Engineering and Testing for EMC and Safety Compliance

APPLICATION FOR FCC CERTIFICATION
DIRECT SEQUENCE SPREAD SPECTRUM TRANSMITTER

Part 15 Unlicensed Modular Transmitter Approval (DA00-1407 June 26, 2000)

CISCO Systems, Inc.
3875 Embassy Parkway
Suite 350
Akron, OH 44333
330-664-7362 (Jim Nicholson)

Model: AIR-MPI352
FCC ID:LDK102042

February 28, 2001

STANDARDS REFERENCED FOR THIS REPORT	
PART 2: 1999	FREQUENCY ALLOCATIONS AND RADIO TREATY MATTERS; GENERAL RULES AND REGULATIONS
PART 15: 1999	RADIO FREQUENCY DEVICES
FCC 97-114	GUIDANCE ON MEASUREMENTS FOR DIRECT SEQUENCE SPREAD SPECTRUM SYSTEMS
ANSI C63.4-1992	STANDARD FORMAT MEASUREMENT/TECHNICAL REPORT PERSONAL COMPUTER AND PERIPHERALS
RSS-210, Issue 3: 2000	LOW POWER LICENCE-EXEMPT RADIOCOMMUNICATION DEVICES (ALL FREQUENCY BANDS)
RSS-102, Issue 1: 1999	EVALUATION PROCEDURE FOR MOBILE AND PORTABLE RADIO TRANSMITTERS

FCC Rules Parts	Frequency Range	Output Power (W)	Freq. Tolerance	Emission Designator
Part 15.247	2412 to 2462 MHz	0.109		
Canadian Sections	**Frequency Range**	**Output Power (W)**	**Freq. Tolerance**	**Emission Designator**
6.2.2 (o)	2412 to 2462 MHz	0.109		

This report concerns (check one): **Original Grant:** X **Class II Change:**
Equipment Type: PCI Board

Deferred grant requested per 47 CFR 0.457 (d) (1) (ii) **Yes:** **No:** X
If yes, defer until: ________________

Company name agrees to notify the Commission by: ________(date) of the intended date of announcement of the product so that the grant can be issued on that date.

Transition Rules Request per 15.37? Yes: **No:** X
If no, assumed Part 15, subpart B for unintentional radiators - the new 47 CFR. [10-1-90 Edition] provision.

REPORT PREPARED BY:

EMC Engineer: **Rachid Sehb** **Signature:** ____________

Supervising Engineer: Desmond A. Fraser **Signature:** ____________

Document Number:2001041

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1 INTRODUCTION

The following Application for FCC Certification for a Direct Sequence Spread Spectrum transmitter is prepared on behalf of Cisco System in accordance with Part 15.247 of the Federal Communications Commissions. The Equipment Under Test (EUT) was the **AIR-MPI352**, **FCC ID: LDK102042**. The test results reported in this document relate only to the item that was tested. The afore mentioned device fulfills the requirement for a Part 15 Unlicensed Modular Transmitter per FCC public notice DA 00-1407 released in June 26, 2000.

All measurements contained in this Application were conducted in accordance with ANSI C63.4 Methods of Measurement of Radio Noise Emissions, 1992. The instrumentation utilized for the measurements conforms to the ANSI C63.4 standard for EMI and Field Strength Instrumentation. Some accessories are used to increase sensitivity and prevent overloading of the measuring instrument. These are explained in the appendix of this report. Calibration checks are performed regularly on the instruments, and all accessories including the high pass filter, preamplifier and cables.

1.1 RELATED SUBMITTAL (S)/GRANT (S)

This is an original application for certification.

1.2 TEST METHODOLOGY

Both conducted and radiated testing were performed according to the procedures in ANSI C63.4 1992. Radiated testing was performed at an antenna to EUT distance of 3 meters. Emissions above 1 GHz were video averaged.

1.3 TEST FACILITY

The open area test site and conducted measurement facility used to collect the radiated data is located on the parking lot of Rhein Tech Laboratories, Inc. 360 Herndon Parkway, Suite 1400, Herndon, Virginia 20170. This site has been fully described in a report dated March 3, 1994, submitted to and approved by the Federal Communication Commission to perform AC line conducted and radiated emissions testing (ANSI C63.4 1992).

