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: NK4-2023336988

October 14, 1998

TABLE OF CONTENTS

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 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** 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

2412 to 2452 MHz Freq. Range

20 MHz Channel Bandwidth

2-Channels Duplex Operation

DQPSK6-SS Modulation

1.544 MB/s Data Rate (T1)

Technical Documentation for *ioLink 1.5* :

2.0 General Specifications

2.1 Electrical

2.1.1 Transmitter

Output Power	25 dBm
Channel Bandwidth	20 MHz
IF Frequency	110 MHz, 70MHz (production)
Frequency Selection	2412MHz and 2452 MHz
Modulation	
Spreading Method	Direct Sequence Spread Spectrum
Code Length	10
Number of Stored Codes	TBD
Clock Source	External

2.1.2 Receiver

Receive Level	-30 dBm to -91 dBm
Max Receive Level	0 dBm
Receive Sensitivity At RF Unit Input	-91 dBm
IF Frequency	70 MHz
Processing Gain	10dB
Interfaces	DSK, G.703
Data Rates	1.544→2.048Mbps before FEC
Line Codes	B8ZS, AMI
Line Build-Out	0→655 Feet

2.2 User Interface

Interfaces	ASYNC Console Mode & IP
Data rates	300 - 19.2k baud
Line Codes	N/A
Line Build-Out	As per RS-232 Spec

2.3 Diagnostics

Front Panel	Alarm LEDs, Keypad, LCD display
Test Mode	POST (Full)
Monitor/Control	Local via keypad, Remote via RS232, Optional SNMP-compliant agent, Hot-standby switch

2.4 Connectors

2.4.1 User Data

DSX-1	RJ-48C, Female
CCITT G.703	Dual BNC, Female

2.4.2 Monitor and Control

Remote	DB-9, Female
Local	Form-C Relay

2.4.3 RF

To Antenna	Type N, Female
To Modem	Type F, Female

2.5 Power

2.5.1 AC Power

Connector	3-Prong Grounded
Voltage	Universal 85-264 VAC input

2.5.2 DC Power

Connector	None

Voltages	+5 V @ 0.8 A +12 V @ 0.15 A +24 V @ 1.0?? A -12 V @ 0.02 A converted to -5 V

2.6 Environmental

	Modem	Outdoor
Operational Temperature		
Storage		
Humidity	0-95%	0-95%

2.7 Mechanical

	Modem	Outdoor
Width	17"	12"
Height	3.47"	12"
Depth	13"	4.125"
Weight	7 lbs.?	7 lbs.?

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 21 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):

