

**NATIONAL CERTIFICATION LABORATORY**

**8370 Court Avenue, Suite B-1  
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**FCC REPORT OF RADIO INTERFERENCE**

**for**

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

**FCC ID: NK4-202333WAVE**

**July 8, 1998**

July 18, 1998

Federal Communications Commission  
7435 Oakland Mills Road  
Columbia, MD 21046

ATTN: Applications Examining Branch

REF: io Wave, Inc., Class II Change Application;  
FCCID: NK4-202333WAVE

Dear Sirs:

Please find the enclosed application for a Class II Change under Part 15.247, for the above referenced equipment.

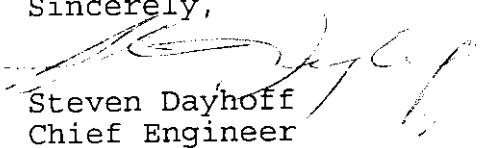
The following changes are made to the original design:

1. The RF unit has incorporated a four-layer PCB design replacing the original two-layer PCB.
2. The modem unit has replaced the 120 VAC switch-mode power module with a 48 VDC input DC-DC power module.

Documents with this submittal include photographs and test data/report.

Your consideration is much appreciated.

Sincerely,

  
Steven Dayhoff  
Chief Engineer

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*NCL PROJ.# IOWAVE-450*

## 1.0 Introduction

This report has been prepared on behalf of io Wave, Inc., to support the attached Application for a Class II Change of a Part 15 Spread Spectrum Transmitter. The Equipment Under Test was the **ioLink 1.5 T1 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.

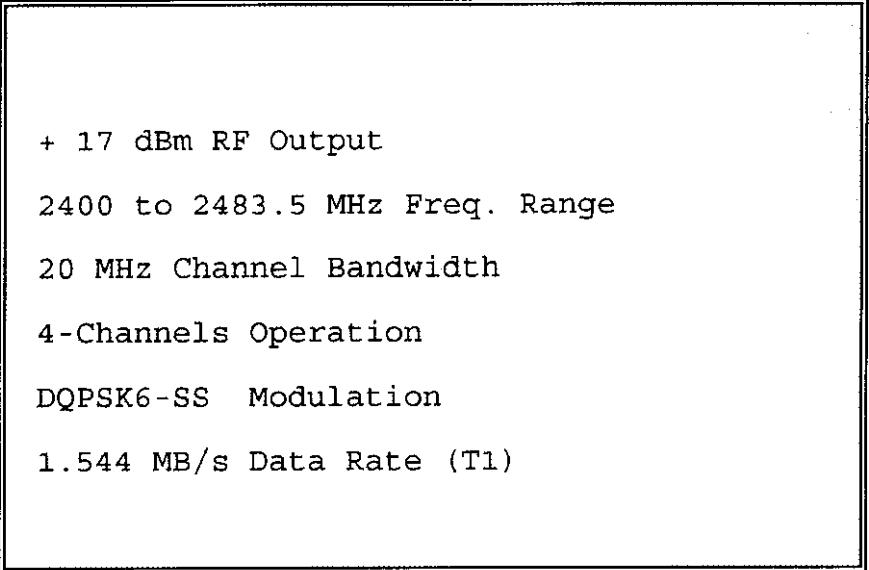
### 1.1 Summary

The io Wave, Inc. **ioLink 1.5 T1 Wireless Modem Transmitter** continues to comply with the FCC limits (15.247) for a Direct Sequence SST, with the following changes:

1. The RF unit has incorporated a four-layer PCB design replacing the original two-layer PCB.
2. The modem unit has replaced the 120 VAC switch-mode power module with a 48 VDC input DC-DC power module.

## 2.0 Description of Equipment Under Test (EUT)

The EUT Features:



- + 17 dBm RF Output
- 2400 to 2483.5 MHz Freq. Range
- 20 MHz Channel Bandwidth
- 4-Channels Operation
- DQPSK6-SS Modulation
- 1.544 MB/s Data Rate (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 Channel Bandwidth.
6. (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 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) :

