

NATIONAL CERTIFICATION LABORATORY

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FCC REPORT OF RADIO INTERFERENCE

for

io Wave, Inc.

1010 Wisconsin Ave., NW Suite 215

Washington, DC 20007

FCC ID: NK4-7039795714

July 21, 1999

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NCL PROJ.# IOWAVE-508

1.0 Introduction

This report has been prepared on behalf of io Wave, Inc., to support the attached Application for Certification of a Part 15 Spread Spectrum Transmitter. The Equipment Under Test was the **ioLink 4 / ioLink1 2.4 Ghz Wireless Modem Transmitter**.

Radio-Noise Emissions tests were performed according to **FCC Public Notice 54797, titled "Guidance on Measurements 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 io Wave, Inc. **ioLink4 / ioLink1 2.4 Ghz Wireless Modem Transmitter** complies with the FCC limits (15.247) for a Direct Sequence SST.

2.0 Description of Equipment Under Test (EUT)

The EUT Features:

ioLink4 or ioLink 1 Modem units
+17 to +25 dBm RF Output
2412 to 2470 MHz Freq. Range
20 MHz Channel Bandwidth
2-Channels Duplex Operation
DQPSK-SS Modulation
Data Rate - (E1 or T1)

3.0 Test Program

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

1. (15.247) Peak RF output power.
2. (15.247) Power Spectral Density (3kHz Bandwidth).
3. (15.247) Field strength of harmonics and spurious out-of-band emissions.
4. (15.247) RF Antenna Conducted of harmonics and spurious out-of-band emissions.
5. (15.247) 6 dB Occupied Bandwidth.
6. (15.247) Processing Gain.
7. (15.207) Power Line Conducted Emissions.

4.0 Test Configuration

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 adjusted 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 worst-case emissions.

PEAK POWER TEST RESULTS

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

Readings from RF peak power meter (Carrier Modulated):

ioLink1	2412 MHz	-	+24.9 dBm
	2430 MHz	-	+25.1 dBm
	2470 Mhz	-	+24.7 dBm

ioLink4	2412 MHz	-	+24.8 dBm
	2430 MHz	-	+25.0 dBm
	2470 Mhz	-	+24.8 dBm

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

Modulation Data Rate: E1

Readings from spectrum analyzer:

ioLink1	2412 MHz	-	-1.4 dBm
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2430 MHz	-	-1.2 dBm
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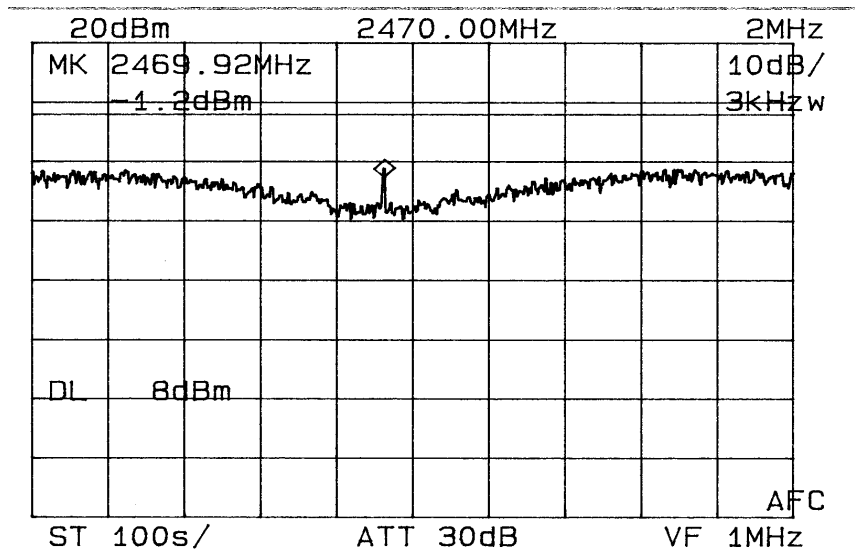
2470 MHz	-	-1.2 dBm
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ioLink4	2412 MHz	-	+6.0 dBm
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2430 MHz	-	+6.0 dBm
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2470 MHz	-	+5.6 dBm
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SEE FOLLOWING 6 PLOTS

