

**EXHIBIT E: REPORT OF MEASUREMENTS [2.1033(B6)]**

**Test Report for FCC ID: PYM-SPAHOME1**  
**FCC Part 2.1031, Part 15 Subpart C(15.231)**

**Report #0400688FH**  
**Issued 06/04/04**



**MODEL SPAHOME1**  
**433.92MHZ TRANSCEIVER**

Prepared for:

Mr. Tony Pipitone  
Balboa Instruments Inc.  
1382 Bell Avenue  
Tustin, CA 92780-6430

Test Date(s): March 25, April 26, May 28-29, 2004

Report prepared by:

Report reviewed by

A handwritten signature in black ink, appearing to read "Ted Chaffee".

Ted Chaffee, NCE

Data recorded by:

A handwritten signature in black ink, appearing to read "Ted Chaffee".

Gordon Helm, NCE  
Ted Chaffee, NCE

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## Statements Concerning this Report

### **NVLAP Accreditation: NVLAP Lab Code 200129-0**

The scope of AHD accreditation is the test methods of:

|                              |                                                                                                          |
|------------------------------|----------------------------------------------------------------------------------------------------------|
| IEC/CISPR 22:                | Limits and methods measurement of radio disturbance characteristics of information technology equipment. |
| FCC Method – 47 CFT Part 15: | Digital Devices.                                                                                         |
| AS/NZS 3548:                 | Electromagnetic Interference – Limits and Methods of Measurement of Information Technology Equipment.    |
| IEC61000-4-2 and Amend.1:    | ElectroStatic Discharge Immunity                                                                         |
| IEC61000-4-5:                | Surge Immunity                                                                                           |

### **Test Data:**

This test report contains data covered by the NVLAP accreditation.

### **Subcontracted Testing:**

This report does not contain data produced under subcontract.

### **Test Traceability:**

The calibration of all measuring and test equipment and the measured data using this equipment are traceable to the National Institute for Standards and Technology (NIST).

### **Limitations on results:**

The test results contained in this report relate only to the Item(s) tested. Any electrical or mechanical modification made to the test item subsequent to the test date shall invalidate the data presented in this report. Any electrical or mechanical modification made to the test item subsequent to this test date shall require an evaluation to verify continued compliance.

### **Limitations on copying:**

This report shall not be reproduced, except in full, without the written approval of AHD.

### **Limitations of the report:**

This report shall not be used to claim product endorsement by NVLAP, FCC, or any agency of the US Government.

**Statement of Test Results Uncertainty:** Following the guidelines of NAMAS publication NIS81 and NIST Technical Note 1297, the Measurement Uncertainty at a 95% confidence level is determined to be:  $\pm 1.4$  dB

**Manufacturer/Applicant [2.1033(b1)]****Applicant:**

Balboa Instruments Inc.  
1382 Bell Avenue  
Tustin, CA 92780-6430

**Manufacturer:**

Balboa Instruments Inc.  
1382 Bell Avenue  
Tustin, CA 92780-6430

**Measurement/Test Site Facility & Equipment****Test Site [2.948, 2.1033(b6)]**

The AHD test facility is centered on 9 acres of rural property near Sister Lakes, Michigan. The mailing address is 92723 M-152, Dowagiac, Michigan 49047. This test facility is NVLAP accredited (LabCode 200129-0). It has been fully described in a report filed with the FCC (No.90413) and Industry Canada (file:IC3161).

**Measurement Equipment Used**

| Equipment                           | Model      | S/N        | Next Cal<br>Date |
|-------------------------------------|------------|------------|------------------|
| HP EMI Receiver system              | HP 8546A   |            |                  |
| RF Filter Section                   | HP-85460A  | 3448A00283 | 27-Aug-04        |
| RF Receiver Section                 | HP-85462A  | 3625A00342 | 27-Aug-04        |
| EMCO BiconiLog Antenna              | 3142       | 1077       | 26-Aug-04        |
| (3-M) Type 129FF Ultra Flex LowLoss | RG58/U     | 9910-12    | 04-Aug-04        |
| (3-M) LMR-400 Ultra Flex            | LMR400     | 9812-11    | 04-Aug-04        |
| (10-M) Amelco 50ohm Coax            | RG213/U    | 9903-10ab  | 04-Aug-04        |
| Double Ridged Horn                  | ONO91202-2 | A00329     | 17-Aug-01        |

**Environment**

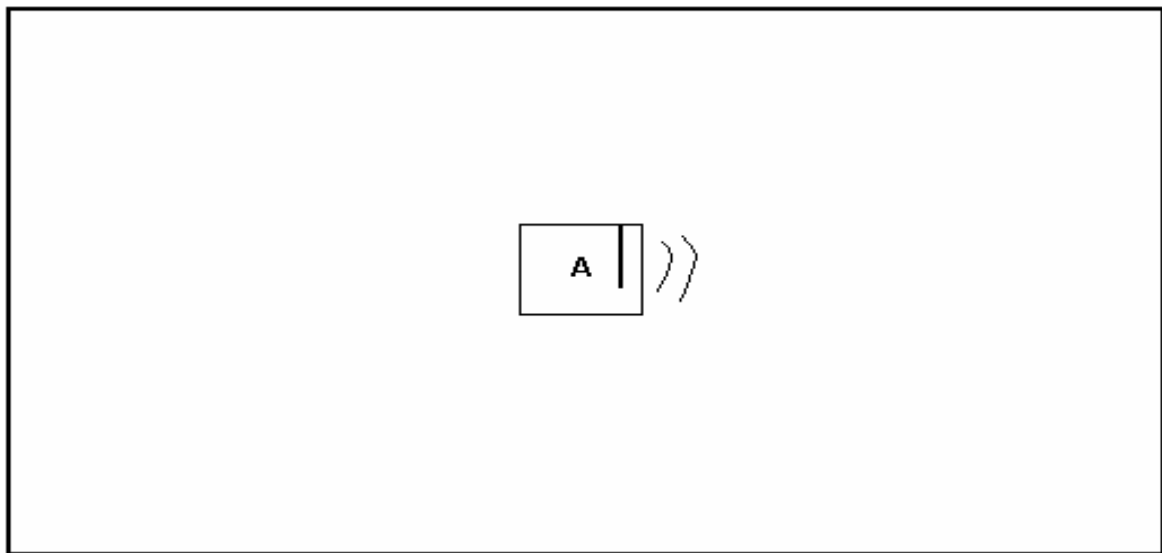
The test was performed with the equipment under test, and measurement equipment inside the all-weather enclosure. Ambient temperature was 22deg.C., the relative humidity 35%.

