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FCC REPORT OF RADIO INTERFERENCE

for

io Wave, Inc.
1010 Wisconsin Ave., NW Suite 215
Washington, DC 20007

FCC ID: NK4-400011

February 27, 1999

TABLE OF CONTENTS

Application Form 731
FCC Label Drawing and Location

1.0 Introduction
1.1 Summary

2.0 Description of Equipment Under Test (EUT)

3.0 Test Program

4.0 Test Configuration

5.0 Conducted Emissions Scheme

6.0 Radiated Emissions Scheme

TABLES

Table 1. Support Equipment
Table 2. Interface Cables
Table 3. Measurement Equipment

EXHIBITS

Exhibit 1. EUT Photographs
Exhibit 2. Schematic Diagram
Exhibit 3. User Manual

1.0 Introduction

This report has been prepared on behalf of io Wave, Inc., to support the original Application for Certification of a Part 15 Spread Spectrum Transmitter. The Equipment Under Test was the **5.8 GHz ioLink 4.0 Wireless Modem Transceiver.**

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. **5.8 GHz ioLink 4.0 Wireless Modem Transceiver** complies with the FCC limits (15.247) for a Direct Sequence SST.

2.0 Description of Equipment Under Test (EUT)

The EUT Features:

+ 25 dBm RF Output

5737.5 to 5837.5 MHz Freq. Range

25 MHz Channel Bandwidth

3-Channel Sets - Full Duplex Operation

DQPSK6-SS Modulation

Data Rate - (T2)

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 Channel 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 adusted to prevent overloading of the front end.

Field strength measurements were taken with the transmitter feeding a 28 dBi gain parabolic dish antenna aimed at the receiving antenna. Full power was developed at the output since a duplex link was not established.

PEAK POWER TEST RESULTS

Limit: 1 watt (30 dBm)

Readings from RF peak power meter (Carrier Modulated):

5737 MHz - +25.3 dBm

5817 MHz - +25.0 dBm

5837 MHz - +25.2 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

Readings from spectrum analyzer:

5737 MHz - +5.1 dBm

5817 MHz - +5.0 dBm

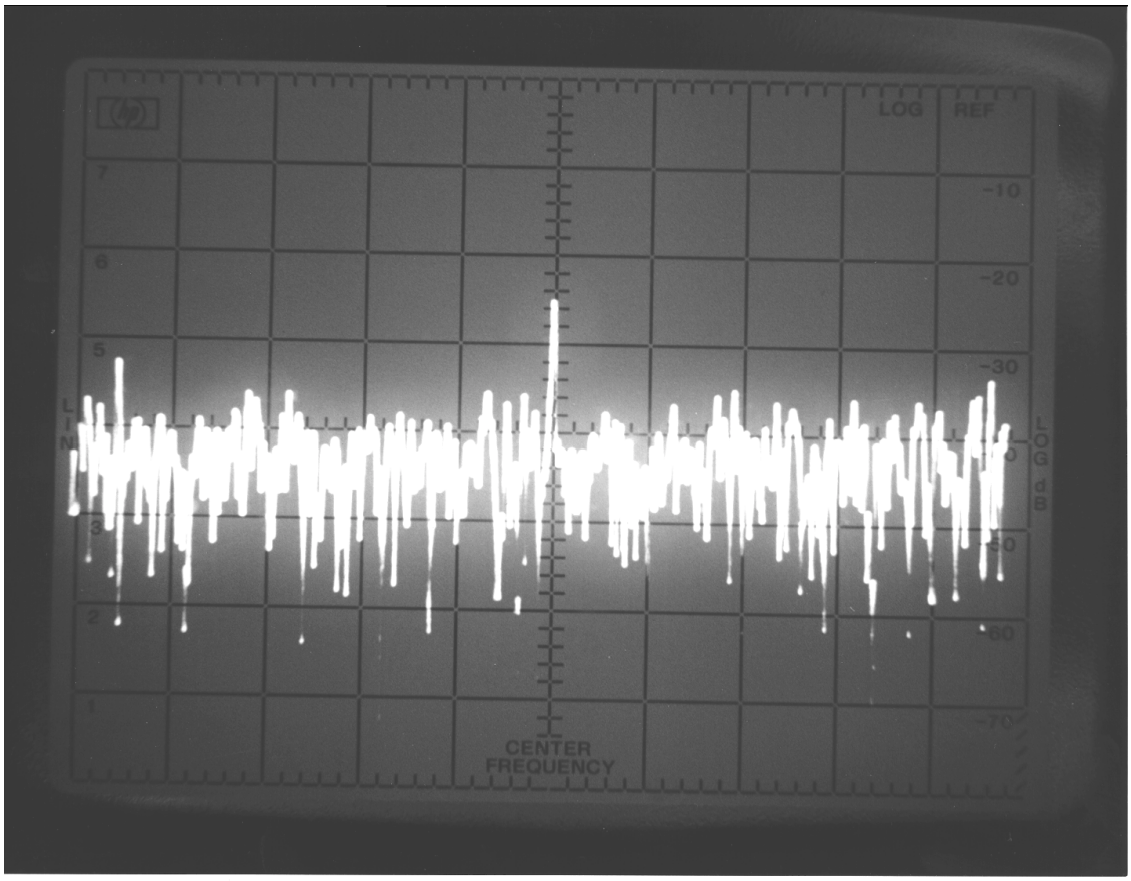
5837 MHz - +5.4 dBm

SEE FOLLOWING 3 PLOTS

POWER SPECTRAL DENSITY PLOT

TOP REFERENCE LEVEL: 30 dBm
RESOLUTION BW: 3 kHz
CENTER FREQUENCY: 5737.5 MHZ
FREQUENCY SPAN: 2 MHZ
SWEEP TIME: 100 SEC/DIV

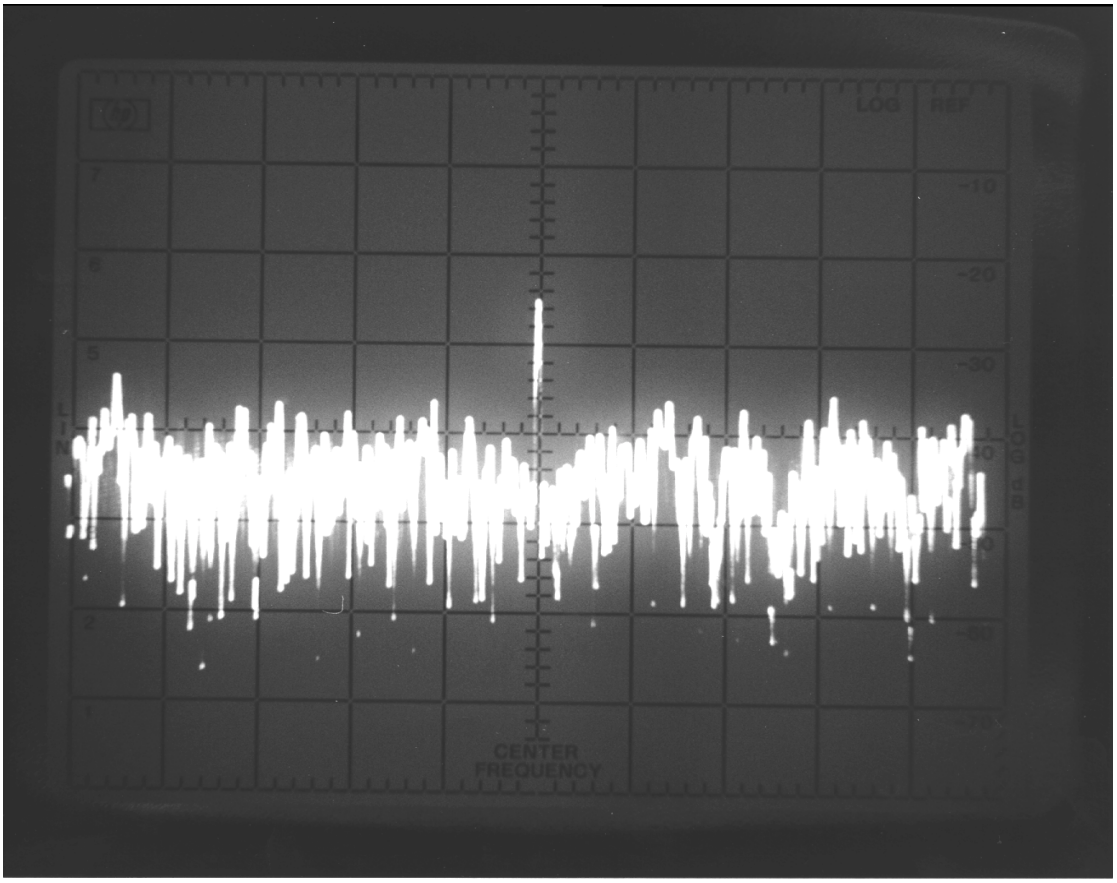
PEAK LEVEL: 5.1 dBm



POWER SPECTRAL DENSITY PLOT

TOP REFERENCE LEVEL: 30 dBm
RESOLUTION BW: 3 kHz
CENTER FREQUENCY: 5817.5 MHZ
FREQUENCY SPAN: 2 MHZ
SWEEP TIME: 100 SEC/DIV

