Emissions Testing
Performed
on the
Raylink, Inc.
Raylink Whisp Card
Model: 24020
To
FCC Part 15 Subpart C, Section 15.247

Date of Test: February 21-23, March 1, and May 3, 2001

Report Number: J20041993
CLC

Contact: Mr. Paul Rice

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Table of Contents

TABLE OF CONTENTS 2

I – INTRODUCTION AND SUMMARY 4

II – TECHNICAL REQUIREMENTS 7

15.1 SCOPE 7

15.15 GENERAL TECHNICAL REQUIREMENTS 8

15.27 SPECIAL ACCESSORIES 8

15.31 MEASUREMENT STANDARDS 8

15.33 FREQUENCY RANGE OF MEASUREMENT 8

MEASUREMENT DETECTOR FUNCTIONS AND BANDWIDTH 9

TRANSITION PROVISIONS 9

15.201 CERTIFICATION 9

15.203 ANTENNA REQUIREMENTS 9

15.204 EXTERNAL RADIO AMPLIFIER 10

15.205 RESTRICTED BANDS OF OPERATION 10

15.207 CONDUCTED LIMITS 10

15.209 RADIATED EMISSION LIMITS; GENERAL REQUIREMENTS 10

15.247 EIRP MEASUREMENTS PROCEDURES 11

III– ATTESTATION 12

IV– SITE DESCRIPTION 13

V – SUMMARY OF EQUIPMENT UNDER TEST 15

VI – CONFIGURATION INFORMATIONS 16

VII– CONFIGURATION PHOTOGRAPHS 19

VIII –EUT'S ANTENNA 26

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IX–EUT'S PHOTOS 30

X – SAMPLE CALCULATION 33

XI – DATA TABLES 34

XII – DUTY CYCLE (AVERAGE FACTOR) 45

XIII–BANDWIDTH 46

XIV–BAND EDGE 53

XV–DWELL TIME 55

XVI–POWER MEASUREMENT 56

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I – Introduction and Summary

TO: Raylink, Inc.
Mr. Paul Rice

FROM: Kouma P. Sinn

DATE: February 21-23, March 1, and, May 3, 2001

JOB #: J20041993

RE: Emissions Testing Performed on Raylink Whisp Card, Model: 24020, Serial: R48CB80

On February 21-23, March 1, and May 3, 2001 we tested the Raylink Whisp Card, Model: 24020 to determine if it was in compliance with the FCC Part 15, Subpart C, Section 15.247-Frequency Hopping Spread Spectrum Transmitter. A production version of the sample was received on Wednesday, February 21, 2001 in good condition. We found that the unit met the applicable requirements when tested as received.

The Equipment Under Test (EUT) was tested in two configurations.

Typical Configuration: The EUT was installed in a typical desktop computer, this is intended to simulate the actual use of the equipment. The tests that were performed with this configuration are:

Unintentional Radiated Emissions
Restricted Band Emissions
Antenna Port Conducted
Bandwidth Measurements
Time of Occupancy
Power Measurements

Modular Configuration: The EUT was installed in a desktop computer. The cover and chassis of the computer were removed, the motherboard, daughterboards, drives, and power supply was placed on the tabletop. This test was performed to insure that the EUT did not rely upon the shielding properties of the host. The test that was performed with this configuration is:

Unintentional Radiated Emissions of a Modular Device

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The following Tables summarize the results of testing:

Worst-Case Unintentional Radiated Emissions

Test	Frequency	Measurement	Requirement	Pass/Fail	Section of FCC Rules	Section of Test Report
Radiated	48.00 MHz	36.00 dBuV/m	40.00 dBuV/m	Pass	15.109	Page 34
Modular Radiated	336.00 MHz	44.70 dBuV/m	46.00 dBuV/m	Pass	15.109	Page 43
Line-conducted	24.00 MHz	48.00 dBuV	48.00 dBuV	Pass	15.207	Page 42

Worst-Case Restricted Band Radiated Emissions

Test Radiated With	Frequency (MHz)	Measurement (dBuV/m)	Requirement (dBuV/m)	Pass/Fail	Section of FCC Rules	Section of Test Report
21.0 Parabolic Antenna	22320.00	52.3	54.00	Pass	15.209	Page 35
12.4 dBi Rod Antenna	22320.00	52.3	54.00	Pass	15.209	Page 36
17.2 Long Panel Antenna	22320.00	52.3	54.00	Pass	15.209	Page 37
12.0 dBi Panel Antenna	22320.00	52.3	54.00	Pass	15.209	Page 38

Worst-Case Antenna Conducted Spurious Emissions

Test Antenna Conducted at	Frequency (MHz)	Measurement (dBm)	Requirement (dBm)	Pass/Fail	Section of FCC Rules	Section of Test Report
2402 MHz	24020.00	-17.1	-0.5	Pass	15.247 (4c)	Page 39
2441 MHz	24410.00	-16.7	-0.1	Pass	15.247 (4c)	Page 40
2480 MHz	24800.00	-13.2	0.15	Pass	15.247 (4c)	Page 41

Bandwidth Measurement

Test	Frequency	Measurement	Requirement	Pass/Fail	Section of FCC Rules	Section of Test Report
Full Bandwidth	2400.00 to 2483.50 MHz	80 Channels	At 75 Channels	Pass	15.247	Page 47
Bandwidth (Hopping)	2443.00 MHz	832.00 kHz	1000.00 kHz	Pass	15.247	Page 48
Bandwidth	2402.00 MHz	835.00 kHz	1000.00 kHz	Pass	15.247	Page 49
Bandwidth	2441.00 MHz	835.00 kHz	1000.00 kHz	Pass	15.247	Page 50
Bandwidth	2480.00 MHz	845.00 kHz	1000.00 kHz	Pass	15.247	Page 51
Channel Separation	2442.00 MHz	1000.00 kHz	>845 kHz	Pass	15.247	Page 52

Time of Occupancy

Test	Measurement	Requirement	Pass/Fail	Section of FCC Rules	Section of Test Report
Dwell Time	23.1 ms	<400 ms	Pass	15.247(a)	Page 55

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Power Measurement

Frequency (MHz)	Measurement (dBm)	Requirement (dBm)	Pass/Fail	Section of FCC Rules	Section of Test Report
2402	20.891	30	Pass	15.247(b)	Page 56
2441	21.754	30	Pass	15.247(b)	Page 57
2480	20.356	30	Pass	15.247(b)	Page 58

Conclusion:

In summary, this report confirms that the Raylink Whisp Card, Model: 24020, Serial: R48CB80 is compliant with the FCC Part 15, Subpart C, Section 15.247 requirements when production units conform with the initial sample. Please address all questions and comments concerning this report to Scott Lambert, ITE/Telco Team Leader.

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II – Technical Requirements

15.1 Scope

The Raylink WHISP device is a spread spectrum transceiver designed to operate in the 2.400 GHz to 2.480GHz ISM frequency range. Designed to operate within the constraints of the IEEE 802.11 standard for Wireless Local Area Networks (WLANs), the Sutter's Mill unit employs a frequency hopping technique, changing frequencies within the 2.4 to 2.48 GHz range many times per second to maximize usage of the available bandwidth. Peak power output to the unit's antenna port is +20dBm (100 milliwatts). The WHISP unit is designed to be connected through a standard Personal Computer Memory Card Interface Adapter (PCMCIA) slot into a laptop or desktop personal computer. DC power for the unit is drawn through the PCMCIA adapter from the PC, referred to as a host.

The Raylink WHISP device is a modified version of the original Sutter's Mill WLAN adapter (FCC grantee code L39G689372). The Raylink WHISP device does not use the integral antenna featured in the original Sutter's Mill WLAN adapter- rather, the device is fitted with a Radiall MMS miniature coaxial connector for use with an external antenna. By virtue of the fact that the MMS connector is not available in standard product catalogs, the connector meets the part 15.203 description of a "unique" connector as verified by J. Dichoso of the Federal Communications Commission.

Four different configurations are presented for FCC approval. All configurations use the Raylink WHISP WLAN adapter, a short length of coaxial cable acting as a MMS to SMA connector adapter, coupled to a 50-foot length of LMR-400 coaxial cable. Four different antennas, ranging from a 12dBi patch antenna to a 21dBi parabolic antenna, were scanned and found to be compliant with FCC part 15 subpart C requirements for radiated emissions.

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The Raylink WHISP PC card derives all of its frequency and microprocessor clock timing from a 16 MHz TCXO (reference designation U11 on schematic page 4). The system microprocessor is a 80C154U (generic 8051 8-bit microprocessor), reference designation U501 on page 2 of the schematic.

This device is an intentional radiator intended to operate in accordance with FCC Part 15, Subpart C, Section 15.247.

15.15 General Technical Requirements

There are no controls accessible to the user that would cause the device to operate in violation of the FCC rules.

15.27 Special Accessories

Four different configurations are presented for FCC approval. All configurations use the Raylink WHISP WLAN adapter, a short length of coaxial cable acting as a MMS to SMA connector adapter, coupled to a 50-foot length of LMR-400 coaxial cable. Four different antennas, ranging from a 12dBi patch antenna to a 24dBi parabolic antenna, were scanned and found to be compliant with FCC part 15 subpart C requirements for radiated emissions.

15.31 Measurement Standards

The measurement procedures specified by ANSI C63.4:1992 were used to setup and test the device. See Section IV of this test report for detailed description of the test procedure.

The unit was powered by the computer through PCMCIA card slot.

15.33 Frequency range of measurement

The device was scanned for spurious and harmonic emissions from 30 MHz to the 10th harmonic of the fundamental emission.

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15.35 Measurement detector functions and bandwidth

The following table illustrates the detector functions and bandwidth used to test the device.

Frequency Range	Measurement Detector	Measurement Bandwidth
450 kHz to 30 MHz	Quasi-Peak	9 kHz
30 MHz to 1000 MHz	Quasi-Peak	120 kHz
1000 MHz to 10th harmonic	Average	1 MHz

The quasi-peak detector meets the requirements of CISPR 16.

An averaging factor was not used for the device because it has a high duty cycle.

15.36 Transition Provisions

Transition provisions were not applied to the device.

15.201 Certification

The device is required to be certified in accordance with Part 2 of the FCC rules, Subpart J.

15.203 Antenna Requirements

There are four different antennas listed in Section VI in this report that will be presented for FCC approval.

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15.204 External Radio Amplifier

The device is not an amplifier.

15.205 Restricted bands of operation

All unwanted emissions from the transmitter, within the restricted bands, were compared to the general limits in Section 15.209. Please note that only worst-case emissions are listed below

Test Radiated with	Frequency (MHz)	Measurement (dBuV/m)	Requirement (dBuV/m)	Pass/Fail
21.0 dBi Parabolic Antenna	7449.00	52.40	54.00	Pass
12.4 dBi Rod Antenna	7449.00	52.40	54.00	Pass
17.2 dBi Long Panel Antenna	7449.00	52.40	54.00	Pass
12.0 dBi Panel Antenna	7323.00	52.1	54.00	Pass

15.207 Conducted limits

All unwanted line conducted emissions met the general limits in Section 15.207.

15.209 Radiated emission limits; general requirements

All unwanted emissions from the transmitter met the general limits in Section 15.209.
Only the measurement procedures of Part 15 are required for this device. The device was not evaluated to the requirements of 2.1046 through 2.1057.

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15.247 EIRP Measurement Procedure:

The test was performed at the unit's antenna port with 30 dB attenuator at the spectrum analyzer input. The shortest SMA cable was used to minimize the loss. The spectrum analyzer was set as follows during this test:

RBW: 1 MHz
VBW: 3 MHz
Span: 5 MHz
Sweep: 5ms
Detector: Peak

Antenna Description	Frequency (MHz)	Measured Power (dBm)	Antenna Gain (dBi)	Net EIRP (dBm)	Limit EIRP (dBm)
Panel	2402.00	20.891	12.0	31.5	40.0
Panel	2441.00	21.754	12.0	31.9	40.0
Panel	2483.00	20.356	12.0	30.6	40.0
Rod	2402.00	20.891	12.4	31.9	40.0
Rod	2441.00	21.754	12.4	32.3	40.0
Rod	2483.00	20.356	12.4	31.0	40.0
Long Panel	2402.00	20.891	17.2	36.7	44.2
Long Panel	2441.00	21.754	17.2	37.1	44.2
Long Panel	2483.00	20.356	17.2	35.8	44.2
Parabolic	2402.00	20.891	21.0	40.5	46.0
Parabolic	2441.00	21.754	21.0	40.9	46.0
Parabolic	2483.00	20.356	21.0	39.6	46.0

EIRP limit is calculated as follows:

Antenna Gain (dBi) – 6 = X,
Reduction for every 3 dB gain = X/3,
EIRP limit = 30 dBm – (X/3) + [Antenna Gain],

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III - Attestation

LABORATORY MEASUREMENTS

Pursuant To
Part 15, Subpart C
For
Intentional Radiators

Company Name:	Raylink, Inc.
Address:	436 Cloverleaf Drive Baldwin Park, CA 91706
Model:	24020
Date of Test(s):	February 21-23, March 1, and May 3, 2001
Test Site Location:	INTERTEK TESTING SERVICES NA INC. 70 Codman Hill Road Boxborough, MA 01719
Site:	3C

I attest to the accuracy of this report:

Signature

Candy L. Campbell
Testing Performed By:

Project Engineer
Title

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IV - Site Description

Introduction

The following is a description of the test procedure used by Intertek Testing Services in the measurements of transmitters operating under Part 15, Subpart C, General Requirements.

A. **Test Set-Up**: The test set-up and procedures described below are designed to meet the requirements of ANSI C63.4 (1992).

1. The test site is a Plastic/Fiberglass structure with a groundplane. The site has attenuation characteristics which meet the requirements of ANSI C63.4 (1992). Information on the site has been filed with the FCC as required by Rule 2.948. The address of the site is 70 Codmand Hill Road, Boxborough, MA 01719.