**Tested Configuration /Setup: [2.1033(b8)]****Support Equipment & Cabling**

| Setup Diagram Legend | Description                       | Model                 | Serial No. / Part No. | EMC Consideration    |
|----------------------|-----------------------------------|-----------------------|-----------------------|----------------------|
| A                    | [EUT]<br>433.92MHz<br>Transceiver | [Ballboa]<br>SPAHOME1 | Pre-production        | FCC ID: PYM-SPAHOME1 |
|                      |                                   |                       |                       |                      |

**Setup Diagram**

Note: Setup photographs are located in Attached Electronic File, Exhibit E.



setup\_1a1b

BASIC EUT SETUP  
(Legend designation is above)

---

## Description of Equipment Under Test

The tested unit is the portable portion of a 433.92MHz transceiver pair. This unit will receive information of a remotely located "hot tub" regarding abnormal conditions. The user can also initiate a command to control water temperature, on/off lights, or on/off pump.

There is one printed circuit board.

2-layer PCB, #XS0084 Rev.3. Microprocessor: PIC16F648A; Receiver IC: RFRXD0420.  
Oscillators: 8.0MHz, 26.45125MHz, 433.92MHz. 10.7MHz IF filter.

The antenna is a foil trace on the printed circuit board. It can not be altered.

## Summary of Results:

1. This test series evaluated the Equipment Under Test to FCC Part 15, SubPart C.
2. The system tested is compliant to the requirement of CFR 47, FCC Part 15, SubPart C for periodic operation in the allowed frequency bands above 70MHz, ( Part 15.231 ).
3. The system tested is compliant to the requirement of CFR 47, FCC Part 15, SubPart B as a digital device.
4. The equipment under test was received on March 25, 2004 and this test series commenced on March 25, 2004.
5. The line conducted emission testing does not apply to this product. The device is powered from three 1.5vdc batteries.
7. Occupied Band Width of the transmitted signal, at the 20dB point, was measured to be 388KHz. This measurement is within the allowed 1.084MHz bandwidth.
8. The field strength level of the fundamental showed the emission nearest the limit occurred with the EUT was positioned on the 'end' and the receive antenna oriented in the vertical polarization. This signal was calculated to be 7.6dB below the 15.231(a) limit of 80.8dBuV/m (10,997uV/m).
9. The evaluation of the field strength levels of the harmonics showed the emission nearest the limit occurred at the second harmonic. The EUT was positioned on the 'flat' and the receive antenna oriented in the horizontal polarization. This signal, at 867.8MHz, was calculated to be 1.2dB below the 15.231(a) limit of 60.8dBuV/m (1100uV/m)
10. The field strength evaluation of other spurious emissions showed the emission nearest the limit occurred at 1529.6MHz. This emission was calculated to be 45.7dBuV/m average which is 8.3dB below the average limit of 54.0dBuV/m.

**Changes made to achieve compliance**

1. NONE

**Standards Applied to Test: [2.1033(b6)]**

ANSI C63.4 - 2001

CFR47 FCC Part 2, Part 15, SubPart C, 15.231 Intentional Radiator; SubPart B, Digital Device  
Public Notice DA 02-2850

**Test Methodology: [2.1033(b6)]**

The pictures in this report, showing test setups, indicate the agreed upon configuration of testing for this product-type.

The line conducted emission testing does not apply to this product. The device is powered from three 1.5vdc batteries.

For the testing, the SPAHOME1 was placed in an engineering mode, which allowed it to continuously transmit a data pulse stream.

**Radiated**

The system was placed upon a 1 x 1.5 meter non-metallic table 80cm above the open field site ground plane in the prescribed setup per ANSI C63.4. For the testing, the SPAHOME1 was placed at the center of the table pursuant to ANSI C63.4 for stand-alone equipment.

The table sits upon a remote controlled turntable. The receiving antenna, located at the appropriate standards distance of 3 or 10 meters from the table center, is also remote controlled.

The principle settings of the EMI Receiver for radiated testing include:

IF Bandwidth: 120KHz for frequencies less than 1GHz.  
1 MHz for frequencies greater than 1GHz.

Detector Function: Peak Mode

The Average levels were determined mathematically based upon the on time of the pulsed modulation of the transmitted signal.

Detector Function: Quasi-Peak for spurious emission less than 1GHz.

At frequencies up to 1000MHz a BiconiLog broadband antenna was used for measurements.

At frequencies above 1000MHz a double-ridge Horn broadband antenna was used for measurements.

During the evaluation the EUT was transmitting continuously.

The turntable was rotated 360 degrees and the receiving antenna height varied from 1 to 4 meters to search out the highest emissions.

