

## **RF Measurement Report**

**Prepared by:**

### **National Certification Laboratory**

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**In Support of:**

### **FCC APPLICATION FOR CLASS II CHANGE**

**For:**

**ioWave Inc.  
2100 Washington Blvd.  
Arlington, Virginia 22204**

**Model: ioStar 2.4 GHz Spread Spectrum Transceiver**

**FCCID: NK4-7039795714**

**Demonstration of Compliance with FCC Rules Part 15.247**

**May 10, 2001**

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## **1.0 Introduction:**

This report has been prepared on behalf of ioWave, Inc., to support the attached Application for Class II Permissive Change of a Part 15 Spread Spectrum Transmitter. The Equipment Under Test was the **ioStar 2.4 Ghz SST Transceiver**.

Radio-Noise Emissions tests were performed according to **FCC Public Notice 54797, titled “Guidance on Measurement for Direct Sequence SST”**. The measuring equipment conforms to ANSI C63.2 Specifications for Electromagnetic Noise and Field Strength Instrumentation.

Testing was performed at National Certification Laboratory in Ellicott City, MD. Site description and site attenuation data have been placed on file with the FCC's sampling and Measurements Branch. FCC acceptance was granted on May 26, 1993.

## **1.1 Summary:**

The ioWave, Inc. **ioStar 2.4 Ghz SST Transceiver** complies with the FCC limits (15.247) for a Direct Sequence SST.

## **2.0 Description of Equipment Under Test (EUT):**

The EUT features:

Direct Sequence Spread Spectrum Modulation

25 dBm Peak RF Output

2412 to 2470 MHz Frequency Range

20 MHz 6 dB Emission Bandwidth

DQPSK-SS Modulation

2 Channels / TDMA Operation

E1 or T1 Data Speed

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### **3.0 Test Program:**

This report contains measurement charts and data as evidence for the following tests performed:

1. (15.247b) Peak RF output power.
2. (15.247c) Field Strength of harmonics and spurious out-of-band emissions.
3. (15.247c) RF Antenna Conducted output of harmonics and spurious out-of-band emissions.
4. (15.247a) 6 dB Emission Bandwidth.
5. (15.207 A.C. Power Line Conducted emissions.
6. (15.247c) Band Edge emissions.
7. (15.247d) Power Spectral Density



#### **4.0 Test Configuration for Antenna Terminal Conducted:**

RF antenna output tests such as Bandwidth, Spurious/Harmonics, Power output, Power Spectral Density, and Processing Gain, were taken with the transmitter antenna connector feeding directly into the spectrum analyzer or power meter. No external attenuators were used, however the analyzer's internal attenuator was adusted to prevent overloading of the front end.

Field strength measurements were taken with the transmitter feeding a 21 dBi gain parabolic dish antenna via 10 ft. cable, aimed at the receiving antenna. Full power was developed at the output since a duplex link was not established.

The E1 data rate was used for all testing in order to show worse-case emissions.

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## PEAK POWER TEST RESULTS

Limit: 1 watt (30 dBm)  
Modulation Data Rate: E1

Readings from RF peak power meter (Carrier Modulated):

2412 MHz: +24.8 dBm

2430 MHz: +25.2 dBm

2470 MHz: +24.9 dBm

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## 6 dB EMISSION BANDWIDTH

Minimum 6 dB BW: 0.500 MHz  
RBW Setting on S.A.: 100 kHz  
Modulation Data Rate: E1

Condition: Transmitter is set to a E1 data channel at full power.

Readings from Spectrum Analyzer:

2412 MHz: 11.4 MHz

2430 MHz: 11.6 MHz

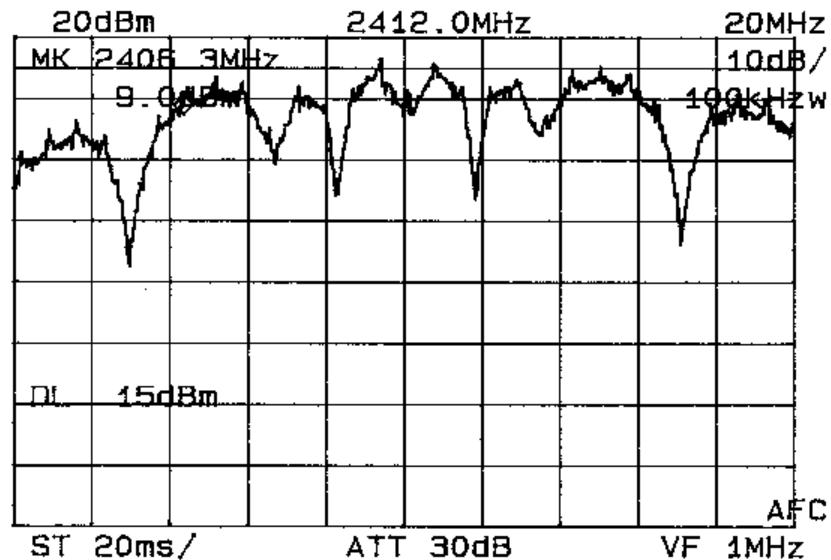
2470 Mhz: 11.8 MHz

**SEE FOLLOWING THREE (3) PLOTS OF MODULATED CARRIER**

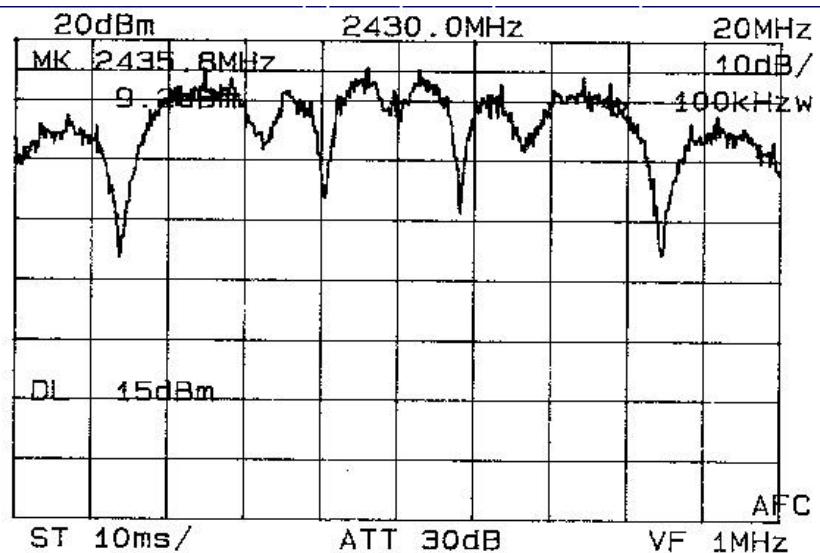
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**6 dB EMISSION BANDWIDTH – MODULATED CARRIER**

