all orientations. The measurements up to 1000 MHz (Fig. 5.1) are used for initial evaluation only, but those above 1000 MHz (Fig. 5.2) are used in final assessment for compliance.

### 5.2 Open Site Radiated Emission Tests

The DUT was then moved to the 3 meter Open Field Test Site where measurements were repeated up to 1000 MHz using a small bicone, or dipoles when the measurement is near the limit. The DUT was exercised as described in Sec. 5.1 above. The measurements were made with a spectrum analyzer using 120 kHz IF bandwidth and peak detection mode, and, when appropriate, using Quasi-Peak or average detection. When emissions are narrow band, as in a case of an LO, measurements in the 800 MHz range are made with 10 kHz RBW to help discriminate emissions from the ambient signals and noise. The test set-up photographs are in the Appendix (i.e., end of this report).

The emissions from digital circuitry were measured using a standard bicone. These results are noted in Table 5.1.

### 5.3 Computations and Results for Radiated Emissions

To convert the dBm's measured on the spectrum analyzer to dB( $\mu$ 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 3.1 dB.

### 5.4 Conducted Emission Tests

These tests do not apply, since the DUT is powered from an automotive 12-volt system.

## 6. Other Measurements

### 6.1 Emission Spectrum Near Fundamental

Near operating frequency the emission spectrum is measured typically over 50 MHz span with and without injection signal. These data are taken with the DUT close to antenna and hence amplitudes are relative. The plots are shown in Figure 6.1.

### 6.2 Effect of Supply Voltage Variation

The DUT has been designed to operate from 12 VDC power. Using a spectrum analyzer, relative radiated emissions were recorded at the "fundamental" (304.3 MHz) as voltage was varied from 5.5 to 18.0 VDC. Figure 6.2 shows the emission variation.

### 6.3 Operating Voltage and Current

V = 12.8 VDC  
I = 40.0 mADC (includes the control box)

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**Table 5.1 Highest Emissions Measured**

| <b>Radiated Emission - RF</b> |           |           |           |        |           |         |       |           |              |         | Motorola RX; 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                      |
| 1                             | 304.3     | Dip       | H         | -63.0  | Pk        | 18.6    | 22.1  | 40.5      | 46.0         | 5.5     | flat                          |
| 2                             | 304.3     | Dip       | H         | -60.6  | Pk        | 18.6    | 22.1  | 42.9      | 46.0         | 3.1     | side                          |
| 3                             | 304.3     | Dip       | H         | -66.5  | Pk        | 18.6    | 22.1  | 37.0      | 46.0         | 9.0     | end                           |
| 4                             | 304.3     | Dip       | V         | -68.5  | Pk        | 18.6    | 22.1  | 35.0      | 46.0         | 11.0    | flat                          |
| 5                             | 304.3     | Dip       | V         | -66.8  | Pk        | 18.6    | 22.1  | 36.7      | 46.0         | 9.3     | side                          |
| 6                             | 304.3     | Dip       | V         | -69.0  | Pk        | 18.6    | 22.1  | 34.5      | 46.0         | 11.5    | end                           |
| 7                             | 608.5     | Dip       | H         | -89.3  | Pk        | 24.9    | 18.8  | 23.8      | 46.0         | 22.2    | max. of all; 10 kHz BW        |
| 8                             | 608.5     | Dip       | V         | -91.9  | Pk        | 24.9    | 18.8  | 21.2      | 46.0         | 24.8    | max. of all; 10 kHz BW        |
| 9                             | 912.8     | Dip       | H         | -92.0  | Pk        | 28.6    | 16.5  | 27.0      | 46.0         | 19.0    | max. of all, noise; 10 kHz BW |
| 10                            | 912.8     | Dip       | V         | -90.9  | Pk        | 28.6    | 16.5  | 28.1      | 46.0         | 17.9    | max. of all, noise; 10 kHz BW |
| 11                            | 1217.0    | Horn      | H         | -71.4  | Pk        | 20.4    | 28.0  | 28.0      | 54.0         | 26.0    | max. of all, noise floor      |
| 12                            | 1522.0    | Horn      | H         | -71.5  | Pk        | 20.6    | 28.0  | 28.1      | 54.0         | 25.9    | max. of all, noise floor      |
| 13                            | 1826.0    | Horn      | H         | -70.5  | Pk        | 20.8    | 28.2  | 29.1      | 54.0         | 24.9    | max. of all, noise floor      |
| 14                            |           |           |           |        |           |         |       |           |              |         |                               |
| 15                            |           |           |           |        |           |         |       |           |              |         |                               |
| 16                            |           |           |           |        |           |         |       |           |              |         |                               |
| 17                            |           |           |           |        |           |         |       |           |              |         |                               |
| 18                            |           |           |           |        |           |         |       |           |              |         |                               |