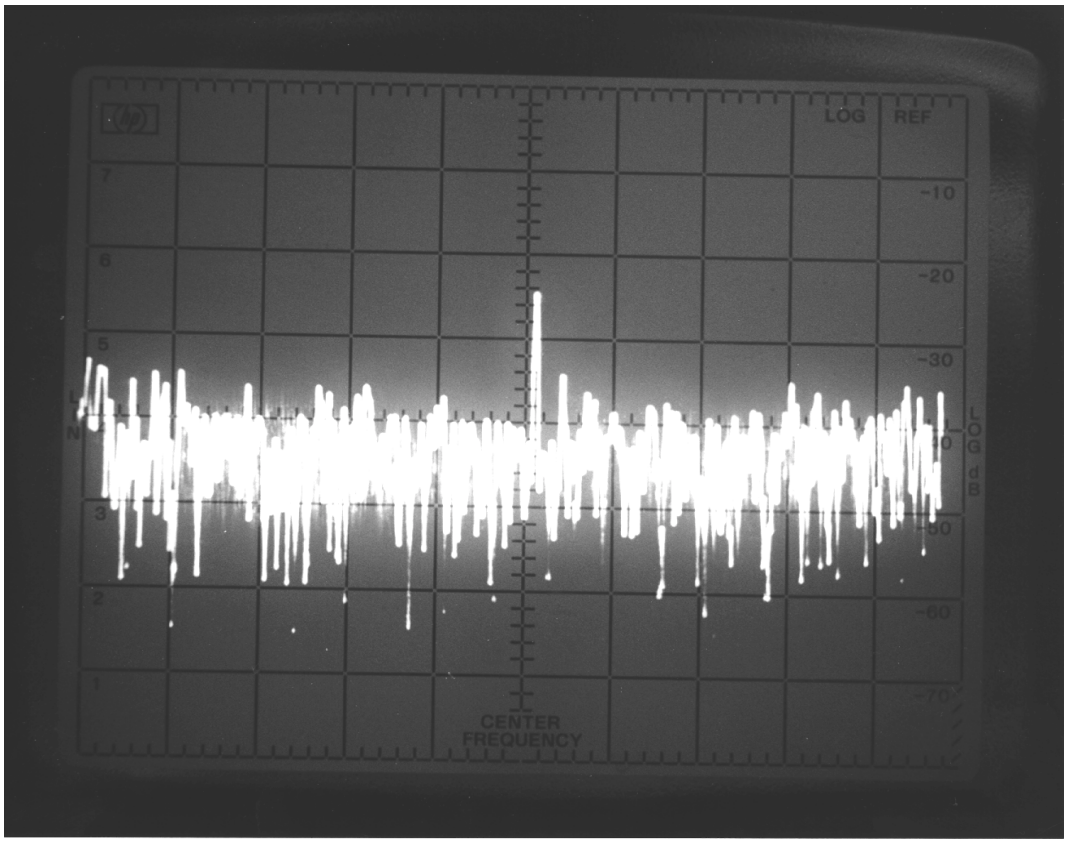
PEAK LEVEL: 5.0 dBm


LOG
REF
-10
-20
-30
CENTER
FREQUENCY

POWER SPECTRAL DENSITY PLOT

TOP REFERENCE LEVEL: 30 dBm
RESOLUTION BW: 3 kHz
CENTER FREQUENCY: 5837.5 MHZ
FREQUENCY SPAN: 2 MHZ
SWEEP TIME: 100 SEC/DIV

PEAK LEVEL: 5.4 dBm


LOG
REF
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-20
-30
-50
-60
-70
7
6
5
3
2
1
LOG
dB
CENTER
FREQUENCY

6 dB Channel Bandwidth

Minimum 6 dB BW: 500 kHz
RBW Setting on S.A.: 100 kHz

Readings from spectrum analyzer:

5737 MHz - 10.1 MHz

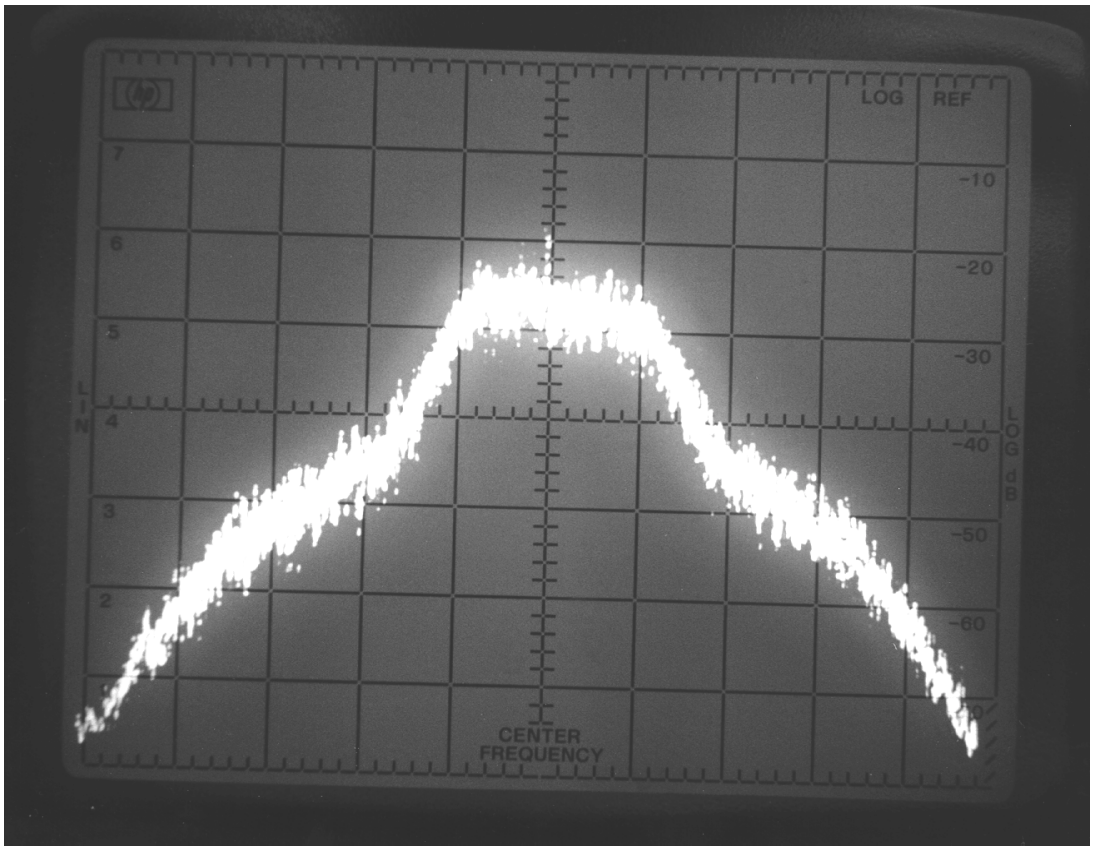
5817 MHz - 10.8 MHz

5837 MHz - 10.3 MHz

SEE FOLLOWING 3 PLOTS

6 dB CHANNEL BANDWIDTH PLOT

TOP REFERENCE LEVEL: 30 dBm
RESOLUTION BW: 100 KHZ
CENTER FREQUENCY: 5737.5 MHZ



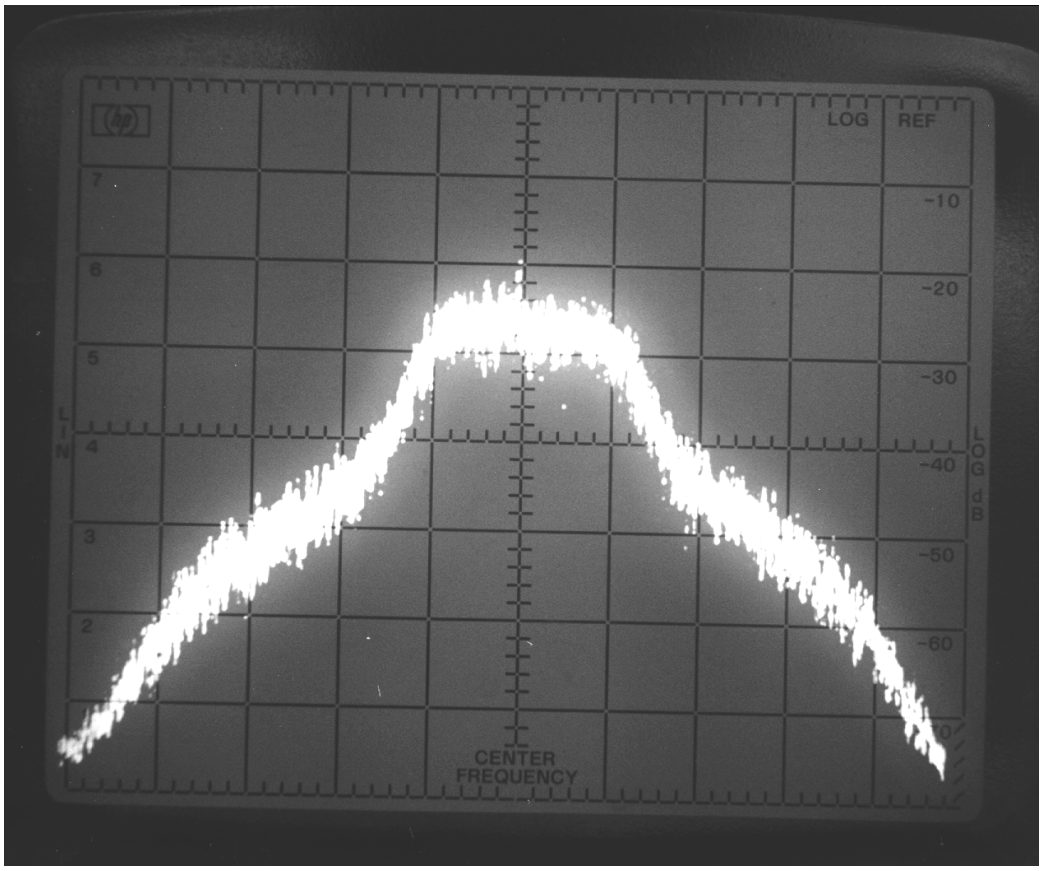
FREQUENCY SPAN: 50 MHZ (5 MHZ/DIV)