1.4 EMISSIONS EQUIPMENT LIST

RTL Asset Number	Manufacturer	Model	Part Type	Serial Number	Calibration due date
900969	Hewlett Packard	85650A	Quasi-Peak Adapter (30 Hz – 40 GHz)	2412A00414	03/23/01
900929	Hewlett Packard	85650A	Quasi-Peak Adapter (30 Hz – 40 GHz)	2811A01276	03/28/01
900901	Hewlett Packard	85650A	Quasi-Peak Adapter (30 Hz – 40 GHz)	3145A01599	11/02/01
900339	Hewlett Packard	85650A	Quasi-Peak Adapter (30 Hz – 40 GHz)	2521A00743	03/27/01
900042	Hewlett Packard	85650A	Quasi-Peak Adapter (30 Hz – 40 GHz)	2521A01032	11/05/01
900924	Amplifier Research	75A220	Amplifier (10 kHz – 220 MHz)		N/A
900933	Hewlett Packard	11975A	Power Amplifier (2 - 8 GHz)	2304A00348	11/15/01
901067	Hewlett Packard	8903B	Audio Analyzer	2303A00307	06/28/01
901055	Hewlett Packard	8901A Opt. 002-003	Modulation Analyzer	2545A04102	06/08/01
900718	Voltech	PM3000A	Power Analyzer	6836-002-10	11/08/01
900397	Associated Research, Inc.	6554SA	Electrical Safety Compliance Analyzer	940281	11/08/01
900926	Hewlett Packard	8753D	RF Vector Network Analyzer	3410A09659	03/28/01
901089	Hewlett Packard	HP875ET	Transmission/Reflection Network Analyzer	US39170052	N/A
900968	Hewlett Packard	8567A	Spectrum Analyzer (10 kHz – 1.5 GHz)	2602A00160	03/23/01
900903	Hewlett Packard	8567A	Spectrum Analyzer (10 kHz – 1.5 GHz)	2841A00614	11/02/01
900897	Hewlett Packard	8567A	Spectrum Analyzer (10 kHz – 1.5 GHz)	2727A00535	11/08/01
900931	Hewlett Packard	8566B	Spectrum Analyzer (100 Hz – 22 GHz)	3138A07771	03/27/01
900912	Hewlett Packard	8568A	RF Spectrum Analyzer (100 Hz – 1.5 GHz)	2634A02704	08/02/01
900824	Hewlett Packard	8591E	RF Spectrum Analyzer (9 KHz – 1.8 GHz)	3710A06135	11/14/01
900724	ARA	LPB-2520	Log Periodic / Biconical Antenna (25-1000 MHz)	1037	2/1/01
900725	ARA	LPB-2520	Log Periodic / Biconical Antenna (25-1000 MHz)	1036	07/12/01
900967	A.H. Systems	TDS-206/535-1 through TDS-206/535-4	Tuned Dipole set (30 – 1000 MHz)	126, 128, 129, 132	12/15/00
900154	Compliance Design	Roberts Dipole	Adjustable Elements Dipole antenna (30-1000MHz)	N/A	7/26/01
900814	Electro-Metrics	RGA-60	Double Ridges Guide Antenna (1-18 GHz)	2310	2/26/01
900081	EMCO	3146	Log-Periodic Antenna (200-1000 MHz)	1850	
900800	EMCO	3301B	Active Monopole (Rod antenna) (30 Hz – 50 MHz)	9809-4071	05/02/01
900151	Rohde@ Schwarz	HFH@-Z2	Loop Antenna (9kHz-30 MHz)	82825/019	05/26/01
900791	Schaffner –Chase	CSL6112	Bilog antenna (30 MHz – 2GHz)	2099	2/22/01
901053	Schaffner –Chase	CBL6112B	Bilog Chase antenna (200 MHz – 2 GHz)	2648	05/24/01
900060	Hewlett Packard	86634B	Auxiliary Section for External Pulse Modulator	1314A02913	11/08/01
901041	ACO Pacific	511E	Sound Level Calibrator	028751	In calibration
900970	Hewlett Packard	85662A	Spectrum Analyzer Display	254211239	03/23/01
900930	Hewlett Packard	85662A	Spectrum Analyzer Display	3144A20839	03/28/01
900911	Hewlett Packard	85662A	Spectrum Analyzer Display	2542A12739	08/02/01
900902	Hewlett Packard	85662A	Spectrum Analyzer Display	2848A17585	11/02/01
900896	Hewlett Packard	85662A	Spectrum Analyzer Display	2816A16471	11/02/01