The final measurements were made with the EUT placed in three orthogonal positions. At each position the receive antenna was placed in vertical and horizontal positions.

The unit was evaluated up to the tenth harmonic of the fundamental as an intentional radiator, and up to 2000MHz as a digital device.

The orthogonal positions of EUT are:



Flat



Side



End

---

**FORMULAS AND SAMPLE CALCULATIONS:**

THE HP8546A EMI Receiver has stored in memory the antenna and coax correction factors used in this test. The resultant Field Strength (FS) in dBuV/m presented by the HP8546A is the summation in decibels (dB) of the Received Level (RF), the Antenna Correction Factor (AF), and the Cable Loss Factor (CF).

Formula 1: 
$$FS(\text{dBuV/m}) = RF(\text{dBuV}) + AF(\text{dB/m}) + CF(\text{dB})$$

The resultant Field Strength measurement is recorded using the peak hold detector of the HP8546A.

This recorded peak level is further corrected, by calculation, to an average level by summing and averaging the on time of the pulsed transmission over the specified 100mSec.

**Determining the Signal average of the SPAHOME1**

In any 100mSec period the transmitter will have at most only one transmission. This transmission is firmware controlled. At the time the transmission is activated it will initially output at a level that will be the zero (low) level of the packet communication. After 1.0mSec the Manchester encoded packet of ones and zeros are transmitted. This packet transmission continues for 24.85mSec. When the packet transmission ends the carrier continues to transmit at the low level for 0.60mSec.

The average level of the pulsed signal was determined by summing all the signals levels during a 100mSec period, then dividing by 100mSec to arrive at an average level per 100mSec. All terms used in the calculations were linear. Emission levels were expressed in 'uV/m' and time expressed in mSec.

There are two levels of emissions during any 100mSec period.

First is the carrier level representing the zero bit (low level).

Second is the high level representing the one bit (high level).

Then no transmissions for the remainder of the 100mSec.

Formula 3: 
$$\{ [\text{Low uV/m}] \times [\text{ON mSec}] + [\text{High uV/m}] \times [\text{ON mSec}] \} / \{ 100\text{mSec} \}$$

During the measurement of the SPAHOME1 both the peak level when transmitting a 'one' (high) and the peak level when transmitting a 'zero' (low) were recorded.

**Example of using formula 3 to determine average level:**

$$\begin{aligned}\text{Level recorded at the bit one level (high)} &= 35,480\text{uV/m} \\ \text{Level recorded at the bit zero and carrier only level (low)} &= 1,318\text{uV/m}\end{aligned}$$

The firmware has determined that –

- before the packet transmission the on time of the carrier is 1.00mSec.
- during packet transmission the high and low levels are equal in on time because of the 50% duty cycle of the Manchester encoding. Therefore, the packet transmission of 24.85mSec is shared equally with 12.425mSec at the zero level and 12.425mSec at the one level.
- after the packet transmission the carrier remains on 0.60mSec at the low level.

Applying formula 3:

$$\begin{aligned}& \{ [ 1318\text{uV/m}] \times [1.0 + 12.425 + 0.6]\text{mSec} + [35480\text{uV/m}] \times [12.425\text{mSec}] \} / 100\text{mSec} \\ &= \{ 18485\text{uV/m} + 440839\text{uV/m} \} / 100 = 459324 / 100\end{aligned}$$

Therefore the average level of this emission in a 100mSec period is 4593.2uV/m

Formula 3 was utilized for all pulsed emissions for which the average level was applicable.

**Calculation of FCC limits. Part 15.231**

## 15.231(a)

For the frequency range 260MHz - 470MHz, the limit is a linear interpolation between 3750uV/m and 12500uV/m where the limit at 260MHz is 3750uV/m and the limit at 470MHz is 12500uV/m.

## 15.231(e)

For the frequency range 260MHz - 470MHz, the limit is a linear interpolation between 1500uV/m and 5000uV/m where the limit at 260MHz is 1500uV/m and the limit at 470MHz is 5000uV/m.

A formula to calculate the limit is established with a ratio linearly equating the frequency range to the limit range.

$$(F_0 - F_L) / (F_H - F_L) = (L_0 - L_L) / (L_H - L_L)$$

where  $F_0$  and  $L_0$  represent the frequency in question and its limit

where  $F_L$  and  $L_L$  represent the lower frequency and its respective limit.

Where  $F_H$  and  $L_H$  represent the higher frequency and its respective limit.

The calculations for 433.92MHz

## 15.231(a)

$$(433.92 - 260) / (470 - 260) = (L_0 - 3750) / (12500 - 3750)$$

$$(173.92 / 210) * (8750) = L_0 - 3750$$

$$L_0 = 7246.7 + 3750$$

$$L_0 = 10996.7 \text{ uV/m is LIMIT at 433.92MHz}$$

The limit in dB terms is calculated as the result of 20 times the log of the uV/m limit.

$$\text{dB limit is } 20 * \text{LOG}(10996.7 \text{ uV/m}) = 80.8 \text{ dBuV/m}$$

## 15.231(e)

$$(433.92 - 260) / (470 - 260) = (L_0 - 1500) / (5000 - 1500)$$

$$(173.92 / 210) * (3500) = L_0 - 1500$$

$$L_0 = 2898.7 + 1500$$

$$L_0 = 4398.7 \text{ uV/m is LIMIT at 433.92MHz}$$

The limit in dB terms is calculated as the result of 20 times the log of the uV/m limit.

$$\text{dB limit is } 20 * \text{LOG}(4398.7 \text{ uV/m}) = 72.9 \text{ dBuV/m}$$

**Test Data [2.1033(b6)]****Modulation Characteristics**

The transmitter is Amplitude modulated.

