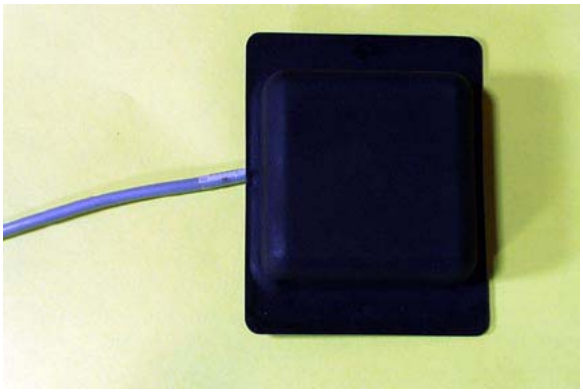
EXHIBIT E: REPORT OF MEASUREMENTS [2.1033(B6)]

Test Report for FCC ID: PYM-SPASIDE1

FCC Part 2.1031, Part 15 Subpart C(15.231)

Report #0400688FS
Issued 06/05/04



MODEL SPASIDE1
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 27, June 1, 5, 2004

Report prepared by:

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Report reviewed by

Data recorded by:

Gordon Helm, 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: ± 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 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)]

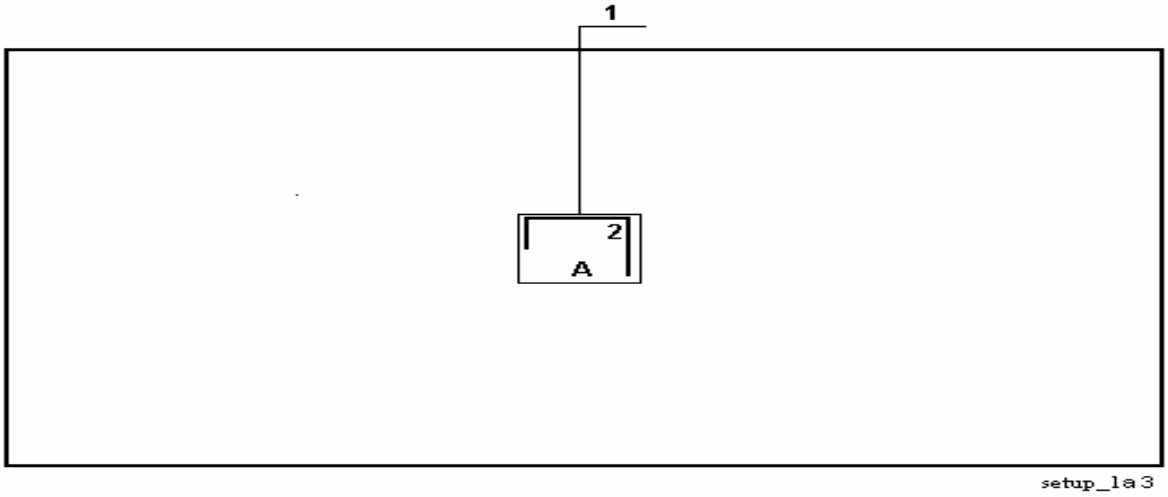
Support Equipment & Cabling

Setup Diagram Legend	Description	Model	Serial No. / Part No.	EMC Consideration
A	[EUT] 433.92MHz Transceiver	[Ballboa] SPASIDE1	Pre-production	FCC ID: PYM-SPASIDE1
B	SPA Controller	[Ballboa] EL8000	56869	
1	9 vdc cable	--	--	2 Meters, Unshielded
2	EUT Antenna	--	--	Foil trace on PCB
3	AC power cable	--	--	1 Meter, Unshielded

Setup Diagrams

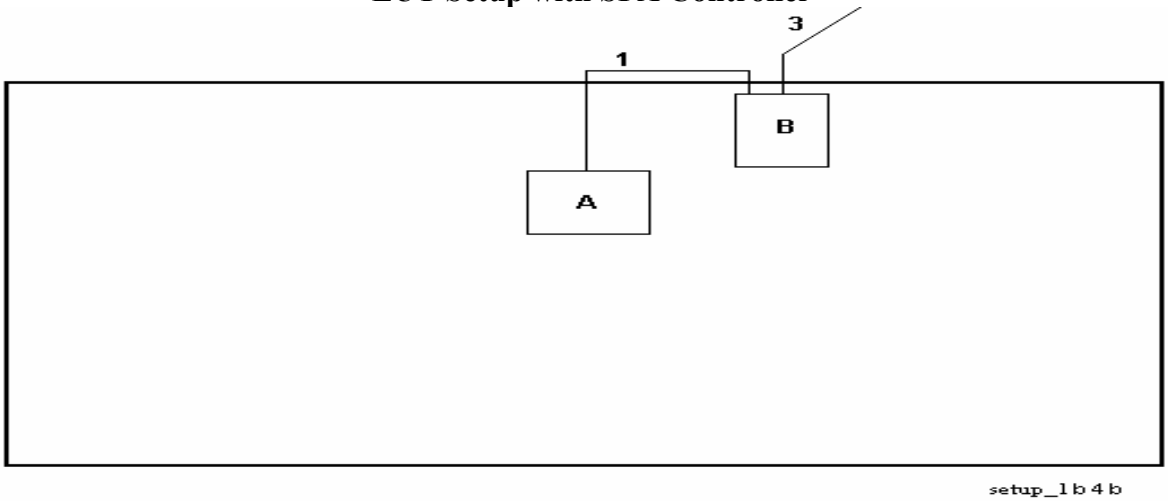
Note: Setup photographs are located in Attached Electronic File, Exhibit E.