RTL Asset Number	Manufacturer	Model	Part Type	Serial Number	Calibration due date
900914	Hewlett Packard	8546OA	RF Filter Section, (100 KHz to 6.5 GHz)	3330A00107	11/07/01
901057	Hewlett Packard	3336B	Synthesizer/Level Generator	2514A02585	06/21/01
900059	Hewlett Packard	8660C	Signal Generator (9 KHz – 3200 MHz)	1947A02956	11/08/01
900960	Hewlett Packard	8444A	Tracking Generator (0.5 –1500MHz)	2325A07827	03/08/01
900917	Hewlett Packard	8648C	Synthesized. Signal Generator (9 KHz – 3200 MHz)	3537A01741	03/28/01
900821	Hewlett Packard	33120A	15 MHz Function / Arbitrary Waveform Generator	US36029992	11/14/01
900059	Hewlett Packard	8660C	Synthesized. Signal Generator (9 kHz –3200 MHz)	1947A02956	11/08/01
900560	Haefely	PESD 1600	ESD Generator	H 703146	10/05/01
900099	Marconi	52022-910E	Signal Generator (10 kHz – 1 GHz)	119044-189	11/14/01
900195	Tektronix	CFG280	Function Generator (0.1 Hz – 11 MHz)	TW12167	N/A
900927	Tektronix	ASG 100	Audio Signal Generator	B03274 V2.3	N/A
900935	Wavetek	3510B	Signal Generator	5372160	03/28/00
900660	Philips	PM5418TDS	TV Generator	LO 604891	11/21/01
900369	Philips	PM5418TDS	TV Generator	LR81436C	N/A
900268	Taylor	5565	Hygrometer / Thermometer	N/A	09/05/01
901056	Hewlett Packard	8954A, Opt.H03	Transceiver Interface	2924A00830	06/02/01
901088	Hewlett Packard	8954A	Transceiver Interface	2146A00139	07/28/01
901082	AFJ International	AFJ LS16	LISN (9 kHz – 30 MHz)	16010020081	06/16/01
901083	AFJ International	AFJ LS16	LISN (9 kHz – 30 MHz)	16010020082	06/16/01
901084	AFJ International	AFJ LS16	LISN (9 kHz – 30 MHz)	16010020080	06/16/01
901090	Bajog electronic	4V-100/200	LISN (150 kHz – 30 MHz)	00-44-007	08/03/01
900726	Solar	7225-1	LISN	N/A	03/29/01
900727	Solar	7225-1	LISN	N/A	03/29/01
900078	Solar	7225-1	LISN	N/A	03/29/01
900077	Solar	7225-1	LISN	N/A	03/29/01
901054	Hewlett Packard	HP 3586B	Selective Level Meter	1928A01892	06/08/01
900770	Hewlett Packard	437B	Power Meter	2949A02966	In cal.
900793	Hewlett Packard	432A	Thermistor Power Meter	1848a22632	N/A
900126	Hewlett Packard	11970A	Harmonic Mixer (26-40 GHz)	2332A01199	11/10/02
900396	Hewlett Packard	11970K	Harmonic Mixer (18-26 GHz)	2332A00563	11/00/02
900921	Haefely	IP 6.2	Coupling Network	083-334-13	11/10/01
900918	Voltech	IEC Standard 555	Reference Impedance Network (rented)	7701	11/08/01
900061	Hewlett Packard	86603A	RF Plug-in (1 to 2600 MHz)	2221A02967	11/08/01
900160	Pacific	112-AMX	AC Power Source (rented)	0187	11/15/01
900932	Hewlett Packard	8449B OPT H02	Preamplifier (1-26.5 GHz)	3008A00505	09/15/01
900045	Hewlett Packard	8447F	Preamplifier	2944A03783	N/A
901040	Industrial	SMX100	Wide Band Preamplifier (0.01-1000 MHz)	1736-0696	11/17/01
900721	Hewlett Packard	8447D	Preamplifier (0.1-1300 MHz)	2727A05397	N/A
900889	Hewlett Packard	85685A	RF Preselector for HP 8566B or 8568B (20Hz-2GHz)	3146A01309	11/14/01
900566	Amplifier Research	FP 2000	Isotropic Field Probe	20760	08/29/01
900174	FCC	F-120-9A	RF Injection Probe (10 kHz – 300 MHz)	N/A	05/31/01
901044	FCC	F-120-5	Bulk Current Injection Probe (10 kHz – 150 MHz)	17	05/12/01
901042	FCC	F-72-1	RF Current Probe (10 Hz – 100 MHz)	44	05/11/01
900704	FCC	F-14-1	Current Probe (10 Hz – 500 kHz)	33	05/12/01