Low Channel

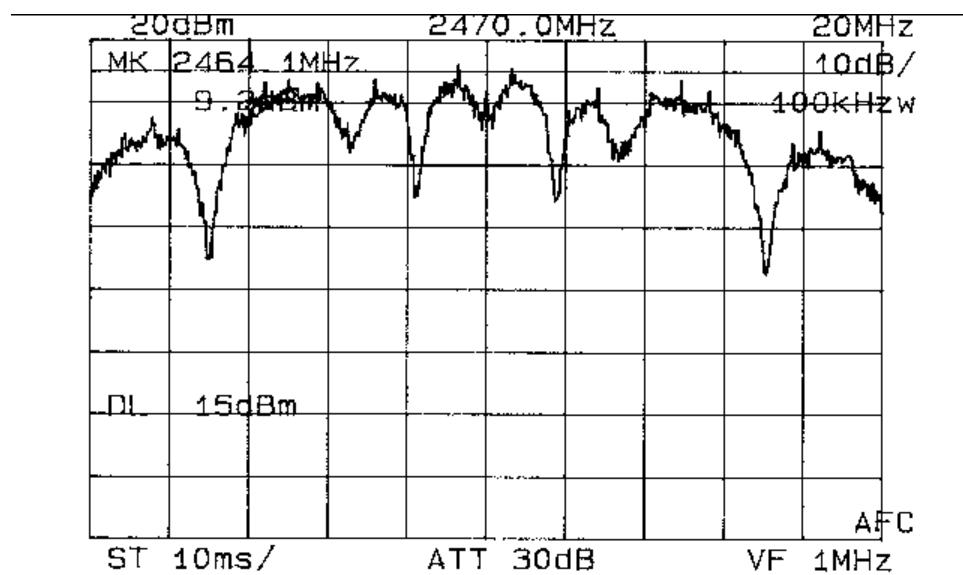


Mid Channel



NC  
E

High Channel



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## POWER SPECTRAL DENSITY

Limit: 8 dBm

Resolution Bandwidth: 3 kHz

Average Time Interval: 1 second/3 kHz

Actual Time Interval used

for testing: 1.5 seconds/3 kHz

Condition: Transmitter is set to a E1 data channel at full power

Readings from spectrum analyzer:

2412 MHz - -1.4 dBm

2430 MHz - -1.2 dBm

2470 MHz - -1.2 dBm

SEE FOLLOWING 3 PLOTS

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Low Channel

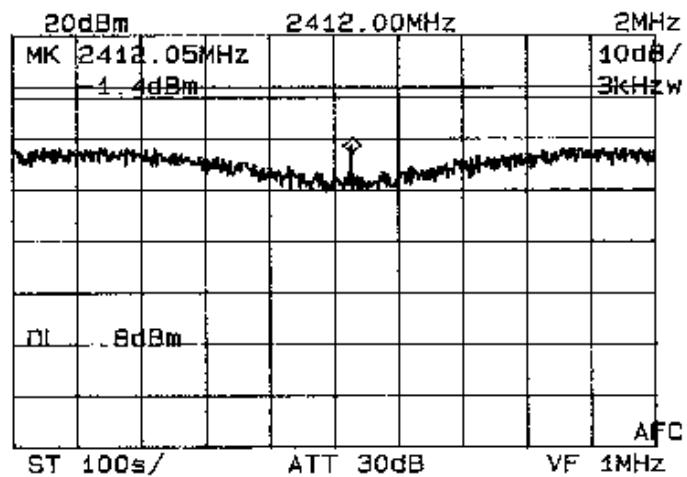
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SPECTRAL POWER DENSITY LEVEL - ioLink1