MEASURED BANDWIDTH: 10.1 MHZ

6 dB CHANNEL BANDWIDTH PLOT

TOP REFERENCE LEVEL: 30 dBm
RESOLUTION BW: 100 KHZ
CENTER FREQUENCY: 5817.5 MHZ
FREQUENCY SPAN: 50 MHZ (5 MHZ/DIV)

MEASURED BANDWIDTH: 10.8 MHZ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REF
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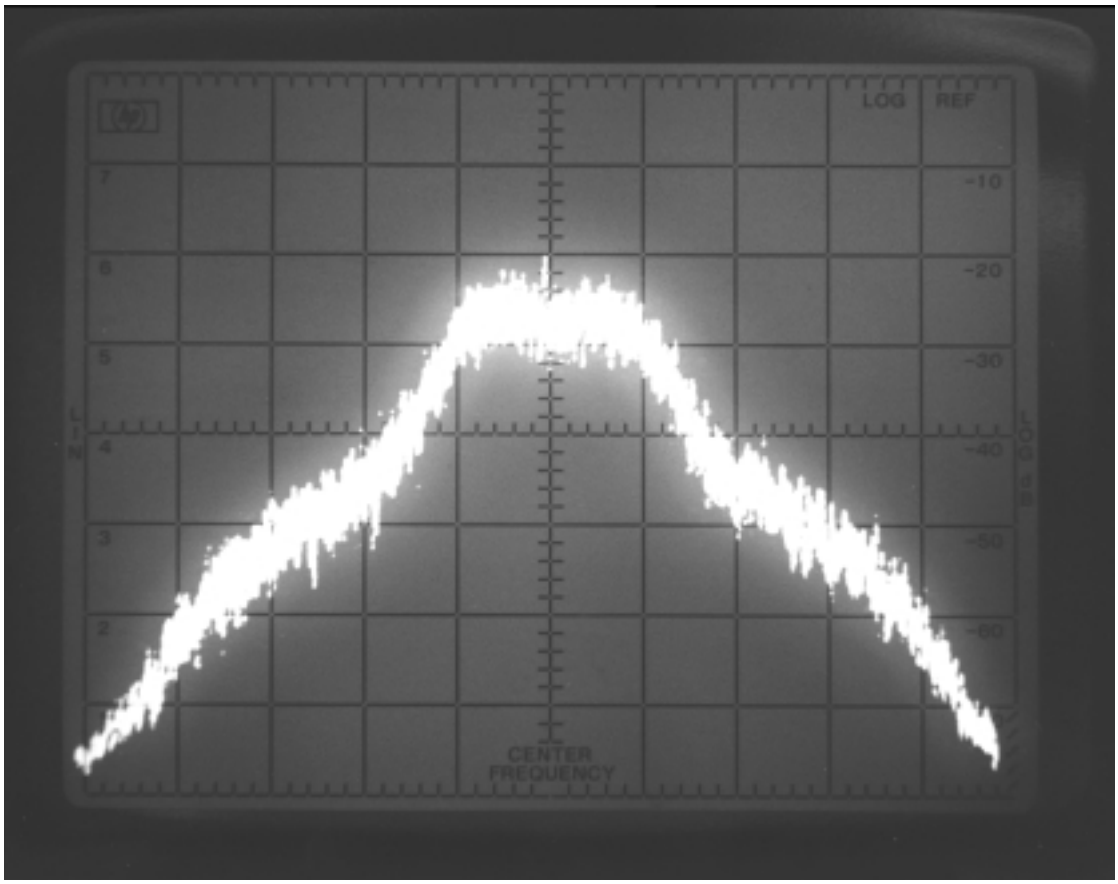
-20
-30
-40
-50
-60
7
6
5
4
3
2
LIN
LOG
dB
CENTER
FREQUENCY

6 dB CHANNEL BANDWIDTH PLOT

TOP REFERENCE LEVEL: 30 dBm
RESOLUTION BW: 100 KHZ
CENTER FREQUENCY: 5837.5 MHZ
FREQUENCY SPAN: 50 MHZ (5 MHZ/DIV)

MEASURED BANDWIDTH: 10.3 MHZ


LOG
REF
7
6
5
4
3
2
-10
-20
-30
-40
-50
-60
CENTER
FREQUENCY

RF ANTENNA CONDUCTED SPURIOUS/HARMONICS EMISSIONS

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

SEE FOLLOWING DATA TABLES

FCC PART 15.247 - CONDUCTED SPURIOUS EMISSIONS

Frequency of Carrier = 5737.5 MHz
Limit = 20 dBc

TEST RESULTS

LIMIT: -20 dB FROM PEAK CARRIER

COMPONENT	FREQUENCY (MHZ)	RESULT (dB FROM PEAK)
HARMONIC	11475.00	- 46
HARMONIC	17212.50	- 62
HARMONIC	22950.00	- 65
HARMONIC	28687.50	- 71
HARMONIC	34425.00	- 74