RTL Asset Number	Manufacturer	Model	Part Type	Serial Number	Calibration due date
900894	FCC	F-33-1	RF Current Probe (10 kHz – 250 MHz)	303	05/30/01
900854	Solar Electronics Co	9119-IN	RF Current Probe	972501	
900849	Solar Electronics Co	9121-IN	Injection Probe (10 MHz – 1 GHz)	953501	
900848	Solar Electronics Co	9320-IN	RF Current Probe	990521	
900913	Hewlett Packard	85462A	EMI Receiver RF Section (9 KHz – 6.5 GHz)	3325A00159	03/29/01
900769	Hewlett Packard	8481B	Power Sensor	2702A05059	In cal.
900937	Hewlett Packard	8482H	3-watt Power Sensor (100 KHz to 4.2 GHz)	3318A08961	12/02/01
900928	Hewlett Packard	83752A	Synthesized Sweeper, 0.01 to 20 GHz	3610A00866	03/28/01
900946	Tenney Engineering, Inc.	TH65	Temperature Chamber with Humidity	11380	11/07/01
900111	Omega Engineering	DP41-TC-DSS	Temperature Monitor	2060123	In cal.
901043	FCC		Terminator for RF Current Probe F-72-1		05/12/01
900731	Haefely	PEFT.1	Burst Tester with Coupling Network	082 106-29	11/10/01
900402	BAPCO Electro-Com	IEC 601 L	Safety Tester	000028	11/10/01
900720	Haefely	Psurge 4.1	Surge Tester	083-342-02	11/10/01
900839	Bird	43P	Peak Reading Wattmeter	3110	11/10/01
901137	Par Electronics	Notch	Notch Filter (2.3 GHz to 2.5 GHz)	N/A	N/A

2 SYSTEM TEST CONFIGURATION

2.1 JUSTIFICATION

The EUT was tested in all three orthogonal planes in order to determine worst-case emission. Channel 1 at 2.412 GHz, Channel 6 at 2.442 GHz and Channel 11 at 2.462 GHz were tested and investigated from 9kHz to 24GHz. All three channels were investigated and tested. Data for all three channels are presented in this report.

To complete the configuration required by the FCC, the transmitter was tested in a full computer with an external antenna connected to the antenna port similar to its intended use.

The EUT was investigated with the external antenna. The worst-case data taken in this report represents the highest data rate at 11 MBPS. Data rates of 5.5MBPS, 2 MBPS and 1 MBPS were investigated and found to be in compliance.

2.2 EUT EXERCISE SOFTWARE

The EUT was provided with the software to continuously transmit during testing. The carrier was also checked to verify that the information was being transmitted.

2.3 SPECIAL ACCESSORIES

N/A.

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2.4 TEST SYSTEM DETAILS

The FCC Identifiers for all equipment, plus descriptions of all cables used in the tested system (including inserted cards, which have grants) are:

TABLE 1: EQUIPMENT UNDER TEST

PART	MANUFACTURER	MODEL	SERIAL NUMBER	FCC ID	CABLE DESCRIPTION	RTL BAR CODE
WIRELESS LAN CARD (EUT)	**CISCO SYSTEM, VA**	**AIR-MP1350 (100mW)**	**LDK102042 (001)**	**DOC**	**N/A**	**013054**