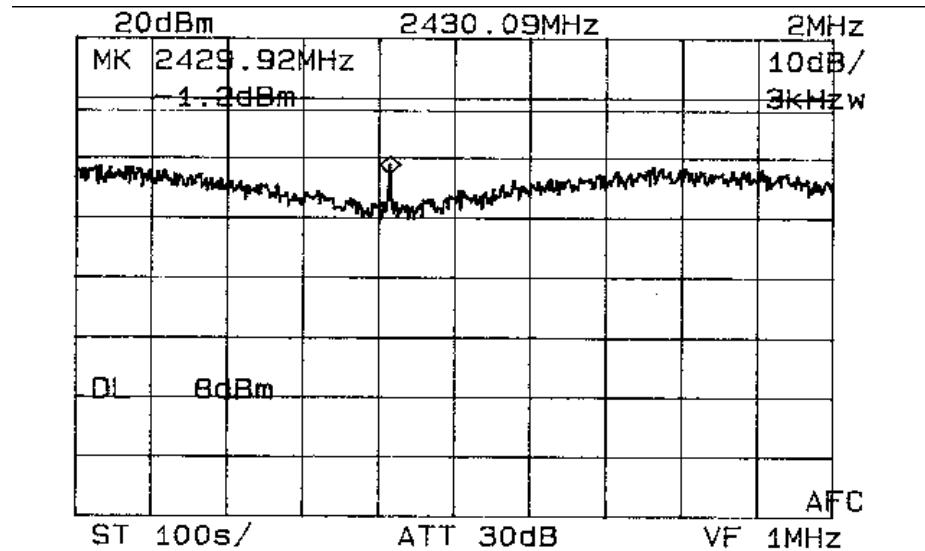
MODULATED

2 MHZ SPAN

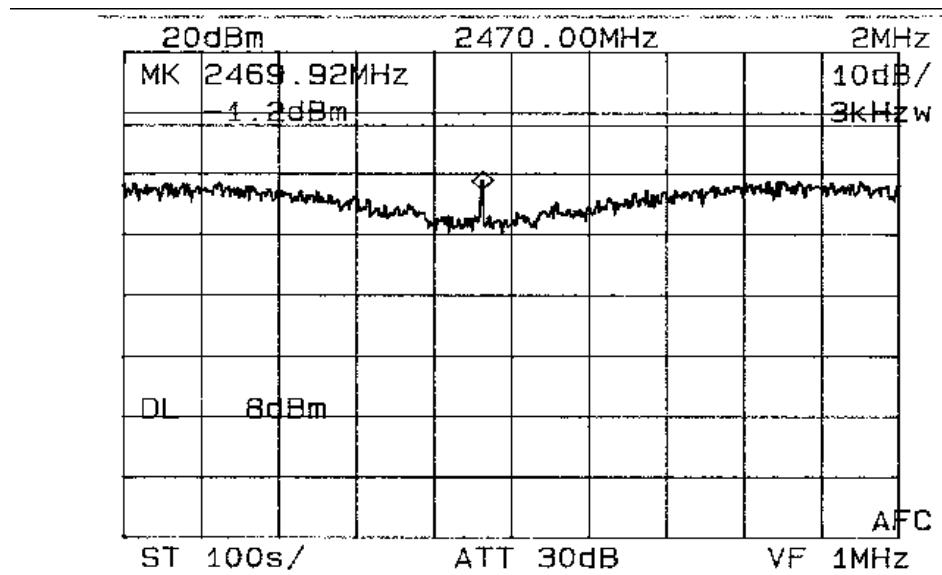
3 KHZ BW



## Mid Channel



## High Channel





## RF ANTENNA CONDUCTED SPURIOUS/HARMONICS EMISSIONS

Limit: 20 dB below Carrier Level Measured with 100 kHz RBW  
RBW Setting on S.A.: 100 kHz

Condition: Transmitter is set to a E1 data channel at full power  
Measurements taken at amplifier antenna connector

Three separate measurements are performed to show harmonic and spurious emissions generated with the transmitter tuned to low, middle, and high parts of the spectral range.

SEE FOLLOWING THREE (3) DATA TABLES

## FCC Part 15.247(c) – Conducted Spurious Emissions

Frequency of Carrier = 2412 MHz  
Limit = 20 dBc

Condition: Transmitter is set to a single modulated channel.

### TEST RESULTS

LIMIT: -20 dB FROM PEAK CARRIER

<u>Component</u>	<u>Frequency (MHz)</u>	<u>Result (dBc)</u>
Harmonic	4824.00	-50.0
Harmonic	7236.00	-55.0
Harmonic	9648.00	-71.0
Harmonic	12060.00	-72.0
Harmonic	14472.00	-74.0
Harmonic	16884.00	-75.0
Harmonic	19296.00	-75.0
Harmonic	21708.00	-75.0
Harmonic	24120.00	-75.0

## FCC Part 15.247(c) – Conducted Spurious Emissions

Frequency of Carrier = 2430 MHz  
Limit = 20 dBc

Condition: Transmitter is set to a single modulated channel.

### TEST RESULTS

LIMIT: -20 dB FROM PEAK CARRIER

<u>Component</u>	<u>Frequency (MHz)</u>	<u>Result (dBc)</u>
Harmonic	4860.00	-54.0
Harmonic	7290.00	-60.0
Harmonic	9720.00	-72.0
Harmonic	12150.00	-73.0
Harmonic	14580.00	-74.0
Harmonic	17010.00	-74.0
Harmonic	19440.00	-75.0
Harmonic	21870.00	-75.0
Harmonic	24300.00	-75.0

## FCC Part 15.247(c) – Conducted Spurious Emissions

Frequency of Carrier = 2470Hz  
Limit = 20 dBc

Condition: Transmitter is set to a single modulated channel.