2. Power to the site is nominal line voltage of 117 V_{AC} and 230 V_{AC}, 50 Hz.

3. The equipment under test (EUT) is placed on a wooden turntable which is four feet in diameter and approximately one meter in height above the groundplane. During the radiated emissions test, the turntable is rotated 360 degrees and any cables leaving the EUT are manipulated to find the configuration resulting in maximum emissions. The antenna height and polarization are also varied during the search for maximum signal levels. The height of the antenna is varied from one meter to four meters. Body-worn, hand-held and small portable devices are mounted on a non-conductive box and emissions are investigated on three orthogonal axis.

4. EMCO Biconolog antenna, model: 3142, was used for frequency below 1000 MHz. For measurements between 1000 MHz and 18000 MHz , an EMCO horn antenna, model: 3115 is used. The Antennas used are listed in the Test Equipment Summary in Section 6

5. The field strength measuring equipment used included:

Description	Manufacturer	Model	Serial #	Cal Due
ANTENNA	EMCO	3142	9711-1224	11/17/01
LISN	SOLAR ELECTRONICS	9252-50-R-24-BNC	955107	3/20/01
LISN	SOLAR ELECTRONICS	8012-50-R-24-BNC	865575	4/20/01
RECEIVER	HEWLETT PACKARD	85422E	3520A00125	11/21/01
HORN ANTENNA	EMCO	3115	9512-4632	10/9/01
ATTENUATOR	WEINSCHEL	47-30-34	BD4327	08/14/01
SPECTRUM ANALYZER	AGILENT	E7045A	US40240205	11/28/01
HORN ANTENNA	EMCO	3116	2090	03/15/01

6. The frequency range to be scanned is from the lowest radio frequency signal generated in the device which is greater than 9 kHz to the tenth harmonic of the highest fundamental frequency, or 40 GHz, whichever is lower. For line-conducted emissions, the range scanned is 450 kHz to 30 MHz.

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7. The EUT is warmed up for 15 minutes prior to the test. AC power to the unit is varied from 85% to 115% nominal and variation in the fundamental emission field strength is recorded. If battery powered, a new battery is used.

8. Conducted measurements were made as described in ANSI C63.4 (1992). An IF bandwidth of 9 kHz is used, and peak or quasi-peak detection is employed.

9. The IF bandwidth used for measurement of radiated signal strength was 100 kHz or greater below 1000 MHz. Where pulsed transmissions of short enough pulse duration warrant, a greater bandwidth is selected according to the recommendations of Hewlett Packard Application No. 150-2. A discussion of whether pulse desensitivity is applicable to this unit is included in this report. Above 1000 MHz, a bandwidth of 1 MHz is generally used.

10. Transmitter measurements are normally conducted at a measurement distance of three meters. However, to assure low enough noise floor in the forbidden bands and above 1 GHz (where no preamplifier is used), signals are acquired at a distance of one meter or less. All measurements are extrapolated to three meters using inverse scaling, but those measurements taken at a closer distance are so marked.

11. For measurements made in the 9 kHz to 30 MHz range, a distance of 30 meters was used unless a good signal-to-noise ratio could not be obtained. In that case, a closer distance was used and that distance is so marked in the data table.

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V – Summary of Equipment Under Test

1	**Manufacturer**:	Raylink, Inc. 436 Cloverleaf Drive Baldwin Park, CA 91706
2	**Grantee**:	Raylink, Inc. 436 Cloverleaf Drive Baldwin Park, CA 91706
3	**Equipment Under Test**:	PCMCIA Card
4	**Trade Name**:	Raylink Whisp Card
5	**Model No.**:	24020
6	**Serial No.**:	R48CB80
7	**Date of Test**:	February 21-23, March 1 and May 3, 2001
8	**Frequencies to which device can be tuned**:	None
9	**Can customer tune device?**	No
10	**Detailed description of operation pursuant to 15.247**:	See 15.247
11	**Applicable emissions limits**:	15.209, 15.205,15.207
12	**Additional Comments**:	

The system was configured for testing in a typical fashion (as a customer would normally use it), and in the confines as outlined in ANSI C63.4 (1992).

During testing, the peripheral locations were not varied with respect to the main unit.

All interconnecting cables dropped from the rear of the turntable, but none were within 40 cm of the groundplane.

For maximizing emissions, the system was rotated through 360°, the antenna height was varied from 1 meter to 4 meters above the ground plane, and the antenna polarization was changed. This step by step procedure for maximizing emissions led to the data reported in this report.

Radiated emissions were tested in the range of 30 MHz to 24.830 GHz.

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VI - Configuration Information

Equipment Under Test: Raylink Whisp Card

Model No.: 24020
Serial No.: R48CB80

FCC Identifier: L39G689372

Support Equipment:

Computer

Manufacturer:	e-machine, Inc.
Model Number:	etower 500ix
Serial Number:	BG036AAC00645
FCC ID:	Not Applicable

Monitor

Manufacturer:	Gateway 2000
Model Number:	Gateway 2000 500CS
Serial Number:	15013B097072
FCC ID:	BEJCS587W

Mouse

Manufacturer:	Microsoft
Model Number:	SK-1000RE
Serial Number:	M941074567
FCC ID:	GYU10SK

Printer

Manufacturer:	Hewlett Packard
Model Number:	C2106A
Serial Number:	US35011181
FCC ID:	B94C2106X

Modem

Manufacturer:	U.S. Robotic
Model Number:	14,400FAX Modem
Serial Number:	0002680200126659
FCC ID:	Not Labelled

AC Adapter

Manufacturer:	U.S. Robotic
Part Number:	HA-419700
Serial Number:	Not Labelled
FCC ID:	Not Applicable

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Cables:

QTY	Description	Shield Description	Hood Description	Length (m)
1	Parallel Power Cable	Braid Shield	Metal with 360° connection	3.5
1	Modem Cable	Braid Shield	Metal with 360° connection	1.0
3	AC Power Cords	None	Plastic	2.0
1	Antenna Cable	Coaxial	Metal	10.0

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The following antennas were used on the device during testing:

17.20 dBi Long Panel Antenna

Manufacturer:	Young Design, Inc.
Model Number:	A2.45LP17
Serial Number:	Not Labelled
FCC ID:	Not Applicable

12 dBi gain Panel Antenna

Manufacturer:	Young Design, Inc.
Model Number:	A2.45FP12
Serial Number:	Not Labelled
FCC ID:	Not Applicable

12.4 dBi gain Rod Antenna

Manufacturer:	Young Design, Inc.
Model Number:	A-2412
Serial Number:	Not Labelled
FCC ID:	Not Applicable

21 dBi gain Parabolic Antenna

Manufacturer:	Young Design, In.
Model Number:	PT2424 2nd PT2421
Serial Number:	Not Labelled
FCC ID:	Not Applicable

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VII - Configuration Photographs

21 dBi Parabolic Antenna

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12 dBi Rod Antenna

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17.2 dBi Long Panel Antenna

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12 dBi Panel Antenna

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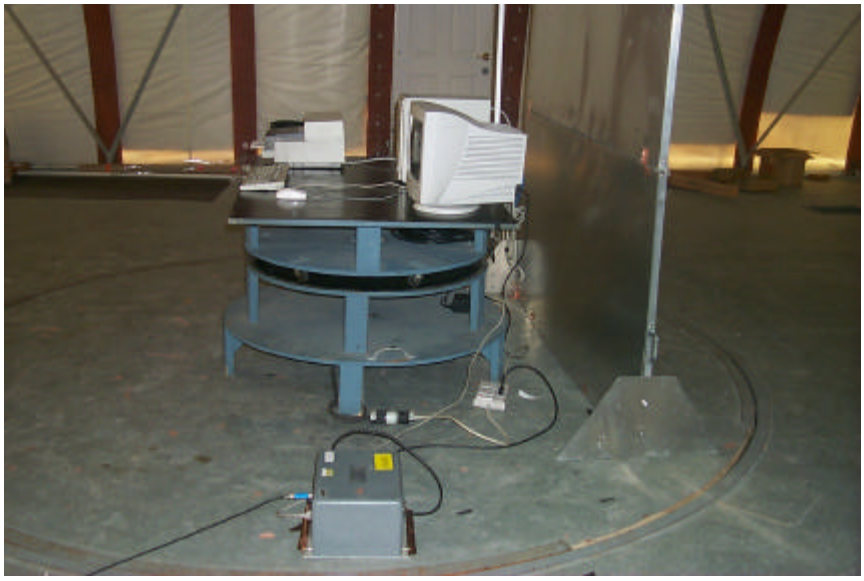
Line-Conducted Photographs



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Modular Radiated Photographs

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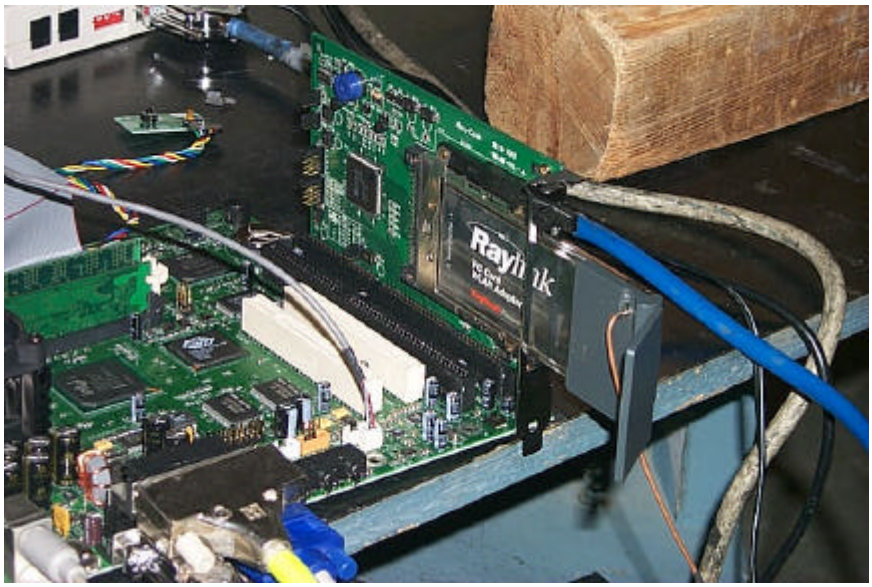
Modular Radiated Photographs



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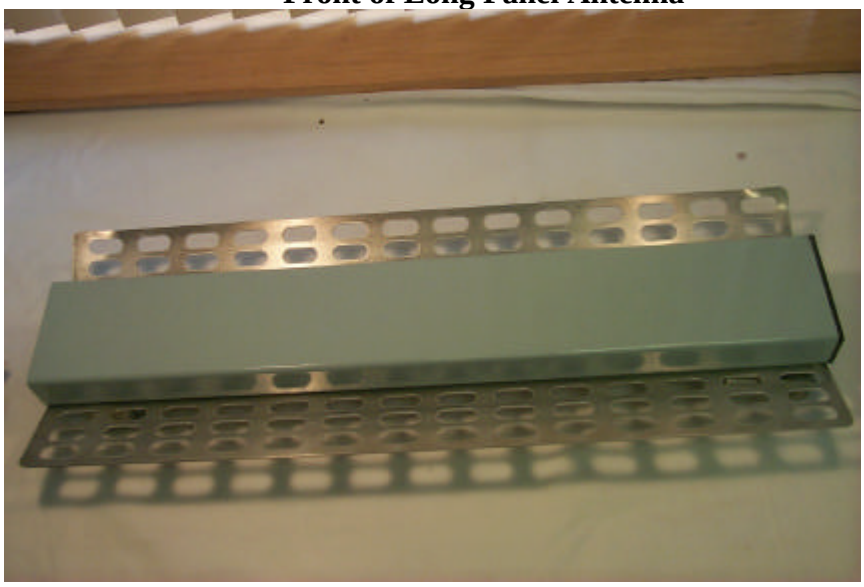
VIII - EUT's Antenna

Front of Long Panel Antenna



Back of Long Panel Antenna

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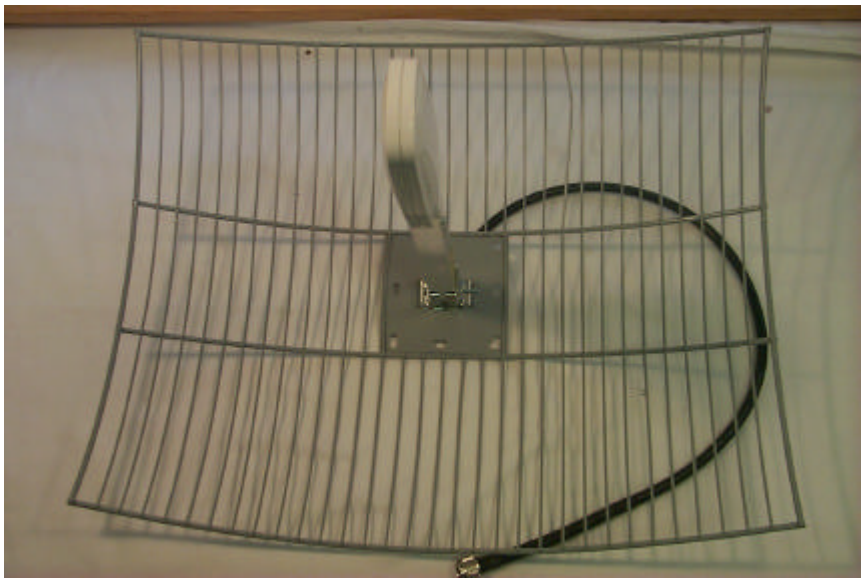
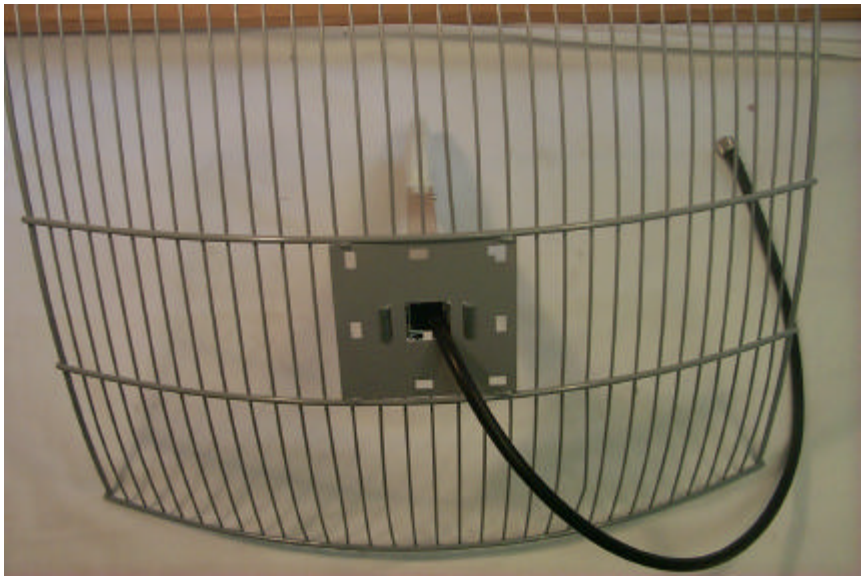
EUT's Antenna