2412 MHz - +16.6 dBm

2452 MHz - +16.4 dBm

MEASUREMENTS TAKEN FROM ANTENNA CONNECTOR INTO RF POWER METER

## 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:

2412 MHz - +2.8 dBm

2452 MHz - +4.4 dBm

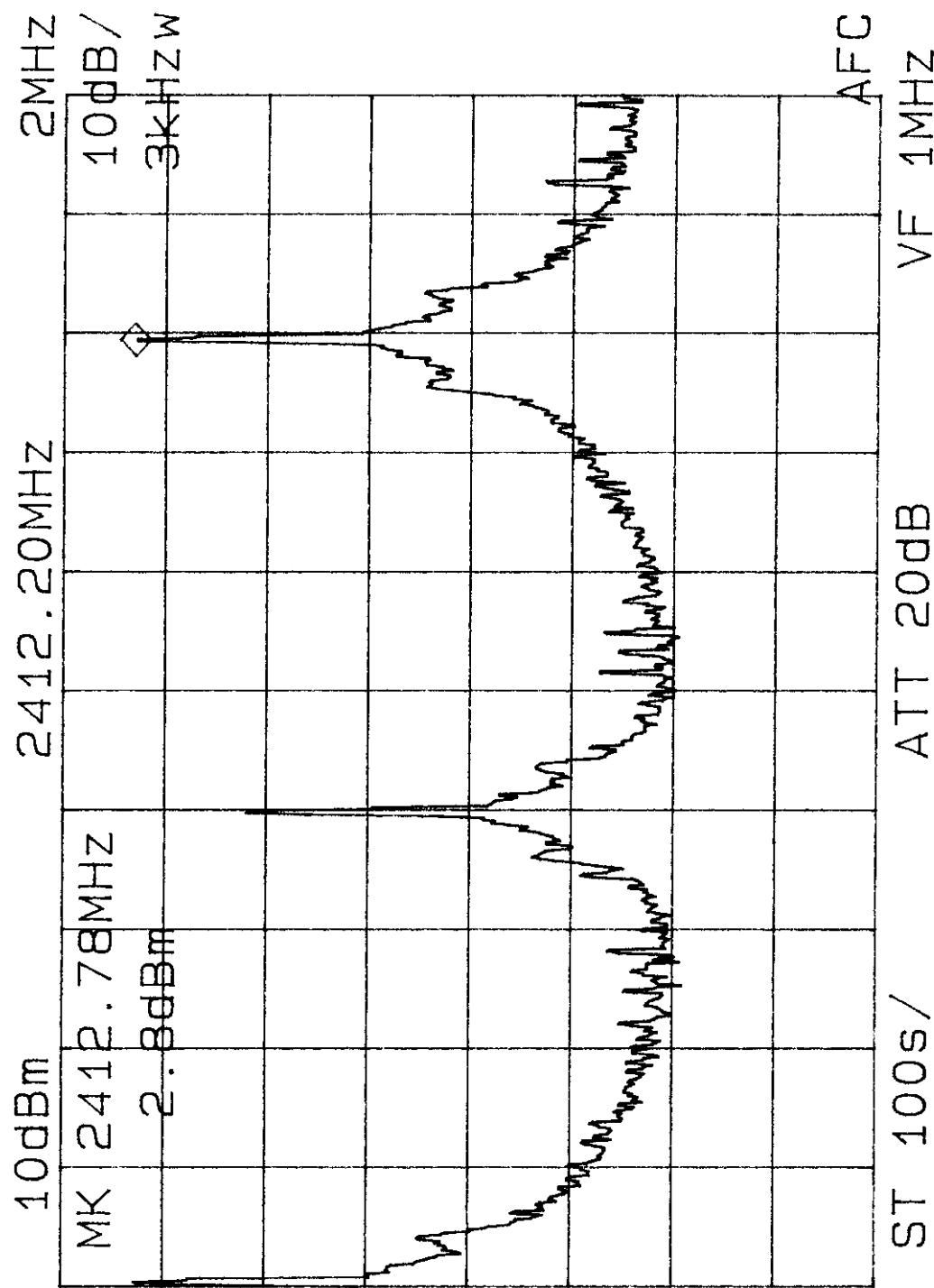
SEE FOLLOWING 2 PLOTS

SPECTRAL POWER DENSITY MEASUREMENT OF SPREADING SIGNAL OUTPUT

MODULATED

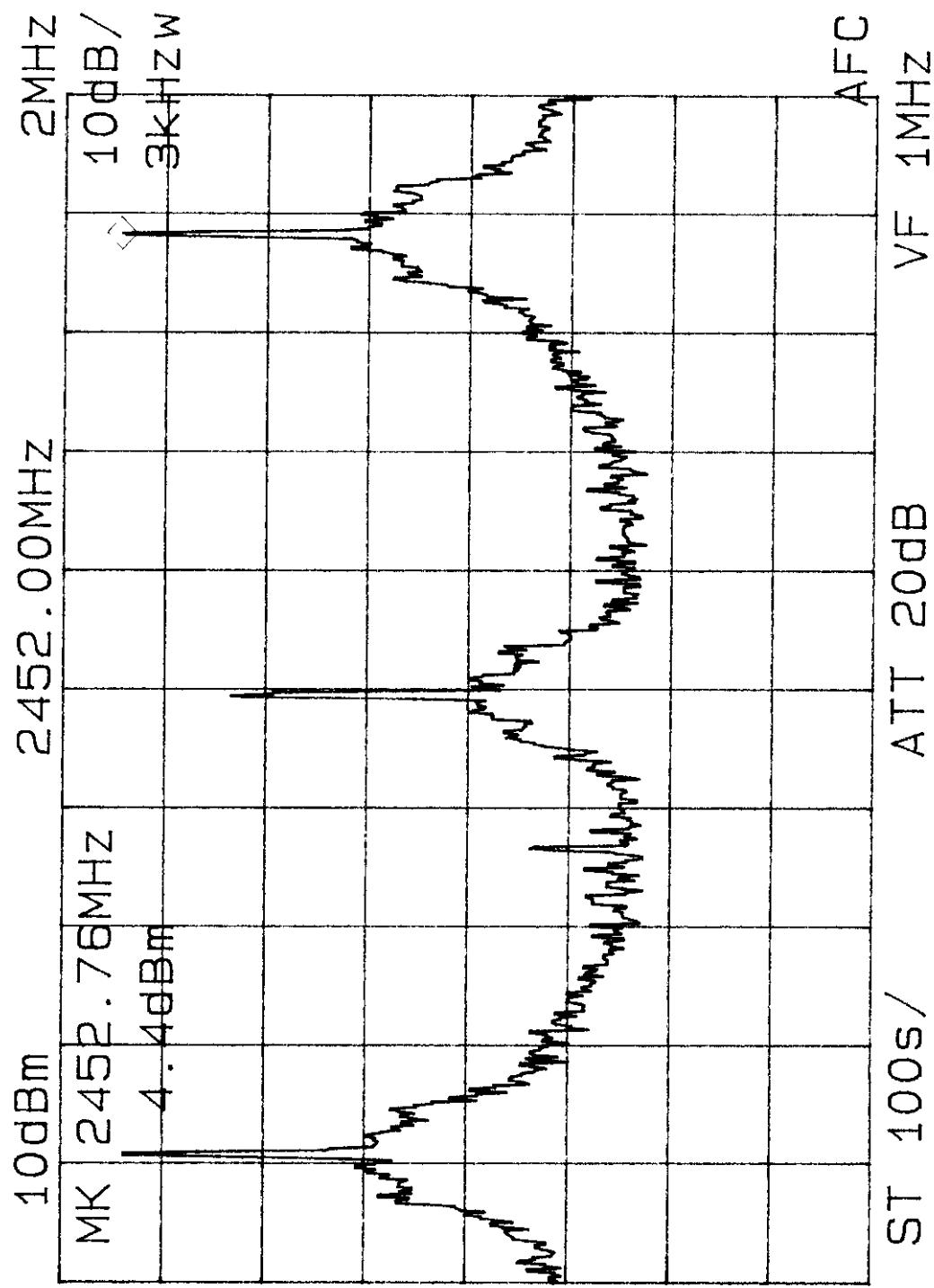
2.0 MHZ SPAN

3.0 KHZ RES. BW



SPECTRAL POWER DENSITY MEASUREMENT OF SPREADING SIGNAL OUTPUT

MODULATED      2.0 MHZ SPAN      3.0 KHZ RES. BW



## 6 dB Channel Bandwidth

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

Readings from spectrum analyzer:

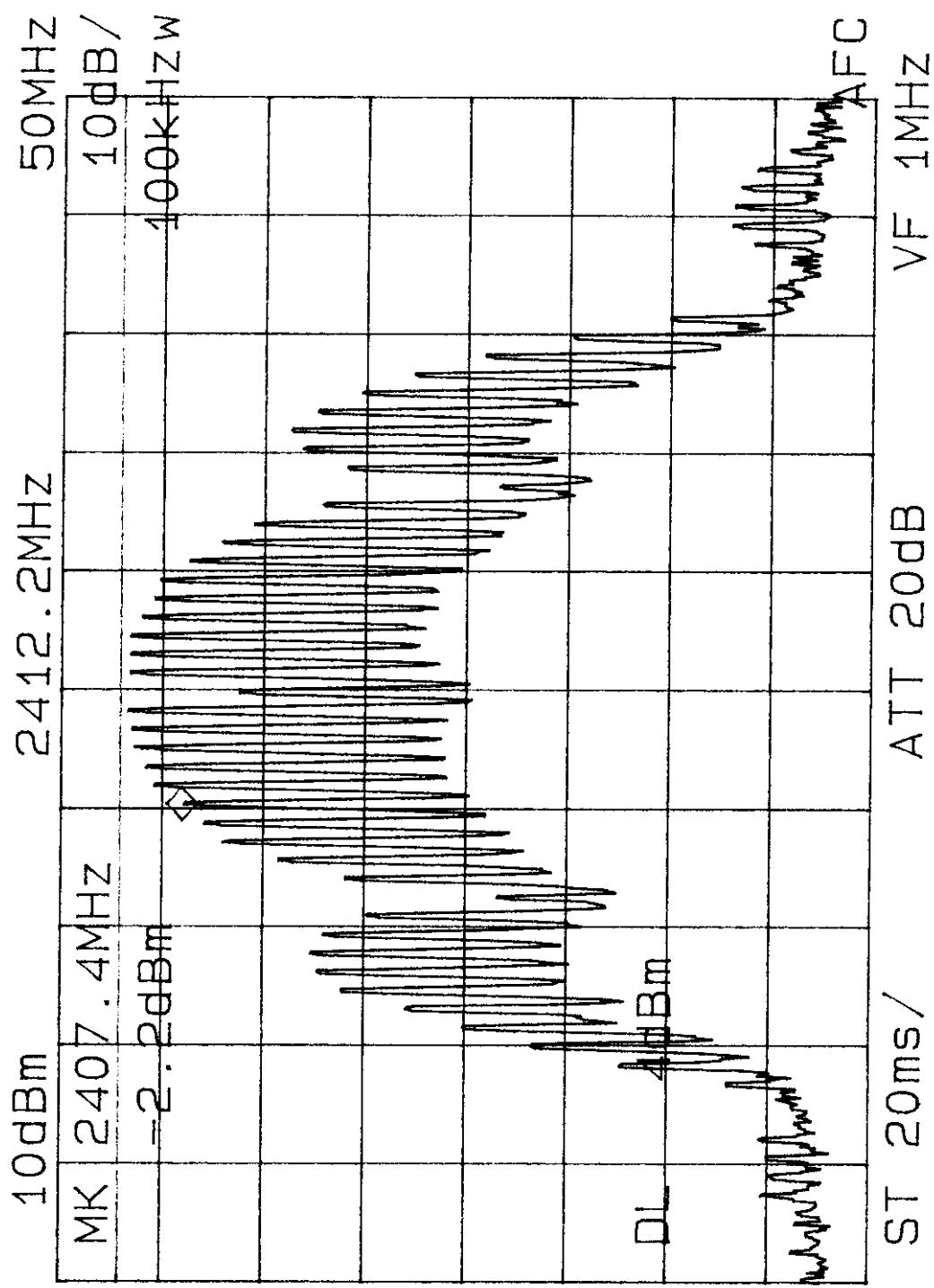
2412 MHz - 9.6 MHz

2452 MHz - 11.0 MHz

SEE FOLLOWING 2 PLOTS

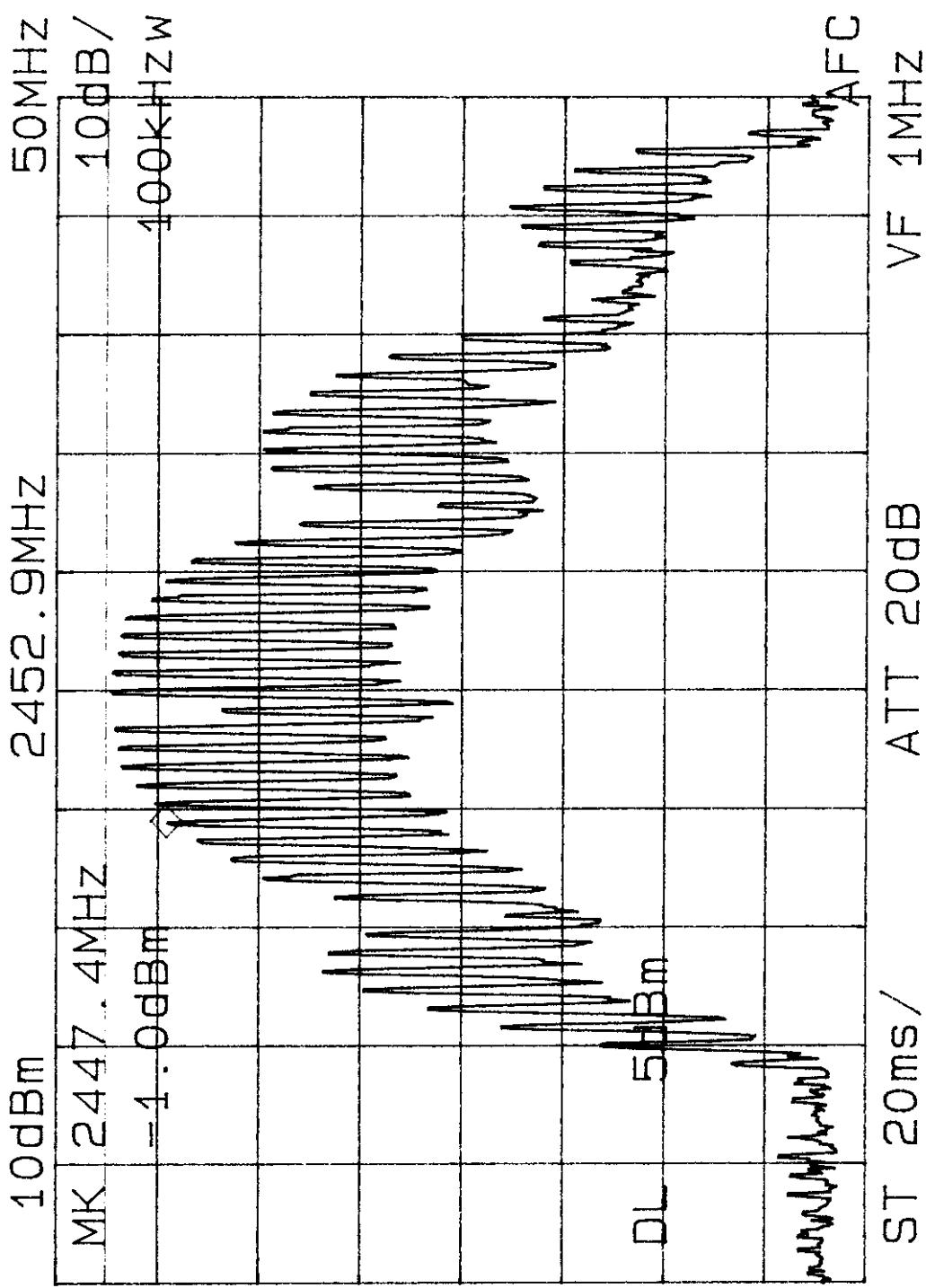
6 DB BANDWIDTH MEASUREMENT OF SPREADING SIGNAL OUTPUT

MODULATED 50 MHZ SPAN 100 KHZ RES. BW



6 DB BANDWIDTH MEASUREMENT OF SPREADING SIGNAL OUTPUT

MODULATED 50 MHZ SPAN 100 KHZ RES. BW



## **RF ANTENNA CONDUCTED SPURIOUS/HARMONICS EMISSIONS**

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

SEE FOLLOWING 2 PLOTS & DATA TABLES

## FCC PART 15.247 - CONDUCTED SPURIOUS EMISSIONS

Frequency of Carrier = 2412 MHz

Limit = 20 dBc

### TEST RESULTS

LIMIT: -20 dB FROM PEAK CARRIER

<u>COMPONENT</u>	<u>FREQUENCY (MHZ)</u>	<u>RESULT (dB FROM PEAK)</u>
SPURIOUS	1620.00	- 63
HARMONIC	4824.00	- 67
HARMONIC	7236.00	- 68
HARMONIC	9648.00	- 72
HARMONIC	12060.00	- 70
HARMONIC	14472.00	- 73
HARMONIC	16884.00	- 76
HARMONIC	19296.00	- 74
HARMONIC	21708.00	- 75
HARMONIC	24120.00	- 77