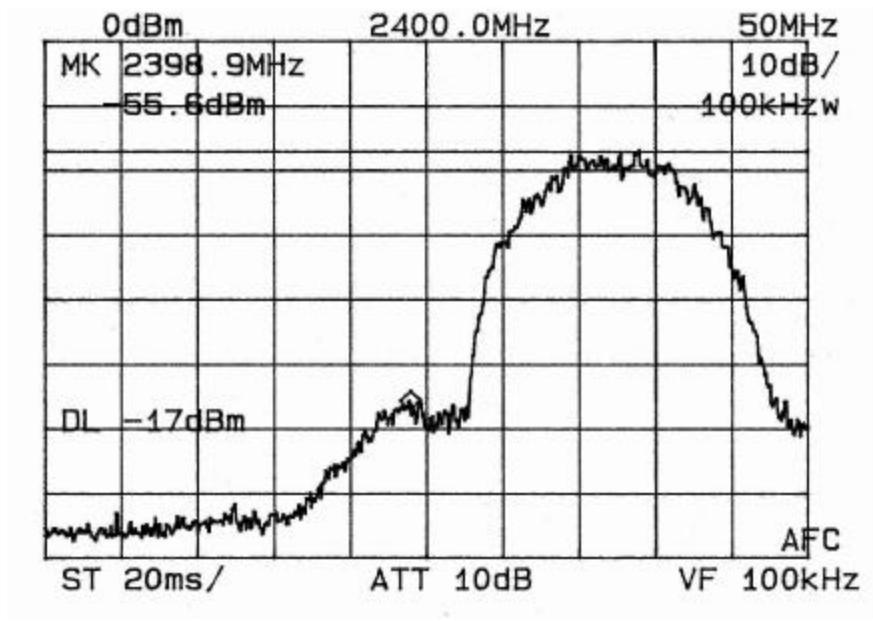
### TEST RESULTS

LIMIT: -20 dB FROM PEAK CARRIER

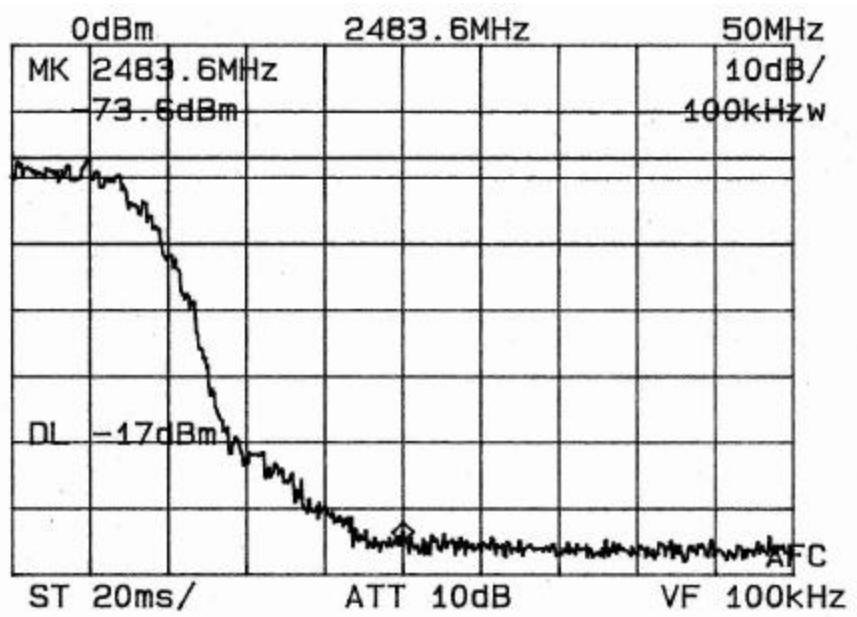
<u>Component</u>	<u>Frequency (MHz)</u>	<u>Result (dBc)</u>
Harmonic	4940.00	-53.0
Harmonic	7410.00	-59.0
Harmonic	9880.00	-69.0
Harmonic	12350.00	-71.0
Harmonic	14820.00	-74.0
Harmonic	17290.00	-74.0
Harmonic	19760.00	-74.0
Harmonic	22230.00	-75.0
Harmonic	24700.00	-75.0