**Radiated Emission - Digital (Class B)**

|    |  |  |  |  |  |  |  |  |  |  |  |
|----|--|--|--|--|--|--|--|--|--|--|--|
| 1  |  |  |  |  |  |  |  |  |  |  |  |
| 2  |  |  |  |  |  |  |  |  |  |  |  |
| 3  | Digital Emissions more than 20 dB below FCC Class B limits |  |  |  |  |  |  |  |  |  |  |
| 4  |  |  |  |  |  |  |  |  |  |  |  |
| 5  |  |  |  |  |  |  |  |  |  |  |  |
| 6  |  |  |  |  |  |  |  |  |  |  |  |
| 7  |  |  |  |  |  |  |  |  |  |  |  |
| 8  |  |  |  |  |  |  |  |  |  |  |  |
| 9  |  |  |  |  |  |  |  |  |  |  |  |
| 10 |  |  |  |  |  |  |  |  |  |  |  |
| 11 |  |  |  |  |  |  |  |  |  |  |  |
| 12 |  |  |  |  |  |  |  |  |  |  |  |

**Conducted Emissions**

| # | Freq. MHz      | Line Side | Det. Used | Vtest dBμV | Vlim dBμV | Pass dB | Comments |
|---|----------------|-----------|-----------|------------|-----------|---------|----------|
| 1 |                |           |           |            |           |         |          |
| 2 | Not applicable |           |           |            |           |         |          |
| 3 |                |           |           |            |           |         |          |