TABLE 2: EXTERNAL COMPONENTS OF TESTED CONFIGURATION

PART	MANUFACTURER	MODEL	SERIAL NUMBER	FCC ID	CABLE DESCRIPTION	RTL BAR CODE
MOUSE	MICROSOFT	INTELLIMOUSE 1.1A	00332324	C3KKMP5	SHIELDED I/O	900589
KEYBOARD	NMB TECHNOLOGIES	PCB:44J	PS2	SAMPLE	SHIELDED I/O	012728
MONITOR	LG ELECTRONICS	EVF700 17"	N/A	SAMPLE	SHIELDED, FERRITE BOTH ENDS I/O UNSHIELDED POWER	011929
SYSTEM	CISCO SYSTEM, VA	N/A	253886	N/A	UNSHIELDED POWER	012956

TABLE 3: INTERNAL COMPONENTS OF TESTED CONFIGURATION

PART	MANUFACTURER	MODEL	SERIAL NUMBER	FCC ID	CABLE DESCRIPTION	RTL BAR CODE
Cisco AIR-ANT1499	Centurion	Cisco Dipole	LDK 102042	N/A	NONE	013055
LDA8220D	MURATA	Toshiba Chip	N/A	N/A	0.4 m cable	
Dell 360YM	Centurion	Dell Inverted-F	N/A	N/A	0.4 m cable pcb 0.07m cable	
FX01L03-P1	FOXCONN	Dell Dipole	N/A	N/A	2 cables 0.26 m pcb for diversity 0.07 m cable	
HTL004	Hitachi Cable	Toshiba Inverted-F	B36087211		0.6 m cable	
CONTROLLER CARD	CATALYST COMMUNICATIONS TECHNOLOGIES, INC.	PCIAX564	384-0030-002 REV B	N/A	N/A	013047
MINI PCI CARD	CATALYST COMMUNICATIONS TECHNOLOGIES, INC.	TYPE III	WIRELESS LAN SUPPORT	N/A	N/A	013053
MODEM	CISCO SYSTEM, VA	V1456VQH-R7	00V237C00135480	DOC	N/A	013048
MOTHERBOARD	CISCO SYSTEM, VA	EP-693A	N/A	N/A	INTERNAL I/O INTERNAL POWER	013049
CD-ROM DRIVE	DELTA PRODUCTS CORPORATION, CA	CD5200A	011039052161	DOC	INTERNAL I/O INTERNAL POWER	013058
POWER SUPPLY	ASTEC CUSTOM POWER	SA320-3505-1412	99-3578	N/A	UNSHIELDED POWER	011211
FLOPPY DRIVE	MITSUMI	D359M3D	0J15AX0837	N/A	INTERNAL I/O INTERNAL POWER	013057