Stand-Alone Setup



setup_1a3

EUT Setup with SPA Controller



setup_1b4b

(Legend designation is above)

Description of Equipment Under Test

The tested unit is the fixed installed portion of a 433.92MHz transceiver pair. This unit will receive information from the SPA controller via RS485 communication. If an alarm/safety condition is detected, it will alert the homeowner via RF communication to the "Homeside1" unit. The SPASIDE1 can also receive command signals from the homeowner to control water temperature, on/off lights, or on/off pump.

There is one printed circuit board.
2-layer PCB, #XS0085 Rev.4, S/N2.
Microprocessor: PIC16F648A; Receiver IC: RFRXD0420.
Oscillators: 20.0MHz, 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 device is powered from 9vdc source in an associated Spa Controller. The Spa Controller used during evaluations is a model EL8000.
6. The line conducted evaluation of the SPASIDE1/Spa Controller system showed the emissions nearest the limit occurred at 19.5MHz. This emission was measured to be 23.8dB below the Class B Quasi-Peak limit 60dBuV/m.
7. Occupied Band Width of the transmitted signal, at the 20dB point, was measured to be 338KHz. 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 horizontal polarization. This signal was calculated to be 2.1dB 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 ninth harmonic. The EUT was positioned on the 'side' and the receive antenna oriented in the horizontal polarization. This signal, at 3905MHz, was measured to be 1.3dB below the 15.231(a)/15.205 limit of 54.0dBuV/m (500uV/m)
10. The field strength evaluation of other spurious emissions showed the emission associated with the EUT as a digital in RS485 communication with a spa controller. The emission nearest the limit occurred at 120.6MHz. This emission was measured to be 0.7dB below the Quasi-peak 43.5dBuV/m.

Changes made to achieve compliance

1. The values of resistors were changed to: R11=120Ω, R17=120Ω,

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 was performed with the EUT connected to the 9vdc power supply from an associated Spa Controller. The Controller, in turn, was connected to the LISN and line conducted emissions measured of the system.

Spurious emission evaluation was performed with the EUT and Spa Controller connected. The RF emission evaluation related to the transceiver section of the SPASIDE1 was performed with the SPASIDE1 stand alone.

For the testing, the SPASIDE1 was placed in an engineering mode, which allowed it to continuously transmit a data pulse stream.

Line Conducted

The system was placed upon a 1 x 1.5 meter non-metallic table 80cm from the ground floor and 40cm from the vertical conducting plane in the prescribed setup per ANSI C63.4. This table is housed in a shielded enclosure to prevent the detection of unwanted ambients.

The mains power is nominally 120VAC, 60Hz.

The host unit was connected to the LISN being monitored by the EMI Receiver.

The EUT was continuously exercised using the RS485 communication cabling.

While monitoring the display of the EMI Receiver, via remote video monitor, the cables were manipulated to determine a position that maximized the emissions being observed.

The configuration that created an emission closest to the limit was used during the course of taking final measurements. Pictures of this final configuration are recorded in this report.

The principal settings of the EMI Receiver for line conducted testing include:

Bandwidth = 9KHz

Detector Function: scanning and signal search = Peak Detection Mode
measurements = Quasi Peak Detection and Average Detection

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 SPASIDE1 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 when evaluating the transceiver portion of the EUT. While evaluated the digital spurious emissions the EUT was connected to the spa controller.

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 the two positions that may be encountered when installation is complete. 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.

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(dBuV/m) = RF(dBuV) + AF(dB/m) +CF(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 SPASIDE1

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 approximately 5.0mSec the Manchester encoded packet of ones and zeros are transmitted. This packet transmission continues for 31.15mSec. When the packet transmission ends the carrier continues to transmit at the low level for approximately 0.60mSec.