2412 MHz - +24.7 dBm

2452 MHz - +25.1 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:

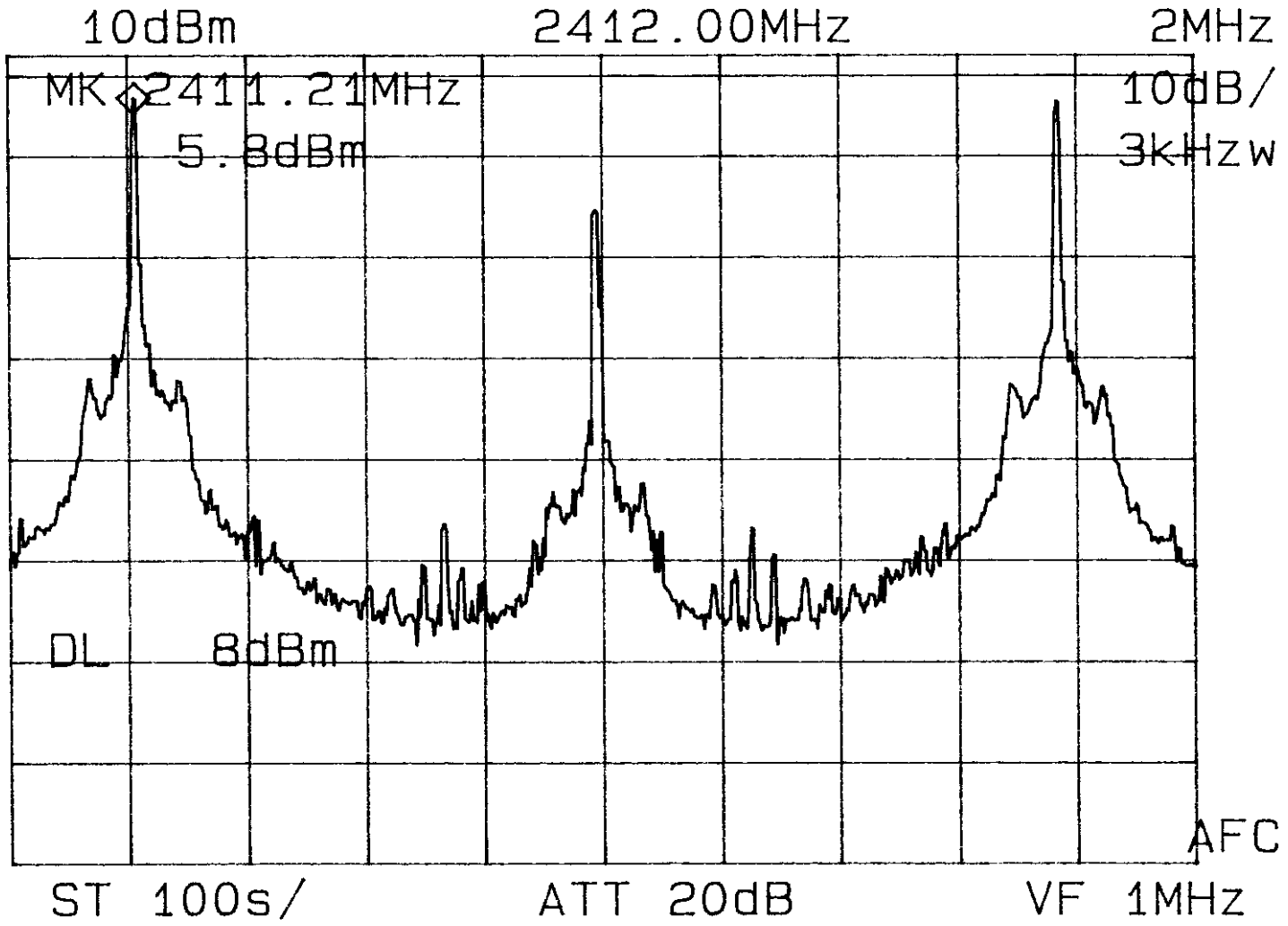
2412 MHz - +5.8 dBm

2452 MHz - +6.6 dBm

SEE FOLLOWING 2 PLOTS

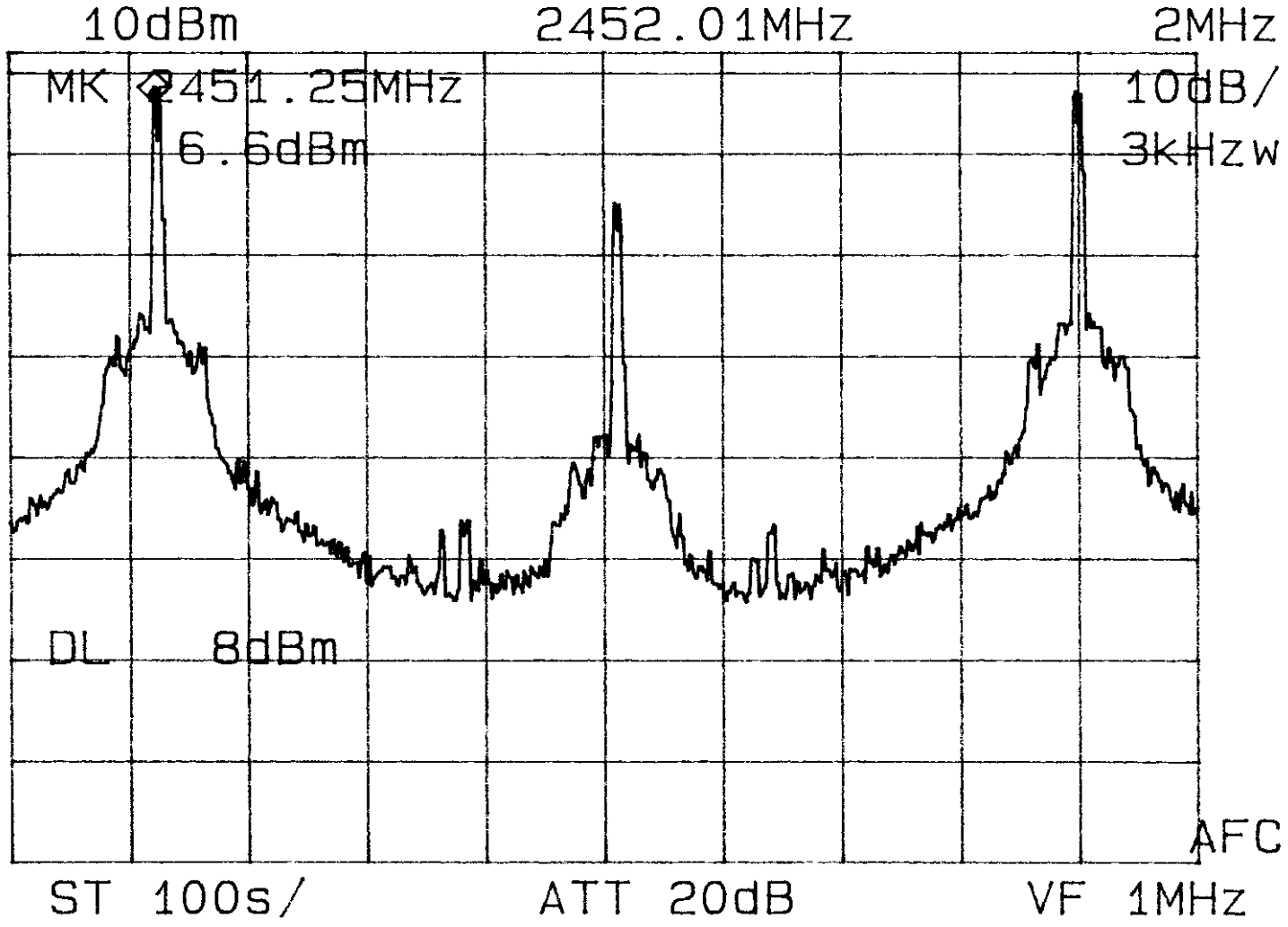
POWER SPECTRAL DENSITY - LOW CHANNEL

MODULATED **2.0 MHZ SPAN** **3.0 KHZ RES. BW**



POWER SPECTRAL DENSITY - HIGH CHANNEL

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:

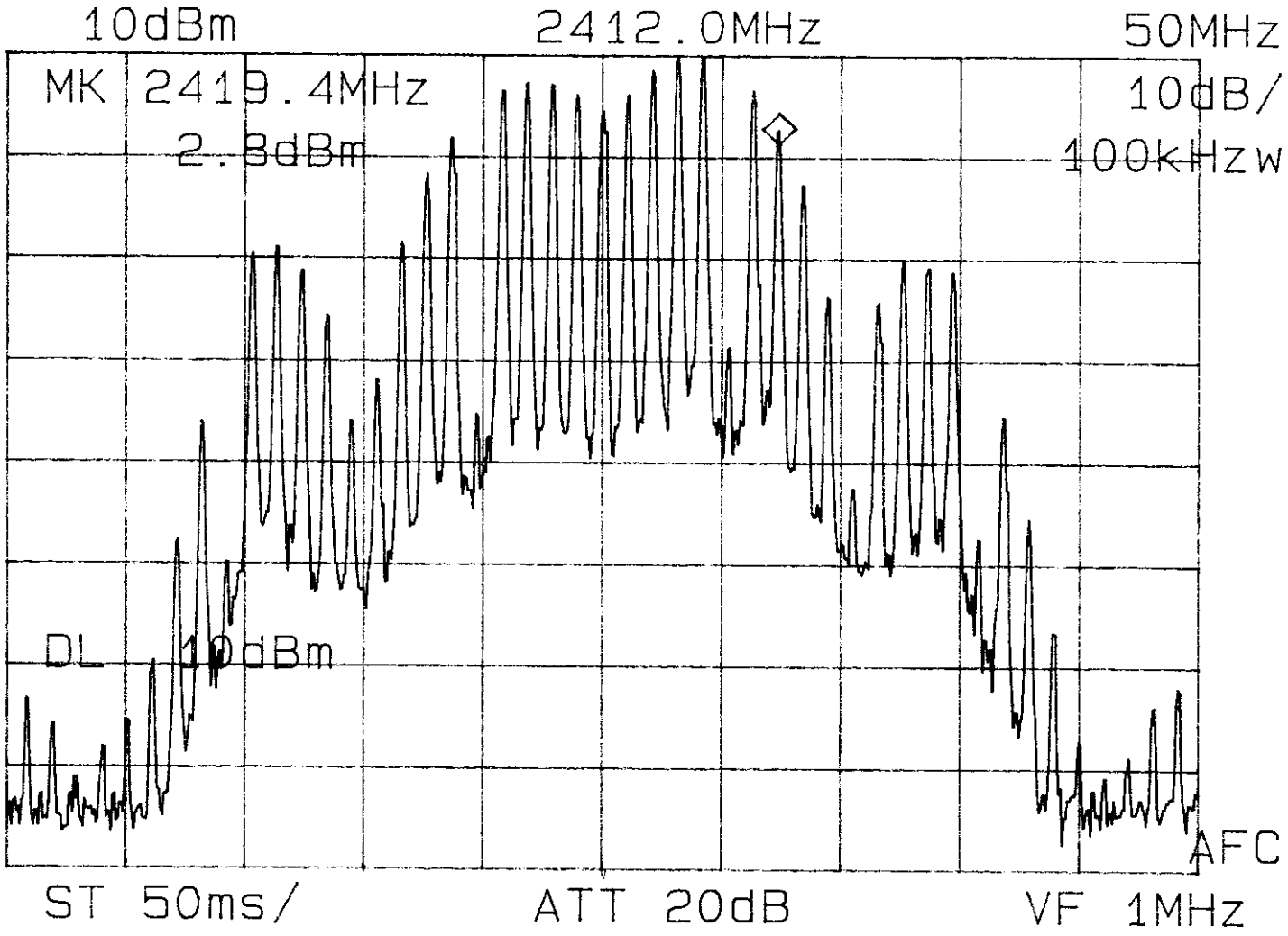
2412 MHz - 14.8 MHz

2452 MHz - 15.2 MHz

SEE FOLLOWING 2 PLOTS

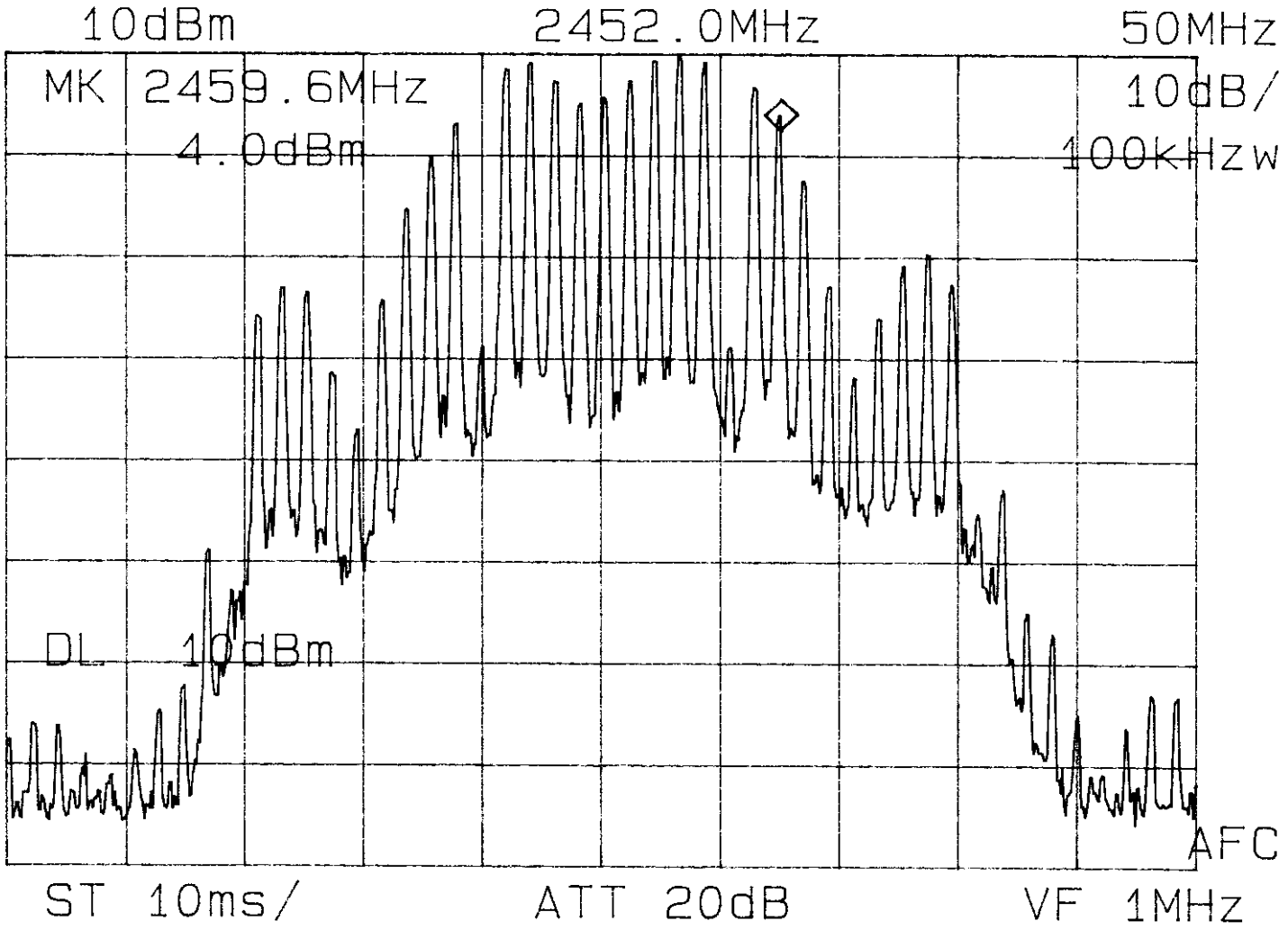
6 dB BANDWIDTH - LOW CHANNEL

MODULATED **50 MHZ SPAN** **100 KHZ RES. BW**



6 dB BANDWIDTH - HIGH CHANNEL

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

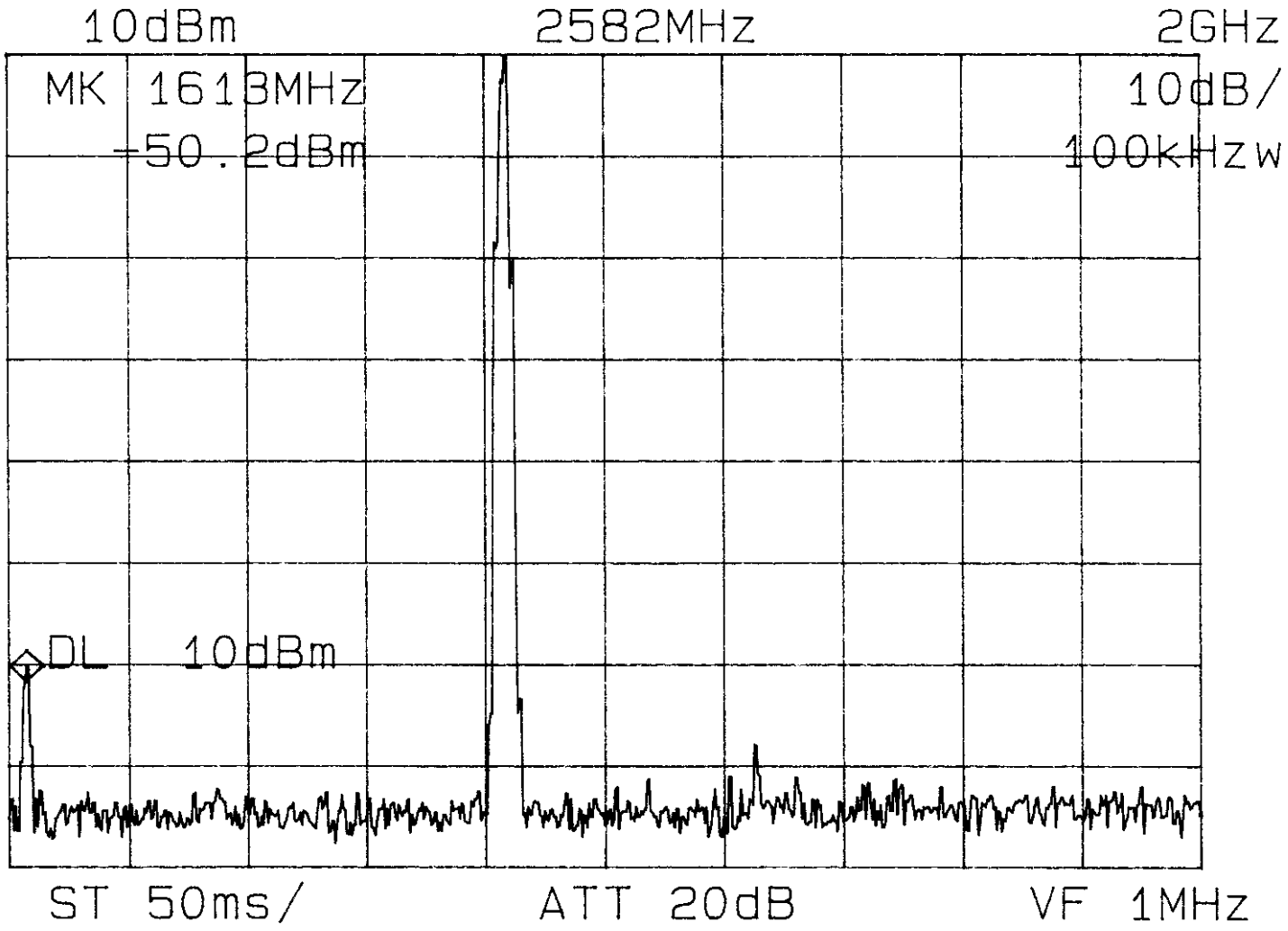
TEST RESULTS

LIMIT: -20 dB FROM PEAK CARRIER

COMPONENT	FREQUENCY (MHZ)	RESULT (dB FROM PEAK)
SPURIOUS	1620.00	- 60
HARMONIC	4824.00	- 66
HARMONIC	7236.00	- 65
HARMONIC	9648.00	- 66
HARMONIC	12060.00	- 69
HARMONIC	14472.00	- 68
HARMONIC	16844.00	- 71
HARMONIC	19296.00	- 77
HARMONIC	21708.00	- 77
HARMONIC	24120.00	- 77

CONDUCTED SPURIOUS OUTPUT - LOW CHANNEL

MODULATED **2.0 GHZ SPAN** **100 KHZ RES. BW**



FCC PART 15.247 - CONDUCTED SPURIOUS EMISSIONS

Frequency of Carrier = 2452 MHz
Limit = 20 dBc

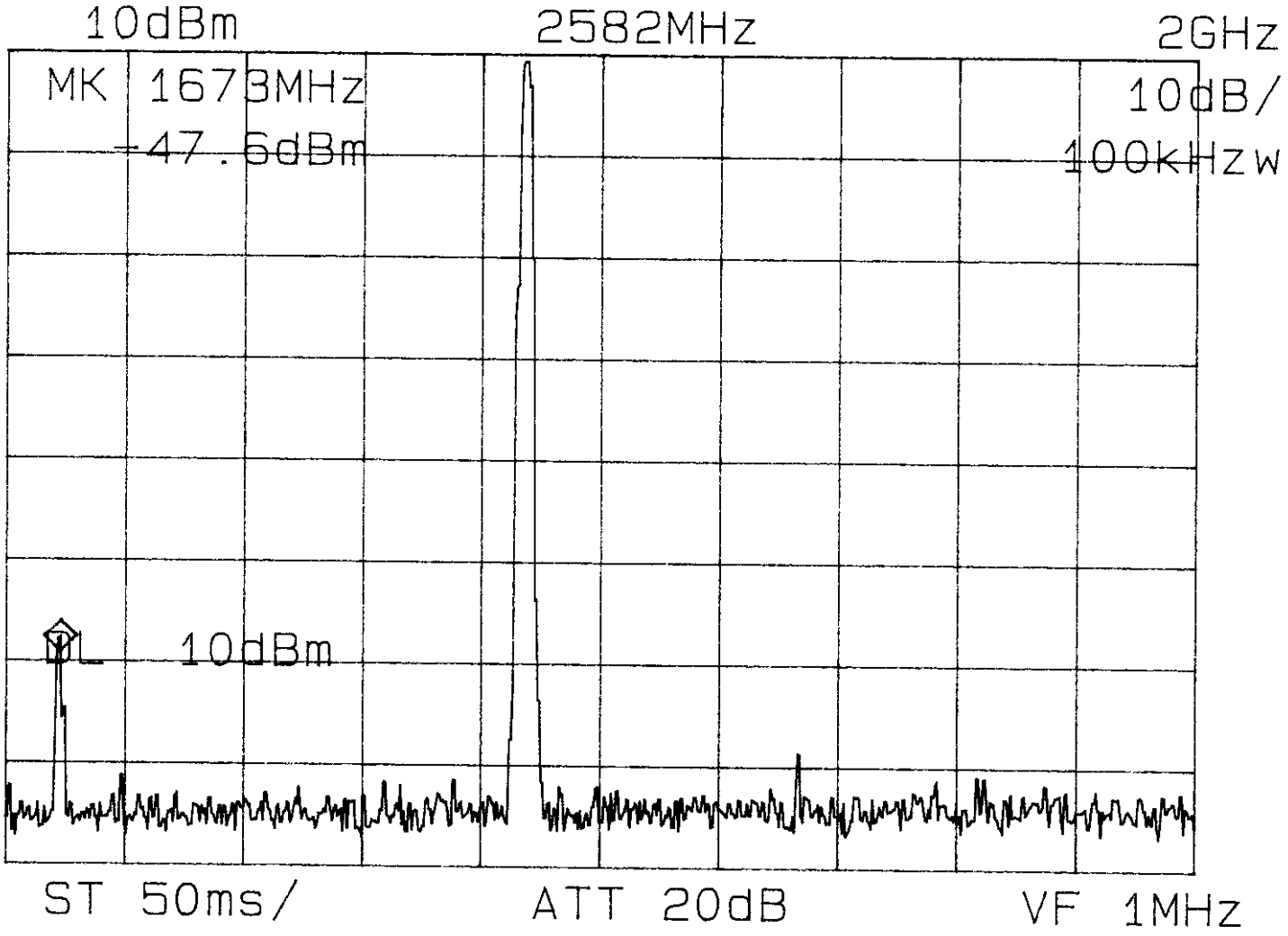
TEST RESULTS

LIMIT: -20 dB FROM PEAK CARRIER

COMPONENT	FREQUENCY (MHZ)	RESULT (dB FROM PEAK)
SPURIOUS	1675.00	- 58
HARMONIC	4904.00	- 66
HARMONIC	7356.00	- 65
HARMONIC	9808.00	- 70
HARMONIC	12260.00	- 69
HARMONIC	14712.00	- 68
HARMONIC	17164.00	- 73
HARMONIC	19616.00	- 77
HARMONIC	22068.00	- 77
HARMONIC	24520.00	- 77