## CONDUCTED BAND EDGE EMISSIONS – MODULATED CARRIER (100 kHz RES. BW)

## LOW CHANNEL



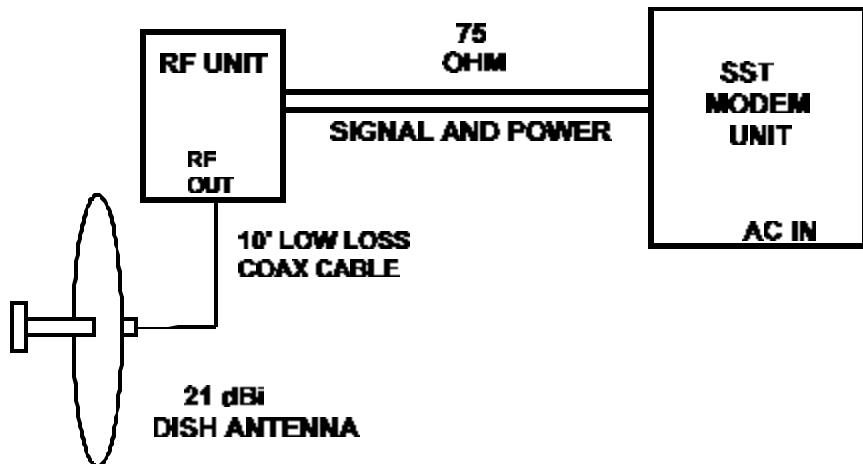
## HIGH CHANNEL



## **5.0 Test Configuration for Conducted and Radiated Emissions:**

The EUT was set up on the center of the test table, in a manner which follows the general guidelines of ANSI C63.4, Section 6 **“General Operating Conditions and Configurations”**. Two sets of measurements were taken: First set with amplifier, second set without amplifier.

This is described below:



## **6.0 A.C. Conducted Emissions Scheme:**

The EUT is placed on an 80 cm high 1 X 1.5 m non-conductive table. Power to the RF amplifier is provided through a Solar Corporation 50  $\Omega$  / 50 uH Line Impedance Stabilization Network bonded to a 2.2 X 2 meter horizontal ground plane, and a 2.2 X 2 meter vertical ground plane. The LISN has its AC input supplied from a filtered AC power source. A separate LISN provides AC power to the peripheral equipment. I/O cables are moved about to obtain maximum emissions.

The 50  $\Omega$  output of the LISN is connected to the input of the spectrum analyzer and emissions in the frequency range of 450 kHz to 30 MHz are searched. The detector function is set to Quasi-Peak and the resolution bandwidth is set at 9 kHz, with all post detector filtering no less than 10 times the resolution bandwidth for final measurements. All emissions within 20 dB of the limit are recorded in the data tables.

## **7.0 Radiated Emissions Scheme:**

The EUT is placed on an 80 cm high 1 X 1.5 meter non-conductive motorized turntable for radiated testing on the 3 meter open area test site. The emissions from the EUT are measured continuously at every azimuth by rotating the turntable. Guided horn and log periodic broadband antennas are mounted on an antenna mast to determine the height of the maximum emissions. The heights of the antennas are varied between 1 and 4 meters. Both the horizontal and vertical field components are measured.

The RF spectrum is searched from 30 MHz to 25 GHz.

The output from the antenna is connected to the input of the preamplifier. The pre-amp out is connected to the spectrum analyzer. The detector function is set to PEAK. The resolution bandwidth of the spectrum analyzer is set at 100 kHz for the frequency range of 30-1000 MHz, and 1 MHz for the frequency range of 1-25 GHz. A 10Hz video BW setting is used to average readings above 1 GHz when applicable. All emissions within 20 dB of the limit are recorded in the data tables.

To convert the spectrum analyzer reading into a quantified E-field level to allow comparison with the FCC limits, it is necessary to account for various calibration factors. These factors include cable loss (CL) and antenna factors (AF). The AF/CL in dB/m is algebraically added to the Spectrum Analyzer Voltage in dB $\mu$ V/m. This level is then compared to the FCC limit.