The average level of the pulsed signal was determined by summing all the signals levels during a 100mSec period, then dividing by 100 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: { [Low uV/m] x [ON mSec] + [High uV/m] x [ON mSec] } / { 100mSec }

During the measurement of the SPASIDE1 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:

Level recorded at the bit one level (high) = 35,480uV/m
Level recorded at the bit zero and carrier only level (low) = 1,318uV/m

The firmware has determined that –

- before the packet transmission the on time of the carrier is 5.00mSec.
- 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 31.15mSec is shared equally with 15.575mSec at the zero level and 15.575mSec at the one level.
- after the packet transmission the carrier remains on 0.60mSec at the low level.

Applying formula 3:

{ [1318uV/m] x [5.0 + 15.575 + 0.6]mSec + [35480uV/m] x [15.575mSec] } / 100mSec

= { 27909uV/m + 552601uV/m } / 100 = 580510 / 100 = 5805.1

Therefore the average level of this emission in a 100mSec period is 5805.1uV/m

Formula 3 was utilized for the 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)

$(433.92 - 260) / (470 - 260) = (L_0 - 3750) / (12500 - 3750)$
$(173.92 / 210) * (8750) = L_0 - 3750$
$L_0 = 7246.7 + 3750$
$L_0 = 10996.7$ 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.
dB limit is 20 * LOG(10996.7 uV/m) = 80.8 dBuV/m

15.231(e)

$(433.92 - 260) / (470 - 260) = (L_0 - 1500) / (5000 - 1500)$
$(173.92 / 210) * (3500) = L_0 - 1500$
$L_0 = 2898.7 + 1500$
$L_0 = 4398.7$ uV/m is LIMIT at 433.92MHz

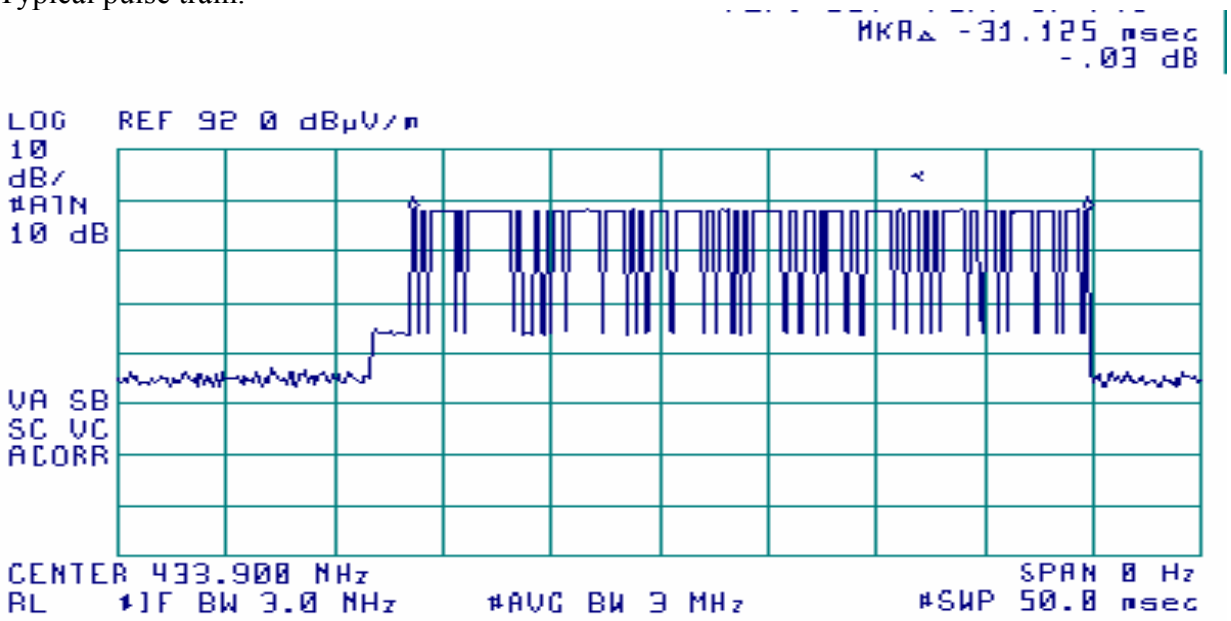
The limit in dB terms is calculated as the result of 20 times the log of the uV/m limit.
dB limit is 20 * LOG(4398.7 uV/m) = 72.9 dBuV/m

Test Data [2.1033(b6)]