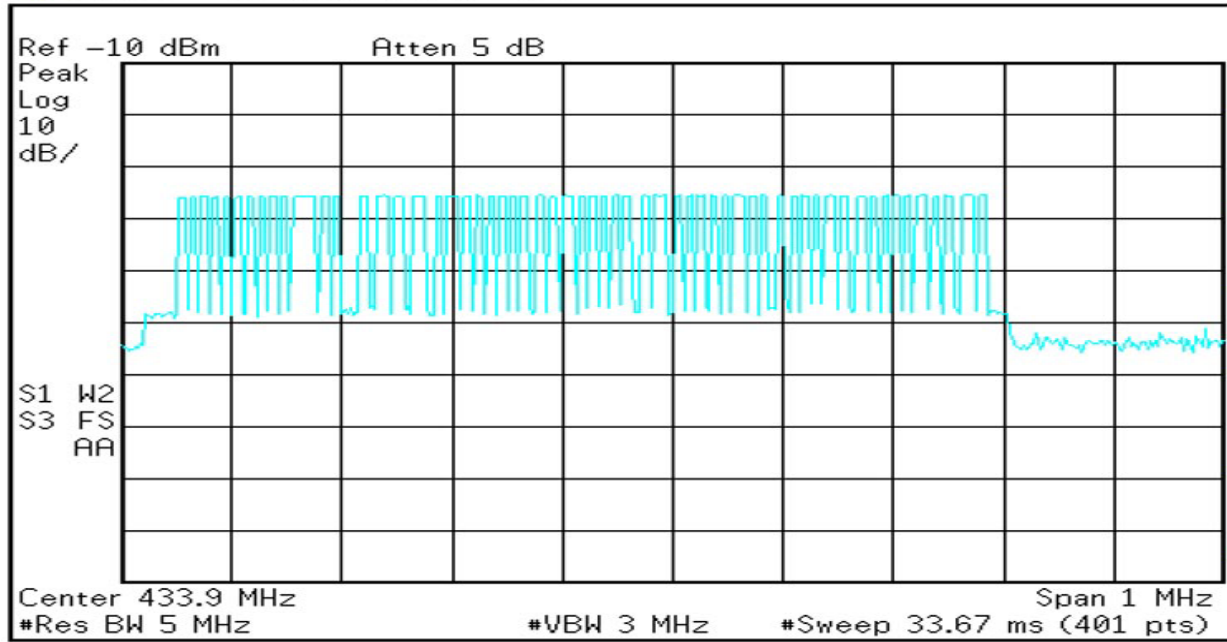
At time 0.0mSec the transmitter is turned on.

At time 0.1mSec the pulse modulation of the carrier begins.

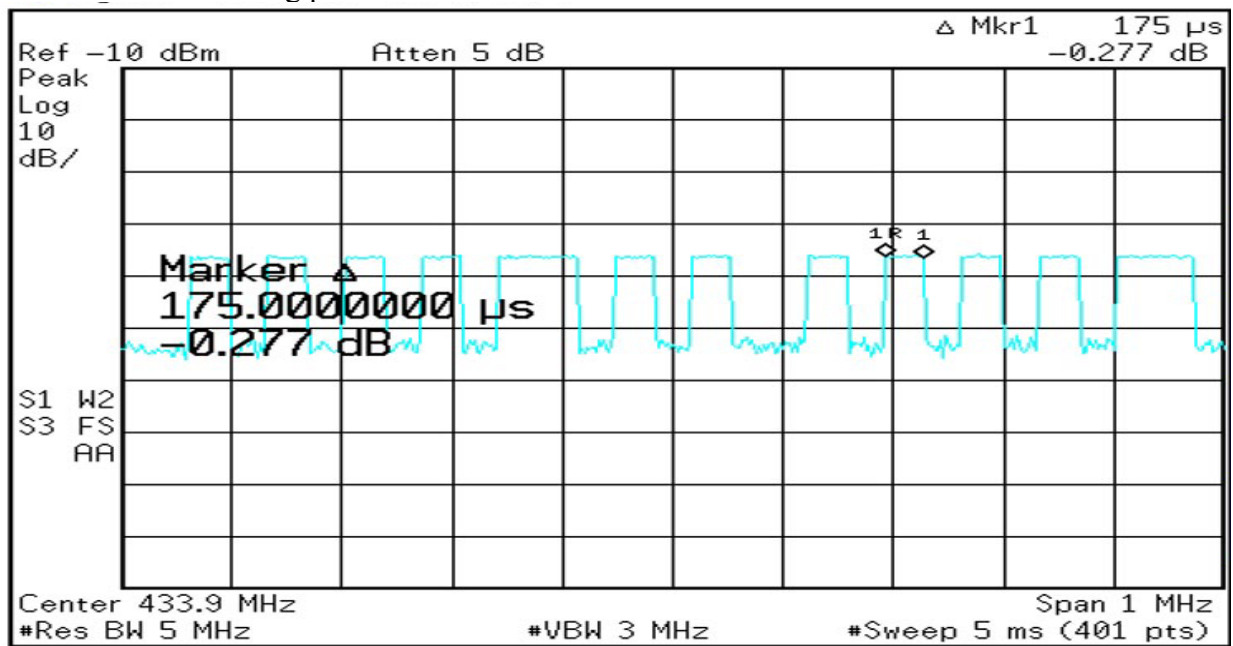
Pulsed signals continue for 24.85mSec. The Manchester encoding ensures a 50% duty cycle.

At time 26.45mSec the transmitter is turned off.

Typical pulse train.