### **EXAMPLE:**

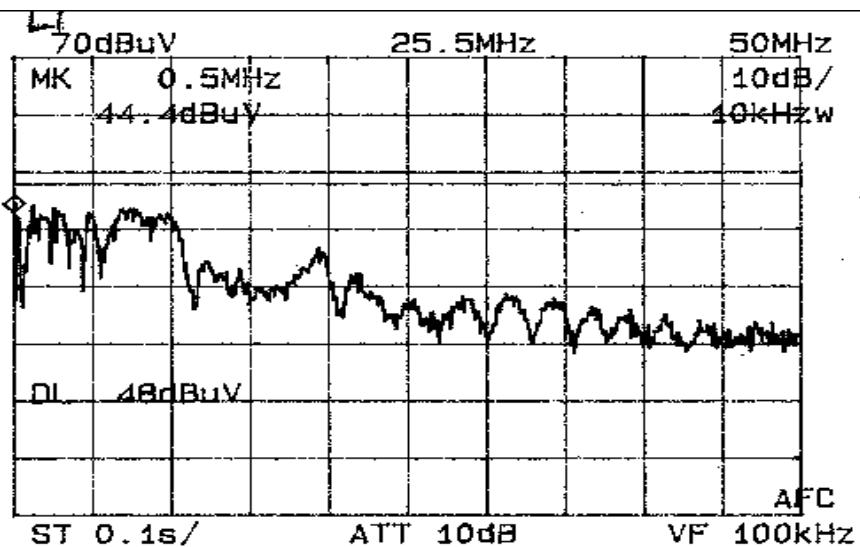
**Spectrum Analyzer Voltage:**  $V \text{ dBmV}$

**Composite Factor:**  $AF/CL \text{ dB/m}$

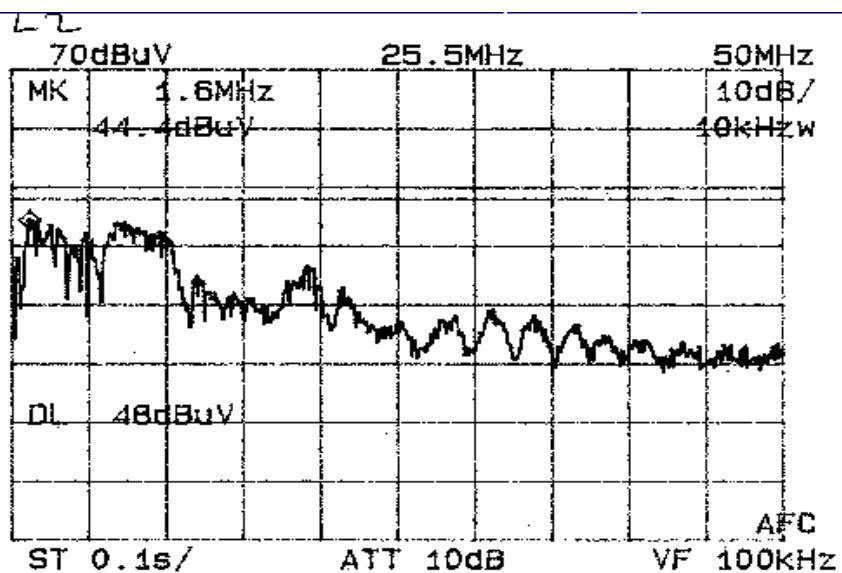
**Electric Field:**  $E \text{ dBmV/m} = V \text{ dBmV} + AF/CL \text{ dB/m}$