## FCC PART 15.247 - CONDUCTED SPURIOUS EMISSIONS

Frequency of Carrier = 2452 MHz

Limit = 20 dBc

### TEST RESULTS

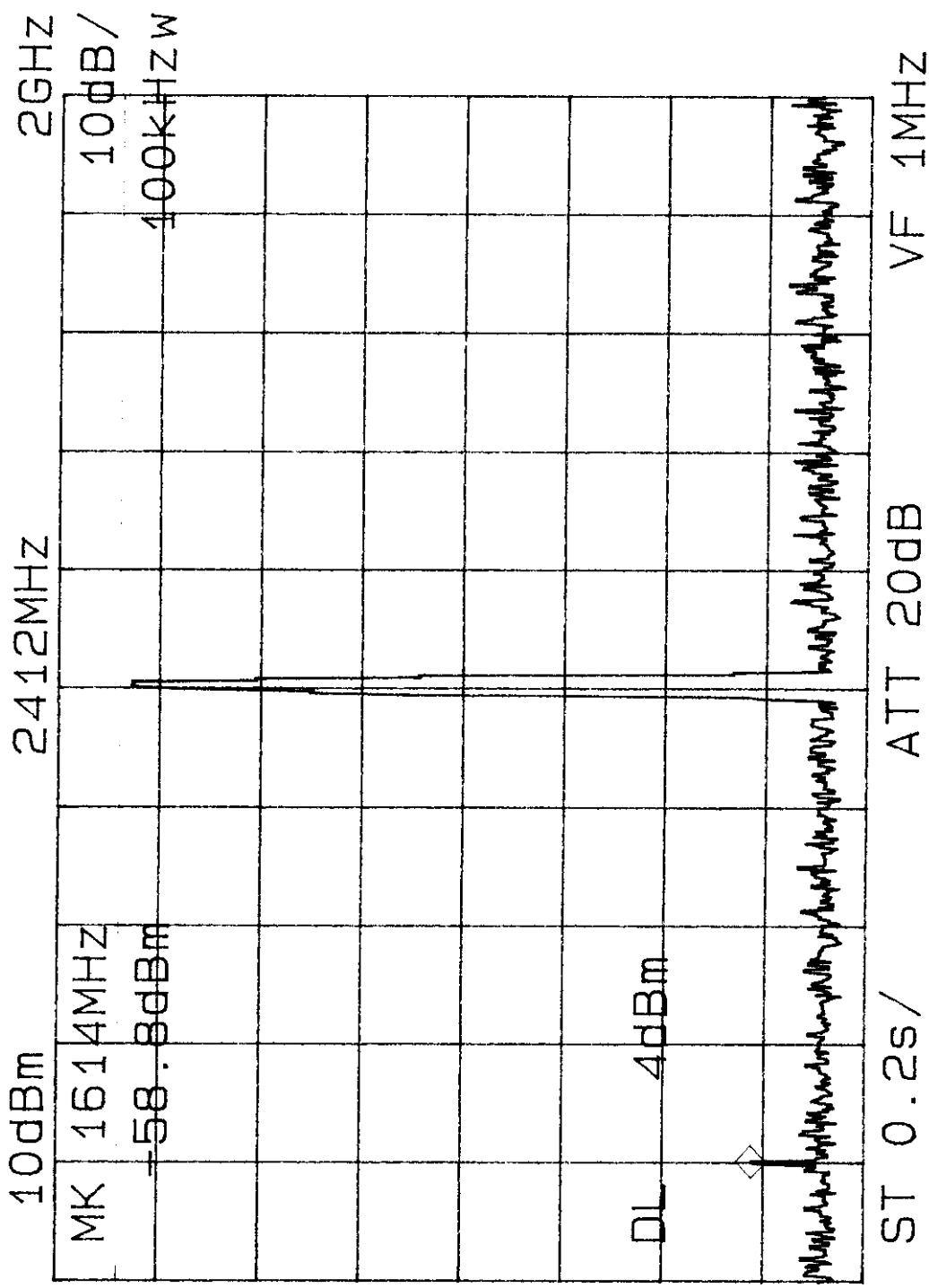
LIMIT: -20 dB FROM PEAK CARRIER

<u>COMPONENT</u>	<u>FREQUENCY (MHZ)</u>	<u>RESULT (dB FROM PEAK)</u>
SPURIOUS	1675.00	- 62
HARMONIC	4904.00	- 70
HARMONIC	7356.00	- 65
HARMONIC	9808.00	- 72
HARMONIC	12260.00	- 74
HARMONIC	14712.00	- 72
HARMONIC	17164.00	- 75
HARMONIC	19616.00	- 75
HARMONIC	22068.00	- 77
HARMONIC	24520.00	- 76