Front of Parabolic Antenna



Back of Parabolic Antenna



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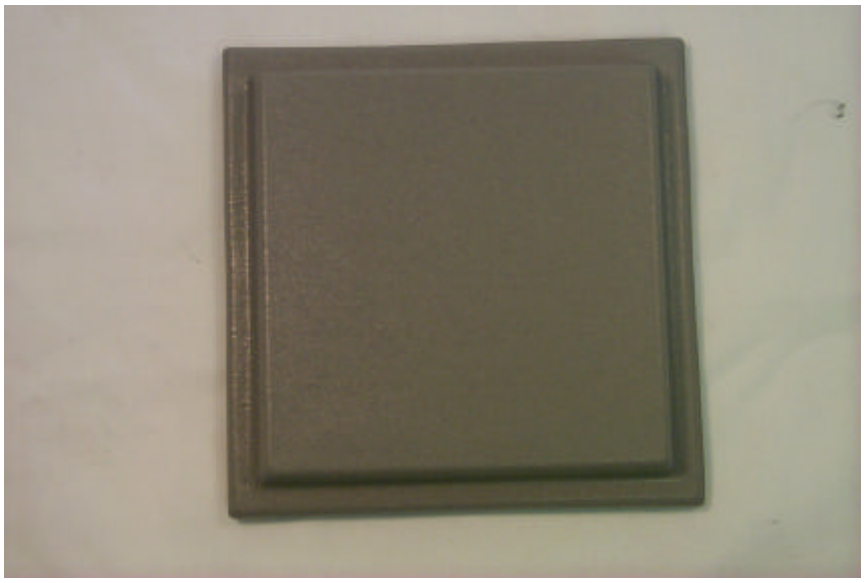
EUT's Antenna

Front of Panel Antenna



Back of Panel Antenna

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EUT's Antenna

Rod Antenna

Extension of Rod Antenna

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IX - EUT

Front View

Back View

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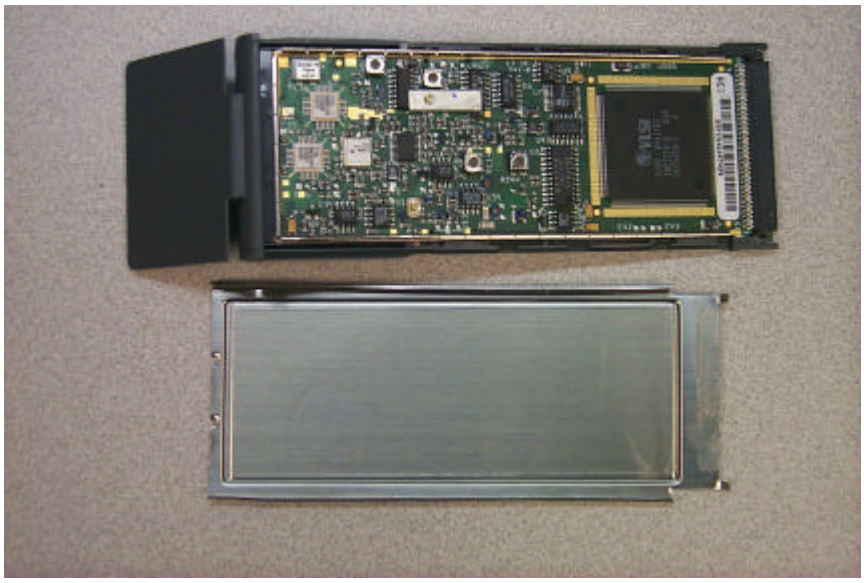
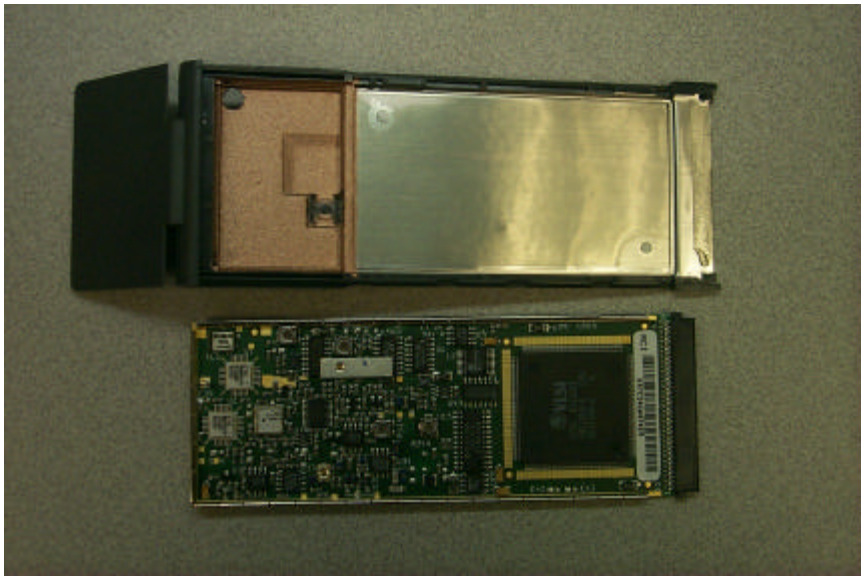
EUT's Cover

Back Cover



Back Cover



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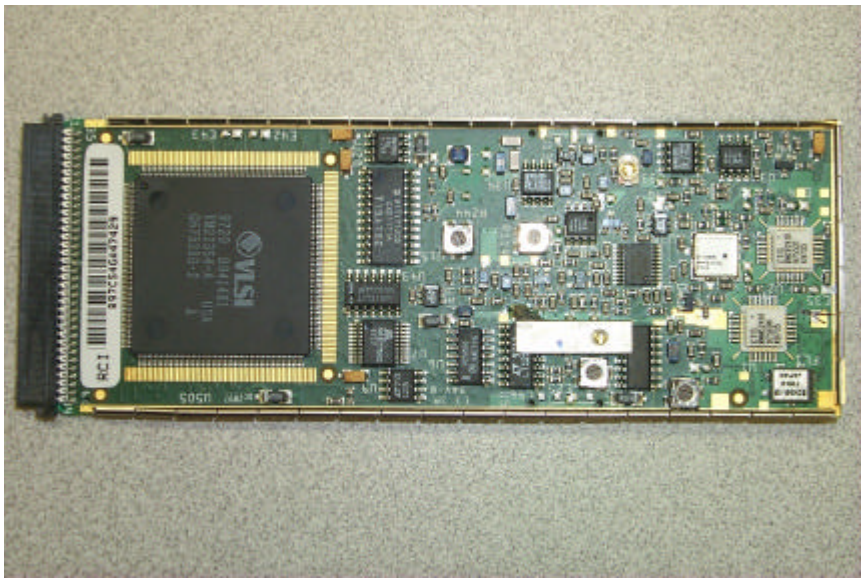
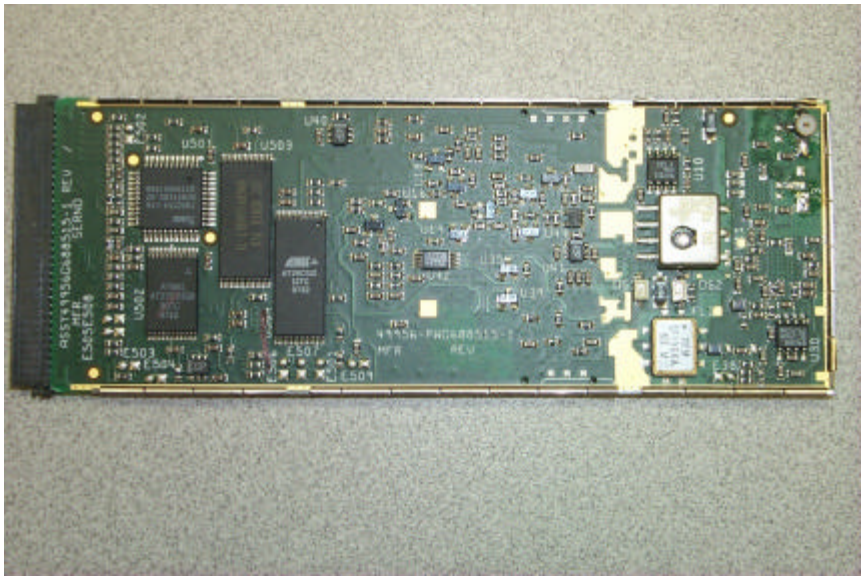
EUT's Board

Front View



Back View



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X - Sample Calculation

The field strength is calculated by adding the Antenna Factor and Cable Factor, and subtracting the Amplifier Gain (if any) from the measured reading. The basic equation with a sample calculation is as follows:

FS = RA + AF + CF - AG
where FS = Field Strength in dBμV/m
RA = Receiver Amplitude (including preamplifier) in dBμV
CF = Cable Attenuation Factor in dB
AF = Antenna Factor in dB/m
AG = Amplifier Gain in dB

In the following table(s), the reading shown on the data table reflects the preamplifier gain. An example for the calculations in the following table is as follows:

Assume a receiver reading of 52.0 dBμV is obtained. The antenna factor of 7.4 dB and cable factor of 1.6 dB is added. The amplifier gain of 29 dB is subtracted, giving a field strength of 32 dBμV/m. This value in dBμV/m was converted to its corresponding level in μV/m.

RA = 52.0 dBμV
AF = 7.4 dB/m
CF = 1.6 dB
AG = 29.0 dB
FS = 32 dBμV/m

Level in μV/m = $10^{(32\ \mathrm{dB\mu V/m}/20)}$ = 39.8 μV/m

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XI - Data Tables

Radiated Emissions / Interference

Table: 1

Company: Raylink , Inc.
Model: 24020
Job No.: J20041993
Date: 03/01/01
Standard: FCC15
Class: B Group: None
Notes: Unintentional radiated scan from 30 MHz-2000 MHz
12.4 dBi Rod antenna was used for this test

Tested by: Kouma Sinn
Location: Site 3C
Detector: HP 8542E
Antenna: LOG3 11-17-00 H10
PreAmp: None
Cable(s): 3C,10 METER PRIMARY 216
Distance: 10 meters

	Ant. Pol. (V/H)	Frequency MHz	Reading dB(uV)	Antenna Factor dB(1/m)	Cable Loss dB	Pre-amp Factor dB	Distance Factor dB	Net dB(uV/m)	Limit dB(uV/m)	Margin dB	
NB	V	192.000	11.9	10.0	2.3	0.0	-10.5	34.6	43.5	-8.9	
NB	V	48.000	15.0	9.4	1.1	0.0	-10.5	36.0	40.0	-4.0	P
NB	V	330.000	7.0	14.8	3.0	0.0	-10.5	35.2	46.0	-10.8	
NB	V	336.000	6.1	15.2	3.0	0.0	-10.5	34.8	46.0	-11.2	
NB	H	300.000	12.9	13.6	2.9	0.0	-10.5	39.9	46.0	-6.1	
NB	H	288.000	11.0	13.3	2.8	0.0	-10.5	37.6	46.0	-8.4	
NB	H	310.000	8.6	13.9	2.9	0.0	-10.5	35.9	46.0	-10.1	
NB	H	352.000	7.5	16.3	3.1	0.0	-10.5	37.3	46.0	-8.7	
NB	H	360.000	6.4	16.5	3.2	0.0	-10.5	36.5	46.0	-9.5	
NB	H	384.000	7.1	16.8	3.3	0.0	-10.5	37.7	46.0	-8.3	
NB	H	274.100	9.1	13.0	2.7	0.0	-10.5	35.3	46.0	-10.7	
NB	H	281.500	6.9	13.2	2.8	0.0	-10.5	33.3	46.0	-12.7	
BB	H	436.000	8.1	16.9	3.6	0.0	-10.5	39.1	46.0	-6.9	
BB	H	466.300	1.6	17.8	3.7	0.0	-10.5	33.6	46.0	-12.4	
BB	H	498.800	6.1	18.4	3.8	0.0	-10.5	38.7	46.0	-7.3	
BB	H	600.000	5.5	20.5	4.3	0.0	-10.5	40.8	46.0	-5.2	
NB	H	698.100	1.4	22.2	4.8	0.0	-10.5	38.8	46.0	-7.2	
BB	H	732.200	1.8	22.7	4.9	0.0	-10.5	39.8	46.0	-6.2	
BB	H	1131.000	9.7	26.6	1.6	0.0	9.5	28.4	54.0	-25.6	1M
BB	H	1266.000	8.2	26.7	1.7	0.0	9.5	27.0	54.0	-27.0	1M