CONDUCTED SPURIOUS OUTPUT - HIGH CHANNEL

MODULATED **2.0 GHZ SPAN** **100 KHZ RES. BW**

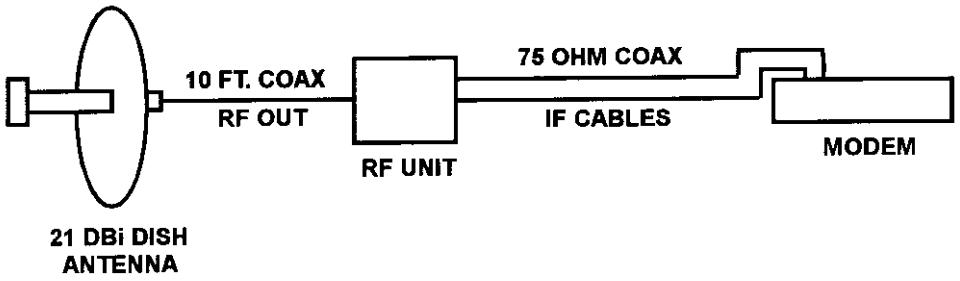


4.0 Test Configuration

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: NK4-2023336988

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
0.812	43.8	154.9	250	-4.2
10.7	42.4	131.8	250	-5.6
16.7	41.1	113.5	250	-6.9
18.4	45.8	195.0	250	-2.2
20	44.8	173.8	250	-3.2

LINE 2 - PHASE

FREQ MHz	VOLTAGE dBuV	VOLTAGE uV	FCC LIMI uV	MARGIN dB
0.503	42.6	134.9	250	-5.4
6.2	39.6	95.5	250	-8.4
7.2	37.4	74.1	250	-10.6
10.8	38.6	85.1	250	-9.4
13.5	37.8	77.6	250	-10.2

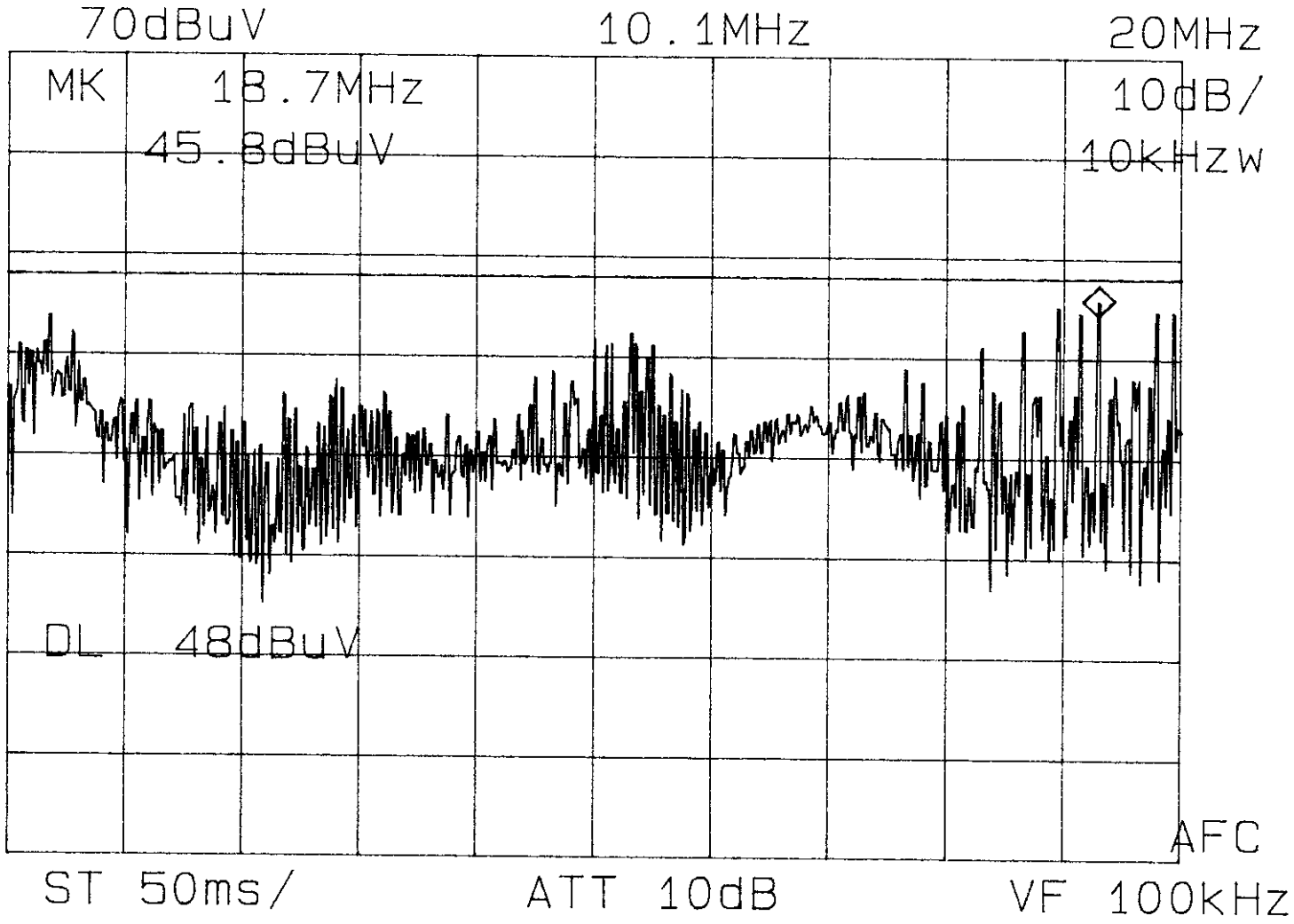
TEST ENGINEER

_____ DATE _____

STEVE DAYHOFF

A.C. LINE-CONDUCTED EMISSIONS - L1

MODULATED **20 MHZ SPAN** **10 KHZ RES. BW**



Processing Gain Measurement
Using CW Jamming Margin

Introduction

Part 15.247(e) of the FCC rules and regulations specifies a test procedure for processing gain which consists of comparison of measurements on the Direct Sequence Spread Spectrum (DSSS) receiver under test to the theoretical performance of a non-spread spectrum (narrowband) receiver for the same kind of modulation.

Processing Gain Measurement

The Stanford Telecommunications Z2000 spread spectrum chip utilized in the ioWave ioLink 1.5 Modem uses Differential Quadrature Phase Shift Keying (DQPSK). Narrowband DQPSK receiver at 12.5 dB Energy/Bit gives 2×10^{-6} BER [1]. However Energy/Bit may be converted to signal to noise ratio using a correction factor as follows[2]

$$\frac{S}{N} = \frac{E_b}{N_o} \times \frac{R}{W}$$

where, (W/R)=1/2 for QPSK. Thus, SNR=15.5 dB for theoretical DQPSK narrowband system that gives 2×10^{-6} BER.

Processing gain is measured using the CW jamming margin method. Figure 1 shows the test configuration. The equipment used for this test are listed in table 1. The test consists of stepping a signal generator in 50 KHz increment across the passband of the system with the transmit carrier frequency of **2.45** GHz. At each point, the generator level required to produce the recommended bit error rate (2×10^{-6}) is recorded. This level is the jammer level. The output power of the transmitting unit is measured at the same point. The jammer to signal (J/S) ratio is then calculated. Having the theoretical and measured value at hand, the processing gain (G_p) will be calculated using the following formula given by part 15.247(e);

$$G_p = (S/N)_o + M_j + L_{sys}$$

where

$(S/N)_o$= Signal to noise ratio
M_j= J/S ratio, and
L_{sys}= System Losses.

The processing gain was evaluated using the above formula with L_{sys} of 1.0 dB.

Example and Conclusion:

At CW jammer frequency of **2452.700** MHz, the jammer power at the output of the splitter is -7.9 dBm and the signal power is -2.5 dBm. This gives a signal to jammer (S/J) ratio of 5.4 dB. Using the given processing gain formula with the measured (S/J)=5.4 dB, theoretical narrowband required signal to noise ratio $(S/N)_o$=15.5 dB, and system losses L_{sys}=1.0 dB will yield a processing gain of 10.1 dB (11.1 dB, including 1.0dB system

losses). Using this measurement and calculation, any processing gain found to be greater than 10 dB is considered a pass; otherwise it is not a pass.