FCC PART 15.247 - CONDUCTED SPURIOUS EMISSIONS

Frequency of Carrier = 5817.5 MHz
Limit = 20 dBc

TEST RESULTS

LIMIT: -20 dB FROM PEAK CARRIER

COMPONENT	FREQUENCY (MHZ)	RESULT (dB FROM PEAK)
HARMONIC	11635.0	- 47
HARMONIC	17452.5	- 59
HARMONIC	23270.0	- 67
HARMONIC	29087.5	- 73
HARMONIC	34905.0	- 74

FCC PART 15.247 - CONDUCTED SPURIOUS EMISSIONS

Frequency of Carrier = 5837.5 MHz
Limit = 20 dBc

TEST RESULTS

LIMIT: -20 dB FROM PEAK CARRIER

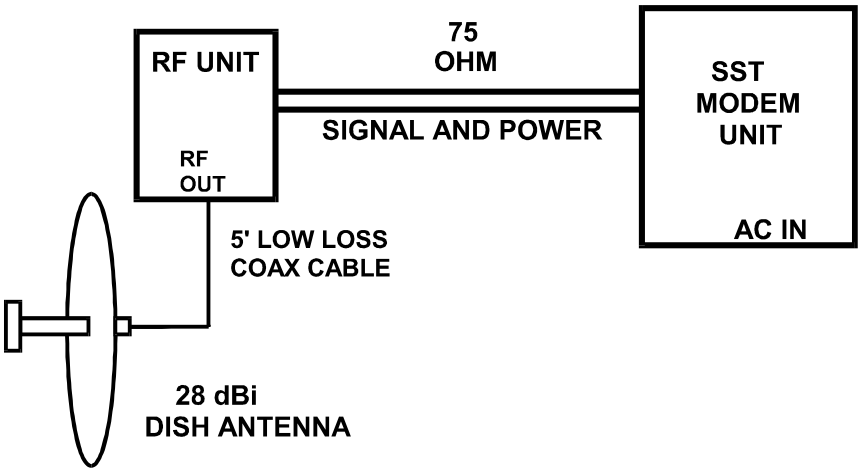
COMPONENT	FREQUENCY (MHZ)	RESULT (dB FROM PEAK)
HARMONIC	11675.0	- 48
HARMONIC	17512.5	- 61
HARMONIC	23350.0	- 69
HARMONIC	29187.5	- 72
HARMONIC	35025.0	- 74

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 μH 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.

FCC CLASS B CONDUCTED EMISSIONS DATA

FCC ID: NK4-400011

CLIENT: IO WAVE, INC.