NB=Narrowband emissions, BB=Broadband emissions, P=Peak readings, 1M=resolution bandwidth used at these frequencies

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Parabolic Antenna

Radiated Emissions/ Interference
Radiated Emissions / Interference
Table: 2

Company: Raylink, Inc.
Model: 24020
Job No.: J20041993
Date: 03/01/01
Standard: FCC15
Class: B Group: None
Notes: Radiated scan at low, middle, and high channel

Tested by: Kouma Sinn
Location: Site 3C
Detector: Agilent Spectrum Analyzer
Antenna: HORN1 10-9-00 H3m
PreAmp: None
Cable(s): CBL009 1-18-00 216
Distance: 0.3 meters

Ant. Pol. (V/H)	Frequency MHz	Reading dB(uV)	Antenna Factor dB(1/m)	Cable Loss dB	Pre-amp Factor dB	Distance Factor dB	Net dB(uV/m)	Limit dB(uV/m)	Margin dB
Parabolic antenna									
Operated at 2480 MHz									
V	4960.000	9.4	35.7	11.0	0.0	15.5	40.6	54.0	-13.4
V	7440.000	11.3	38.8	13.4	0.0	15.5	48.0	54.0	-6.0
V	12400.000	6.6	41.7	17.9	0.0	20.0	46.2	54.0	-7.8
V	19840.000	-0.4	45.0	24.0	0.0	20.0	48.6	54.0	-5.4
V	22320.000	0.0	44.3	28.0	0.0	20.0	52.3	54.0	-1.7
Operated at 2441MHz									
V	4882.000	16.8	35.6	0.9	0.0	20.0	33.2	54.0	-20.8
V	7323.000	30.0	38.5	1.1	0.0	20.0	49.6	54.0	-4.4
V	12205.000	14.7	41.3	2.4	0.0	20.0	38.3	54.0	-15.7
V	19528.000	4.4	50.0	3.8	0.0	20.0	38.2	54.0	-15.8
Operated at 2402 MHz									
V	4804.000	12.1	35.4	0.9	0.0	20.0	28.4	54.0	-25.6
V	12010.000	14.8	40.8	2.3	0.0	20.0	38.0	54.0	-16.0
V	19216.000	4.5	49.2	3.7	0.0	20.0	37.5	54.0	-16.5
V	24020.000	4.5	45.8	4.7	0.0	20.0	35.0	54.0	-19.0

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12 dBi Rod Antenna

Date: 03/01/01
Standard: FCC15
Class: B Group: None
Notes:

Antenna: HORN1 10-9-00 H3m
PreAmp: None
Cable(s): CBL009 1-18-00 216
Distance: 3 meters

Ant. Pol. (V/H)	Frequency MHz	Reading dB(uV)	Antenna Factor dB(1/m)	Cable Loss dB	Pre-amp Factor dB	Distance Factor dB	Net dB(uV/m)	Limit dB(uV/m)	Margin dB
12 dBi Rod antenna									
Operated at 2480 MHz									
V	4960.00	9.4	35.7	11.0	0.0	15.5	40.6	54.0	-13.4
V	7440.00	11.3	38.8	13.4	0.0	15.5	48.0	54.0	-6.0
V	12400.00	6.6	41.7	17.9	0.0	20.0	46.2	54.0	-7.8
V	19840.00	-0.4	45.0	24.0	0.0	20.0	48.6	54.0	-5.4
V	22320.00	0.0	44.3	28.0	0.0	20.0	52.3	54.0	-1.7
Operated at 2441MHz									
V	4882.000	16.8	35.6	0.9	0.0	20.0	33.2	54.0	-20.8
V	7323.000	31.9	38.5	1.1	0.0	20.0	51.4	54.0	-2.6
V	12205.000	14.7	41.3	2.4	0.0	20.0	38.3	54.0	-15.7
V	19528.000	4.4	50.0	3.8	0.0	20.0	38.2	54.0	-15.8
Operated at 2402 MHz									
V	4804.000	12.1	35.4	0.9	0.0	20.0	28.4	54.0	-25.6
V	12010.000	14.8	40.8	2.3	0.0	20.0	38.0	54.0	-16.0
V	19216.000	4.5	49.2	3.7	0.0	20.0	37.5	54.0	-16.5
V	24020.000	4.5	45.8	4.7	0.0	20.0	35.0	54.0	-19.0

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17.2 dBi Long Panel Antenna

Radiated Emissions / Interference

Table 4

Company:	Raylink, Inc.	Tested by:	Kouma Sinn
Model:	24020	Location:	Site 3C
Job No.:	J20041993	Detector:	Agilent Spectrum Analyzer
Date:	03/01/01	Antenna:	HORN1 10-9-00 H3m
Standard:	FCC15	PreAmp:	None
Class:	B Group: None	Cable(s):	CBL009 1-18-00 216
Notes:		Distance:	3 meters

Ant. Pol. (V/H)	Frequency MHz	Reading dB(uV)	Antenna Factor dB(1/m)	Cable Loss dB	Pre-amp Factor dB	Distance Factor dB	Net dB(uV/m)	Limit dB(uV/m)	Margin dB
Tested 17.2 dBi Gain Long Panel Antenna									
Operated at 2480MHz									
V	4960.000	9.4	35.7	11.0	0.0	15.5	40.6	54.0	-13.4
V	7440.000	11.3	38.8	13.4	0.0	15.5	48.0	54.0	-6.0
V	12400.000	6.6	41.7	17.9	0.0	20.0	46.2	54.0	-7.8
V	19840.000	-0.4	45.0	24.0	0.0	20.0	48.6	54.0	-5.4
V	22320.000	0.0	44.3	28.0	0.0	20.0	52.3	54.0	-1.7
Operated at 2441MHz									
V	4882.000	16.8	35.6	0.9	0.0	20.0	33.2	54.0	-20.8
V	7323.000	30.0	38.5	1.1	0.0	20.0	49.6	54.0	-4.4
V	12205.000	14.7	41.3	2.4	0.0	20.0	38.3	54.0	-15.7
V	19528.000	4.4	50.0	3.8	0.0	20.0	38.2	54.0	-15.8
Operated at 2402 MHz									
V	4804.000	12.1	35.4	0.9	0.0	20.0	28.4	54.0	-25.6
V	12010.000	14.8	40.8	2.3	0.0	20.0	38.0	54.0	-16.0
V	19216.000	4.5	49.2	3.7	0.0	20.0	37.5	54.0	-16.5
V	24020.000	4.5	45.8	4.7	0.0	20.0	35.0	54.0	-19.0

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12 dBi Panel Antenna

Table: 5

Company:	Raylink, Inc.	Tested by:	Kouma Sinn
Model:	24020	Location:	Site 3C
Job No.:	J20041993	Detector:	Agilent Spectrum Analyzer
Date:	03/01/01	Antenna:	HORN1 10-9-00 H3m
Standard:	FCC15	PreAmp:	None
Class:	B Group: None	Cable(s):	CBL009 1-18-00 216
Notes:		Distance:	0.3 meters

Ant. Pol. (V/H)	Frequency MHz	Reading dB(uV)	Antenna Factor dB(1/m)	Cable Loss dB	Pre-amp Factor dB	Distance Factor dB	Net dB(uV/m)	Limit dB(uV/m)	Margin dB
Tested 12 dBi Gain Panel Antenna									
Operated at 2480 MHz									
V	4960.000	9.4	35.7	11.0	0.0	15.5	40.6	54.0	-13.4
V	7440.000	11.3	38.8	13.4	0.0	15.5	48.0	54.0	-6.0
V	12400.00	6.6	41.7	17.9	0.0	20.0	46.2	54.0	-7.8
V	19840.00	-0.4	45.0	24.0	0.0	20.0	48.6	54.0	-5.4
V	22320.00	0.0	44.3	28.0	0.0	20.0	52.3	54.0	-1.7
Operated at 2441 MHz									
V	4882.000	16.8	35.6	0.9	0.0	20.0	33.2	54.0	-20.8
V	7323.000	32.5	38.5	1.1	0.0	20.0	52.1	54.0	-1.9
V	12205.000	14.7	41.3	2.4	0.0	20.0	38.3	54.0	-15.7
V	19528.000	4.4	50.0	3.8	0.0	20.0	38.2	54.0	-15.8
Operated at 2402 MHz									
V	4804.000	12.1	35.4	0.9	0.0	20.0	28.4	54.0	-25.6
V	12010.000	14.8	40.8	2.3	0.0	20.0	38.0	54.0	-16.0
V	19216.000	4.5	49.2	3.7	0.0	20.0	37.5	54.0	-16.5
V	24020.000	4.5	45.8	4.7	0.0	20.0	35.0	54.0	-19.0

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Antenna Conducted

Table: 6

Company: Raylink, Inc.
Model: 24020
Job No.: J20041993
Date: 03/01/01
Standard: FCC Part 15, Section 15.247
Class: None Group: None
Notes: Antenna conducted measurement

Tested by: Kouma Sinn
Location: Site 3C
Detector: Agilent Spectrum Analyzer
Antenna: HORN1 10-9-00 H3M
Pre-Amp: None
Cables: CBL009 1-18-00
Distance: N/A Meter

Frequency (MHz)	Reading (dBm)	Cable Loss (dB)	Attenuator (dB)	Net Reading (dBm)	Limit (dBm)	Margin (dB)
2402.00	-11.0	0.46	30.0	19.5	N/A	N/A
4804.00	-86.5	1.28	30.0	-55.2	-0.5	-54.7
7206.00	-78.8	2.01	30.0	-46.8	-0.5	-46.3
9608.00	-83.2	5.10	30.0	-48.1	-0.5	-47.6
12010.00	-83.7	4.25	30.0	-49.4	-0.5	-48.9
14412.00	-79.6	2.62	30.0	-47.0	-0.5	-46.5
16814.00	-81.0	19.70	30.0	-31.3	-0.5	-30.8
19216.00	-81.2	23.36	30.0	-27.8	-0.5	27.3
21618.00	-79.7	30.00	30.0	-19.7	-0.5	-19.2
24020.00	-79.1	32.00	30.0	-17.1	-0.5	-16.6

Note: For all harmonic emissions, the spectrum analyzer's noise floor was recorded.

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Antenna Conducted

Table: 7

Company: Raylink, Inc.
Model: 24020
Job No.: J20041993
Date: 03/01/01
Standard: FCC Part 15, Section 15.247
Class: None Group: None
Notes: Antenna conducted measurement

Tested by: Kouma Sinn
Location: Site 3C
Detector: Agilent Spectrum Analyzer
Antenna: HORN1 10-9-00 H3M
Pre-Amp: None
Cables: CBL009 1-18-00
Distance: N/A Meter

Frequency (MHz)	Reading (dBm)	Cable Loss (dB)	Attenuator (dB)	Net Reading (dBm)	Limit (dBm)	Margin (dB)
2441.00	-10.5	0.41	30.0	19.9	N/A	N/A
4882.00	-87.2	1.19	30.0	-56.0	-0.1	-55.9
7323.00	-80.5	2.31	30.0	-48.2	-0.1	-48.1
9764.00	-83.6	4.87	30.0	-48.7	-0.1	-48.6
12205.00	-83.9	2.49	30.0	-51.4	-0.1	-51.3
14646.00	-79.3	1.20	30.0	-48.1	-0.1	-48.0
17087.00	-81.1	28.52	30.0	-22.6	-0.1	-22.5
19528.00	-80.6	27.18	30.0	-23.4	-0.1	-23.3
21969.00	-79.3	30.00	30.0	-19.3	-0.1	-19.2
24410.00	-78.7	32.00	30.0	-16.7	-0.1	-16.6

Note: For all harmonic emissions, the spectrum analyzer's noise floor was recorded.

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Antenna Conducted

Table: 8

Company: Raylink, Inc.
Model: 24020
Job No.: J20041993
Date: 03/01/01
Standard: FCC Part 15, Section 15.247
Class: None Group: None
Notes: Antenna conducted measurement

Tested by: Kouma Sinn
Location: Site 3C
Detector: Agilent Spectrum Analyzer
Antenna: HORN1 10-9-00 H3M
Pre-Amp: None
Cables: CBL009 1-18-00
Distance: N/A Meter

Frequency (MHz)	Reading (dBm)	Cable Loss (dB)	Attenuator (dB)	Net Reading (dBm)	Limit (dBm)	Margin (dB)
2480.00	-10.19	0.34	30.0	20.15	N/A	N/A
4960.05	-86.2	0.96	30.0	-55.2	0.15	-55.17
7440.50	-77.2	2.06	30.0	-45.2	0.15	-45.17
9920.00	-83.3	5.40	30.0	-47.9	0.15	-48.05
12400.00	-84.0	6.36	30.0	-47.6	0.15	-47.75
14880.00	-79.7	4.49	30.0	-45.2	0.15	-45.17
17360.00	-81.4	22.89	30.0	-28.5	0.15	-28.20
19840.00	-80.4	24.37	30.0	-25.6	0.15	-25.75
22320.00	-80.0	30.00	30.0	-20.0	0.15	-20.15
24800.00	-78.5	35.00	30.0	-13.5	0.15	-13.20

Note: For all harmonic emissions, the spectrum analyzer's noise floor were recorded.

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Conducted Emissions / Interference

Table: 9

Company: Raylink, Inc.
Model: 24020
Job No.: J20041993
Date: 03/01/01
Standard: FCC15
Class: B Group: None
Notes:
System Loss: Includes the Cable and LISN loss.