2.5 CONFIGURATION OF TESTED SYSTEM

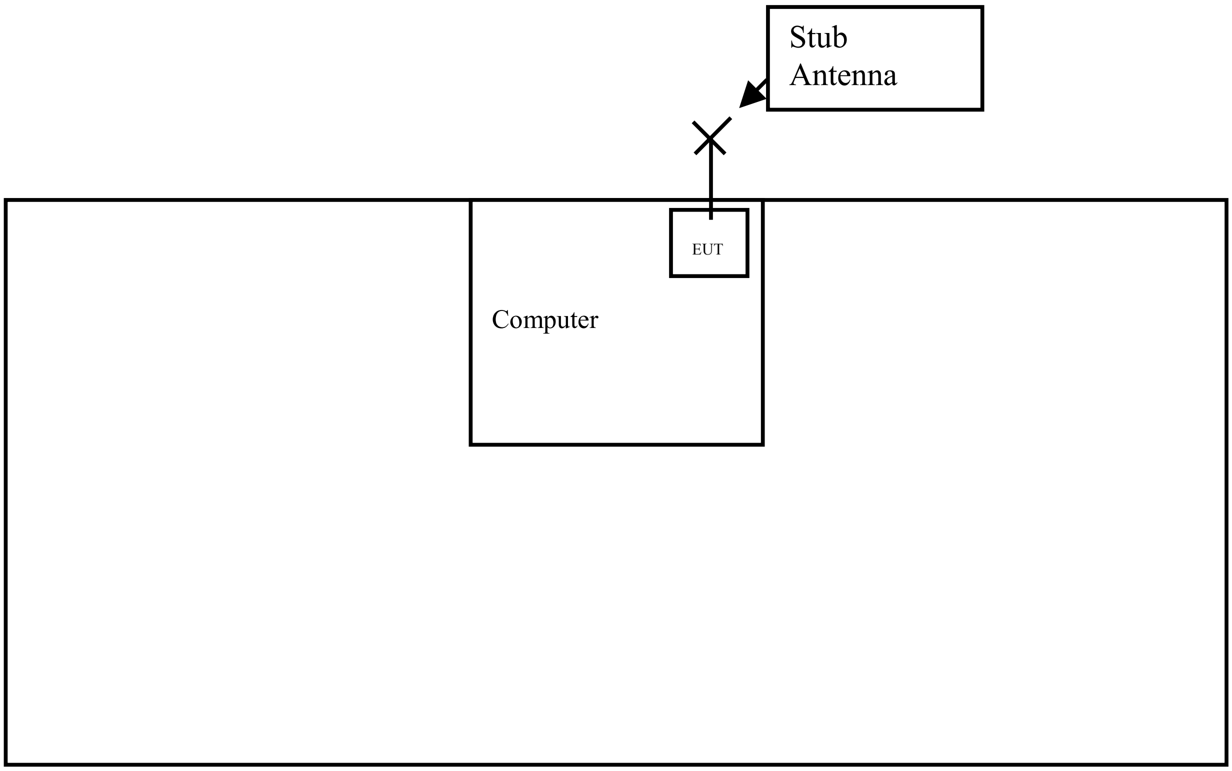

FIGURE 1: TESTED CONFIGURATION

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http://www.rheintech.com

3 CONFORMANCE STATEMENT

STANDARDS REFERENCED FOR THIS REPORT	
PART 2: 1999	FREQUENCY ALLOCATIONS AND RADIO TREATY MATTERS; GENERAL RULES AND REGULATIONS
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Canadian Sections	**Frequency Range**	**Output Power (W)**	**Freq. Tolerance**	**Emission Designator**
6.2.2 (o)	2412 to 2462 MHz	0.109		

I, the undersigned, hereby declare that the equipment tested and referenced in this report conforms to the identified standard(s) as described above. Modifications were not made during testing to the equipment in order to achieve compliance with these standards.

Furthermore, there was no deviation from, additions to or exclusions from the ANSI C63.4 test methodology.

Signature: ________________ Date: *February 28, 2001*

Typed/Printed Name: Desmond A. Fraser Position: President
(NVLAP Signatory)

Accredited by the National Voluntary Accreditation Program for the specific scope of accreditation under Lab Code 20061-0.

Note: This report may not be used by the client to claim product endorsement by NVLAP or any agency of the U.S. Government.

4 FIELD STRENGTH 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:

$$FI(dBuV/m) = SAR(dBuV) + SCF(dB/m)$$

FI = Field Intensity
SAR = Spectrum Analyzer Reading
SCF = Site Correction Factor

The Site Correction Factor (SCF) used in the above equation is determined empirically, and is expressed in the following equation:

$$SCF(dB/m) = - PG(dB) + AF(dB/m) + CL(dB)$$

SCF = Site Correction Factor
PG = Pre-amplifier Gain
AF = Antenna Factor
CL = Cable Loss

The field intensity in microvolts per meter can then be determined according to the following equation:

$$FI(uV/m) = 10^{FI(dBuV/m)/20}$$

For example, assume a signal at a frequency of 125 MHz has a received level measured as 49.3 dBuV. The total Site Correction Factor (antenna factor plus cable loss minus preamplifier gain) for 125 MHz is -11.5 dB/m. The actual radiated field strength is calculated as follows:

$$49.3 \text{ dBuV} - 11.5 \text{ dB/m} = 37.8 \text{ dBuV/m}$$

$$10^{37.8/20} = 10^{1.89} = 77.6 \text{ uV/m}$$

EIRP calculation: Power from power meter in (dBm) + antenna gain in (dBi)

5 CONDUCTED EMISSIONS MEASUREMENTS

The power line conducted emission measurements were performed in a Series 81 type shielded enclosure manufactured by Rayproof. The EUT was assembled on a wooden table 80 centimeters high. Power was fed to the EUT through a 50 ohm / 50 microhenry Line Impedance Stabilization Network (EUT LISN). The EUT LISN was fed power through an A.C. filter box on the outside of the shielded enclosure. The filter box and EUT LISN housing are bonded to the ground plane of the shielded enclosure. A second LISN, the peripheral LISN, provides isolation for the EUT test peripherals. This peripheral LISN was also fed A.C. power. A metal power outlet box, which is bonded to the ground plane and electrically connected to the peripheral LISN, powers the EUT host peripherals.