A view of the encoding pulse width



**Occupied Bandwidth [15.231(c)]**

The maximum allowed 20dB bandwidth is determined pursuant to 15.23(c). For fundamental signals between 70MHz and 900MHz the bandwidth allowed is 0.25% of the fundamental.

The maximum allowed 20dB bandwidth is determined pursuant to 15.231(c) and ANSI C63.4.

The limit, pursuant to 15.231(c) is 0.25% of fundamental.

The bandwidth limit for 433.92MHz is  $433.92 \times 0.0025 = 1.085\text{MHz}$ .

The resolution bandwidth of the measuring equipment is to be greater than 5% of the limit. The minimum equipment resolution bandwidth required is calculated as  $.05 \times 1085\text{KHz} = 54.2\text{KHz}$ .

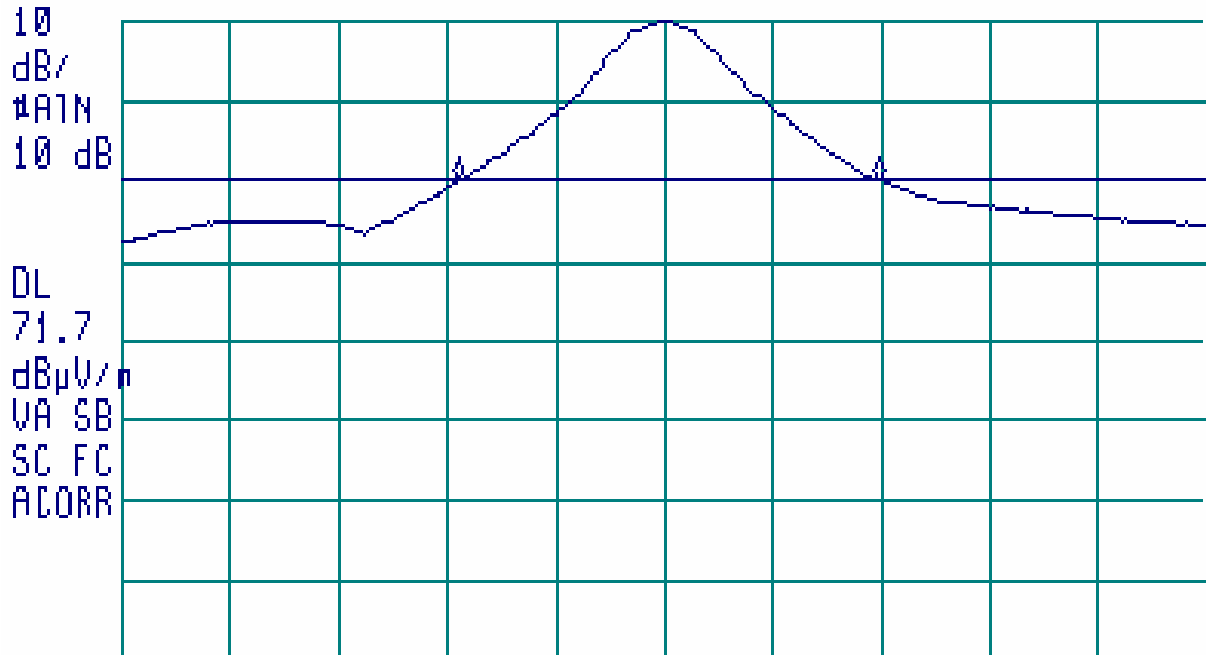
An RBW of 120KHz is selected.

Formula 2: Allowed bandwidth = [ Fundamental ] x [ .0025 ]

| Fundamental<br>(MHz) | Measured<br>20dB Bandwidth | LIMIT<br>Fundamental * .0025 |
|----------------------|----------------------------|------------------------------|
| 433.92               | 388 KHz                    | 1.085MHz                     |
|                      |                            |                              |

This chart shows a measured bandwidth signal.

LOG REF 91 7 dBμV/m



CENTER 433.975 MHz

SPAN 1.000 MHz

RT #1F BW 120 kHz

AUC BW 300 kHz

SWP 20.0 msec

**Restricted Bands: [15.205]**

The following frequency bands are restricted. Only spurious emissions are permitted at levels limited by 15.209:

| MHz               | MHz                 | MHz           | GHz         |
|-------------------|---------------------|---------------|-------------|
| 0.090-0.110       | 16.42-16.423        | 399.9-410     | 4.5-5.25    |
| 0.490-0.510       | 16.69475-16.69525   | 608-614       | 5.35-5.46   |
| 2.1735-2.1905     | 16.80425-16.80475   | 960-1240      | 7.25-7.75   |
| 4.125-4.128       | 25.5-25.67          | 1300-1427     | 8.025-8.5   |
| 4.17725-4.17775   | 37.5-38.25          | 1435-1626.5   | 9.0-9.2     |
| 4.20725-4.20775   | 73-74.6             | 1645.5-1646.5 | 9.3-9.5     |
| 6.215-6.218       | 74.8-75.2           | 1660-1710     | 10.6-12.7   |
| 6.26775-6.26825   | 108-121.94          | 1718.8-1722.2 | 13.25-13.4  |
| 6.31175-6.31225   | 123-138             | 2200-2300     | 14.47-14.5  |
| 8.291-8.294       | 149.9-150.05        | 2310-2390     | 15.35-16.2  |
| 8.362-8.366       | 156.52475-156.52525 | 2483.5-2500   | 17.7-21.4   |
| 8.37625-8.38675   | 156.7-156.9         | 2655-2900     | 22.01-23.12 |
| 8.41425-8.41475   | 162.0125-167.17     | 3260-3267     | 23.6-24.0   |
| 12.29-12.293      | 167.72-173.2        | 3332-3339     | 31.2-31.8   |
| 12.51975-12.52025 | 240-285             | 3345.8-3358   | 36.43-36.5  |
| 12.57675-12.57725 | 322-335.4           | 3600-4400     | Above 38.6  |
| 13.36-13.41       |                     |               |             |