The processing gain at other CW jammer frequencies with 50 KHz apart across the passband was measured. The results are presented in the data sheets attached to the end of this document. Sixty one measurements appear in the data sheets. Twenty percent of the data points which is twelve points were discarded. Eight of these twelve are the points with BER larger than $2x10^{-6}$. The other four are the four worst processing gain measurements. **The lowest processing gain of the remaining 80% of the measurements was 10.3 dB. This processing gain is larger than 10 dB minimum requirements.**

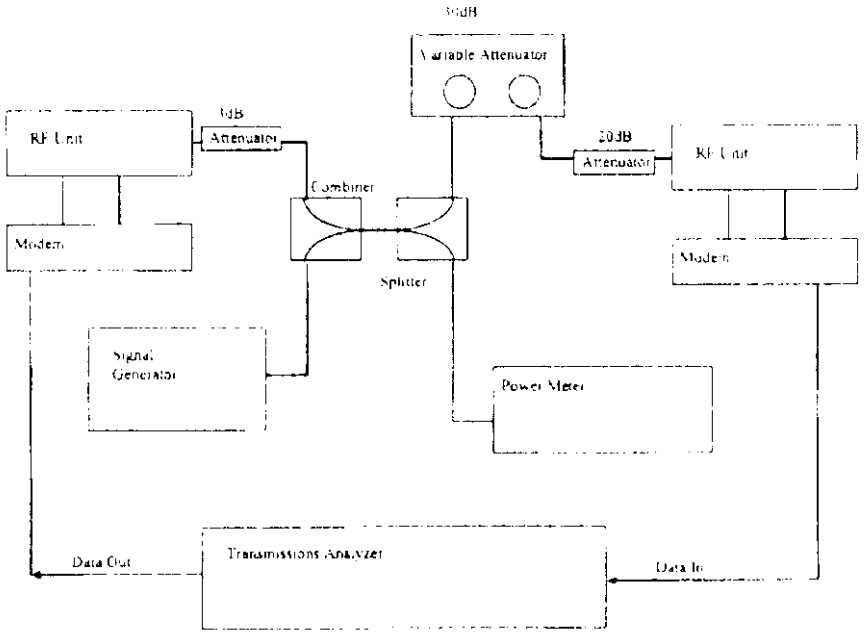


Figure_1

Signal Generator	Rohde and Schwarz, signal generator, 5KHz-3.0GHz SME03
Power Meter	Hewlett packard, 435B power meter
Transmission Analyzer	phoenix Microsystems, model 5575A, T1 micro bert
variable Attenuator	Pasternack PE7033
power Splitter/Combiner	Mini-Circuit, 15542, ZAPD-4, 9630
Fixed Attenuator	Hewlett Packard 8491, 3dB, 10dB

Table-1

Reference

[1]- Proakis, John "Digital Communications" 1989, page 272, figure 4.20.2

[2]- Dixon, Robert "Spread Spectrum Systems" 3rd ed. 1994, page 350, John Wiley & Sons, 1994

SORTED BY PG

50KHz apart Jammer Freq.	DSSS Signal at Splitter out	Jammer at Splitter out		PG, not including Lsys, Relative to NB DQPSK 15.5	PG, including Lsys, Relative to NB DQPSK dB	PG + Lsys >=10 Lsys	1
MHz	dBm	dBm	S/J	dB	PG	BER 10-6	STATUS
2451.550	-2.6	-8.4	5.8	9.7	10.7	2.2	DISCARD
2452.000	-2.5	-6.7	4.2	11.3	12.3	3.0	DISCARD
2452.050	-2.5	-5.9	3.4	12.1	13.1	2.1	DISCARD
2452.200	-2.5	-6.7	4.2	11.3	12.3	2.3	DISCARD
2452.250	-2.5	-7.1	4.6	10.9	11.9	2.6	DISCARD
2452.650	-2.5	-8.1	5.6	9.9	10.9	2.1	DISCARD
2452.750	-2.5	-7.6	5.1	10.4	11.4	2.1	DISCARD
2453.150	-2.5	-8.2	5.7	9.8	10.8	2.05	DISCARD
2450.650	-2.6	-9.0	6.4	9.1	10.1	1.6	DISCARD
2450.700	-2.6	-8.9	6.3	9.2	10.2	1.15	DISCARD
2452.500	-2.5	-8.8	6.3	9.2	10.2	1.43	DISCARD
2452.550	-2.5	-8.8	6.3	9.2	10.2	1.2	DISCARD
2451.400	-2.6	-8.8	6.2	9.3	10.3	1.02	RESULT
2453.200	-2.5	-8.7	6.2	9.3	10.3	1.6	
2453.250	-2.5	-8.7	6.2	9.3	10.3	1.1	
2450.750	-2.6	-8.7	6.1	9.4	10.4	1.13	
2451.450	-2.6	-8.7	6.1	9.4	10.4	1.4	
2452.600	-2.5	-8.6	6.1	9.4	10.4	1.65	
2450.600	-2.6	-8.6	6.0	9.5	10.5	1.33	
2451.350	-2.6	-8.6	6.0	9.5	10.5	1.5	
2451.500	-2.6	-8.6	6.0	9.5	10.5	1.7	
2450.550	-2.6	-8.5	5.9	9.6	10.6	1.6	
2451.300	-2.6	-8.5	5.9	9.6	10.6	1.6	
2452.400	-2.5	-8.4	5.9	9.6	10.6	1.4	
2452.450	-2.5	-8.4	5.9	9.6	10.6	1.8	
2453.300	-2.5	-8.4	5.9	9.6	10.6	1.5	
2450.950	-2.6	-8.4	5.8	9.7	10.7	1.08	
2452.350	-2.5	-8.3	5.8	9.7	10.7	1.01	
2453.350	-2.5	-8.3	5.8	9.7	10.7	1.7	
2453.400	-2.5	-8.3	5.8	9.7	10.7	1.3	
2450.500	-2.6	-8.3	5.7	9.8	10.8	1.6	
2450.800	-2.6	-8.3	5.7	9.8	10.8	1.5	
2453.450	-2.5	-8.2	5.7	9.8	10.8	1.05	
2450.850	-2.6	-8.2	5.6	9.9	10.9	1.28	
2450.900	-2.6	-8.2	5.6	9.9	10.9	1.3	
2451.250	-2.6	-8.2	5.6	9.9	10.9	1.1	
2451.600	-2.6	-8.2	5.6	9.9	10.9	1.1	
2453.100	-2.5	-8.0	5.5	10.0	11.0	1.1	
2451.000	-2.6	-8.0	5.4	10.1	11.1	1.2	
2452.700	-2.5	-7.9	5.4	10.1	11.1	1.6	
2451.050	-2.6	-7.9	5.3	10.2	11.2	1.06	
2452.300	-2.5	-7.8	5.3	10.2	11.2	1.9	
2453.050	-2.5	-7.8	5.3	10.2	11.2	1.14	