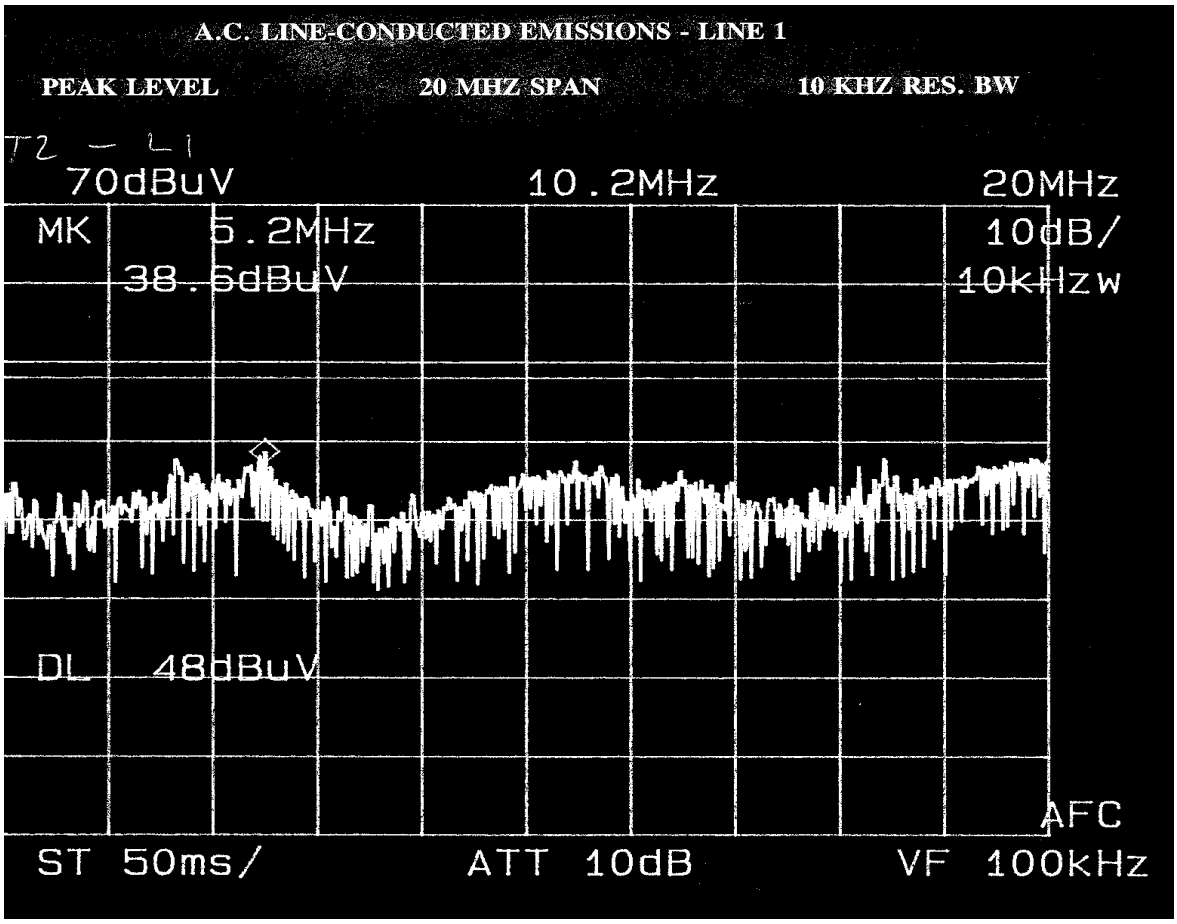
EUT: IO LINK 4.0 TX

CARRIER: 5737.5 MHZ

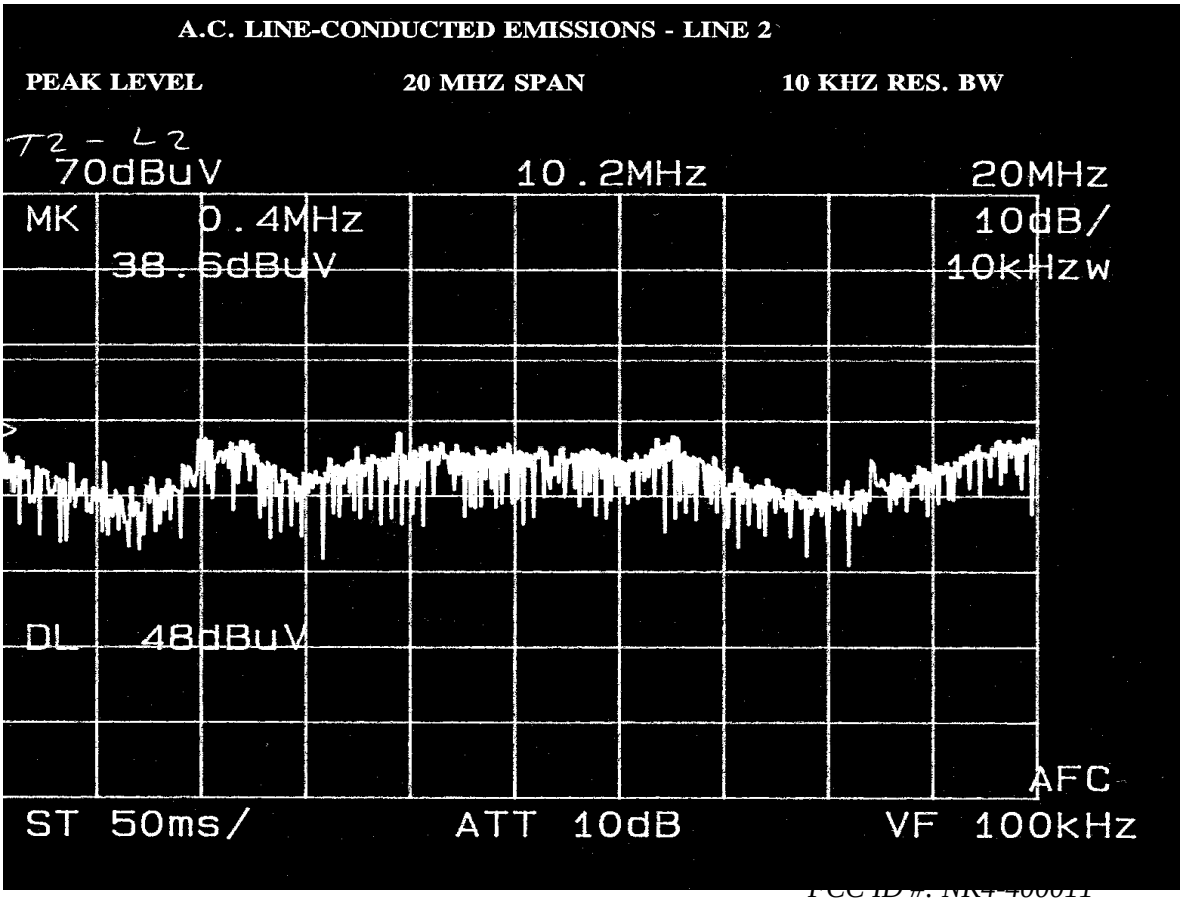
LINE 1 - NEUTRAL

FREQ MHz	VOLTAGE dBuV	VOLTAGE uV	FCC LIMIT uV	MARGIN dB
3.5	37.6	75.9	250	-10.4
5.2	38.4	83.2	250	-9.6
11.2	37.4	74.1	250	-10.6
17.1	37.8	77.6	250	-10.2
20.1	37.6	75.9	250	-10.4