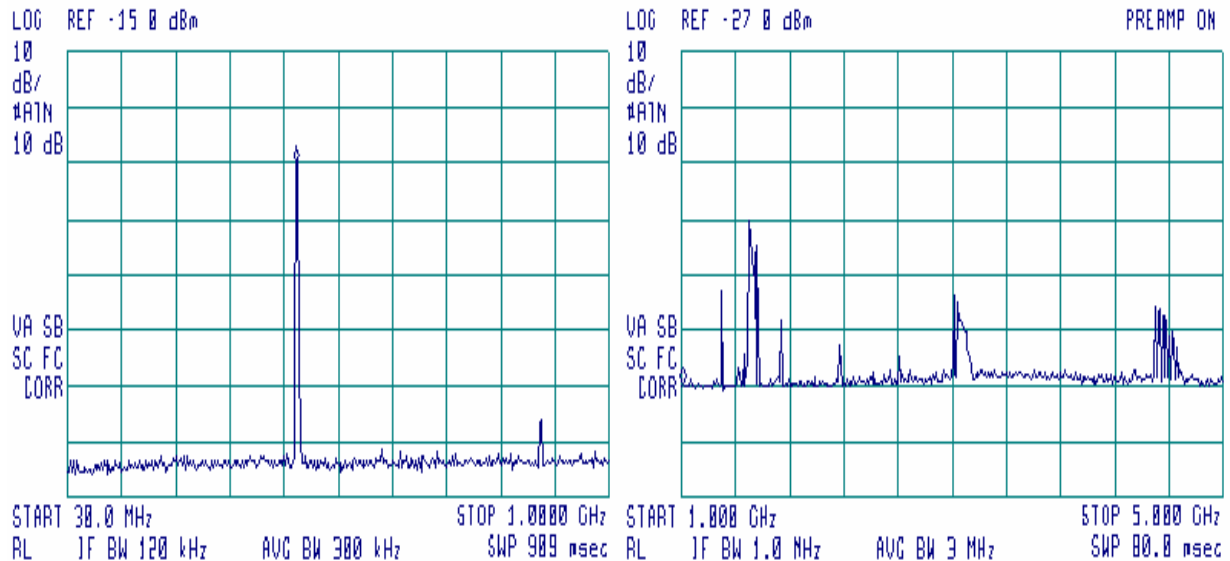
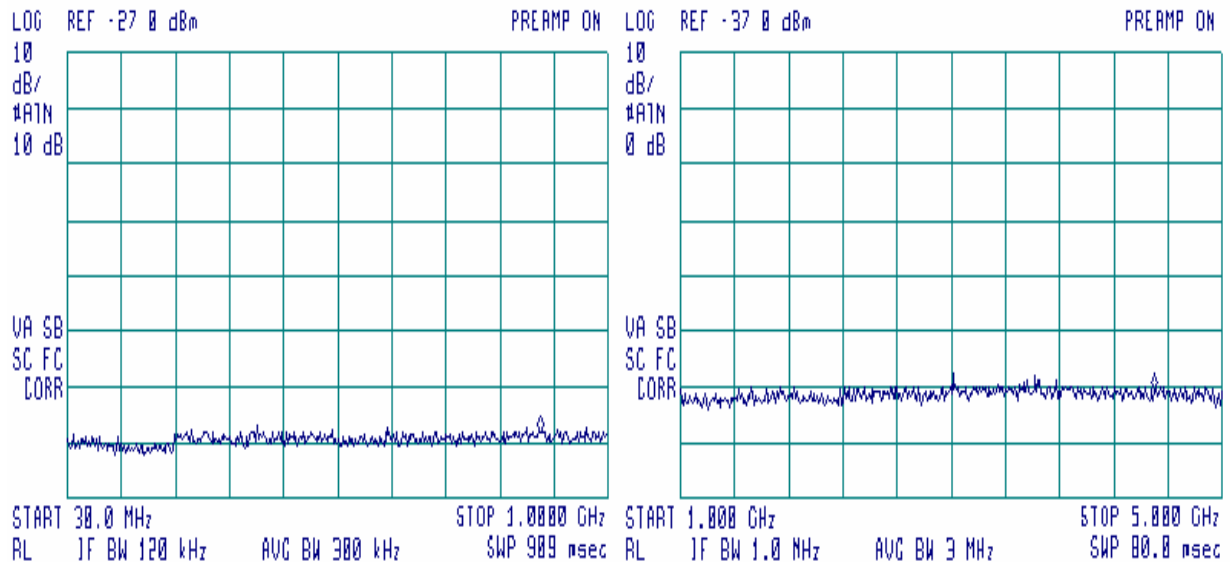
**LIMIT @ 3meter: [15.209(a)]**

|              |         |            |
|--------------|---------|------------|
| 30-88MHz     | 100uV/m | 40dBuV/m   |
| 88-216MHz    | 150uV/m | 43.5dBuV/m |
| 216-960MHz   | 200uV/m | 46dBuV/m   |
| above 960MHz | 500uV/m | 54dBuV/m   |

The spurious emissions observed in the restricted bands did not exceed the allowed limits for the restricted bands.

**Radiated Field Strength Measurements: [15.231(b), 15.205]**

A scan of the SPAHOME1 was made in a shielded room to study the emission profile of the EUT. These scans, shown below, indicate low level spurious emissions from the unit in addition to the fundamental and its associated harmonics.