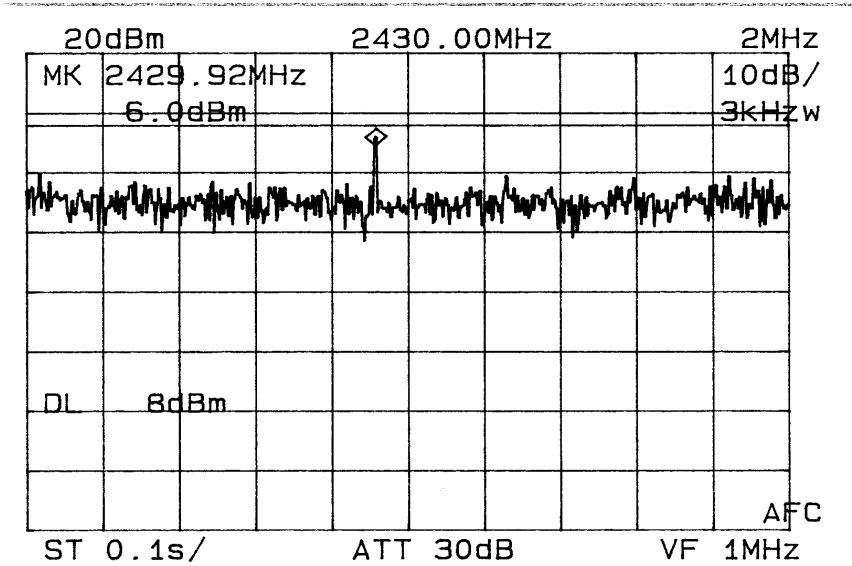
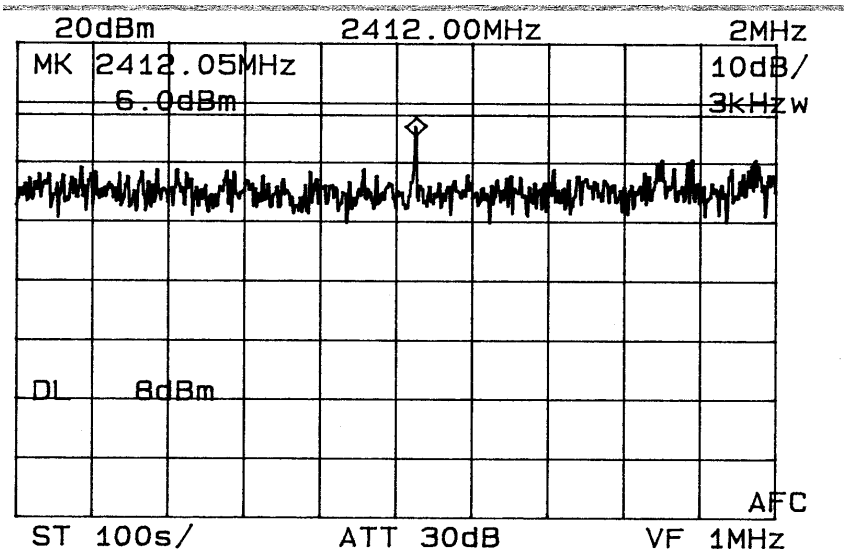


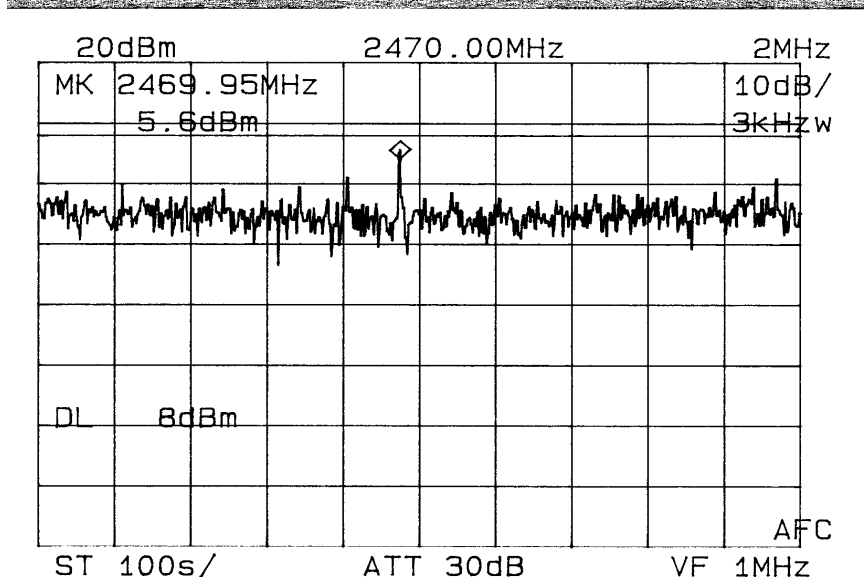
SPECTRAL POWER DENSITY LEVEL - ioLink4

MODULATED

2 MHZ SPAN

3 KHZ BW





6 dB Channel Bandwidth

Minimum 6 dB BW: 500 kHz
RBW Setting on S.A.: 100 kHz
Modulation Data Rate: E1

Readings from spectrum analyzer:

ioLink1	2412 MHz	-	11.4 MHz
	2430 MHz	-	11.6 MHz
	2470 Mhz	-	11.8 MHz

ioLink4	2412 MHz	-	13.8 MHz
	2430 MHz	-	11.0 MHz
	2470 Mhz	-	11.4 MHz

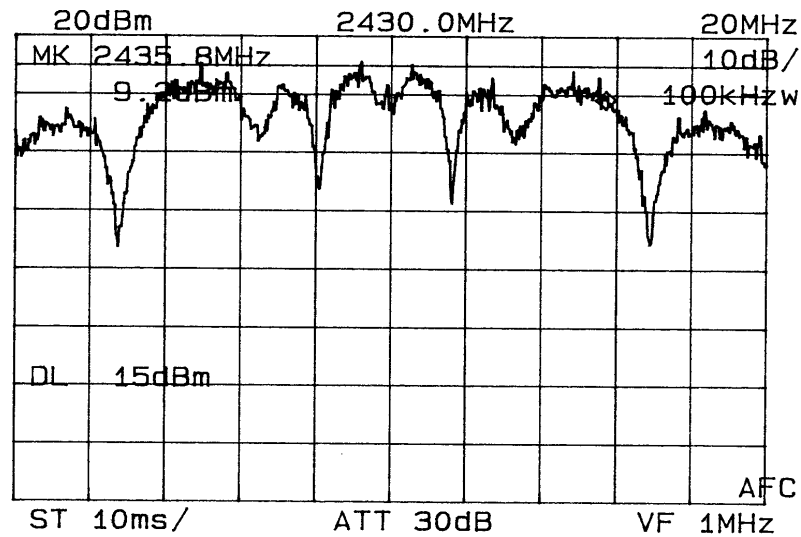
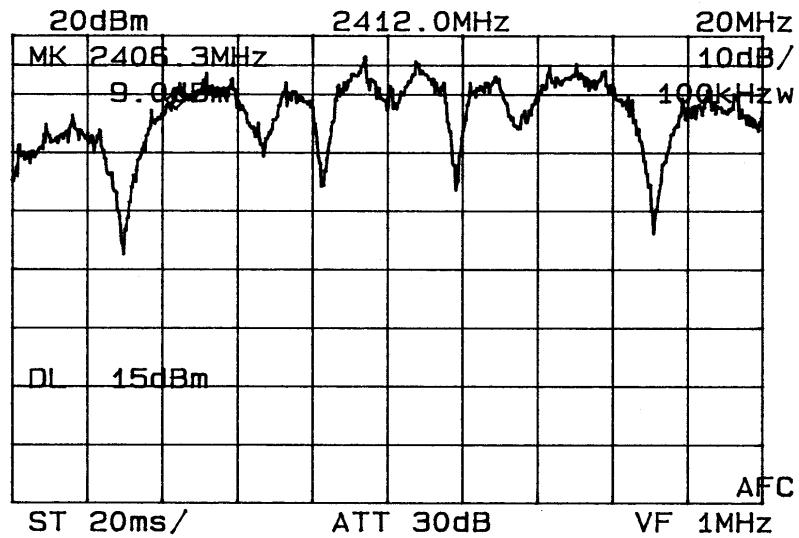
SEE FOLLOWING 6 PLOTS

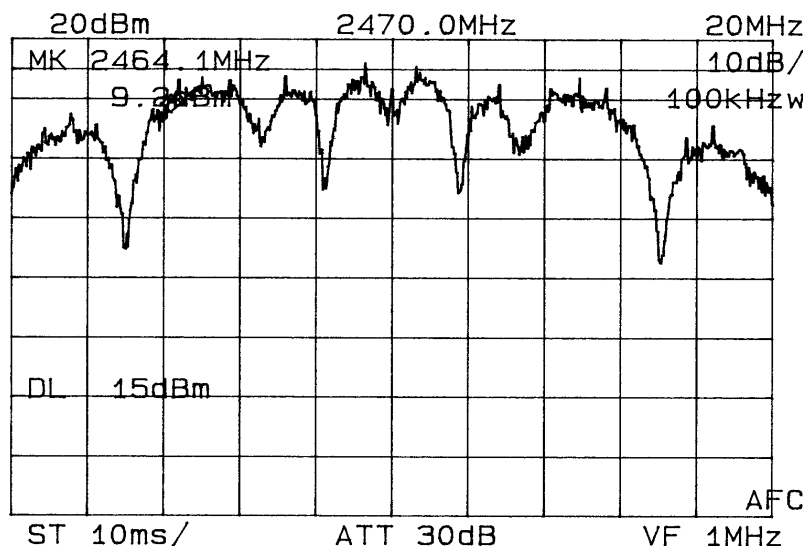
6 dB POWER BANDWIDTH MEASUREMENT - ioLink1