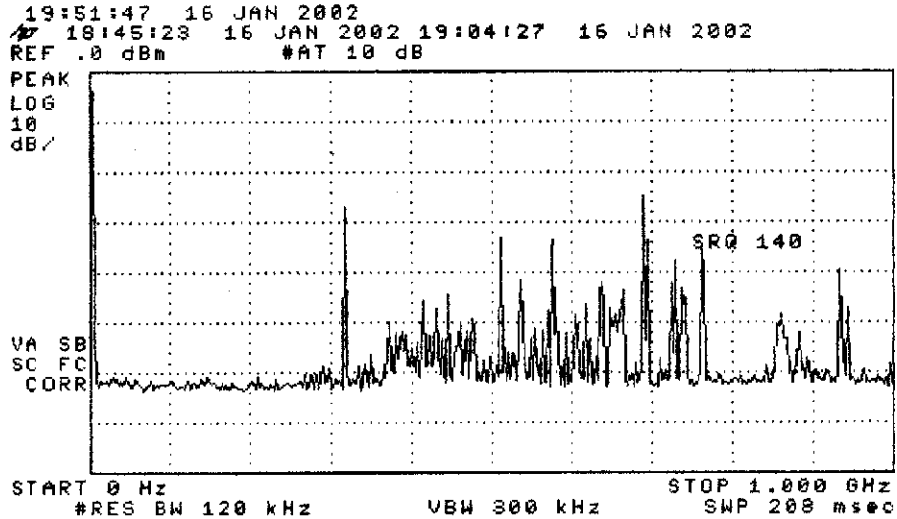
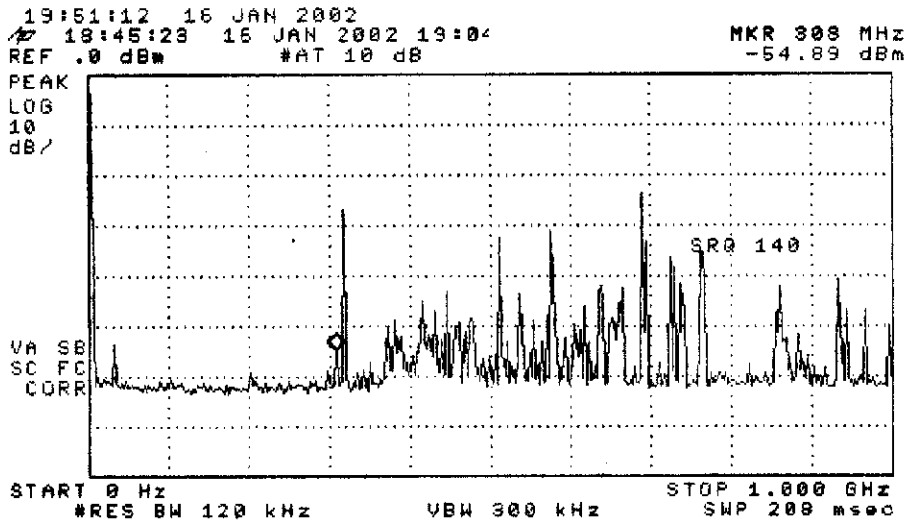


Figure 5.1. Emissions measured at 3 meters in anechoic chamber, 0-1000 MHz.  
 (top) Receiver plus ambient  
 (bottom) Ambient

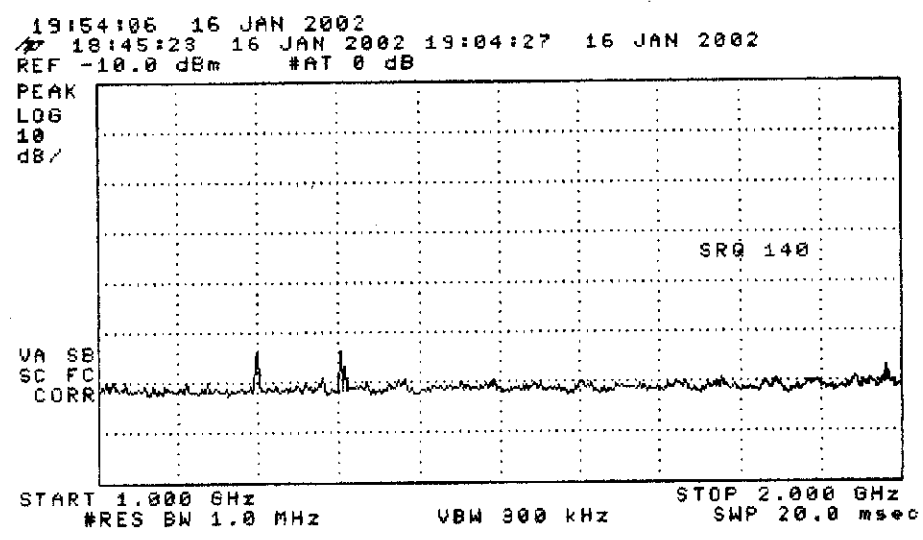
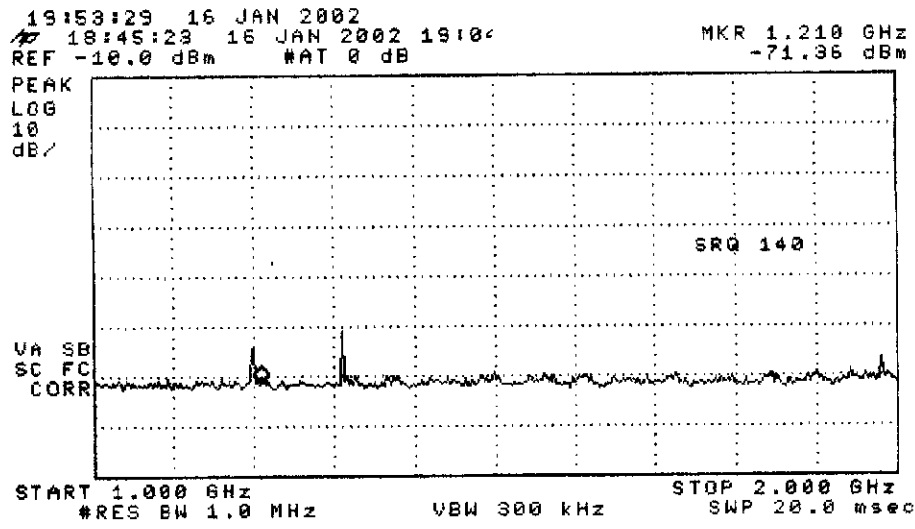