**Linear Conversion:**  $E \text{ mV/m} = \text{Antilog}(E \text{ dBmV/m} / 20)$

## ioStar - A.C. LINE-CONDUCTED EMISSIONS – L1



## ioStar - A.C. LINE-CONDUCTED EMISSIONS – L2



## FCC CLASS B LINE -CONDUCTED EMISSIONS DATA

EUT: ioStar

<b>LINE 1</b>				
<b>FREQ</b>	<b>VOLTAGE</b>	<b>VOLTAGE</b>	<b>FCC LIMIT</b>	<b>MARGIN</b>
<b>MHz</b>	<b>dBuV</b>	<b>uV</b>	<b>uV</b>	<b>dB</b>
0.513	44	166.0	250	-3.6
1.7	44	160.3	250	-3.9
3.1	44	151.4	250	-4.4
7.4	43	147.9	250	-4.6
19.8	37	67.6	250	-11.4
<b>LINE 2</b>				
<b>FREQ</b>	<b>VOLTAGE</b>	<b>VOLTAGE</b>	<b>FCC LIMIT</b>	<b>MARGIN</b>
<b>MHz</b>	<b>dBuV</b>	<b>uV</b>	<b>uV</b>	<b>dB</b>
0.515	41	109.6	250	-7.2
1.6	44	166.0	250	-3.6
3.1	43	147.9	250	-4.6
7.5	44	151.4	250	-4.4
19.8	37	67.6	250	-11.4

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## FCC 15.247 RADIATED EMISSIONS DATA

EUT: ioStar  
 CARRIER : 2412 MHz

FREQ MHz	POL H/V	AVRG SPEC A dBuV	AF/CL dB/m	PREAMP GAIN	E-FIELD dBuV/m	AVRG LIMIT dBuV/m	MRGN dB
4824.00	V	34.0	37.0	-25	46.0	54.0	-8.0
7236.00	V	29.0	39.0	-25	43.0	54.0	-11.0
12060.00	H	22.0	42.0	-25	39.0	54.0	-15.0
14472.00	H	19.0	44.0	-25	38.0	54.0	-16.0
19296.00	V	21.0	36.0	-25	32.0	54.0	-22.0

CARRIER : 2430 MHz

FREQ MHz	POL H/V	AVRG SPEC A dBuV	AF/CL dB/m	PREAMP GAIN	E-FIELD dBuV/m	AVRG LIMIT dBuV/m	MRGN dB
4860.00	V	35.0	37.0	-25	47.0	54.0	-7.0
7290.00	V	29.0	39.0	-25	43.0	54.0	-11.0
12150.00	H	22.0	42.0	-25	39.0	54.0	-15.0
19440.00	V	23.0	36.0	-25	34.0	54.0	-20.0

Note: Peak levels are 9 dB above Average levels reported.

CARRIER : 2470 MHz

FREQ MHz	POL H/V	AVRG SPEC A dBuV	AF/CL dB/m	PREAMP GAIN	E-FIELD dBuV/m	AVRG LIMIT dBuV/m	MRGN dB
4940.00	V	32.0	37.0	-25	44.0	54.0	-10.0
7410.00	V	26.0	39.0	-25	40.0	54.0	-14.0
12350.00	H	21.0	42.0	-25	38.0	54.0	-16.0
19760.00	V	23.0	36.0	-25	34.0	54.0	-20.0
22230.00	V	19.0	38.0	-25	32.0	54.0	-22.0

Note: Peak levels are 9 dB above Average levels reported.

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**Table 1**

**EUT ANTENNAS / ACCESSORIES**

Parabolic Dish Antenna - Comsat Model P-24A24N-1 (2.3-2.5 GHz)

- S/N: 224576

- Gain = 21 dBi

**Table 2**  
**INTERFACE CABLES USED**

7 ft., dual 75 ohm coaxial cables are used to connect the indoor modem unit to the outside RF transmitter unit.

A 10 ft., 1/4" semirigid 50 ohm coax line is used to connect the output of the RF unit to the dish antenna.

**Table 3**

**Measurement Equipment Used**

The following equipment is used to perform measurements:

HP 435A RF Peak Power Meter	- Serial No. 1362016
EMCO Model 3110 Biconical Antenna	- Serial No. 1619
Antenna Research MWH-1825B Horn Antenna	- Serial No. 1005
EMCO Model 3115 Ridged Horn Antenna	- Serial No. 3007
HP 8348A Preamplifier	- Serial No. 197-2564A
Solar 8012-50-R-24-BNC LISN	- Serial No. 924867
Bird 8306-300-N 30dB Attenuator	- S/N: 29198391515
HP 14IT w/8555A Spectrum Analyzer	- Serial No. 6-95-1124
Advanest Model R4131D Spectrum Analyzer	- Serial No. 54378A
4 Meter Antenna Mast	
Motorized Turntable	
Heliax FSJ1-50A 1/4" Superflex Coax Cable (12 Ft.)	