MODULATED

20 MHz SPAN

100 KHZ BW



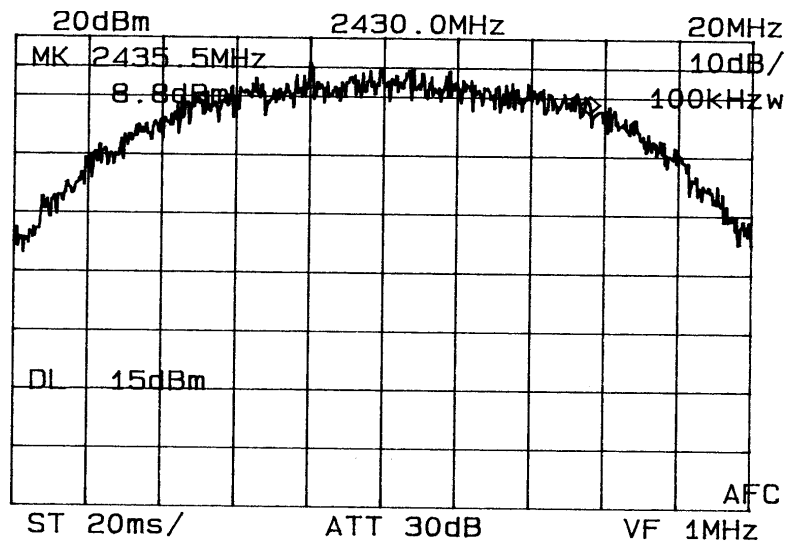
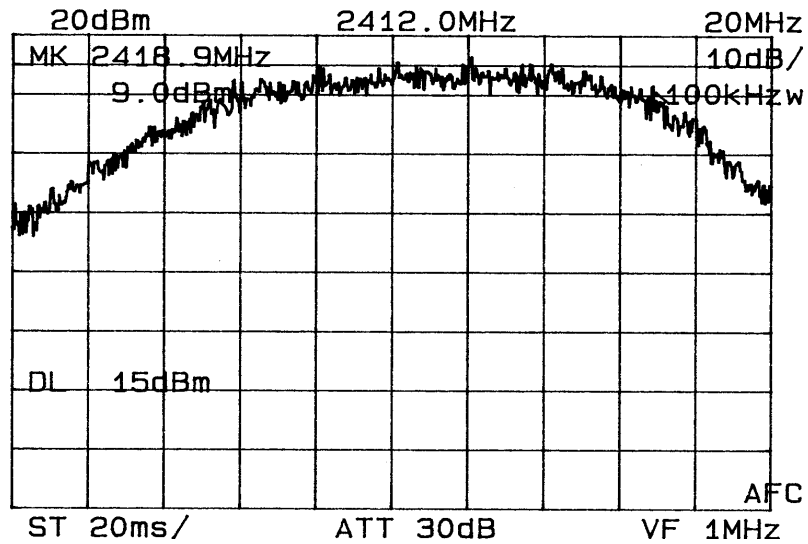


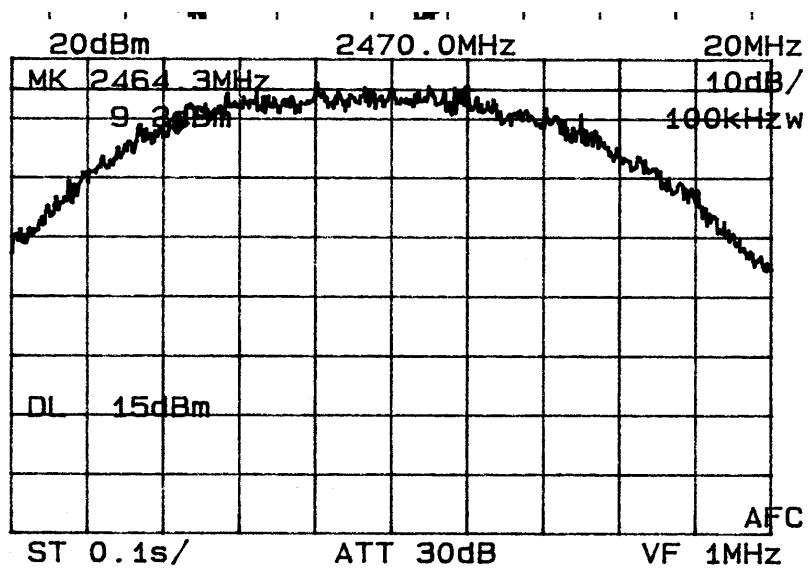
6 dB POWER BANDWIDTH MEASUREMENT - ioLink4

MODULATED

20 MHz SPAN

100 KHZ BW





RF ANTENNA CONDUCTED SPURIOUS/HARMONICS EMISSIONS

Limit: 20 dB below Carrier Level
RBW Setting on S.A.: 100 kHz
Modulation Data Rate: E1