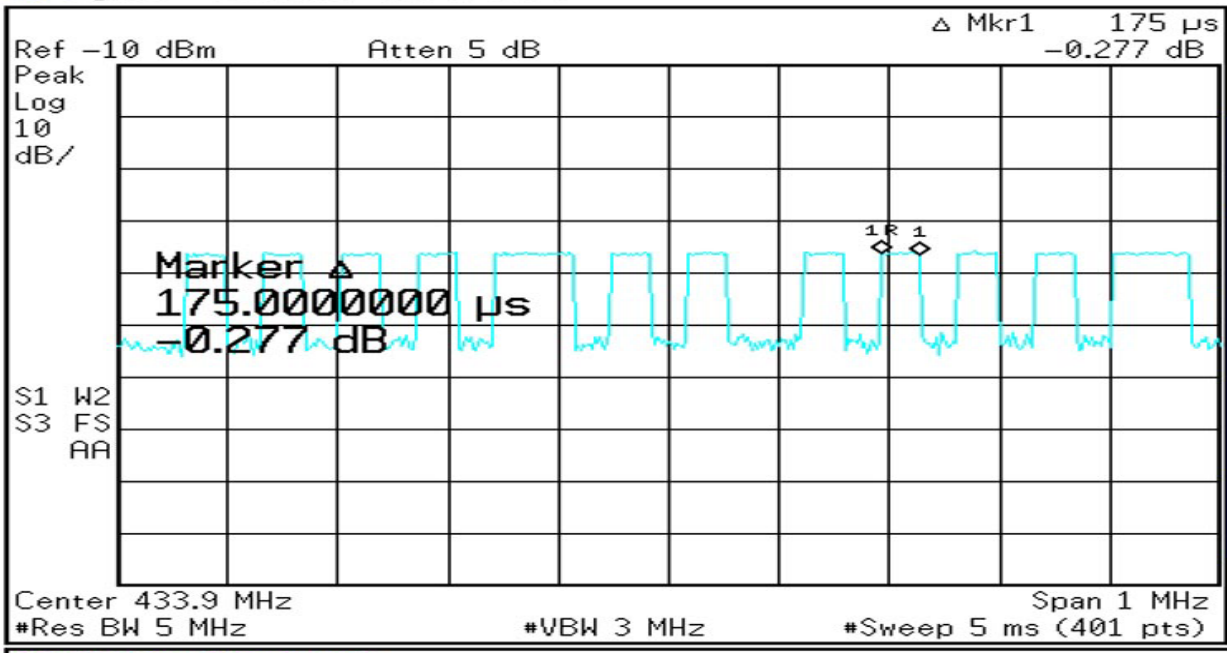
Modulation Characteristics

The transmitter is Amplitude modulated.
At time 0.0mSec the transmitter is turned on.
At time approximately 5mSec the pulse modulation of the carrier begins.
Pulsed signals continue for 31.15mSec. The Manchester encoding ensures a 50% duty cycle.
At time 36.75mSec the transmitter is turned off.

Typical pulse train.



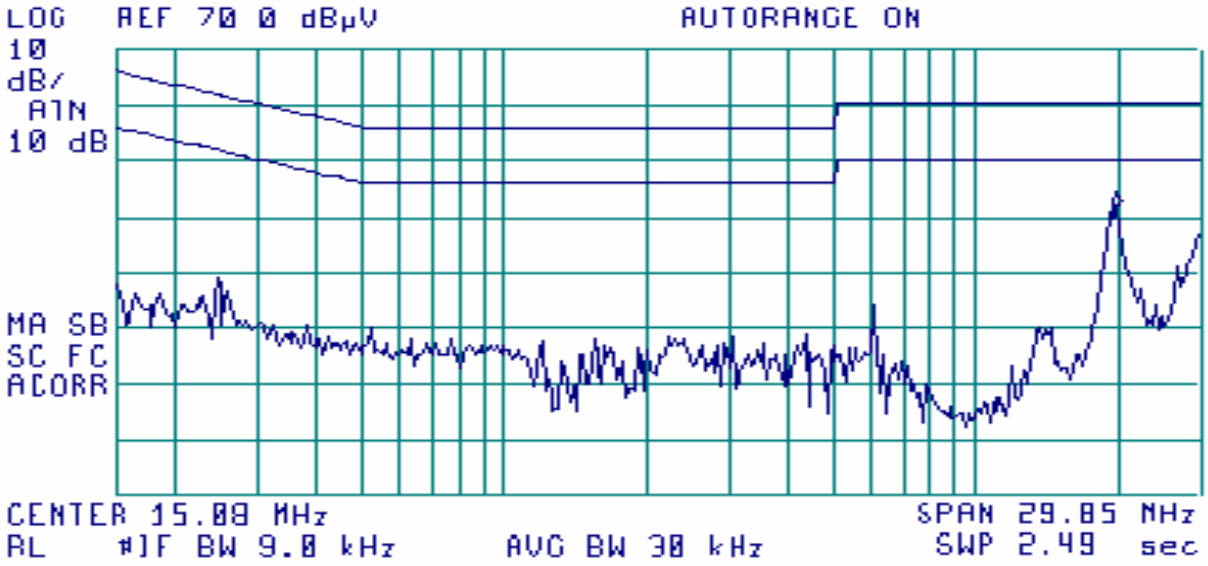
A view of the encoding pulse width



Line Conducted Measurements: [15.207]

Line Conducted 120VAC / 60Hz.