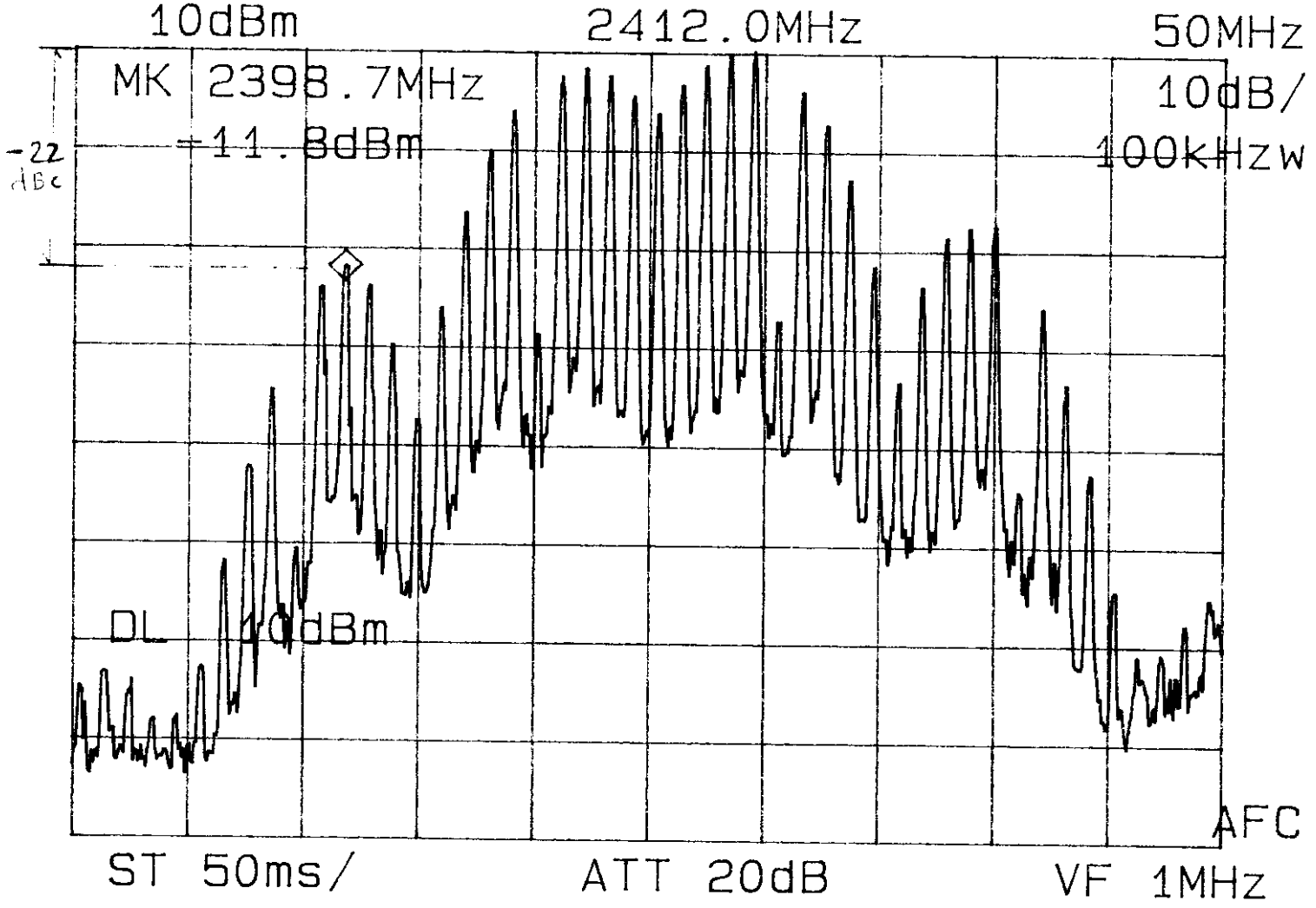
SORTED BY PG

50KHz apart Jammer Freq.	DSSS Signal at Splitter out	Jammer at Splitter out		PG not including Lsys, Relative to NB DQPSK 15.5	PG including Lsys, Relative to NB DQPSK	PG + Lsys >=10 Lsys	1
MHz	dBm	dBm	S/J	dB	PG	BER 10-6	STATUS
2453.500	-2.5	-7.8	5.3	10.2	11.2	1.02	
2451.100	-2.6	-7.7	5.2	10.3	11.3	1.2	
2451.150	-2.6	-7.8	5.2	10.3	11.3	1.1	
2451.200	-2.6	-7.8	5.2	10.3	11.3	1.25	
2453.000	-2.5	-7.7	5.2	10.3	11.3	1.1	
2452.950	-2.5	-7.4	4.9	10.6	11.6	1.8	
2451.650	-2.6	-7.4	4.8	10.7	11.7	1.6	
2452.850	-2.5	-7.2	4.7	10.8	11.8	1.5	
2452.900	-2.5	-7.2	4.7	10.8	11.8	1.3	
2452.800	-2.5	-7.1	4.6	10.9	11.9	1.6	
2451.700	-2.6	-7.1	4.5	11.0	12.0	1.5	
2451.750	-2.6	-6.9	4.3	11.2	12.2	1.04	
2451.950	-2.6	-6.6	4.0	11.5	12.5	1.8	
2451.900	-2.6	-6.5	3.9	11.6	12.6	1.1	
2451.800	-2.6	-6.3	3.7	11.8	12.8	1.01	
2452.100	-2.5	-6.2	3.7	11.8	12.8	1.9	
2452.150	-2.5	-6.2	3.7	11.8	12.8	1.1	
2451.850	-2.6	-6.2	3.6	11.9	12.9	1.6	

61 points

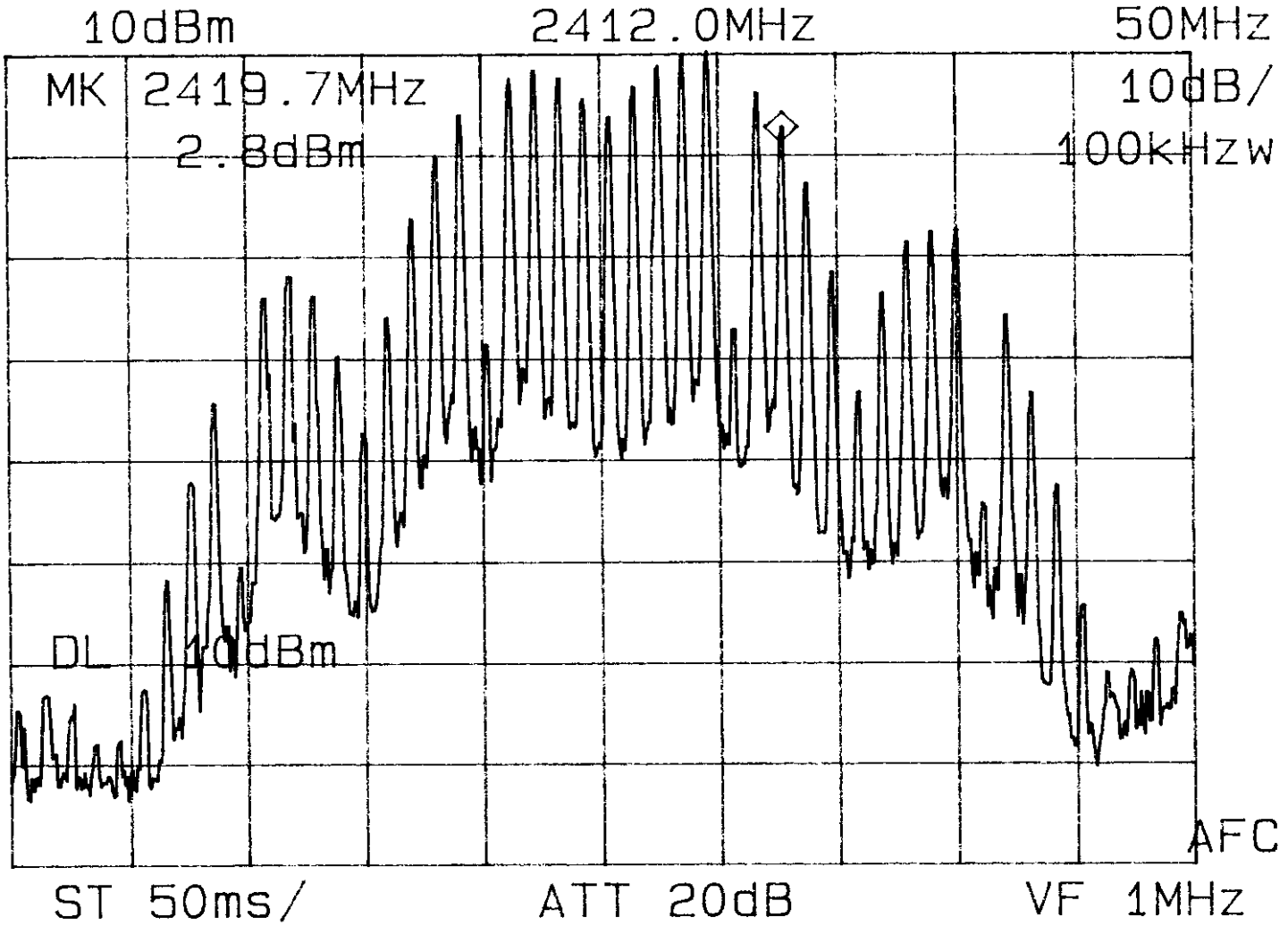
BAND EDGE EMISSIONS -LOW CHANNEL

MODULATED **50 MHZ SPAN** **100 KHZ RES. BW**



6 dB BANDWIDTH - LOW CHANNEL

MODULATED **50 MHZ SPAN** **100 KHZ RES. BW**



FCC 15.209 RADIATED EMISSIONS DATA

FCC ID: NK4-2023336988

CLIENT: IO WAVE, INC.
EUT: IO LINK 1.5 TX

CARRIER: 2452 MHZ

		PEAK				PEAK	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
1675.00	V	40.0	29.0	-25	44.0	158.5	500.0	-10.0
4904.00	V	39.0	37.0	-25	51.0	354.8	500.0	-3.0
7356.00	V	34.0	39.0	-25	48.0	251.2	500.0	-6.0
12260.00	H	32.0	42.0	-25	49.0	281.8	500.0	-5.0
19616.00	V	37.0	36.0	-25	48.0	251.2	500.0	-6.0
22068.00	H	31.0	37.0	-25	43.0	141.3	500.0	-11.0