Figure 5.2. Emissions measured at 3 meters in anechoic chamber, 1000-2000 MHz.  
 (top) Receiver plus ambient  
 (bottom) Ambient



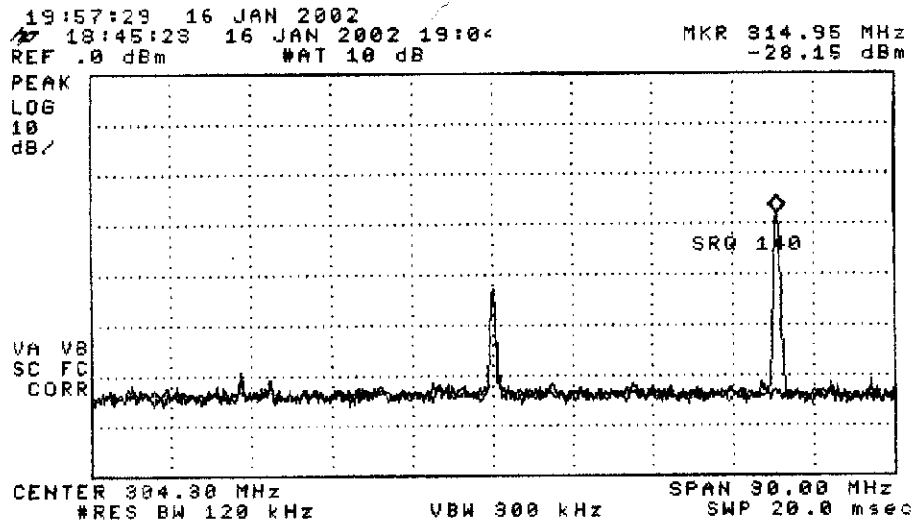


Figure 6.1. Relative receiver emissions in stand-by and "locked-in" modes. The final emission measurements were made with the receiver in "locked-in" mode.