Tested by: Kouma Sinn
Location: Site 3C
Detector: HP 8542E
Cable(s): 3C,10 METER PRI
Limiter: no

Frequency MHz	Reading Line 2 dB(uV)	Reading Line 1 dB(uV)	Attenuator Factor dB	System Loss dB	Quasi-Peak Net dB(uV)	Quasi-Peak Limit dB(uV)	Quasi-Peak Margin dB
0.667	22.6	17.9	20.0	0.9	43.5	48.0	-4.5
1.663	24.7	21.0	20.0	0.9	45.6	48.0	-2.4
6.967	20.5	22.1	20.0	0.7	42.8	48.0	-5.2
18.020	24.2	12.2	20.0	0.4	44.6	48.0	-3.4
18.490	24.4	12.7	20.0	0.4	44.8	48.0	-3.2
24.000	27.9	27.9	20.0	0.1	48.0	48.0	+0.0

Note: All emissions were coming from the computer and not from the EUT. The EUT was completely removed from the computer to verify the emissions

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Radiated Emissions for a Modular Device

Intertek Testing Services

Radiated Emissions / Interference

Table: 10

Company: **Raylink**
Model: **24020**
Job No.: **J20041993**
Date: 05/03/01
Standard: FCC15
Class: B Group: None
Notes: Tested w/ Parabolic antenna high channel

Tested by: Candy L. Campbell
Location: Site 3C
Detector: HP 8542E
Antenna: LOG3 11-17-00 H10
PreAmp: None
Cable(s): 3C,10 METER PRIMARY
Distance: **10** meters

Abbreviations: nb - narrow band, bb - broadband, pk - peak measurement

Ant. Pol. (V/H)	Frequency MHz	Reading dB(uV)	Antenna Factor dB(1/m)	Cable Loss dB	Pre-amp Factor dB	Distance Factor dB	Net dB(uV/m)	Limit dB(uV/m)	Margin dB
V	48.000	16.0	9.4	1.1	0.0	-10.5	37.0	40.0	-3.0
V	50.600	17.9	8.6	1.1	0.0	-10.5	38.0	40.0	-2.0
V	52.400	16.9	8.3	1.1	0.0	-10.5	36.7	40.0	-3.3
V	68.699	18.0	6.6	1.3	0.0	-10.5	36.3	40.0	-3.7
V	192.000	15.0	10.0	2.3	0.0	-10.5	37.7	43.5	-5.8
V	274.100	11.0	13.0	2.7	0.0	-10.5	37.1	46.0	-8.9
V	281.500	8.6	13.2	2.8	0.0	-10.5	35.0	46.0	-11.0
V	288.000	13.7	13.3	2.8	0.0	-10.5	40.3	46.0	-5.7
V	310.000	10.0	13.9	2.9	0.0	-10.5	37.3	46.0	-8.7
V	330.000	10.7	14.8	3.0	0.0	-10.5	38.9	46.0	-7.1
V	352.000	11.8	16.3	3.1	0.0	-10.5	41.7	46.0	-4.3
V	360.000	9.1	16.5	3.2	0.0	-10.5	39.2	46.0	-6.8
V	384.000	10.4	16.8	3.3	0.0	-10.5	41.0	46.0	-5.0
V	436.000	8.4	16.9	3.6	0.0	-10.5	39.4	46.0	-6.6
V	466.000	7.7	17.8	3.7	0.0	-10.5	39.7	46.0	-6.3
V	498.000	5.8	18.4	3.8	0.0	-10.5	38.4	46.0	-7.6
V	698.000	6.0	22.2	4.8	0.0	-10.5	43.4	46.0	-2.6
V	732.000	5.5	22.7	4.9	0.0	-10.5	43.5	46.0	-2.5
H	48.000	17.6	9.4	1.1	0.0	-10.5	38.6	40.0	-1.4
H	50.600	10.1	8.6	1.1	0.0	-10.5	30.2	40.0	-9.8
H	52.400	10.0	8.3	1.1	0.0	-10.5	29.8	40.0	-10.2
H	68.699	12.0	6.6	1.3	0.0	-10.5	30.3	40.0	-9.7
H	192.000	17.9	10.0	2.3	0.0	-10.5	40.6	43.5	-2.9
H	281.500	11.0	13.2	2.8	0.0	-10.5	37.4	46.0	-8.6
H	288.000	16.3	13.3	2.8	0.0	-10.5	42.9	46.0	-3.1
H	310.000	9.1	13.9	2.9	0.0	-10.5	36.4	46.0	-9.6
H	336.000	16.0	15.2	3.0	0.0	-10.5	44.7	46.0	-1.3
H	352.000	11.0	16.3	3.1	0.0	-10.5	40.8	46.0	-5.2
H	360.000	12.3	16.5	3.2	0.0	-10.5	42.4	46.0	-3.6
H	384.000	11.6	16.8	3.3	0.0	-10.5	42.2	46.0	-3.8
H	436.000	13.0	16.9	3.6	0.0	-10.5	44.0	46.0	-2.0
H	466.000	11.2	17.8	3.7	0.0	-10.5	43.2	46.0	-2.8
H	498.000	6.5	18.4	3.8	0.0	-10.5	39.1	46.0	-6.9
H	698.000	5.4	22.2	4.8	0.0	-10.5	42.8	46.0	-3.2
H	732.000	5.7	22.7	4.9	0.0	-10.5	43.7	46.0	-2.3

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Radiated Emissions for a Modular Device

Intertek Testing Services

Radiated Emissions / Interference

Table: 1

Company:	**Raylink**	Tested by:	Candy L. Campbell
Model:	**24020**	Location:	Site 3C
Job No.:	**J20041993**	Detector:	HP 8593A
Date:	05/03/01	Antenna:	LOG3 11-17-00 H10
Standard:	FCC15	PreAmp:	PRE8 9-26-00
Class:	B Group: None	Cable(s):	CBLSHF101, CBLSHF 102
Notes:		Distance:	**3** meters

Abbreviations: nb - narrow band, bb - broadband, pk - peak measurement

Ant. Pol. (V/H)	Frequency MHz	Reading dB(uV)	Antenna Factor dB(1/m)	Cable Loss dB	Pre-amp Factor dB	Distance Factor dB	Net dB(uV/m)	Limit dB(uV/m)	Margin dB
H	1002.500	34.8	26.6	2.5	22.0	0.0	41.9	54.0	-12.1
H	1103.500	31.5	25.6	2.7	22.0	0.0	37.7	54.0	-16.3
H	1169.500	30.3	26.7	2.9	22.1	0.0	37.9	54.0	-16.1
H	1696.750	32.0	28.9	3.5	22.2	0.0	42.2	54.0	-11.8
V	1002.500	37.1	26.6	2.5	22.0	0.0	44.2	54.0	-9.8
V	1103.500	32.3	25.6	2.7	22.0	0.0	38.5	54.0	-15.5
V	1135.500	30.9	26.3	2.7	22.0	0.0	37.8	54.0	-16.2
V	2130.028	32.6	29.4	3.6	22.3	0.0	43.3	54.0	-10.7

Scanned from 1GHz to 24GHz

Please note that during testing the EUT was installed directly in the host computer. There was not an extention board present. In order to prevent the shielding efectiveness of the computers chassis the Motherboard, power supply and drives were removed from the host chassis and places directly on the table top.

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XII - Duty Cycle (Average Factor)

Due to the high duty cycle, an average factor was not applied to emissions.

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XII - Bandwidth

The plots on the following page show the fundamental emission when modulated. Bandwidth is measured 20 dB below the peak carrier. Resolution bandwidth is chosen to be much less than the bandwidth limit but not below 10 kHz.

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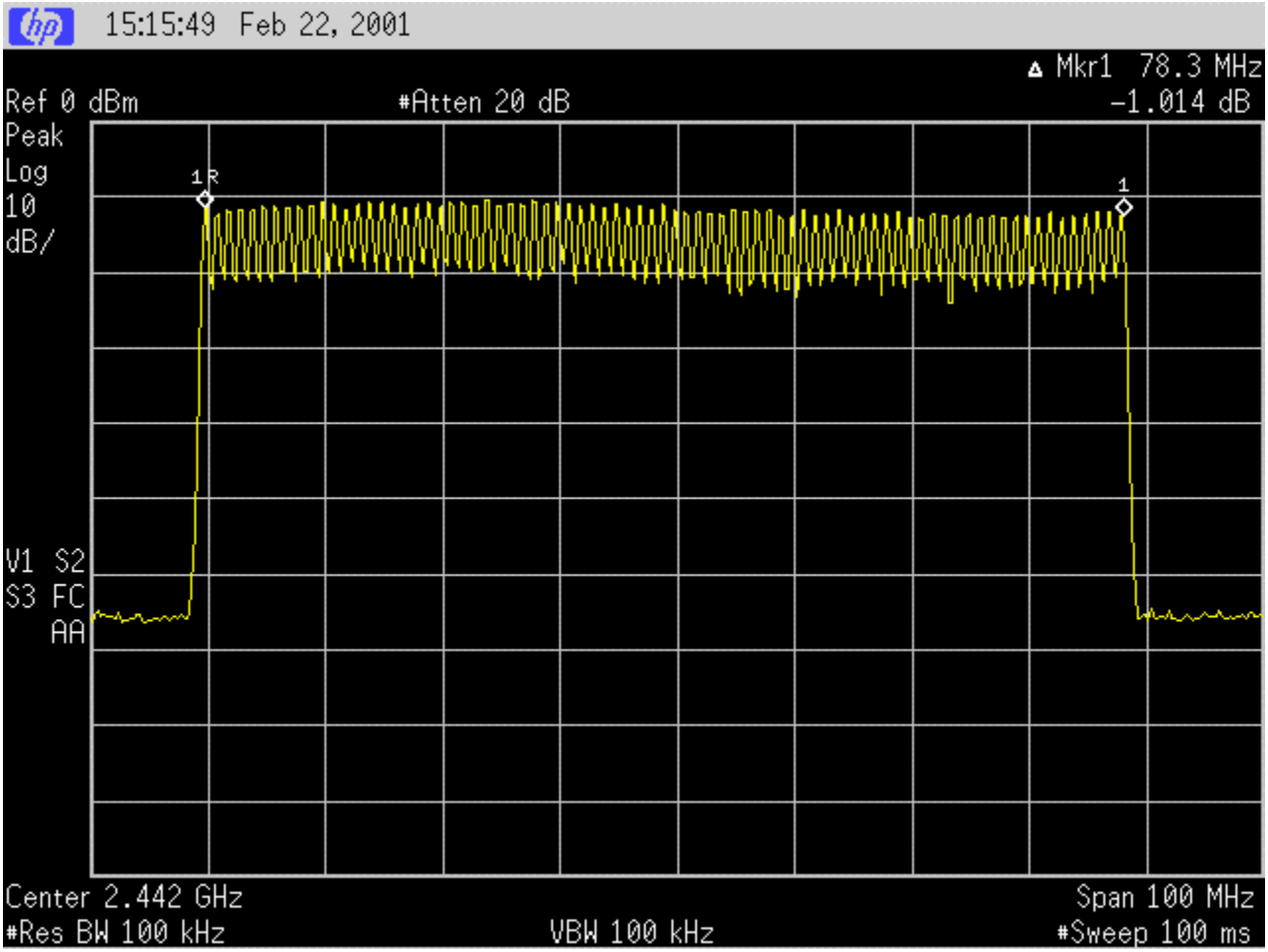
Full Bandwidth



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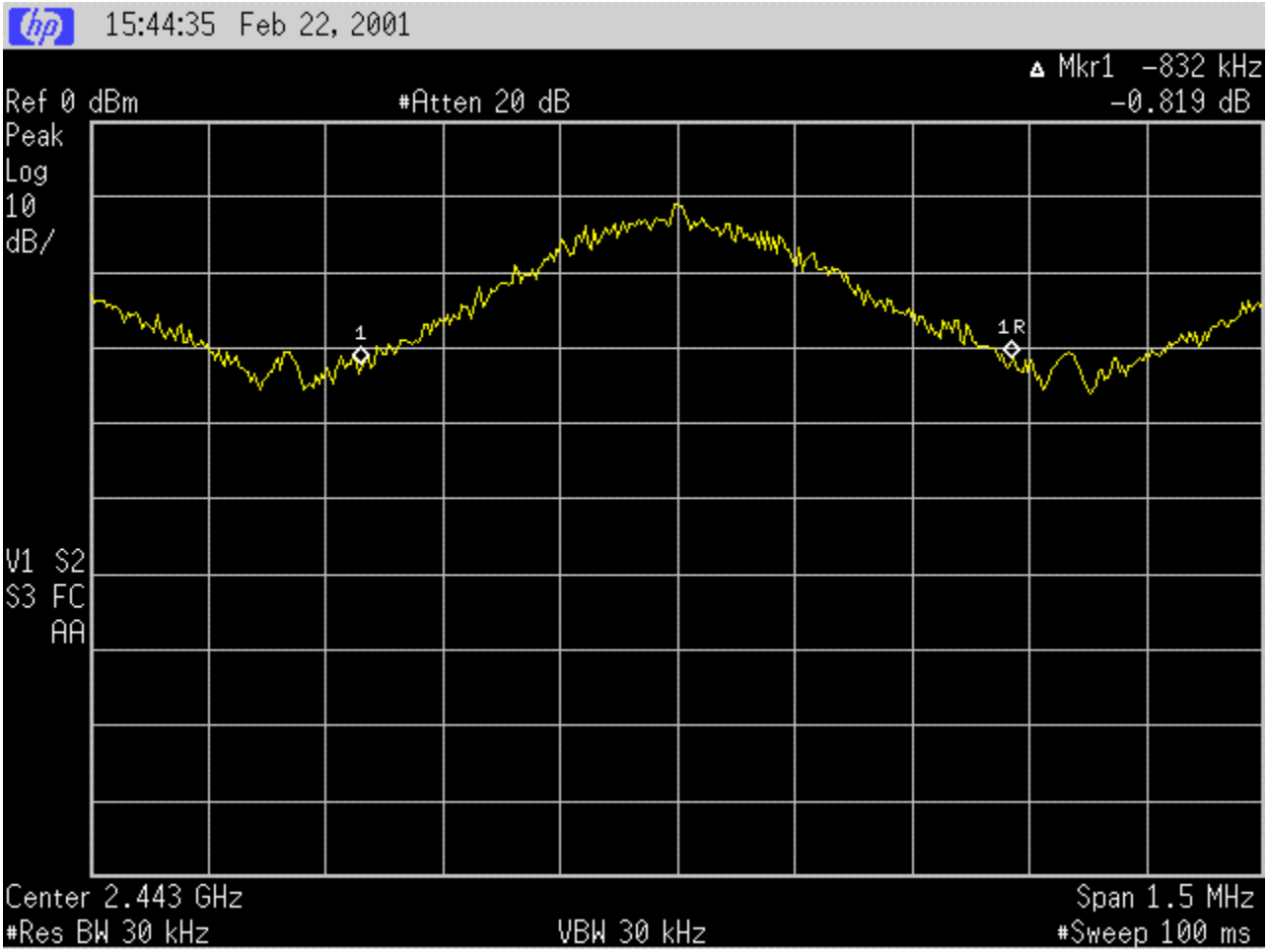
Channel Bandwidth While The Unit Hops