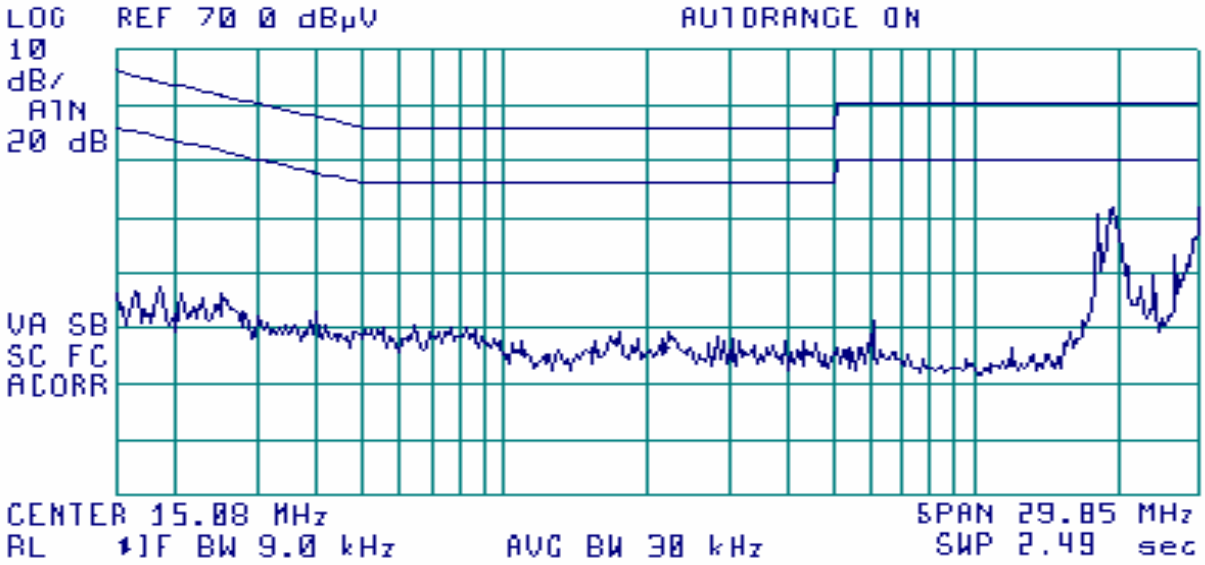
NEUTRAL to Ground Measurement.
Class B
Plot of Peak Values



Tabulated Quasi-Peak/Average Measurements.

Frequency	dBuV Reading		FCC / EN55022 dBuV Class B Limit		dB Margin	
MHz	QP	Avg	QP	Avg	QP	Avg
0.188	27.62	18.74	64.11	54.11	-36.49	-35.37
0.254	26.68	13.41	61.62	51.62	-34.94	-38.21
2.260	14.70	4.00	56.00	46.00	-41.30	-42.00
3.660	10.14	-1.98	56.00	46.00	-45.86	-47.98
6.027	23.49	23.21	60.00	50.00	-36.51	-26.79
19.524	36.23	15.34	60.00	50.00	-23.77	-34.66

PHASE to Ground Measurement.
Class B
Plot of Peak Values



Tabulated Quasi-Peak/Average Measurements.

Frequency	dBuV Reading		FCC / EN55022 dBuV Class B Limit		dB Margin	
MHz	QP	Avg	QP	Avg	QP	Avg
0.209	30.71	21.62	63.25	53.25	-32.54	-31.63
0.265	28.96	18.86	61.27	51.27	-32.31	-32.41
2.278	14.48	3.49	56.00	46.00	-41.52	-42.51
3.651	13.17	-2.47	56.00	46.00	-42.83	-48.47
6.030	18.94	18.37	60.00	50.00	-41.06	-31.63
19.881	35.76	13.73	60.00	50.00	-24.24	-36.27
29.311	31.34	11.77	60.00	50.00	-28.66	-38.23

Conclusion: Compliance is demonstrated.

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.