SEE FOLLOWING 6 DATA TABLES

FCC PART 15.247 - CONDUCTED SPURIOUS EMISSIONS

Frequency of Carrier = 2412 MHz

Limit = 20 dBc

TEST RESULTS - ioLink1

LIMIT: -20 dB FROM PEAK CARRIER

<u>COMPONENT</u>	<u>FREQUENCY (MHZ)</u>	<u>RESULT (dB FROM PEAK)</u>
HARMONIC	4824.00	- 62
HARMONIC	7236.00	- 68
HARMONIC	9648.00	- 70
HARMONIC	12060.00	- 69
HARMONIC	14472.00	- 72
HARMONIC	16844.00	- 75
HARMONIC	19296.00	- 76
HARMONIC	21708.00	- 75
HARMONIC	24120.00	- 76

FCC PART 15.247 - CONDUCTED SPURIOUS EMISSIONS

Frequency of Carrier = 2430 MHz

Limit = 20 dBc

TEST RESULTS - ioLink1

LIMIT: -20 dB FROM PEAK CARRIER

<u>COMPONENT</u>	<u>FREQUENCY (MHZ)</u>	<u>RESULT (dB FROM PEAK)</u>
HARMONIC	4860.00	- 60
HARMONIC	7290.00	- 61
HARMONIC	9720.00	- 65
HARMONIC	12150.00	- 66
HARMONIC	14580.00	- 69
HARMONIC	17010.00	- 73
HARMONIC	19440.00	- 75
HARMONIC	21870.00	- 77
HARMONIC	24300.00	- 77

FCC PART 15.247 - CONDUCTED SPURIOUS EMISSIONS

Frequency of Carrier = 2470 MHz

Limit = 20 dBc

TEST RESULTS - ioLink1 LIMIT: -20 dB FROM PEAK CARRIER

<u>COMPONENT</u>	<u>FREQUENCY (MHZ)</u>	<u>RESULT (dB FROM PEAK)</u>
HARMONIC	4940.00	- 64
HARMONIC	7410.00	- 66
HARMONIC	9880.00	- 69
HARMONIC	12350.00	- 68
HARMONIC	14820.00	- 71
HARMONIC	17290.00	- 70
HARMONIC	19760.00	- 74
HARMONIC	22230.00	- 77
HARMONIC	24700.00	- 77

FCC PART 15.247 - CONDUCTED SPURIOUS EMISSIONS

Frequency of Carrier = 2412 MHz

Limit = **20 dBc**

TEST RESULTS - ioLink4

LIMIT: -20 dB FROM PEAK CARRIER

<u>COMPONENT</u>	<u>FREQUENCY (MHZ)</u>	<u>RESULT (dB FROM PEAK)</u>
HARMONIC	4824.00	- 64
HARMONIC	7236.00	- 68
HARMONIC	9648.00	- 67
HARMONIC	12060.00	- 70
HARMONIC	14472.00	- 74
HARMONIC	16844.00	- 75
HARMONIC	19296.00	- 77
HARMONIC	21708.00	- 76
HARMONIC	24120.00	- 77

FCC PART 15.247 - CONDUCTED SPURIOUS EMISSIONS

Frequency of Carrier = 2430 MHz

Limit = **20 dBc**

TEST RESULTS - ioLink4

LIMIT: -20 dB FROM PEAK CARRIER

<u>COMPONENT</u>	<u>FREQUENCY (MHZ)</u>	<u>RESULT (dB FROM PEAK)</u>
HARMONIC	4860.00	- 62
HARMONIC	7290.00	- 63
HARMONIC	9720.00	- 67
HARMONIC	12150.00	- 66
HARMONIC	14580.00	- 70
HARMONIC	17010.00	- 71
HARMONIC	19440.00	- 73
HARMONIC	21870.00	- 76
HARMONIC	24300.00	- 76

FCC PART 15.247 - CONDUCTED SPURIOUS EMISSIONS

Frequency of Carrier = 2470 MHz

Limit = 20 dBc

TEST RESULTS - ioLink4

LIMIT: -20 dB FROM PEAK CARRIER

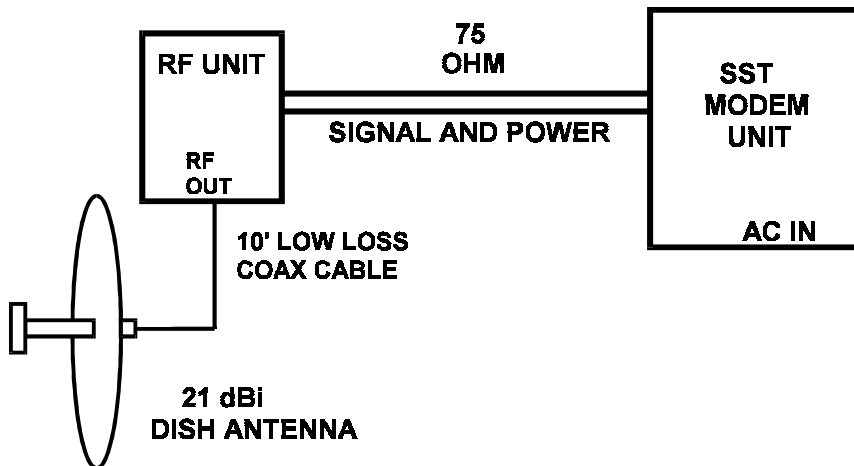
<u>COMPONENT</u>	<u>FREQUENCY (MHZ)</u>	<u>RESULT (dB FROM PEAK)</u>
HARMONIC	4940.00	- 65
HARMONIC	7410.00	- 63
HARMONIC	9880.00	- 69
HARMONIC	12350.00	- 69
HARMONIC	14820.00	- 72
HARMONIC	17290.00	- 71
HARMONIC	19760.00	- 76
HARMONIC	22230.00	- 77
HARMONIC	24700.00	- 77

4.0 Test Configuration

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".