The spectrum analyzer was connected to the A.C. line through an isolation transformer. The 50-ohm output of the EUT LISN was connected to the spectrum analyzer input through a Solar 7 kHz high-pass filter. The filter is used to prevent overload of the spectrum analyzer from noise below 7 kHz. Conducted emission levels were measured on each current-carrying line with the spectrum analyzer operating in the CISPR quasi-peak mode (or average mode if applicable). The analyzer's 6 dB bandwidth was set to 9 kHz. No video filter less than 10 times the resolution bandwidth was used. Average measurements are performed in linear mode using a 10 kHz resolution bandwidth, a 1 Hz video bandwidth, and by increasing the sweep time in order to obtain a calibrated measurement. The range of the frequency spectrum to be investigated is specified in FCC Part 15. The highest emission amplitudes relative to the appropriate limit were measured and have been recorded in this report.

5.1 CONDUCTED EMISSIONS TEST

The following table lists worst-case conducted emission date. Specifically: Emission Frequency, Test Detector, Analyzer Reading, Site Correction Factor, corrected Emission Level, Quasi Peak Limit and Margin, and the Average Limit and Margin.

The initial step in collecting conducted data is a spectrum analyzer peak scan of the measurement range. If the conducted emissions exceed the limit with the instrument set to the quasi-peak mode, then measurements are made in the average mode.

The conducted test was performed with the EUT exercise program loaded, and the emissions were scanned between 150 kHz to 30 MHz on the NEUTRAL SIDE and HOT SIDE, herein referred to as L1 and L2, respectively.

5.1.1 CONDUCTED EMISSIONS (CHANNEL 1 CISCO DIPOLE ANTENNA)

TABLE 4: NEUTRAL SIDE (LINE 1)

Emission Frequency (MHz)	Test Detector	Analyzer Reading (dBμV)	Site Correction Factor (dB)	Emission Level (dBμV)	FCC B Limit (dBμV)	FCC B Margin (dB)
11.781	Pk	47.6	-3.0	44.6	48.0	-3.4
14.727	Pk	47.4	-3.3	44.1	48.0	-3.9
20.617	Pk	48.1	-3.9	44.2	48.0	-3.8
29.454	Pk	45.4	-4.5	40.9	48.0	-7.1

TABLE 5: HOT SIDE (LINE 2)

Emission Frequency (MHz)	Test Detector	Analyzer Reading (dBμV)	Site Correction Factor (dB)	Emission Level (dBμV)	FCC B Limit (dBμV)	FCC B Margin (dB)
11.781	Pk	47.8	-3.0	44.8	48.0	-3.2
20.617	Pk	48.8	-3.9	44.9	48.0	-3.1
26.507	Pk	43.3	-4.3	39.0	48.0	-9.0
29.453	Pk	45.3	-4.5	40.8	48.0	-7.2

[(1)] **Pk = Peak; QP = Quasi-Peak; Av = Average**

TEST PERSONNEL: ELIZABETH BAUMAN

Typed/Printed Name: Elizabeth Dzrajer **Date:** ***February 28, 2001***

6 RADIATED EMISSIONS MEASUREMENTS

Before final measurements of radiated emissions were made on the open-field three/ten meter range; the EUT was scanned indoor at one and three meter distances. This was done in order to determine its emissions spectrum signature. The physical arrangement of the test system and associated cabling was varied in order to determine the effect on the EUT's emissions in amplitude, direction and frequency. This process was repeated during final radiated emissions measurements on the open-field range, at each frequency, in order to insure that maximum emission amplitudes were attained.

Final radiated emissions measurements were made on the three/ten-meter, open-field test site. The EUT was placed on a nonconductive turntable 0.8 meters above the ground plane.