SPURIOUS CONDUCTED EMISSIONS MEASUREMENT OF ANTENNA TERMINAL OUTPUT

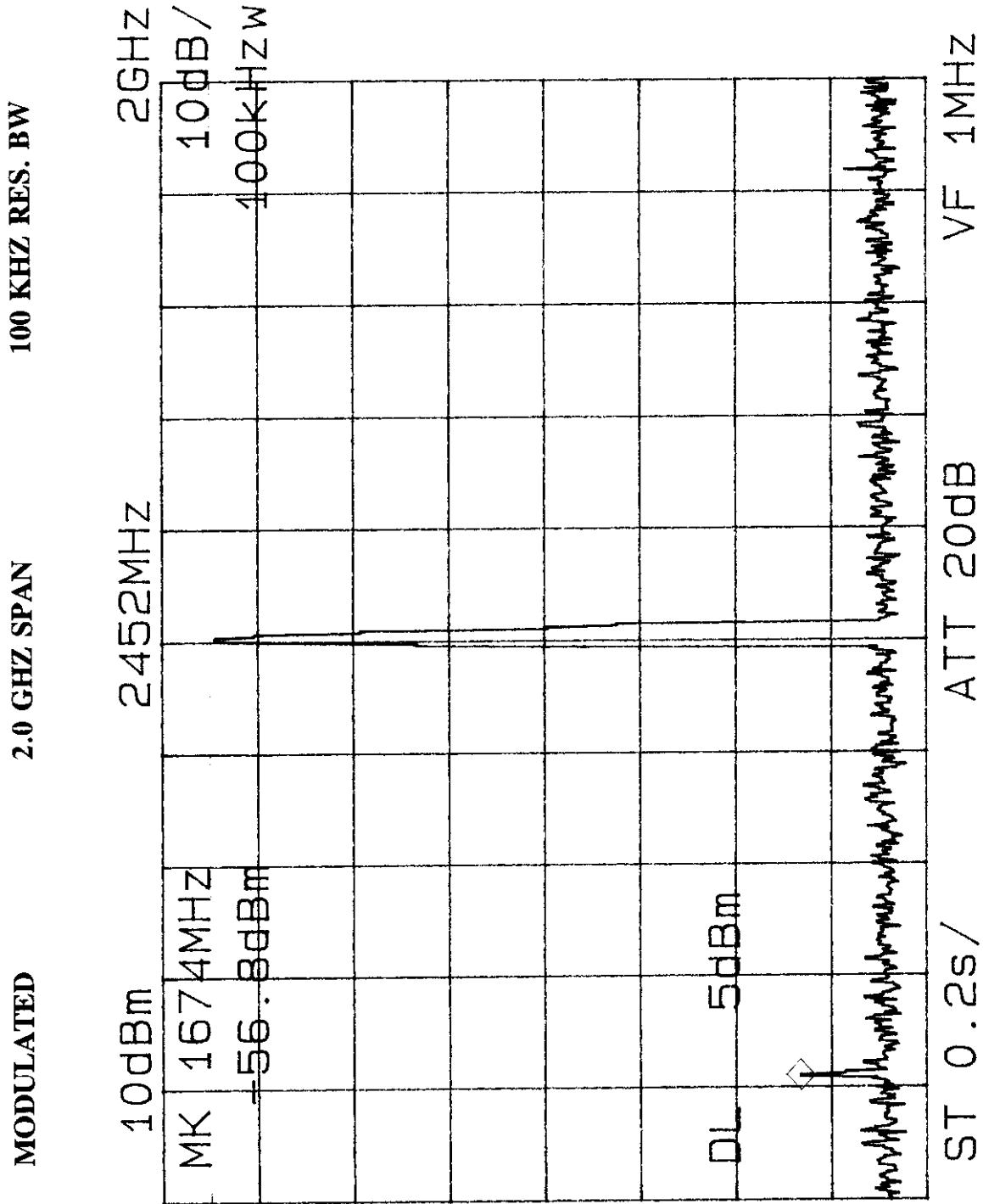
MODULATED                    2.0 GHZ SPAN

100 KHZ RES. BW



SPURIOUS CONDUCTED EMISSIONS MEASUREMENT OF ANTENNA TERMINAL OUTPUT

MODULATED 2.0 GHZ SPAN

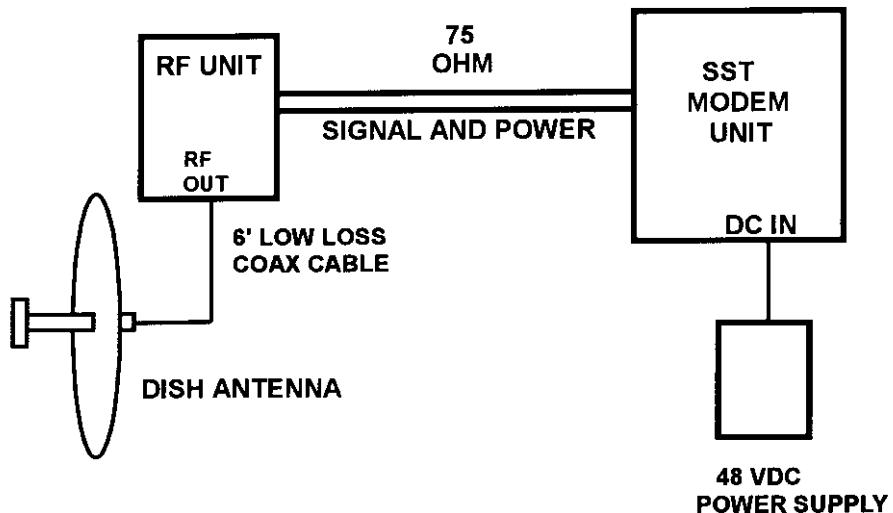


## 4.0 Test Configuration

### 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  $\Omega$ /50  $\mu$ 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  $\Omega$  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.

FCC CLASS B CONDUCTED EMISSIONS DATA

FCC ID: NK4-202333WAVE

CLIENT: IO WAVE, INC.