This is described below:



5.0 Conducted Emissions Scheme

The EUT is placed on an 80 cm high 1 X 1.5 m non-conductive table. Power to the CPU is provided through a Solar Corporation 50 Ω /50 μ H 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 Ω 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.

6.0 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 maximum emissions. The height of the antenna is varied between 1 and 4 meters. Both the horizontal and vertical field components are measured.

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

The output from the antenna is connected to the input of the preamplifier. The preamp out is connected to the spectrum analyzer. The detector function is set to **Peak**. The resolution bandwidth of the spectrum analyzer is set at 120 kHz, for the frequency range of 30-1000 MHz, and 1 MHz for the range of 1 GHz-25 GHz. A 10 Hz video BW setting is used to average readings above 1 GHz. 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 μ V to obtain the Radiated Electric Field in dB μ V/m. This level is then compared with the FCC limit.

Example:

Spectrum Analyzer Volt: VdB μ V

Composite Factor: AF/CLdB/m

Electric Field: EdB μ V/m = VdB μ V + AF/CLdB/m

Linear Conversion: EuV/m = Antilog (EdB μ V/m/20)

FCC 15.209 RADIATED EMISSIONS DATA

EUT: ioLink1
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	33.0	37.0	-25	45.0	54.0	-9.0
7236.00	V	27.0	39.0	-25	41.0	54.0	-13.0
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	20.0	36.0	-25	31.0	54.0	-23.0

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	28.0	39.0	-25	42.0	54.0	-12.0
12150.00	H	20.0	42.0	-25	37.0	54.0	-17.0
19440.00	V	23.0	36.0	-25	34.0	54.0	-20.0

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	33.0	37.0	-25	45.0	54.0	-9.0
7410.00	V	27.0	39.0	-25	41.0	54.0	-13.0
12350.00	H	20.0	42.0	-25	37.0	54.0	-17.0
19760.00	V	21.0	36.0	-25	32.0	54.0	-22.0
22230.00	V	19.0	38.0	-25	32.0	54.0	-22.0

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

FCC 15.209 RADIATED EMISSIONS DATA

EUT: ioLink4
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	27.0	39.0	-25	41.0	54.0	-13.0
12060.00	H	20.0	42.0	-25	37.0	54.0	-17.0
14472.00	H	21.0	44.0	-25	40.0	54.0	-14.0
19296.00	V	20.0	36.0	-25	31.0	54.0	-23.0

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	32.0	37.0	-25	44.0	54.0	-10.0
7290.00	V	25.0	39.0	-25	39.0	54.0	-15.0
12150.00	H	21.0	42.0	-25	38.0	54.0	-16.0
19440.00	V	20.0	36.0	-25	31.0	54.0	-23.0

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	33.0	37.0	-25	45.0	54.0	-9.0
7410.00	V	27.0	39.0	-25	41.0	54.0	-13.0
12350.00	H	22.0	42.0	-25	39.0	54.0	-15.0
19760.00	V	20.0	36.0	-25	31.0	54.0	-23.0
22230.00	V	20.0	38.0	-25	33.0	54.0	-21.0

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

FCC 15.209 RADIATED EMISSIONS DATA

UPPER BAND EDGE

EUT: ioLink1
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	MGRN dB
2488.00	V	35.0	34.0	-25	44.0	54.0	-10

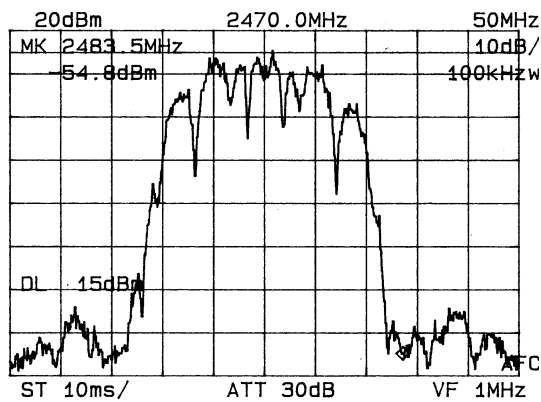
FREQ MHz	POL H/V	PEAK SPEC A dBuV	AF/CL dB/m	PREAMP GAIN	E-FIELD dBuV/m	PEAK LIMIT dBuV/m	MGRN dB
2488.00	V	38.0	34.0	-25	47.0	74.0	-27