**EUT transmitting at 433.92MHz****EUT in receiving mode**

**Field Strength Measurements of Fundamental & Harmonics****MEASUREMENT PROCEDURE:**

1. The EUT was setup to one of the three orthogonal positions.
2. The receiving antenna was placed in vertical and horizontal polarities.
4. Steps 1-2 were repeated to cover all positions and polarities.

Formula 3, which is presented on pages 9 and 10, is used.

$$\{ [\text{Low uV/m}] \times [\text{ON mSec}] + [\text{High uV/m}] \times [\text{ON mSec}] \} / \{ 100\text{mSec} \} = \text{avg.uV/m}$$

The on time of the zero bit (low) level transmission is 14.025mSec.

The on time of the one bit (high) level transmission is 12.425mSec.

| Freq.<br>MHz | DUT<br>position | Ant.<br>Pol. | Corrected data<br>ONE (High)<br>Peak Detector<br>uV/m | Corrected data<br>ZERO (Low)<br>Peak Detector<br>uV/m | Calculated<br>Average<br>Level per<br>100mSec<br>uV/m | FCC<br>15.231a<br>Limit<br>uV/m | Margin<br>dB | Cable<br>+Ant.<br>Factor<br>dB+dB/m |
|--------------|-----------------|--------------|-------------------------------------------------------|-------------------------------------------------------|-------------------------------------------------------|---------------------------------|--------------|-------------------------------------|
| 433.92       | end             | V            | 35,481                                                | 1,318                                                 | 4,593                                                 | 10,997                          | -7.6         | 19.1                                |
| 867.8        | flat            | H            | 5,688                                                 | 1,778                                                 | 956                                                   | 1,100                           | -1.2         | 25.5                                |
| 1302         | side            | V            | 851                                                   | 275                                                   | 144                                                   | 500                             | -10.8        | 29.9                                |
| 1736         | side            | H            | 531                                                   | --                                                    | --                                                    | 1,100                           | -6.3peak     | 31.4                                |
| 2170         | Flat            | V            | 389                                                   | --                                                    | --                                                    | 1,100                           | -9.0peak     | 33.9                                |
| 2604         | side            | V            | 462                                                   | --                                                    | --                                                    | 1,100                           | -7.5peak     | 36.0                                |
| 3037         | Side            | V            | 251                                                   | --                                                    | --                                                    | 1,100                           | -12.8peak    | 37.1                                |
| 3471         | -               | -            | 288**avg.                                             | --                                                    | 288**                                                 | 1,100                           | -11.6        | 38.6                                |
| 3905         | -               | -            | 351**avg.                                             | --                                                    | 351**                                                 | 500                             | -3.1         | 38.8                                |
| 4339         | end             | H            | 412                                                   | --                                                    | --                                                    | 500                             | -1.7peak     | 39.4                                |

\*\* measurement is noise floor. No emission detected.

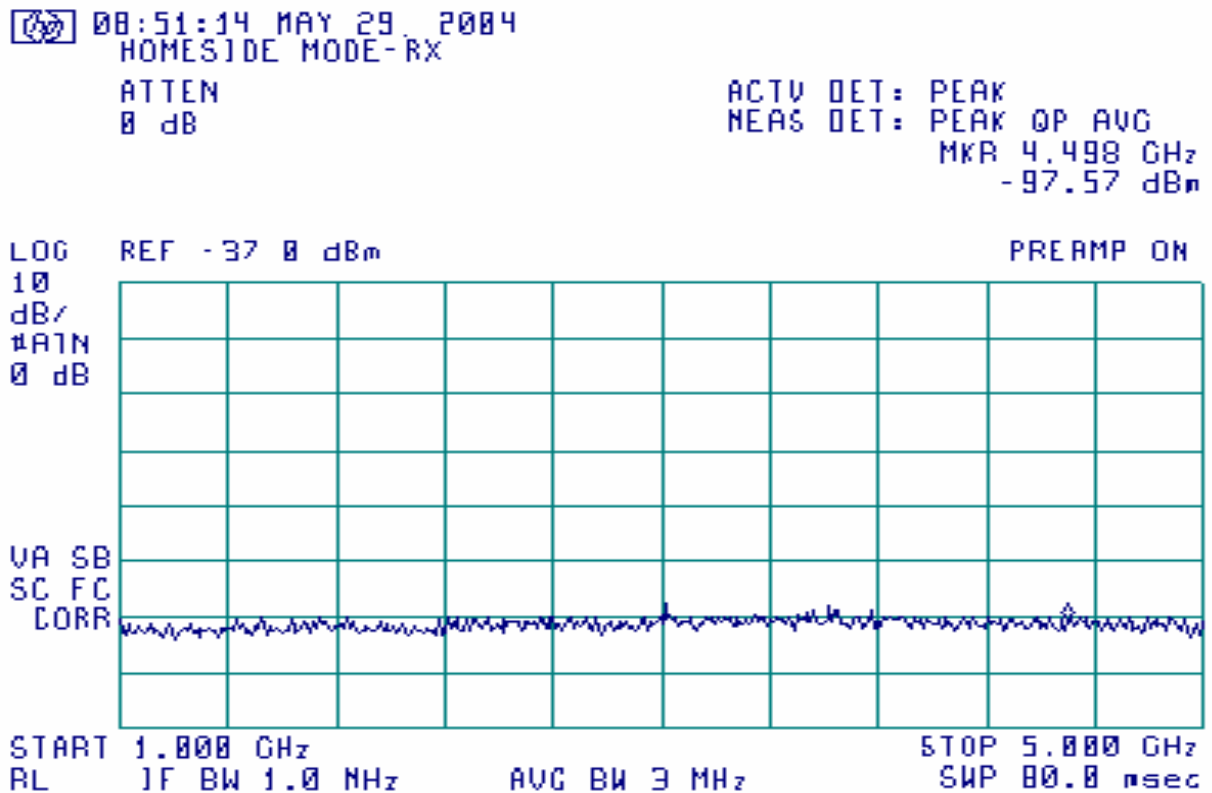
“peak” – indicates the measured peak emission level without corrections is less than the FCC average limit.