EUT: IO LINK 1.5 TX

CARRIER: 2452 MHZ

LINE 1 - NEUTRAL

FREQ MHz	VOLTAGE dBuV	VOLTAGE uV	FCC LIMI uV	MARGIN dB
2.9	41.2	114.8	250	-6.8
4.2	45.4	186.2	250	-2.6
5.1	41.1	113.5	250	-6.9
18.4	42.3	130.3	250	-5.7
18.4	42.4	131.8	250	-5.6

LINE 2 - PHASE

FREQ MHz	VOLTAGE dBuV	VOLTAGE uV	FCC LIMI uV	MARGIN dB
2.1	44	158.5	250	-4
5.2	38.6	85.1	250	-9.4
17.1	39.6	95.5	250	-8.4
18.4	42.4	131.8	250	-5.6
19.7	43.1	142.9	250	-4.9

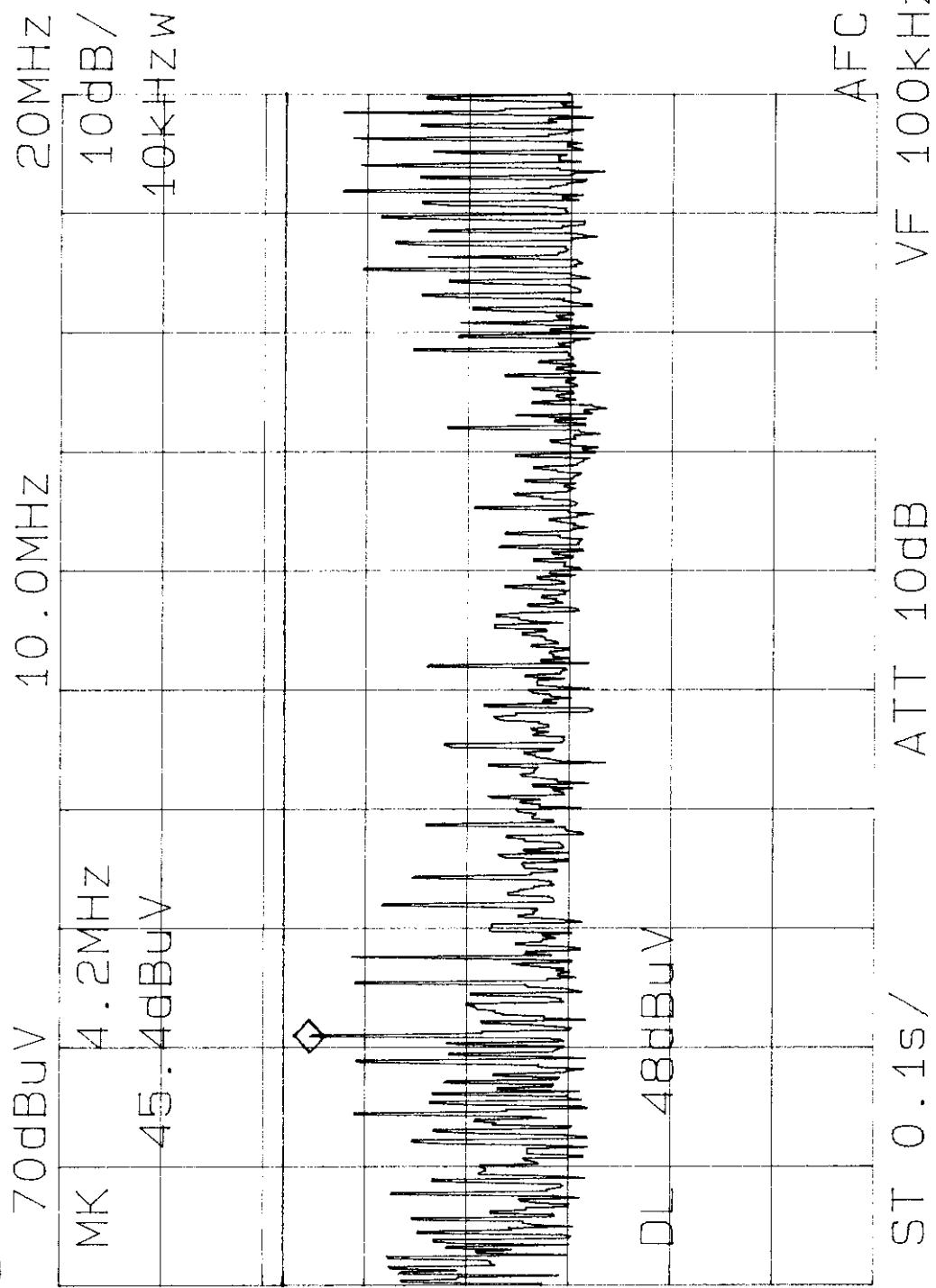
TEST ENGINEER

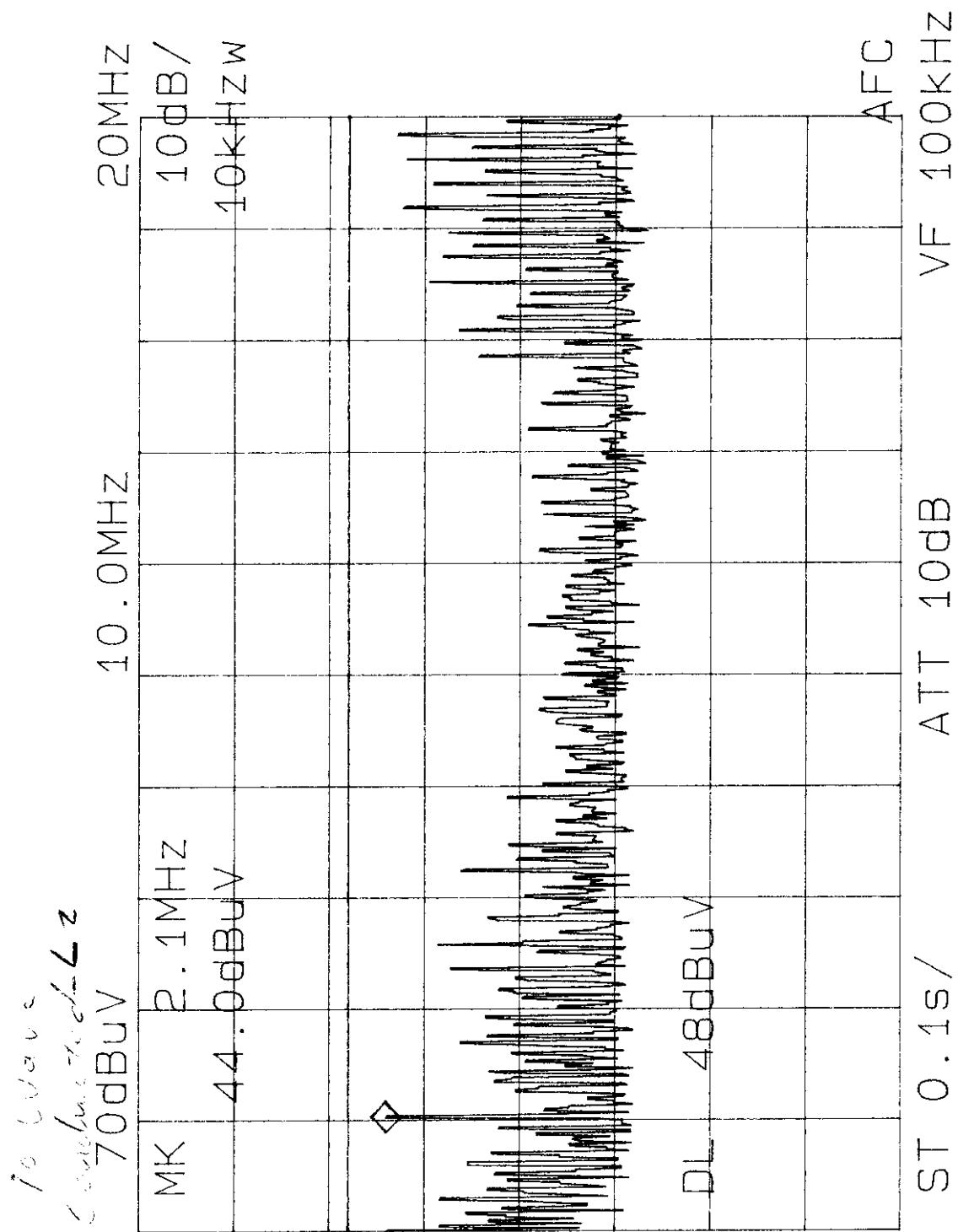
  
STEVE DAYHOFF

DATE 

Conductance

Conductance - 4'





## 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 - 23.000 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-23 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 $\mu$ V to obtain the Radiated Electric Field in dB $\mu$ V/m. This level is then compared with the FCC limit.

### Example:

Spectrum Analyzer Volt: VdB $\mu$ V

Composite Factor: AF/CLdB/m

Electric Field: EdB $\mu$ V/m = VdB $\mu$ V + AF/CLdB/m  
Linear Conversion: EuV/m = Antilog (EdB $\mu$ V/m/20)

## FCC 15.209 RADIATED EMISSIONS DATA

FCC ID: NK4-202333WAVE

CLIENT: IO WAVE, INC.

EUT: IO LINK 1.5 TX

CARRIER: 2412 MHZ

AVRG						AVRG		
FREQ MHz	POL H/V	SPEC A dBuV	AF/C dB/m	PREAMP GAIN	E-FIELD dBuV/m	E-FIELD uV/m	LIMIT uV/m	MRG dB
4824.00	V	32.0	37.0	-25	44.0	158.5	500.0	-10.0
7236.00	V	25.0	39.0	-25	39.0	89.1	500.0	-15.0
12060.00	H	23.0	42.0	-25	40.0	100.0	500.0	-14.0