LINE 2 - PHASE



FREQ MHz	VOLTAGE dBuV	VOLTAGE uV	FCC LIMIT uV	MARGIN dB
0.458	38.6	85.1	250	-9.4
4.3	37.6	75.9	250	-10.4
8.2	38.4	83.2	250	-9.6
13.2	38.1	80.4	250	-9.9
20.1	37.8	77.6	250	-10.2


A.C. LINE-CONDUCTED EMISSIONS - LINE 2
PEAK LEVEL
20 MHZ SPAN
10 KHZ RES. BW
T2 - L2
70dBuV
10.2MHz
20MHz
MK
0.4MHz
38.6dBuV
10dB/
10kHzw
DL 48dBuV
AFC
ST 50ms/
ATT 10dB
VF 100kHz

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 - 40.000 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-40 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 dbμV to obtain the Radiated Electric Field in dBμV/m. This level is then compared with the FCC limit.

Example:

Spectrum Analyzer Volt: VdBuV

Composite Factor: AF/CLdB/m

Electric Field: EdBμV/m = VdBμV + AF/CLdB/m
Linear Conversion: EuV/m = Antilog (EdBμV/m/20)

FCC 15.209 RADIATED EMISSIONS DATA

FCC ID: NK4-400011

CLIENT: IO WAVE, INC.
EUT: IO LINK 4.0 TX

CARRIER: 5737.5 MHZ

FREQ MHz	POL H/V	AVRG SPEC A dBuV	AF/CL dB/m	PREAMP GAIN	E-FIELD dBuV/m	E-FIELD uV/m	AVRG LIMIT uV/m	MRGN dB
11475.00	V	29.0	40.0	-22	47.0	223.8	500.0	-7.0
22950.00	H	21.0	36.0	-22	35.0	56.2	500.0	-19.0

CARRIER: 5737.5 MHZ

FREQ	POL	PEAK SPEC A	AF/CL	PREAMP	E-FIELD	E-FIELD	PEAK LIMIT	MRGN

MHz	H/V	dBuV	dB/m	GAIN	dBuV/m	uV/m	uV/m	dB
11475.00	V	33.0	40.0	-22	51.0	354.8	5000	-23.0
22950.00	H	24.0	36.0	-22	38.0	79.4	5000	-36.0

FCC 15.209 RADIATED EMISSIONS DATA

FCC ID: NK4-400011

CLIENT: IO WAVE, INC.
EUT: IO LINK 4.0 TX

CARRIER: 5817.5 MHZ

FREQ	POL	AVRG SPEC A	AF/CL	PREAMP	E-FIELD	E-FIELD	AVRG LIMIT	MRGN
MHz	H/V	dBuV	dB/m	GAIN	dBuV/m	uV/m	uV/m	dB
11635.00	V	27.0	40.0	-22	45.0	177.8	500.0	-9.0

CARRIER: 5817.5 MHZ

FREQ MHz	POL H/V	PEAK SPEC A dBuV	AF/CL dB/m	PREAMP GAIN	E-FIELD dBuV/m	E-FIELD uV/m	PEAK LIMIT uV/m	MRGN dB
11635.00	V	31.0	40.0	-22	49.0	281.8	5000	-25.0

FCC 15.209 RADIATED EMISSIONS DATA

FCC ID: NK4-400011

CLIENT: IO WAVE, INC.
EUT: IO LINK 4.0 TX

CARRIER: 5837.5 MHZ

FREQ MHz	POL H/V	AVRG SPEC A dBuV	AF/CL dB/m	PREAMP GAIN	E-FIELD dBuV/m	E-FIELD uV/m	AVRG LIMIT uV/m	MRGN dB
11675.00	V	27.0	40.0	-22	45.0	177.8	500.0	-9.0

CARRIER: 5837.5 MHZ

FREQ MHz	POL H/V	PEAK SPEC A dBuV	AF/CL dB/m	PREAMP GAIN	E-FIELD dBuV/m	PEAK E-FIELD uV/m	LIMIT uV/m	MRGN dB
11675.00	V	30.0	40.0	-22	48.0	250.8	5000	-26.0

Table 1

Support Equipment

Parabolic Dish Antenna - Radio Waves, Inc. Model SP2-5.8

- S/N: 100081-2M

- Gain = 28 dBi

Table 2

Interface Cables Used

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

A 5 ft., 1/4" Andrews L4A-NMNM Surflex 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-1826B Horn Antenna	- Serial No. 1005
EMCO Model 3116 Ridged Horn Antenna	- Serial No. 3007
HP 83051A Preamplifier	- Serial No. 72-2564C
Solar 8012-50-R-24-BNC LISN	- Serial No. 924867
Solar 8012-50-R-24-BNC LISN	- Serial No. 927230
HP 14IT w/ 8555 RF Sec. Spectrum Analyzer	- Serial No 1850A16168
4 Meter Antenna Mast	
Motorized Turntable	
Heliax FSJ1-50A 1/4" Superflex Coax Cable (12 Ft.)	