TEST ENGINEER

_____ DATE_____

STEVE DAYHOFF

FCC 15.209 RADIATED EMISSIONS DATA

FCC ID: NK4-2023336988

CLIENT: IO WAVE, INC.
EUT: IO LINK 1.5 TX

CARRIER: 2412 MHZ

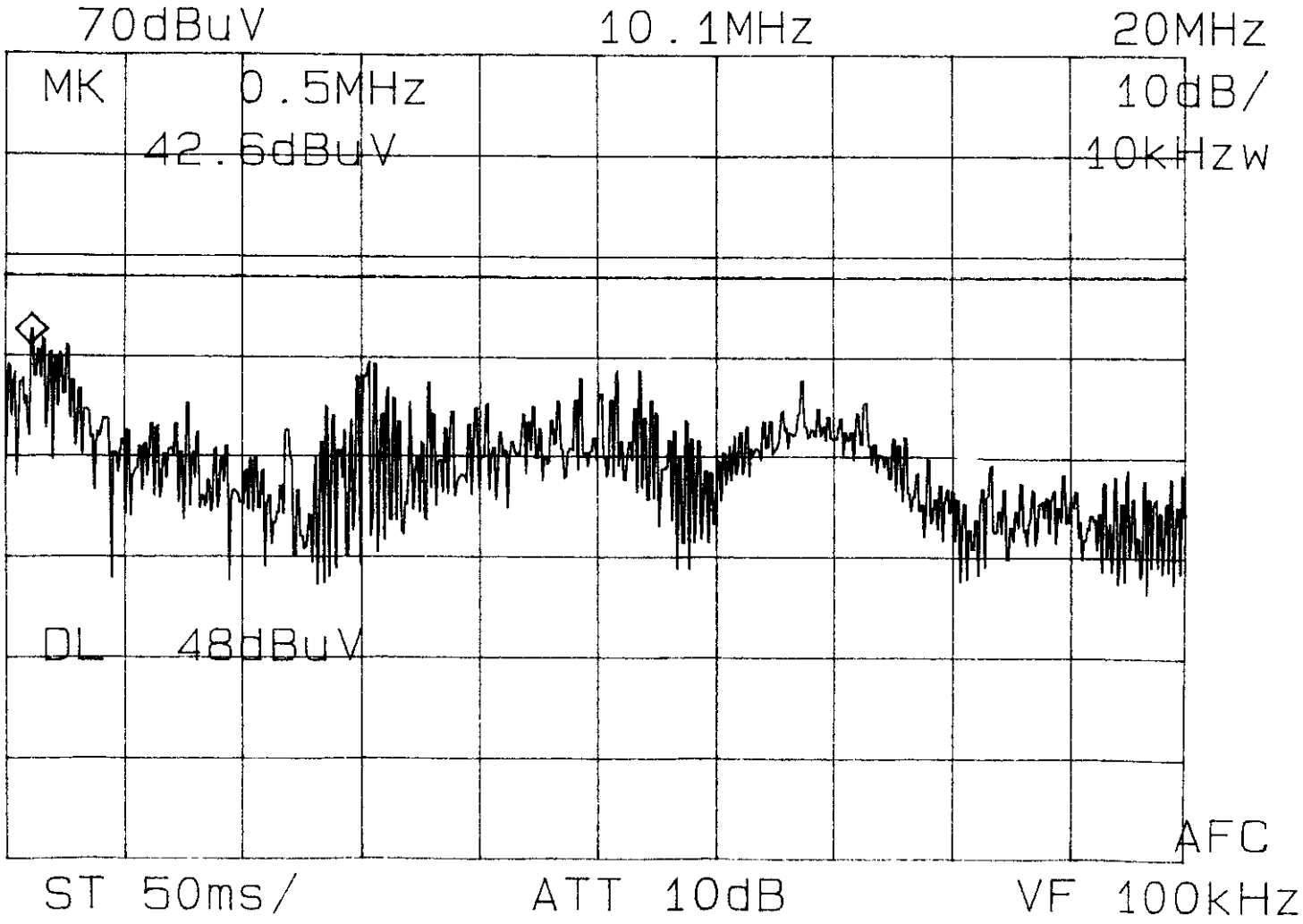
		PEAK				PEAK	AVRG	
FREQ MHz	POL H/V	SPEC A dBuV	AF/C dB/m	PREAM GAIN	E-FIELD dBuV/m	E-FIELD uV/m	LIMIT uV/m	MRG dB
4824.00	V	36.0	37.0	-25	48.0	251.2	500.0	-6.0
7236.00	V	31.0	39.0	-25	45.0	177.8	500.0	-9.0
12060.00	H	32.0	42.0	-25	49.0	281.8	500.0	-5.0
14472.00	H	26.0	44.0	-25	45.0	177.8	500.0	-9.0
19296.00	V	31.0	36.0	-25	42.0	125.9	500.0	-12.0

TEST ENGINEER

_____DATE_____
STEVE DAYHOFF

A.C. LINE-CONDUCTED EMISSIONS - L2

MODULATED **20 MHZ SPAN** **10 KHZ RES. BW**



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 - 24.000 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-24 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: NK4-2023336988

CLIENT: IO WAVE, INC.
EUT: IO LINK 1.5 TX

CARRIER: 2412 MHZ

FREQ MHz	POL H/V	AVRG SPEC A dBuV	AF/C dB/m	PREAM GAIN	E-FIELD dBuV/m	E-FIELD uV/m	AVRG LIMIT uV/m	MRG dB
4824.00	V	31.0	37.0	-25	43.0	141.3	500.0	-11.0
7236.00	V	27.0	39.0	-25	41.0	112.2	500.0	-13.0
12060.00	H	27.0	42.0	-25	44.0	158.5	500.0	-10.0
14472.00	H	22.0	44.0	-25	41.0	112.2	500.0	-13.0
19296.00	V	27.0	36.0	-25	38.0	79.4	500.0	-16.0

TEST ENGINEER

_____ DATE 10/12/01
STEVE DAYHOFF

FCC 15.209 RADIATED EMISSIONS DATA

FCC ID: NK4-2023336988

CLIENT: IO WAVE, INC.
EUT: IO LINK 1.5 TX

CARRIER: 2452 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	MRG dB
1675.00	V	35.0	29.0	-25	39.0	89.1	500.0	-15.0
4904.00	V	34.0	37.0	-25	46.0	199.5	500.0	-8.0
7356.00	V	30.0	39.0	-25	44.0	158.5	500.0	-10.0
12260.00	H	28.0	42.0	-25	45.0	177.8	500.0	-9.0
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