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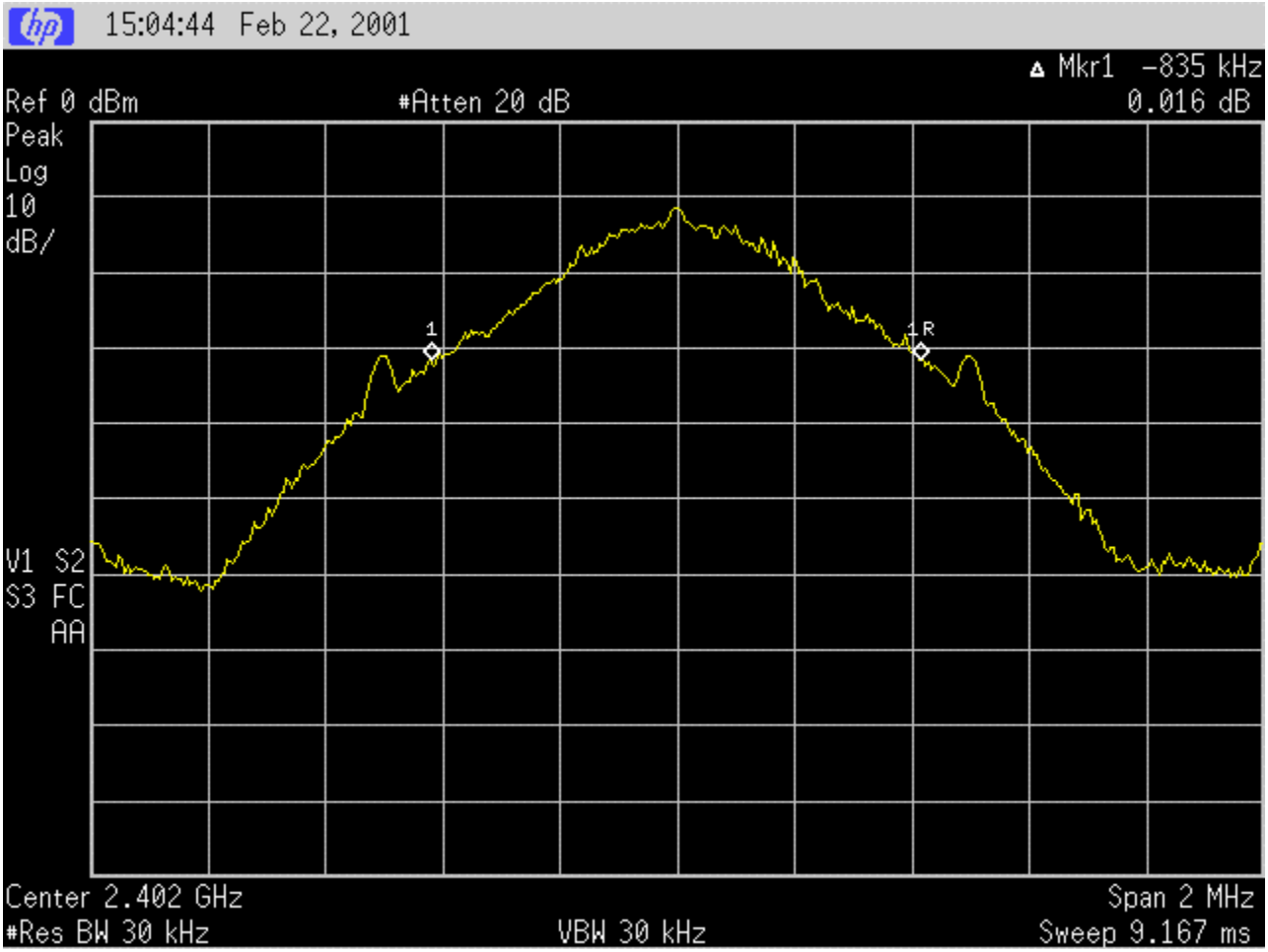
Channel Bandwidth At 2402 MHz



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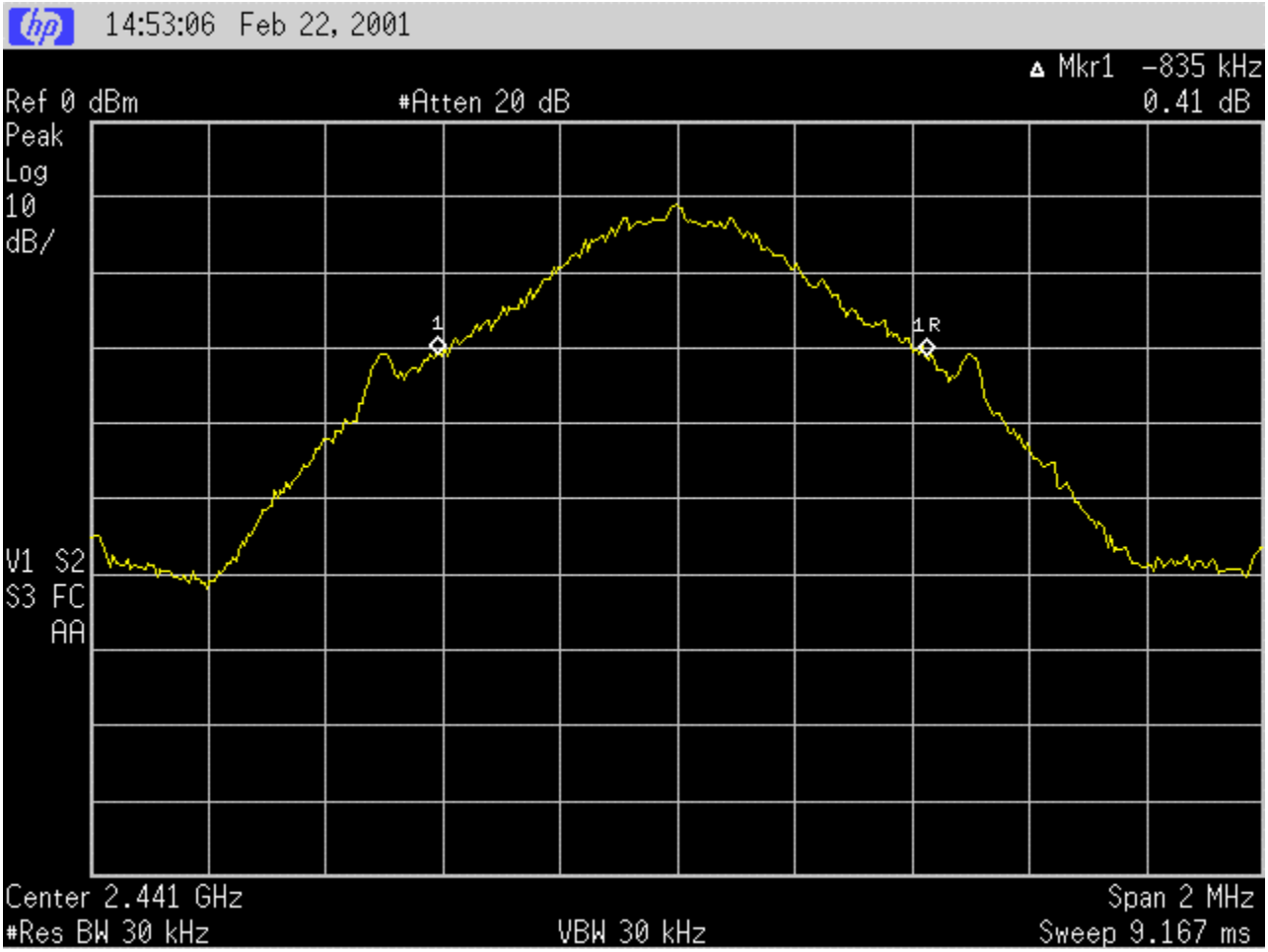
Channel Bandwidth At 2441 MHz



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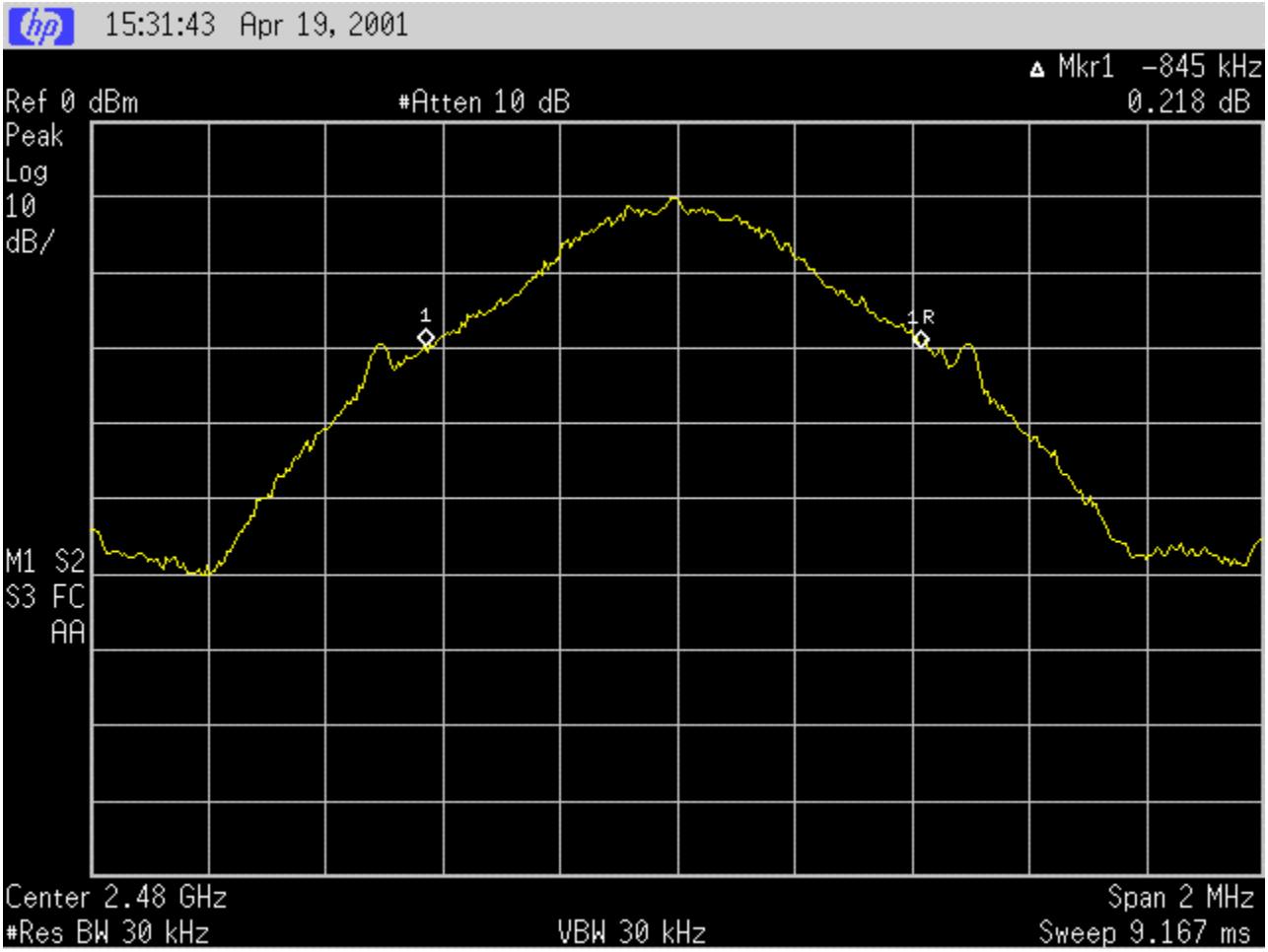
Channel Bandwidth At 2480 MHz