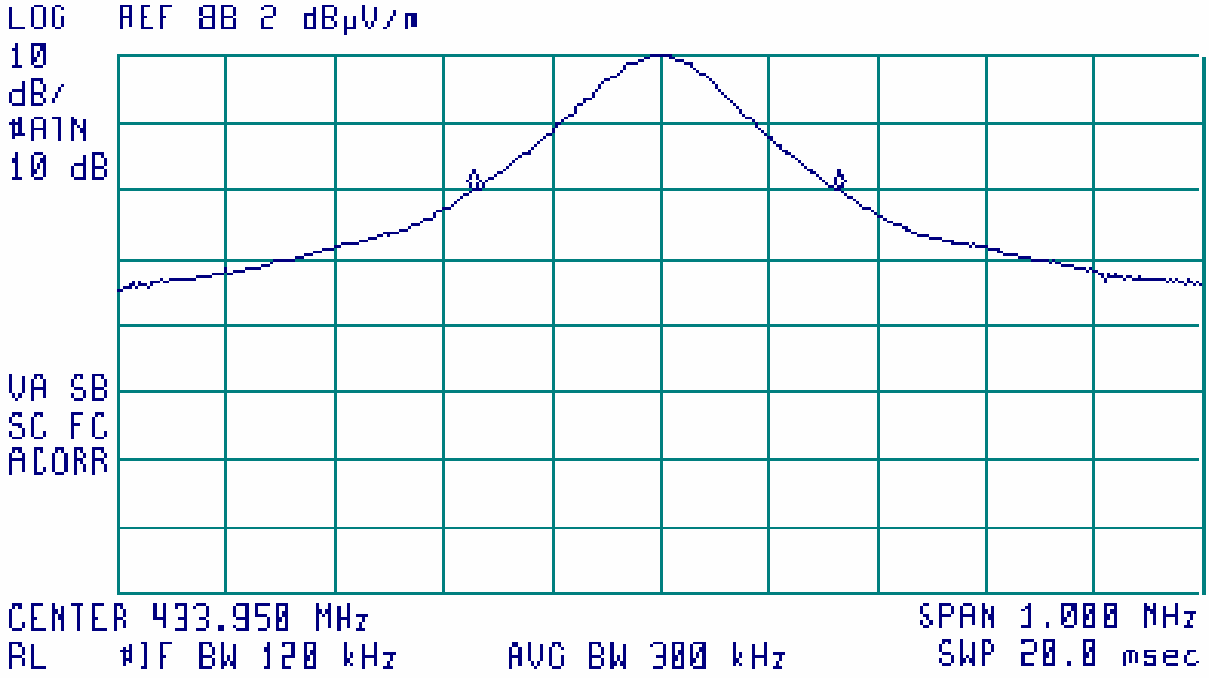
The bandwidth limit for 433.92MHz is 433.92*0.0025=1.085MHz.

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 * 1085KHz = 54.2KHz. An RBW of 120KHz is selected.

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

Fundamental (MHz)	Measured 20dB Bandwidth	LIMIT Fundamental * .0025
433.92	338 KHz	1.085MHz

This chart shows a measured bandwidth signal.



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)]

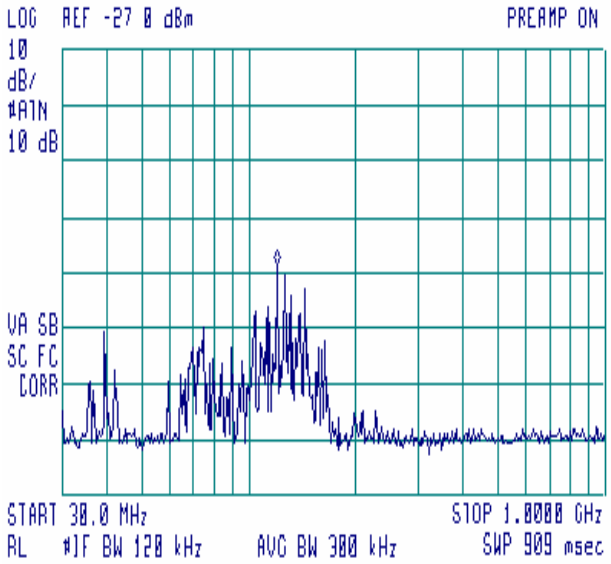
30-88MHz	100uV/m	40dBuV/m
88-216MHz	150uV/m	43.5dBuV/m
216-960MHz	200uV/m	46dBuV/m
above 960MHz	500uV/m	54dBuV/m