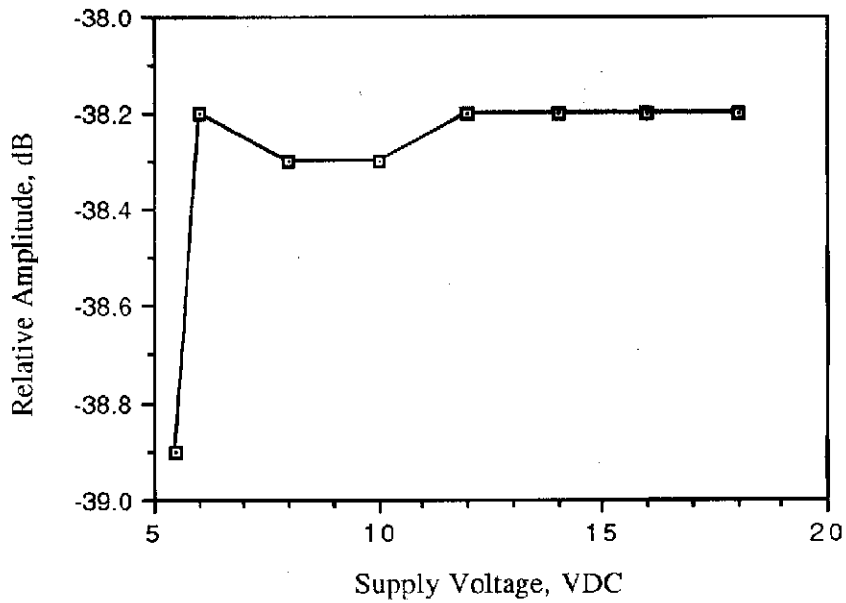
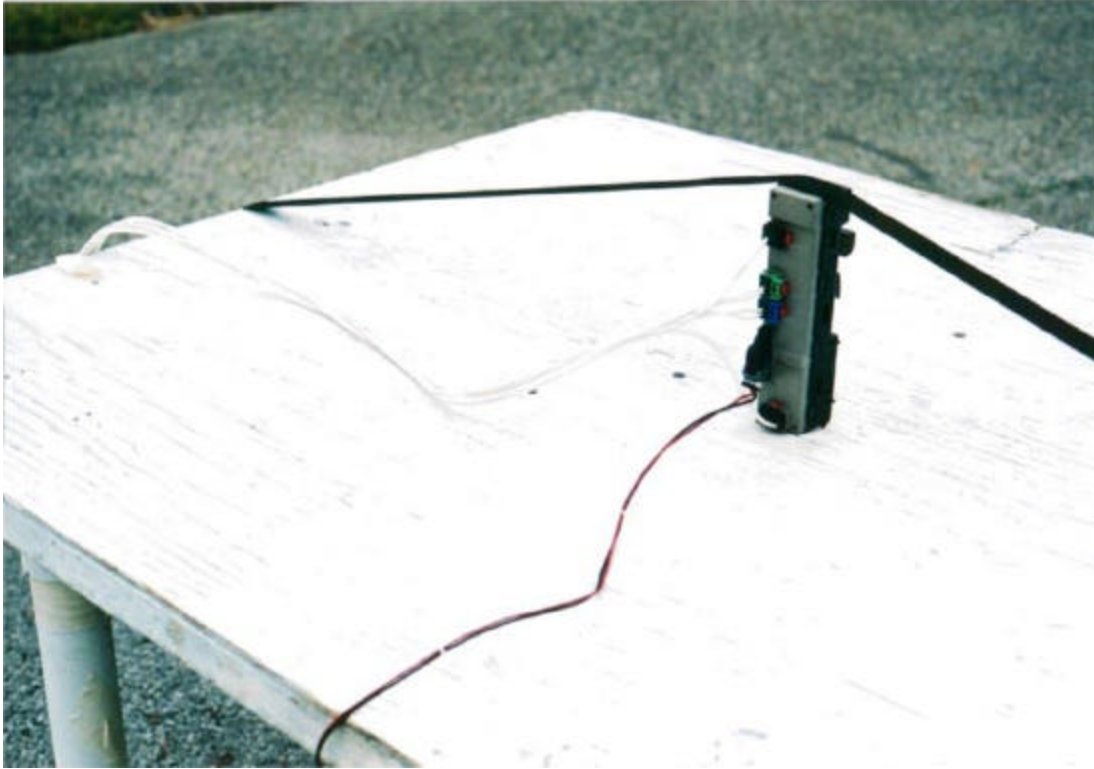


Figure 6.2. Relative emission at "fundamental" vs. supply voltage.



LHM012 Receiver Close-up on OATS



LHM012 Receiver on OATS