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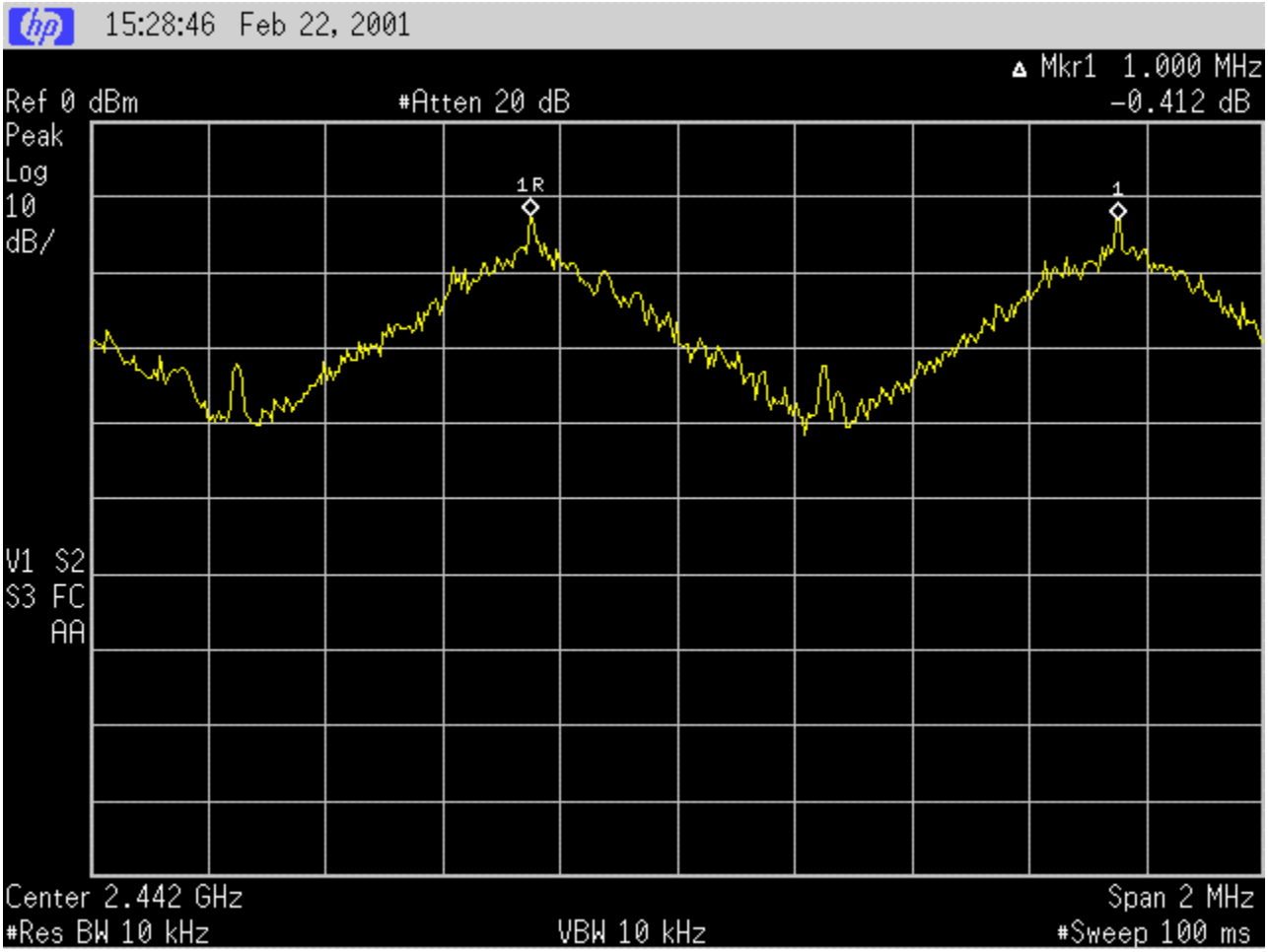
Channel Separation



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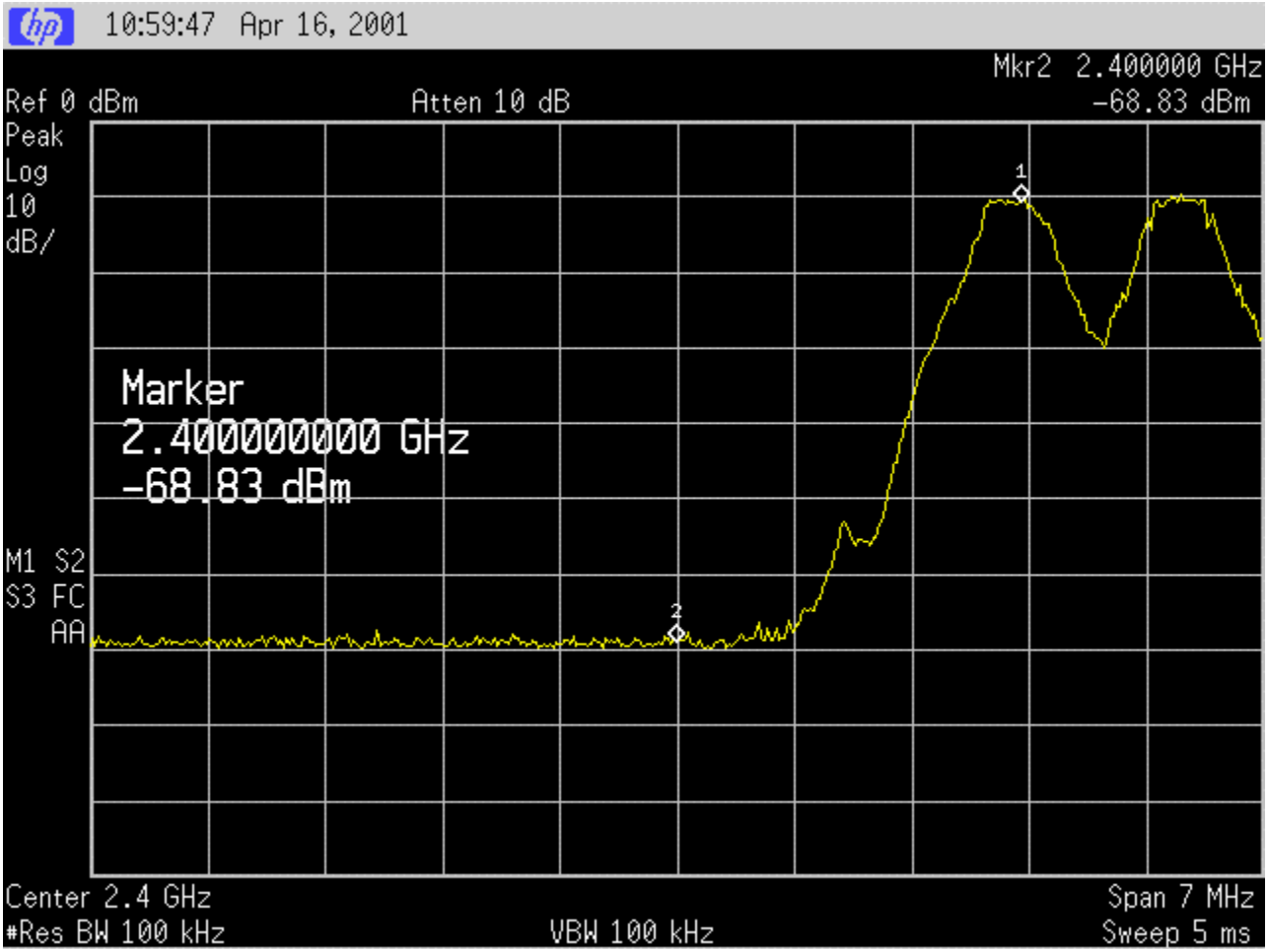
XIV- Band Edge Plot

The plots below show the lower and upper band edge of the transmitting signal.

Lower Channel Band Edge



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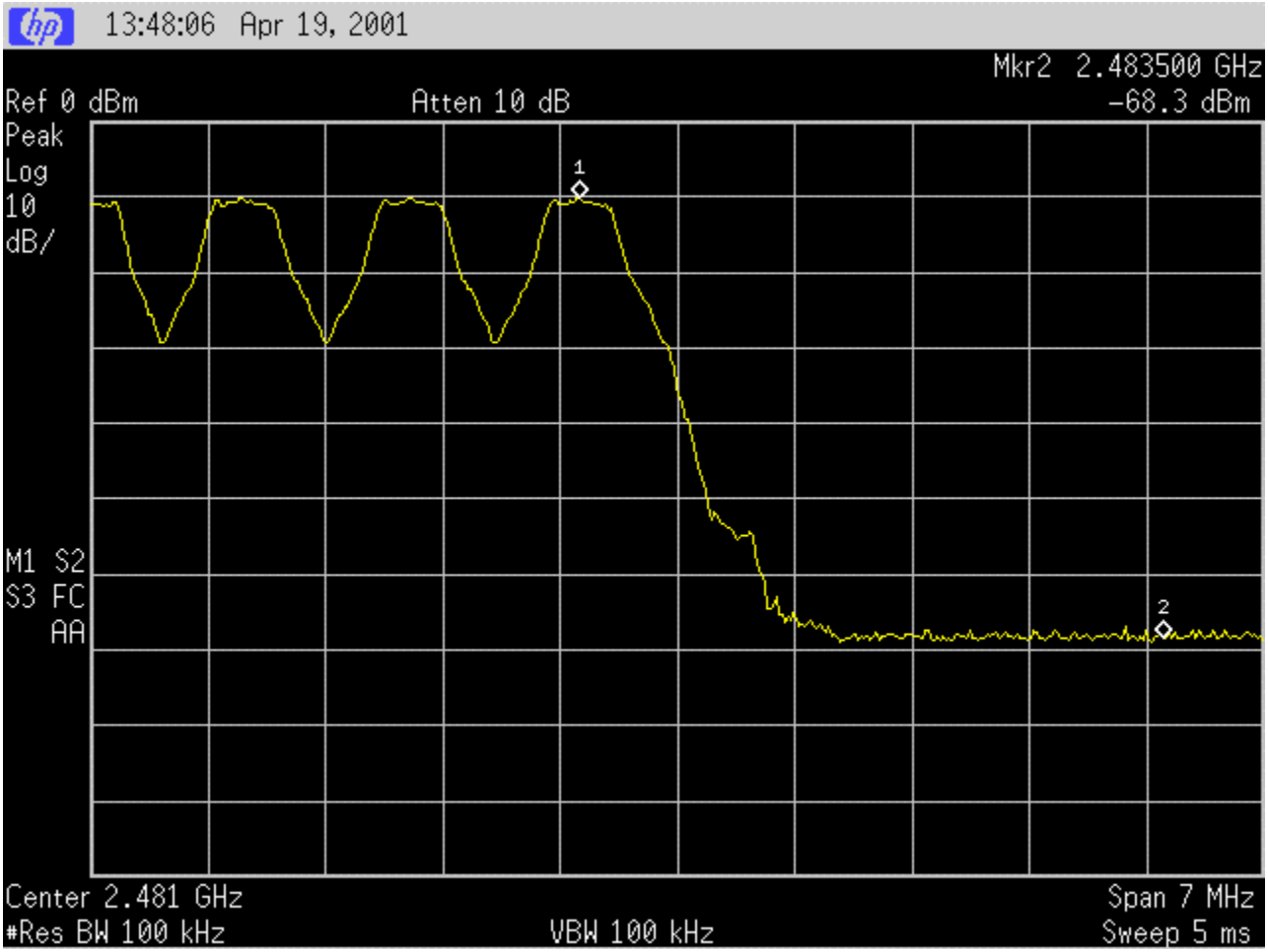
Upper Channel Band Edge



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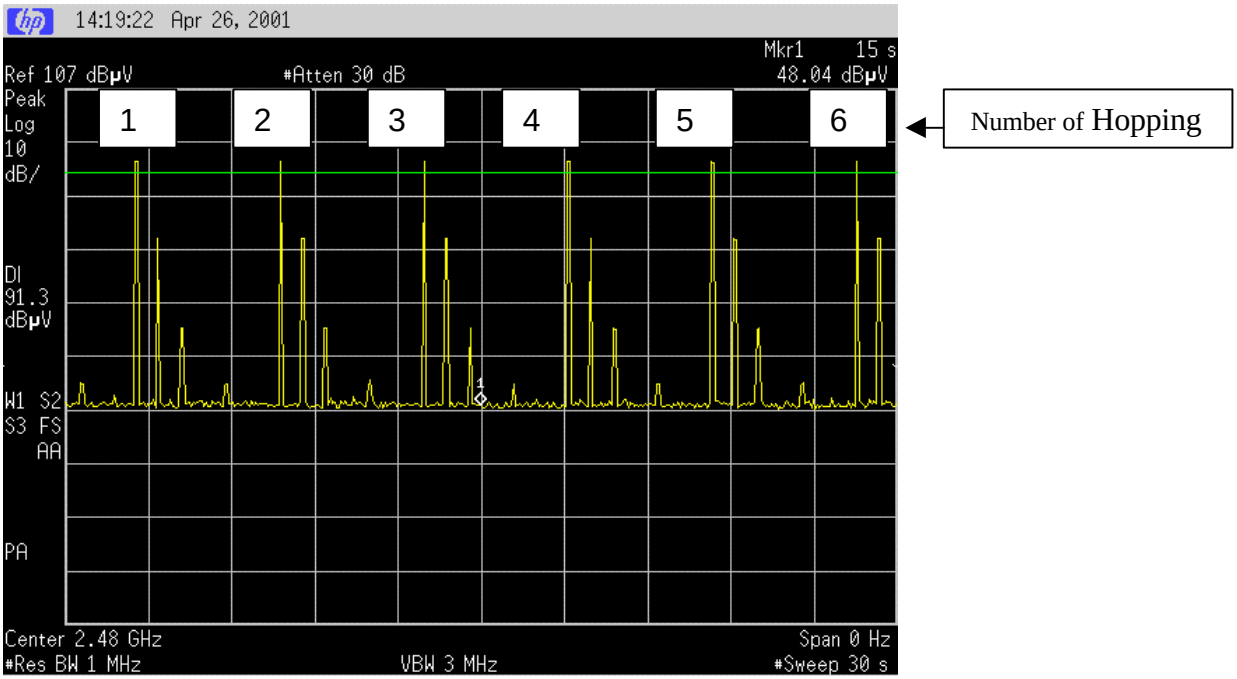
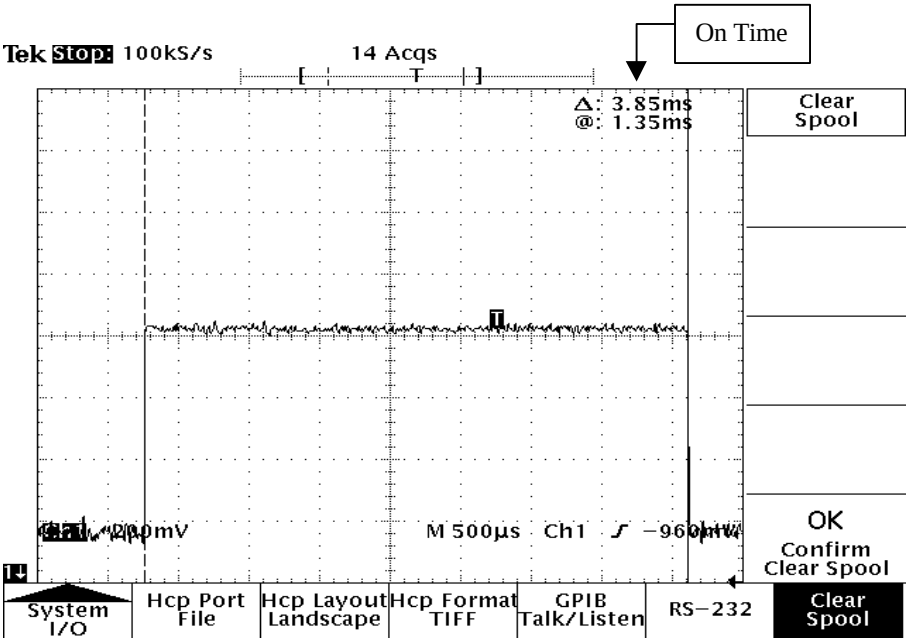
XV-Dwell Time