14472.00	H	19.0	44.0	-25	38.0	79.4	500.0	-16.0
19296.00	V	23.0	36.0	-25	34.0	50.1	500.0	-20.0

TEST ENGINEER

SD DATE 7/1/02  
 STEVE DAYHOFF

## FCC 15.209 RADIATED EMISSIONS DATA

FCC ID: NK4-202333WAVE

CLIENT: IO WAVE, INC.

EUT: IO LINK 1.5 TX

CARRIER: 2452 MHZ

AVRG					AVRG			
FREQ MHz	POL H/V	SPEC A dBuV	AF/CL dB/m	PREAMP GAIN	E-FIELD dBuV/m	E-FIELD uV/m	LIMIT uV/m	MRG dB
2342.00	V	43.0	29.0	-25	47.0	223.9	500.0	-7.0
4904.00	V	36.0	37.0	-25	48.0	251.2	500.0	-6.0
7356.00	V	27.0	39.0	-25	41.0	112.2	500.0	-13.0
12260.00	H	25.0	42.0	-25	42.0	125.9	500.0	-12.0
19616.00	V	32.0	36.0	-25	43.0	141.3	500.0	-11.0
22068.00	H	27.0	37.0	-25	39.0	89.1	500.0	-15.0

TEST ENGINEER

SD DATE 7/5/98  
 STEVE DAYHOFF

**Table 1**  
**Support Equipment**

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Parabolic Dish Antenna - Comsat Model P-24A24N-1 (2.3-2.5 GHz)  
- S/N: 224576

48 VDC Power Supply - Tenma Variable Supply Model TS-70

**Table 2**  
**Interface Cables Used**

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75 ohm coaxial cable is used to connect the indoor modem unit to the outside RF transmitter unit.

A 6 foot low loss Belden coaxial cable is used to connect the RF output of the transmitter to the parabolic dish antenna.

**Table 3**  
**Measurement Equipment Used**

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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.)	