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

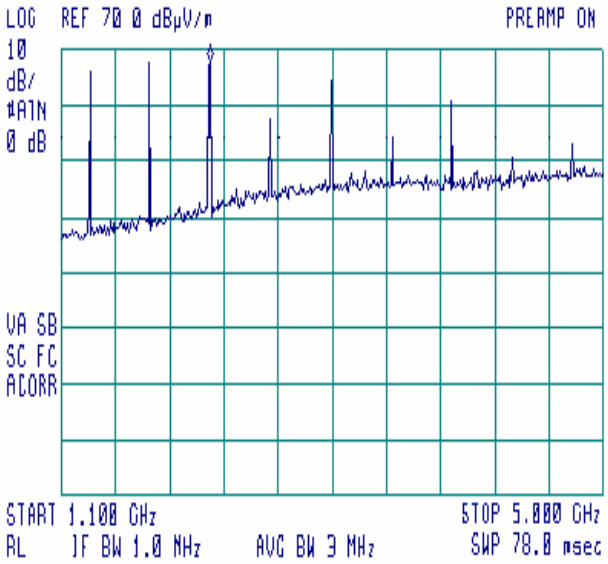
Radiated Field Strength Measurements: [15.231(b), 15.205]

A scan of the SPASIDE1 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. With the SPASIDE transmitting and without the spa controller present only the 433.92MHz fundamental and its harmonics are present.

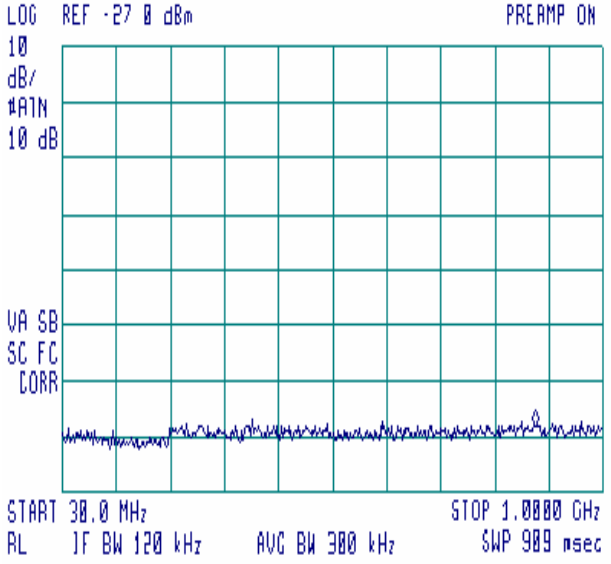
30-1000MHz
EUT and spa controller, RS485 communication.

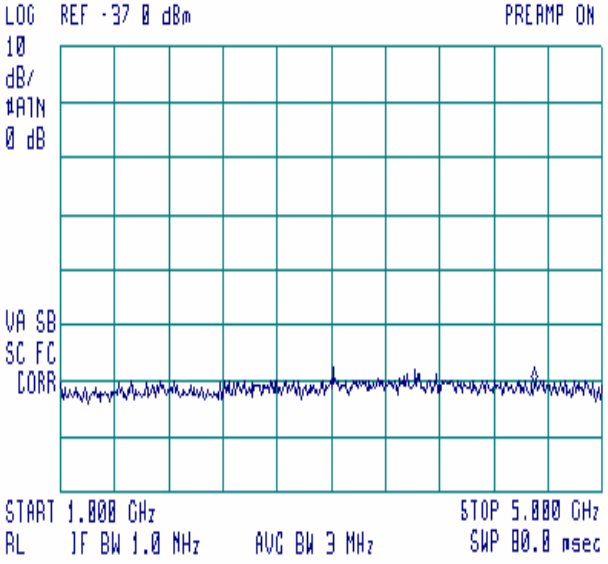


1000-5000MHz
EUT transmitting without spa controller



EUT in receiving mode without spa controller





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.

{ [Low uV/m] x [ON mSec] + [High uV/m] x [ON mSec] } / { 100mSec } = avg.uV/m

The on time of the zero bit (low) level transmission is 21.175mSec.
The on time of the one bit (high) level transmission is 15.575mSec.

Freq. MHz	DUT position	Ant. Pol.	Corrected data ONE (High) Peak Detector uV/m	Corrected data ZERO (Low) Peak Detector uV/m	Calculated Average Level per 100mSec uV/m	FCC 15.231a Limit uV/m	Margin dB	Cable +Ant. Factor dB+dB/m
433.92	end	H	50,119	3802	8611	10,997	**-2.1**	19.1
867.8	side	H	1303	933	400	1,100	**-8.8**	25.5
1302	end	V	1288	426	291	500	**-4.7**	29.9
1736	end	H	700	--	--	1,100	**-3.9peak**	31.4
2170	side	H	1445	1333	507	1,100	**-6.7**	33.9
2604	end	H	1462	1364	516	1,100	**-6.6**	36.0
3037	end	H	2603	2238	879	1,100	**-1.9**	37.1
3471	end	H	2239	1840	738	1,100	**-3.5**	38.6
3905	side	H	1738	750	430	500	**-1.3**	38.8
4339	side	H	1274	881	385	500	**-2.3**	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