Dwell Time Calculation:
Dwell Time = (Number of hopping) X (on time)
= (6)X (3.85 ms)
= 23.1 ms

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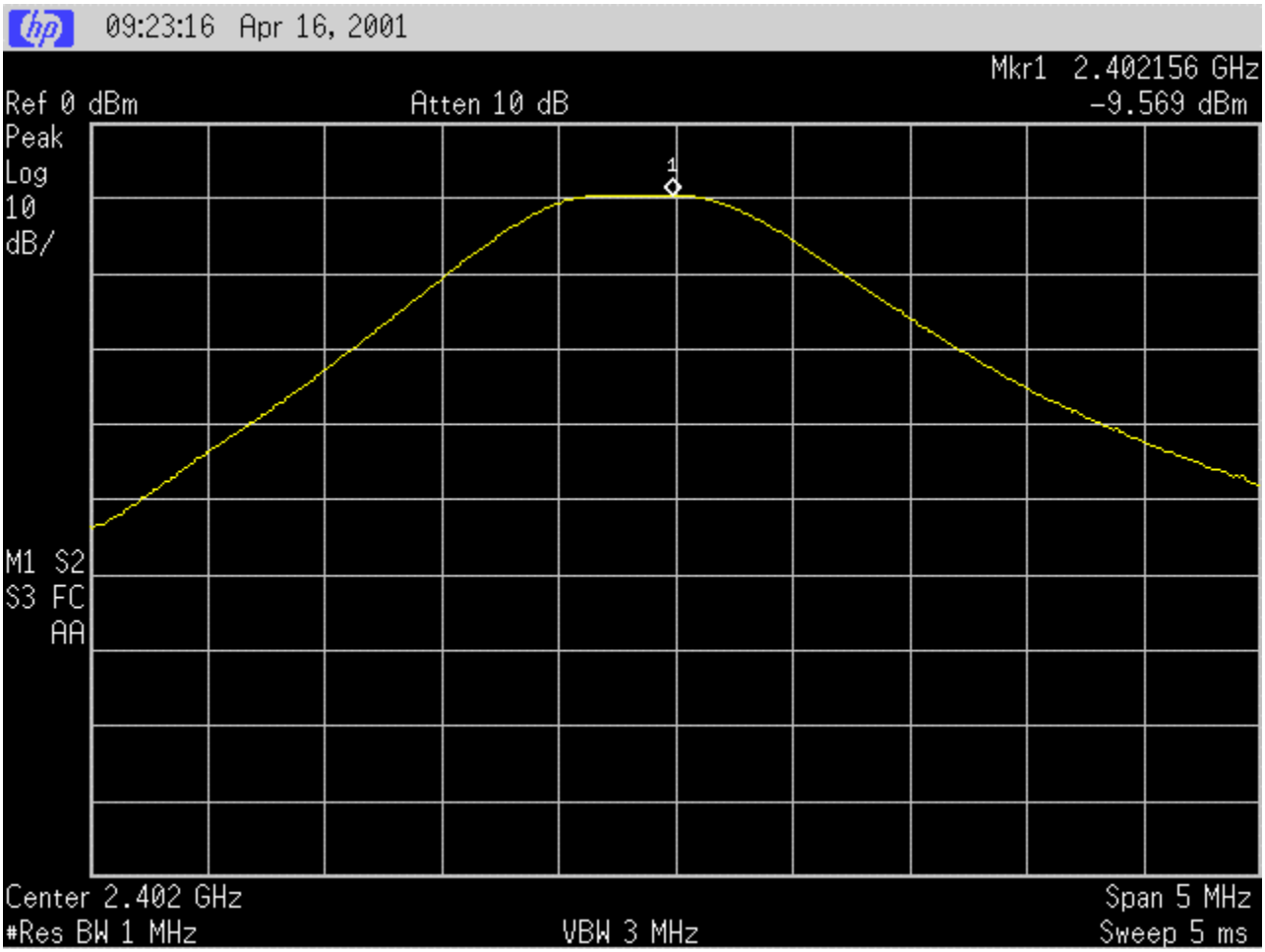
XVI- Power Measurement

Power measurement at 2402 MHz



Net Power = -9.569 dBm + 0.46 dB + 30 dB
= 20.891 dBm

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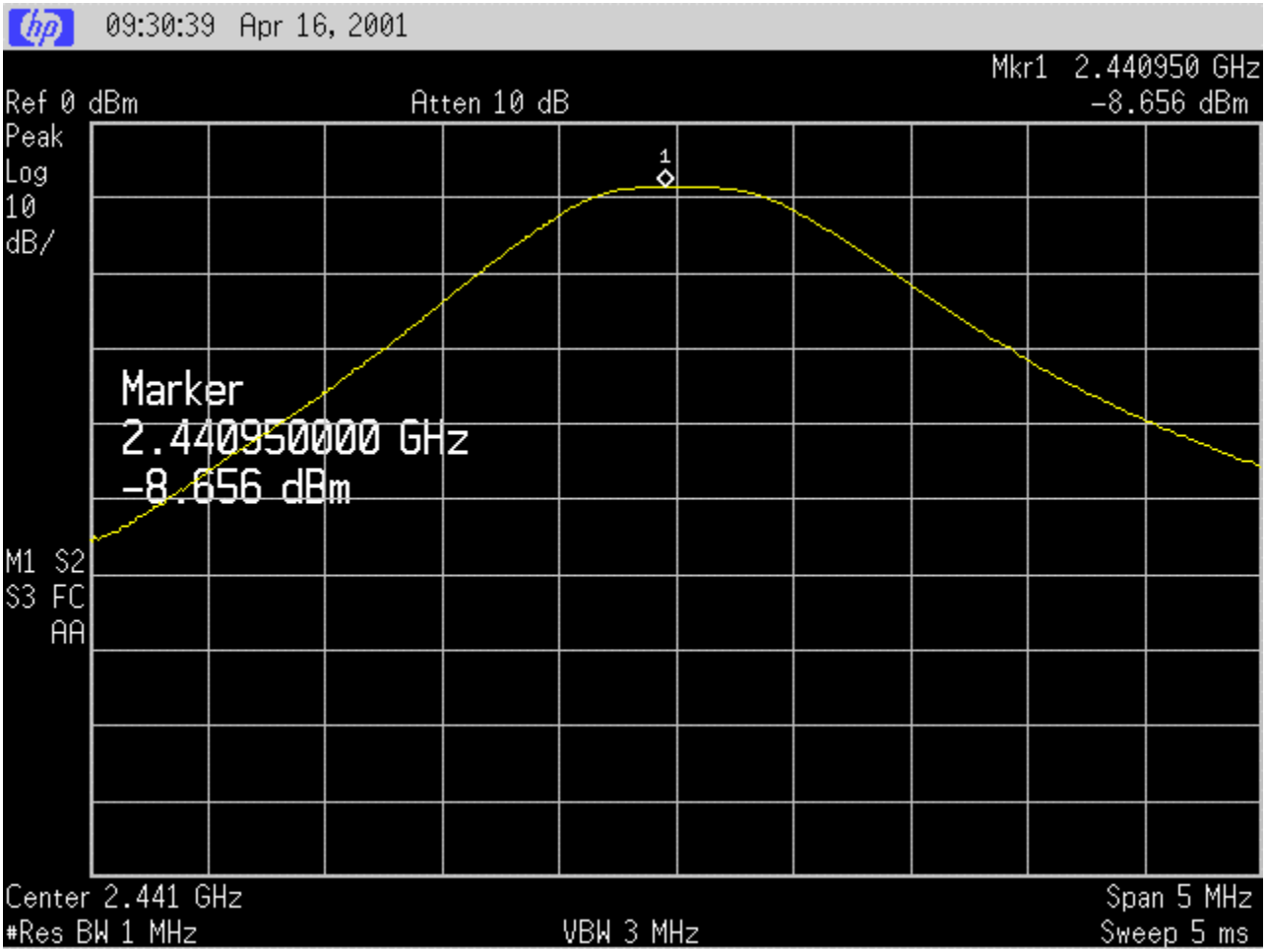
Power Measurement at 2441 MHz



Net Power = -8.656 dBm + 0.41 dB + 30 dB
= 21.754 dBm

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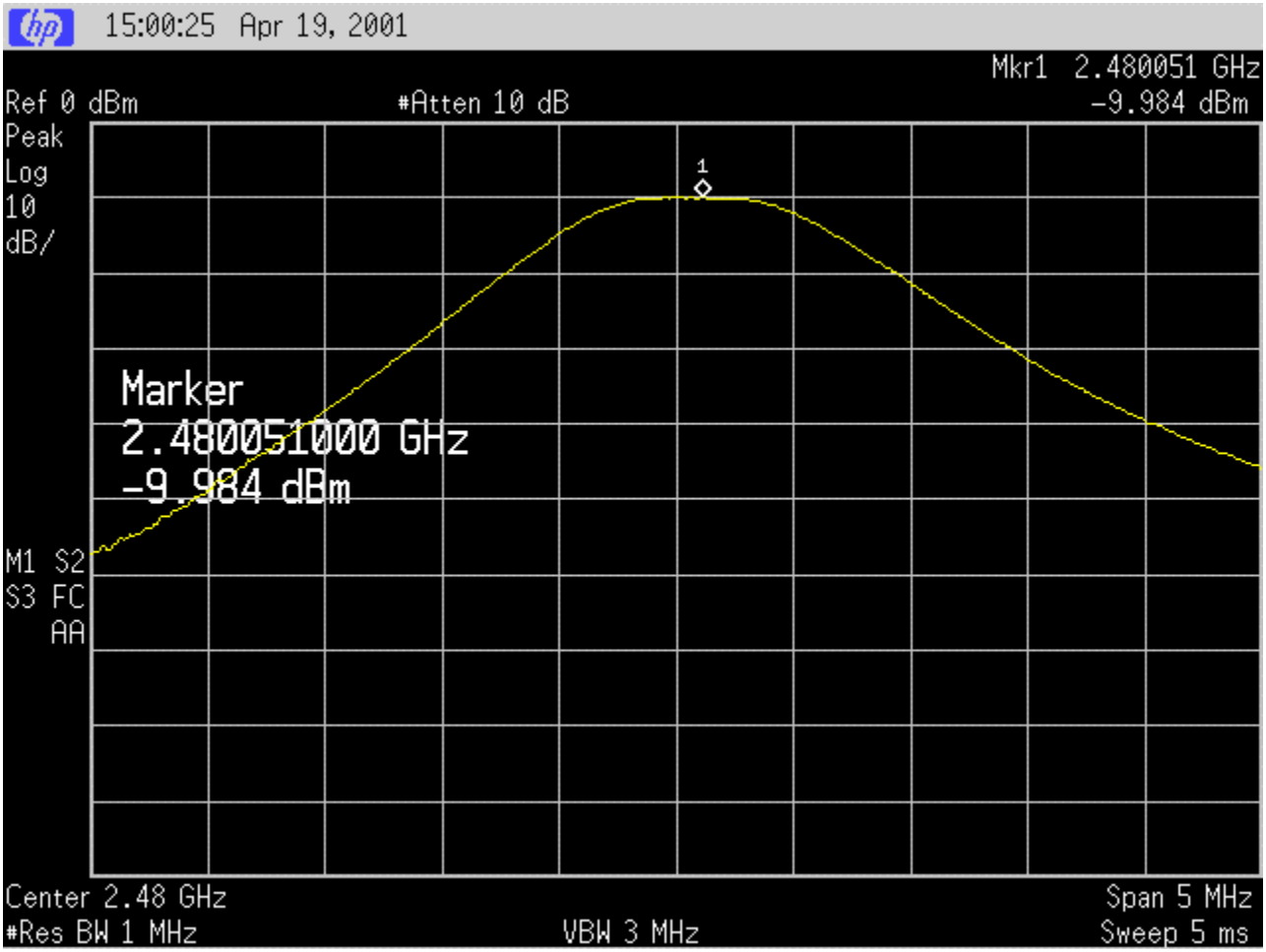
Power Measurement at 2480 MHz



Net Power = -9.984 dBm + 0.34 dB + 30 dB
= 20.356 dBm

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