## Field Strength Measurements of Spurious Emissions

The local oscillator for the superheterodyne receiver operates at 423.2MHz. The local oscillator is derived from the 26.45MHz crystal oscillator. ( $26.45\text{MHz} \times 16 = 423.2\text{MHz}$ ). The IF of the receiver is 10.7MHz.

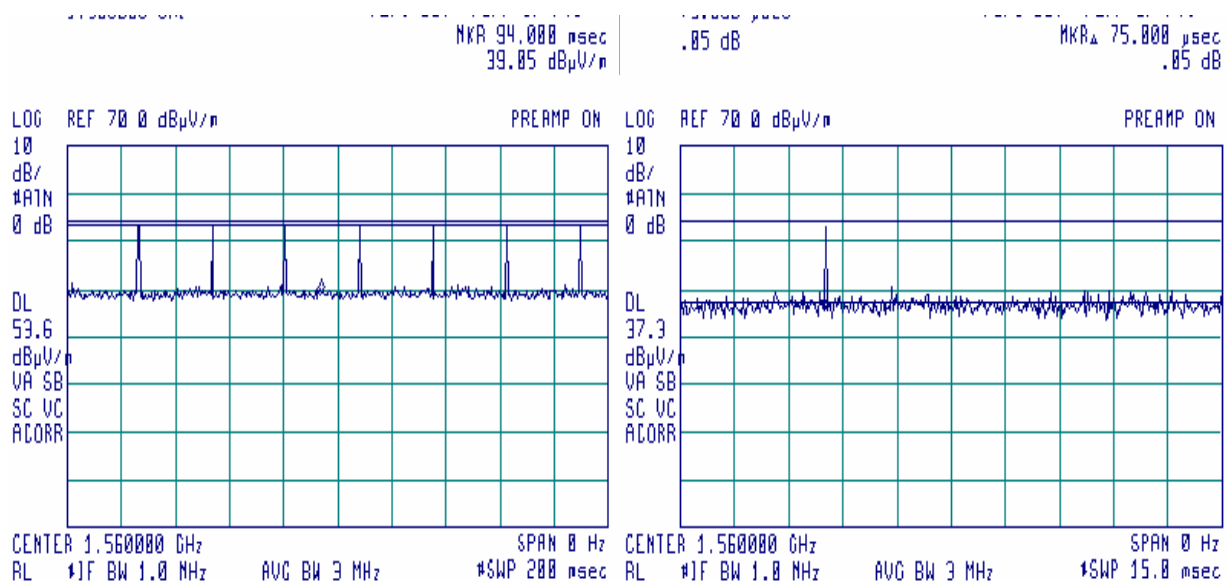
There are no measurable emissions related to the local oscillator or its harmonics.

PreTest Scan of EUT in Receiver mode. 1 meter distance to antenna.



There are no measurable emissions related to the local oscillator or its harmonics.

A set of spurious emissions beginning at 1.5GHz was observed. These emissions have the signature of being a very short pulse with a relatively long period between pulses.



200mSec sweep shows  
4 pulses in a 100mSec window

Each pulse width is determined to be  
to be approximately .075mSec

An examination of these spurious emissions showed that in any 100mSec period the EUT was observed to have at most four pulses. The greatest on time of each pulse was determined to be .075mSec. This calculates to be 0.3mSec (.075mSec x 4) for the four pulses per 100mSec. A duty cycle calculation for the averaging factor results in a 0.3% duty cycle.

For 0.3% the duty cycle factor in dB terms is:  $= 20 * \log(0.003) = -50.4$

The maximum 20dB correction factor is applied to the recorded peak levels before comparison to the limits.

#### Levels of spurious emissions

| Freq.<br>MHz | DUT<br>position | Ant.<br>Pol. | Corrected<br>Data<br>Peak Detector<br>dBuV/m | Peak to<br>Average<br>Factor<br>dB | Calculate<br>d<br>Average<br>Level<br>dBuV/m | FCC<br>Limit<br>dBuV/m | Margin<br>dB | Included<br>Cable<br>+Ant.<br>Factor<br>dB+dB/m |
|--------------|-----------------|--------------|----------------------------------------------|------------------------------------|----------------------------------------------|------------------------|--------------|-------------------------------------------------|
| 1550.07      | flat            | V            | 64.28                                        | -20.0                              | 44.3                                         | 54.00                  | -9.7         | 30.66                                           |
| 1529.64      | flat            | H            | 65.68                                        | -20.0                              | 45.7                                         | 54.00                  | -8.3         | 30.57                                           |
| 3030.48      | flat            | V            | 51.02                                        | -20.0                              | 31.0                                         | 54.00                  | -23.0        | 37.11                                           |
| 4499.37      | flat            | V            | 55.89                                        | -20.0                              | 35.9                                         | 54.00                  | -18.1        | 39.68                                           |
| 4498.75      | flat            | H            | 60.76                                        | -20.0                              | 40.7                                         | 54.00                  | -13.3        | 39.68                                           |

All other suspect emissions from screen room scan were below the 'noise floor' of the measurement system.