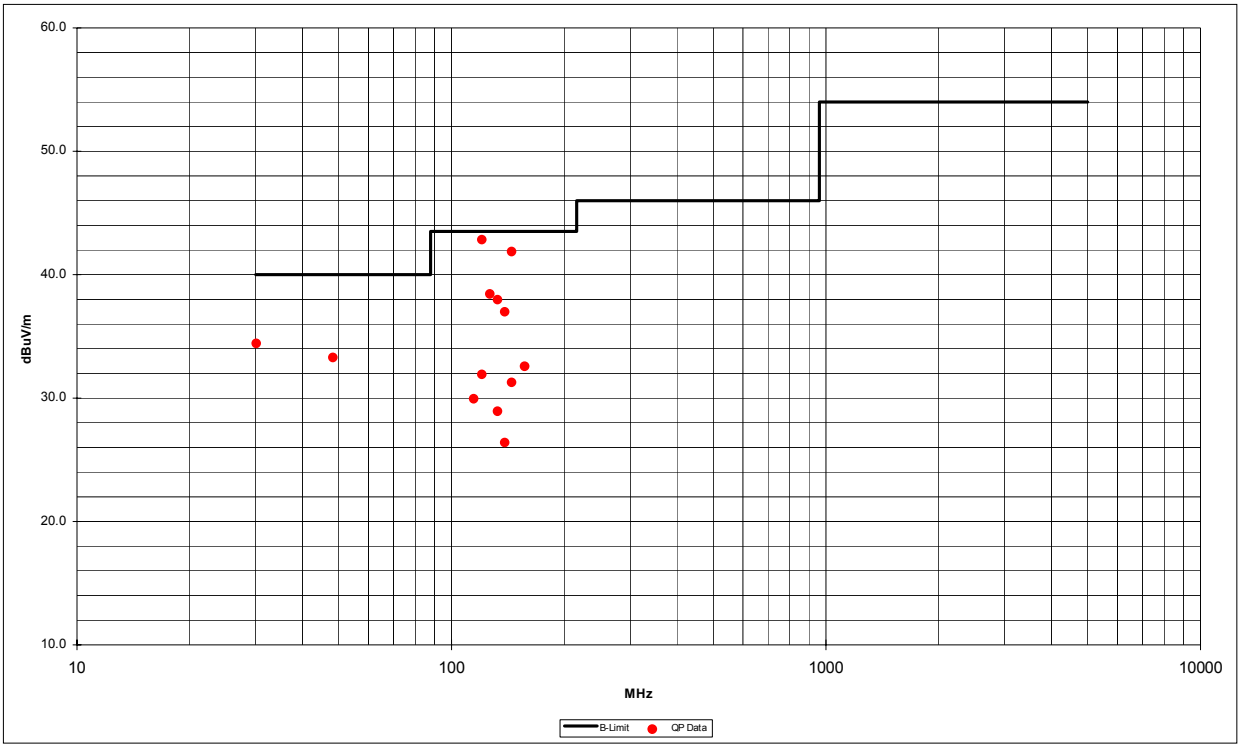
The local oscillator for the superheterodyne receiver operates at 423.2MHz. The local oscillator is derived from the 26.45MHz crystal oscillator. (26.45MHz x 16 = 423.2MHz). The IF of the receiver is 10.7MHz.

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

Field Strength Measurements of Spurious Emissions RS485 communication

A scan of the SPASIDE1 with the spa controller was made in a shielded room to study the emission profile of the EUT. These scans indicate spurious emissions. These suspect signals were measured at the 3-meter open area test site.

Graph of Quasi-Peak Measurements Vertically polarized



Tabulated Quasi-Peak Measurements.

Frequency MHz	Corrected Quasi Peak Measurement dBuV/m	Included Cable+Antenna Factors dB+dB/m	Turntable Azimuth deg	Antenna Height Mtr	Polarity	FCC Class B Limit dBuV/m	Margin dB
48.24	33.29	10.75	0	4.0	H	40.00	-6.71
120.58	42.84	8.71	90	1.7	H	43.50	-0.66
126.61	38.43	8.39	90	1.8	H	43.50	-5.07
132.63	37.98	8.39	90	1.5	H	43.50	-5.52
138.66	37.00	8.77	90	1.4	H	43.50	-6.50
144.70	41.88	9.14	90	2.3	H	43.50	-1.62
156.75	32.57	9.83	80	2.1	H	43.50	-10.93
30.11	34.43	19.01	190	1.0	V	40.00	-5.57

The frequencies for measurements were determined by the suspect list generated from the shielded room prescan.
All other spurious emission are greater than 10dB below limits.