EUT: ioLink4
CARRIER : 2470 MHz

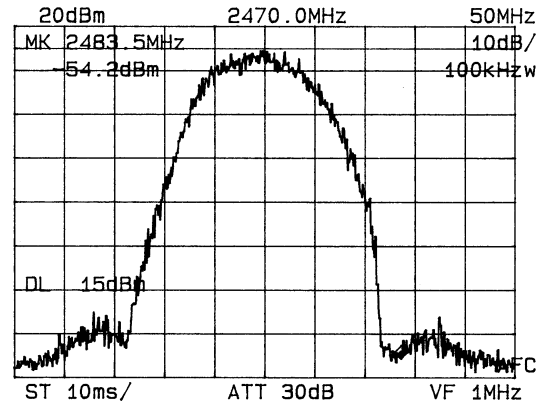
FREQ MHz	POL H/V	AVRG SPEC A dBuV	AF/CL dB/m	PREAMP GAIN	E-FIELD dBuV/m	AVRG LIMIT dBuV/m	MGRN dB
2487.00	V	31.0	34.0	-25	40.0	54.0	-14

FREQ MHz	POL H/V	PEAK SPEC A dBuV	AF/CL dB/m	PREAMP GAIN	E-FIELD dBuV/m	PEAK LIMIT dBuV/m	MGRN dB
2487.00	V	34.0	34.0	-25	43.0	74.0	-31

ioLink1



IoLink4



FCC CLASS B CONDUCTED EMISSIONS DATA

EUT: ioLink1

LINE 1 - NEUTRAL

FREQ MHz	VOLTAGE dBuV	VOLTAGE uV	FCC LIMIT uV	MARGIN dB
0.8	41.0	112	250	-7.0
11.8	43.4	147	250	-4.6
16.6	41.6	120	250	-6.4
23.2	38.6	85	250	-9.4

LINE 2 - PHASE

FREQ MHz	VOLTAGE dBuV	VOLTAGE uV	FCC LIMIT uV	MARGIN dB
0.5	38.1	80	250	-9.4
12.2	44.8	173	250	-10.4
16.3	39.8	98	250	-9.6
21.7	36.4	66	250	-9.9

EUT: ioLink4

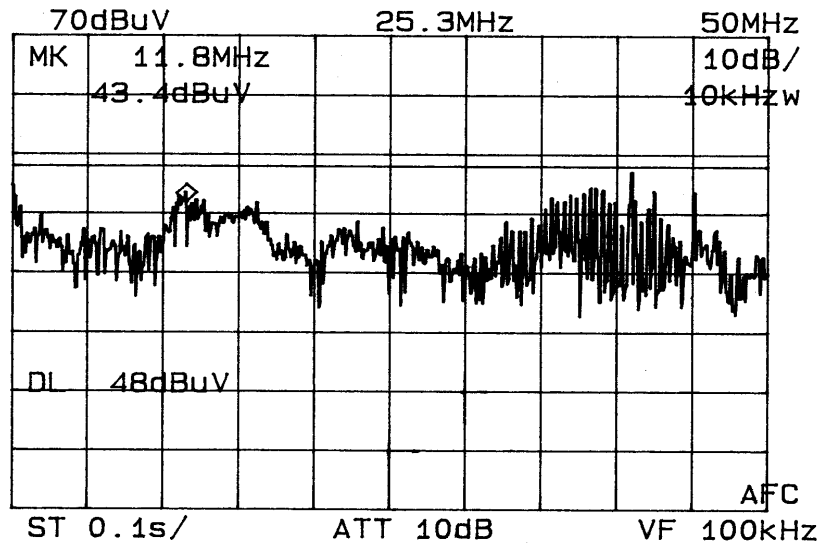
LINE 1 - NEUTRAL

FREQ MHz	VOLTAGE dBuV	VOLTAGE uV	FCC LIMIT uV	MARGIN dB
.6	32.6	42	250	-15.4
3.8	33.2	46	250	-14.8
10.3	36.6	68	250	-11.4
22.8	37.4	74	250	-10.6
29.1	41.4	117	250	-6.6