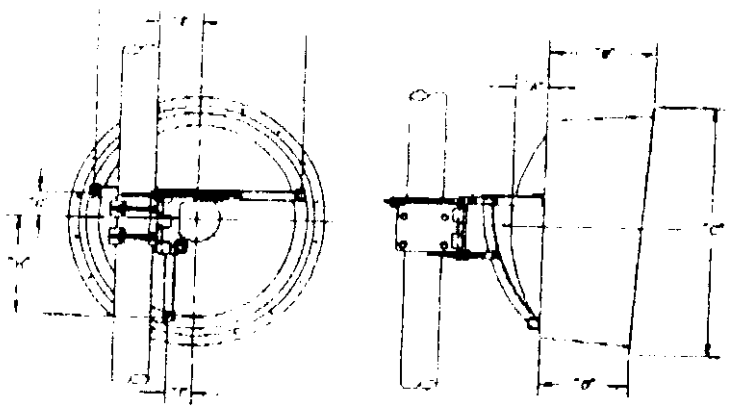
_____DATE_____

STEVE DAYHOFF

Diameter (Ft)	(M)	Model Number	Gain(dBi) Low	Mid	High	H/W Deg.	F/B Ratio (dB)	VSWR	Cross Pol. (dB)
			2.2-2.3 GHz			Feed Input Flange: N Female or 7/8" EIA			
Standard Solid Antennas - Plane Polarized									
2	(0.6)	P 23A24	20.4	20.6	20.7	15.0	31	1.50	26
4	(1.2)	P 23A48	26.4	26.6	26.8	7.6	38	1.30	26
6	(1.8)	P-23A72	29.9	30.1	30.3	5.1	38	1.30	30
8	(2.4)	P-23A96	32.8	33.0	33.2	3.7	42	1.10	30
10	(3.0)	P 23A120	34.7	34.9	35.1	3.0	47	1.10	30
12	(3.7)	P 23A144	35.9	36.1	36.3	2.5	48	1.10	30
Standard Solid Antennas - Plane Polarized - Low VSWR									
2	(0.6)	P 23A24L	20.4	20.6	20.7	15.0	31	1.30	25
4	(1.2)	P 23A48L	26.4	26.6	26.8	7.6	38	1.15	26
6	(1.8)	P-23A72L	29.9	30.1	30.3	5.1	38	1.10	30
8	(2.4)	P 23A96L	32.8	33.0	33.2	3.7	42	1.06	30
10	(3.0)	P-23A120L	34.7	34.9	35.1	3.0	47	1.06	30
12	(3.7)	P-23A144L	35.9	36.1	36.3	2.5	48	1.06	30
High Performance Antennas - Plane Polarized									
4	(1.2)	HP-23A48	26.4	26.6	26.8	7.6	38	1.30	30
6	(1.8)	HP-23A72	30.3	30.5	30.7	5.0	46	1.30	32
8	(2.4)	HP-23A96	32.8	33.0	33.2	3.7	54	1.10	30
10	(3.0)	HP-23A120	34.7	34.9	35.1	2.95	56	1.10	30
12	(3.7)	HP-23A144	35.9	36.1	36.3	2.5	58	1.10	30
High Performance Antennas - Plane Polarized - Low VSWR									
4	(1.2)	HP-23A48L	26.4	26.6	26.8	7.6	38	1.15	30
6	(1.8)	HP 23A72L	30.3	30.5	30.7	5.0	48	1.10	32
8	(2.4)	HP 23A96L	32.8	33.0	33.2	3.7	54	1.06	30
10	(3.0)	HP-23A120L	34.7	34.9	35.1	2.95	56	1.06	30
12	(3.7)	HP-23A144L	35.9	36.1	36.3	2.5	58	1.06	30
Maximum High Performance Antennas - Plane Polarized									
4	(1.2)	MHP-23B48	26.5	26.7	26.8	8.3	50	1.30	24
6	(1.8)	MHP-23B72	30.3	30.5	30.7	4.9	57	1.30	30
8	(2.4)	MHP-23B96	32.8	33.0	33.2	3.7	64	1.10	33
10	(3.0)	MHP-23B120	34.7	34.9	35.1	3.0	65	1.10	32
12	(3.7)	MHP 23B144	35.9	36.1	36.3	2.5	66	1.10	30
Maximum High Performance Antennas - Plane Polarized - Low VSWR									
4	(1.2)	MHP-23B48L	26.5	26.7	26.8	8.3	50	1.15	24
6	(1.8)	MHP-23B72L	30.3	30.5	30.7	4.9	57	1.10	30
8	(2.4)	MHP-23B96L	32.8	33.0	33.2	3.7	64	1.06	33
10	(3.0)	MHP-23B120L	34.7	34.9	35.1	3.0	65	1.06	32
12	(3.7)	MHP 23B144L	35.9	36.1	36.3	2.5	66	1.06	30
			2.3-2.5 GHz			Feed Input Flange: N Female or 7/8" EIA			
Standard Solid Antennas - Plane Polarized									
2	(0.6)	P-24A24	20.7	21.1	21.5	14.0	35	1.50	24
4	(1.2)	P-24A48	26.8	27.1	27.5	7.2	33	1.30	26
6	(1.8)	P-24A72	30.3	30.6	31.0	4.8	36	1.30	26
8	(2.4)	P-24A96	32.7	33.1	33.4	3.6	39	1.10	27
10	(3.0)	P-24A120	34.7	35.1	35.4	2.8	43	1.10	30
12	(3.7)	P-24A144	36.4	36.8	37.1	2.4	47	1.10	30
Standard Solid Antennas - Plane Polarized - Low VSWR									
2	(0.6)	P-24A24L	20.7	21.1	21.5	14.0	35	1.30	24
4	(1.2)	P-24A48L	26.8	27.1	27.5	7.2	33	1.15	26
6	(1.8)	P-24A72L	30.3	30.6	31.0	4.8	36	1.10	26
8	(2.4)	P-24A96L	32.7	33.1	33.4	3.6	39	1.10	27
10	(3.0)	P-24A120L	34.7	35.1	35.4	2.8	43	1.10	30
12	(3.7)	P-24A144L	36.4	36.8	37.1	2.4	47	1.10	30
High Performance Antennas - Plane Polarized (Low VSWR for the 4 Foot Model is 1.15, 6 Foot Thru 12 Foot is 1.10)									
4	(1.2)	HP 24A48	26.8	27.1	27.5	7.0	48	1.30	26
6	(1.8)	HP 24A72	30.3	30.6	31.0	4.8	50	1.30	30
8	(2.4)	HP 24A96	32.7	33.1	33.4	3.6	52	1.10	30
10	(3.0)	HP 24A120	34.7	35.1	35.4	3.1	60	1.10	30
12	(3.7)	HP 24A144	36.4	36.8	37.1	2.4	62	1.10	30
Maximum High Performance Antennas - Plane Polarized (Low VSWR for the 4 Foot Model is 1.15, 6 Foot Thru 12 Foot is 1.10)									
4	(1.2)	MHP 24A48	26.8	27.1	27.5	7.0	50	1.30	24
6	(1.8)	MHP 24A72	30.3	30.6	31.0	4.8	57	1.30	30
8	(2.4)	MHP 24A96	32.7	33.1	33.4	3.6	64	1.10	32
10	(3.0)	MHP 24A120	34.7	35.1	35.4	3.1	68	1.10	34
12	(3.7)	MHP 24A144	36.4	36.8	37.1	2.4	69	1.10	30

Standard, High and Maximum High Performance specifications available upon request.

Adopted

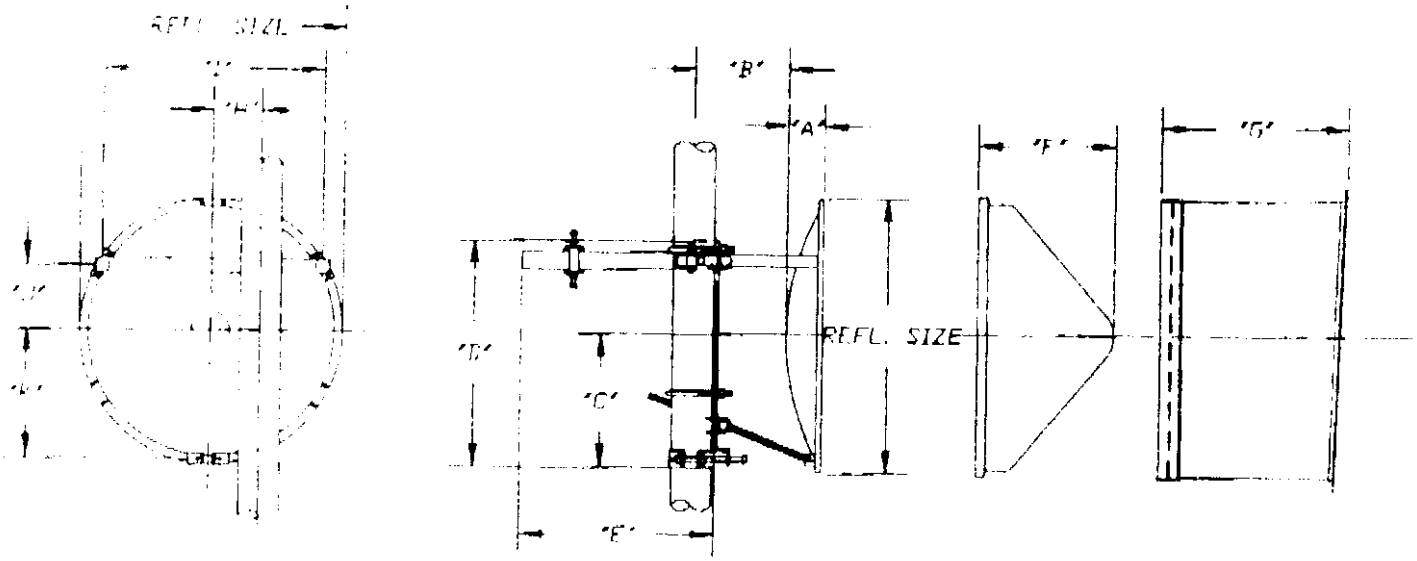


REFLECTOR DIAMETER (CM)

ESTIMATED HIGH & MAXIMUM HIGH PERFORMANCE
DIMENSIONS IN INCHES / (CM) 15 GHz - 40 GHz

	"A"	"B"	"C"	"D"	"E"	"F"	"G"	"H"	"I"
1 FOOT (.30)	3 9/16 (9)	9 1/4 (23)	11 11/16 (30)	19 7/8 (50)	65 (165)	17 3/4 (45)	16 13/16 (43)	3-8 (8-20)	19 15/16 (51)
1.5 FOOT (.46)	5 (13)	9 3/8 (24)	17 1/8 (43)	25 13/16 (66)	65 (165)	– –	13 11/16 (35)	3 1/2-8 (9-20)	26 (66)
2 FOOT (.61)	4 (10)	13 1/4 (34)	31 1/4 (79)	11 1/16 (28)	5 1/8 (13)	24 9/16 (62)	4 (10)	12 1/8 (31)	4 3/8 (11)

Please Call Factory For Crated Dimensions



REFLECTOR DIAMETER (CM)

ESTIMATED STANDARD, HIGH & MAXIMUM HIGH PERFORMANCE
DIMENSIONS IN INCHES / (CM)

	"A"	"B"	"C"	"D"	"E"	"F"	"G"	"H"	"I"	"J"	"K"
2 FOOT* (61)	3 9/16 (9)	9 1/4 (23)	11 11/16 (30)	19 7/8 (50)	65 (165)	17 3/4 (45)	16 13/16 (43)	3-8 (8-20)	19 15/16 (51)	5 3/4 (15)	11 7/16 (29)
2.5 FOOT* (76)	5 (13)	9 3/8 (24)	17 1/8 (43)	25 13/16 (66)	65 (165)	– –	13 11/16 (35)	3 1/2-8 (9-20)	26 (66)	7 8/16 (19)	15 3/32 (38)
4 FOOT* (122)	8 (20)	6 5/8 (17)	26 9/16 (67)	42 1/8 (107)	65 (165)	27 (69)	25 5/16 (64)	3-8 (8-20)	41 9/16 (106)	12 (30)	24 (61)

Please Call Factory For Crated Dimensions
*2 Foot Frequency 47 to 15 GHz, *2.5 Foot Frequency 15 to 23 GHz, *4 Foot Frequency 47 to 23 GHz

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 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.)	

EXHIBIT 1

EUT PHOTOGRAPHS