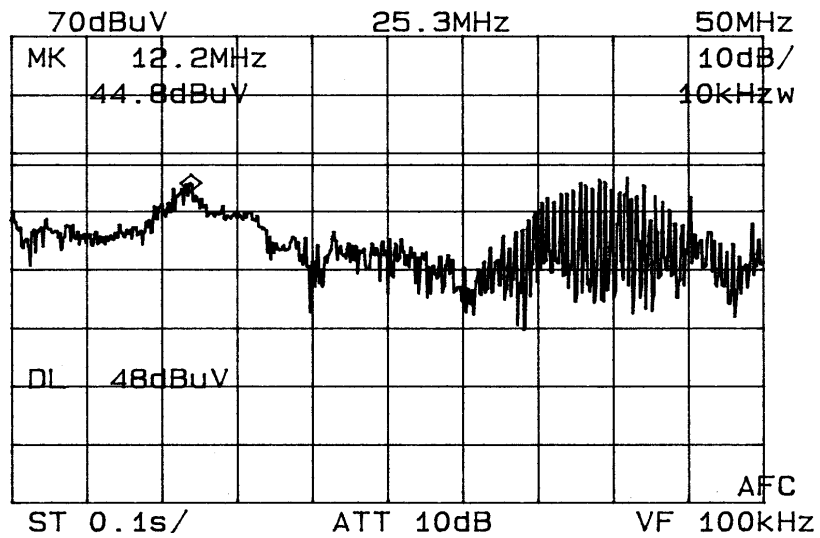
LINE 2 - PHASE

FREQ MHz	VOLTAGE dBuV	VOLTAGE uV	FCC LIMIT uV	MARGIN dB
2.1	32.2	41	250	-15.8
4.1	35.4	59	250	-12.6
11.7	37.2	71	250	-10.8
24.6	35.2	55	250	-12.8
29.6	38.0	79	250	-10.0

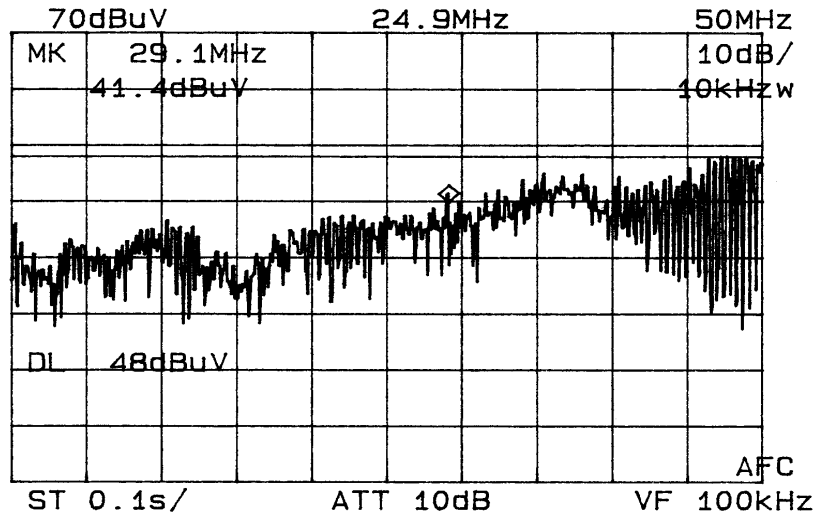
ioLink1 LINE-CONDUCTED EMISSIONS - L1



ioLink1 - A.C. LINE-CONDUCTED EMISSIONS - L2



ioLink4 - A.C. LINE-CONDUCTED EMISSIONS - L1



ioLink4 - A.C. LINE-CONDUCTED EMISSIONS - L2

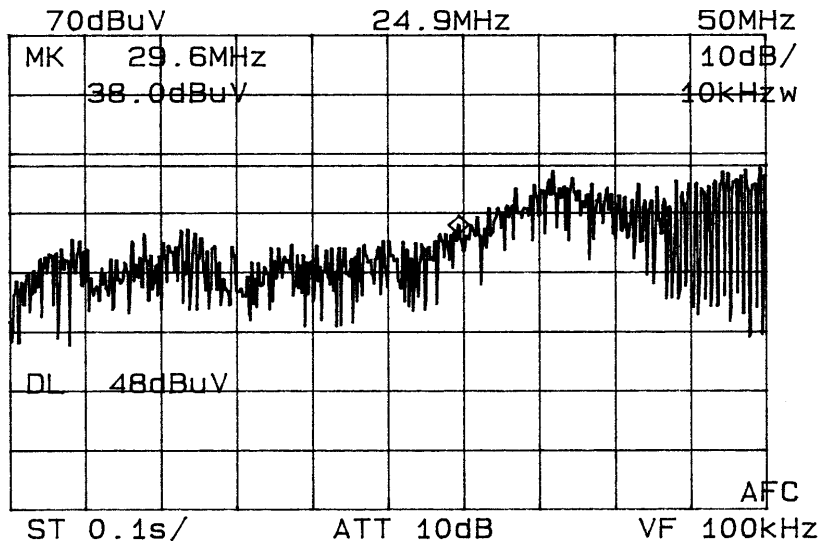


Table 1

EUT 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
Solar 8012-50-R-24-BNC LISN	- Serial No. 927230
Tektronix R3272 Spectrum Analyzer	- Serial No. 6-95-1124
4 Meter Antenna Mast	
Motorized Turntable	
Heliax FSJ1-50A 1/4" Superflex Coax Cable (12 Ft.)	