At each frequency, the EUT was rotated 360 degrees, and the antenna was raised and lowered from one to four meters in order to determine the maximum emission levels. Measurements were taken using both horizontal and vertical antenna polarizations. The spectrum analyzer's 6 dB bandwidth was set to 120 kHz, and the analyzer was operated in the CISPR quasi-peak detection mode. No video filter less than 10 times the resolution bandwidth was used. The range of the frequency spectrum to be investigated is specified in FCC Part 15. The highest emission amplitudes relative to the appropriate limit were measured and recorded in this report. . **For radiated measurements above 1 GHz, a resolution bandwidth of 1 MHz and a video bandwidth of 10 Hz are used.**

Note: Rhein Tech Laboratories, Inc. has implemented procedures to minimize errors that occur from test instruments, calibration, procedures, and test setups. Test instrument and calibration errors are documented from the manufacturer or calibration lab. Other errors have been defined and calculated within the Rhein Tech quality manual, section 6.1. Rhein Tech implements the following procedures to minimize errors that may occur: yearly as well as daily calibration methods, technician training, and emphasis to employees on avoiding error.

6.1 RADIATED EMISSIONS TEST

The following data lists the significant emission frequencies, measured levels, correction factor (includes cable and antenna corrections), the corrected reading, plus the limit.

TABLE 6: DIGITAL NOISE (CHANNEL 1 CISCO DIPOLE)

Emission Frequency (MHz)	Test Detector	Antenna Polarity (H/V)	Turntable Azimuth (deg)	Antenna Height (m)	Analyzer Reading (dBµV)	Site Correction Factor (dB/m)	Emission Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)
263.998	Qp	H	190	1.0	38.2	-13.5	24.7	46.0	-21.3
352.006	Qp	H	160	1.0	44.3	-11.4	32.9	46.0	-13.1
483.998	Qp	H	25	1.3	27.4	-8.3	19.1	46.0	-26.9
747.998	Qp	H	150	1.0	29.1	-4.5	24.6	46.0	-21.4
835.998	Qp	H	145	1.0	25.8	-3.4	22.4	46.0	-23.6
923.998	Qp	H	140	1.0	25.2	-2.4	22.8	46.0	-23.2

QUASI PEAK =120 KHZ

TEST PERSONNEL: ELIZABETH BAUMAN

Typed/Printed Name:  **Date:** ***February 28, 2001***

7 MODULATED BANDWIDTH

The minimum 6 dB bandwidth per FCC 15.247(a)(2) was measured using a 50 ohm spectrum analyzer with the resolution bandwidth set at 100 kHz, and the video bandwidth set at 300 kHz. The Minimum 6 dB modulated bandwidths are the following:

TABLE 7: MODULATED BANDWIDTH

Channel	6(dB) Bandwidth (MHz)
1	11.0
6	11.5
11	11.4

The 6dB bandwidth is listed in figures Section 26 of this report.

8 CONDUCTED POWER OUTPUT

The conducted and radiated output power per FCC 15.247(b) was measured on the EUT using a power meter. The radiated EIRP measurement data are results from our outdoor 3-meter range.

TABLE 8: CONDUCTED POWER OUTPUT

Channel	Radiated EIRP (dBm)*	Power conducted output (dBm)
1	22.5	19.4
6	22.5	20.4
11	20.4	18.4

*Measurement accuracy is +/- 1.5 dB

9 ANTENNA CONDUCTED SPURIOUS EMISSIONS

Antenna spurious emission per FCC 15.247(c) was measured from the EUT antenna port using a 50 ohm spectrum analyzer with the resolution bandwidth set at 100 kHz, and the video bandwidth set at 300 kHz. The modulated carrier was identified at 2.413GHz for Channel 1, 2.443GHz for Channel 6 and 2.462GHz for Channel 11. No other harmonics or spurs were found within 20 dB of the carrier level, and from 9kHz to the carriers 10th harmonic. See antenna conducted spurious noise table.
FCC 97 114 appendix C specifies 100KHz/300KHz resolution and video bandwidth for the authorized band up to the 10th harmonic. All spurs and harmonic must be 20 dB down from the carrier within the authorized band. A 2.4 GHz notch filter was used to attenuate the carrier so that the spectrum analyzer would not be overloaded. The insertion loss of the notch filter was added to the spurious level on the table below.

TABLE 9: CHANNEL 1

Frequency (MHz)	Spurious level (dBm)	FCC Margin (dB)
18.990	-45.0	-30.0
602.300	-28.0	-13.0
801.760	-33.0	-18.0
951.954	-46.0	-31.0
1808.600	-35.0	-20.0
2445.510	-49.0	-34.0
2548.070	-55.0	-40.0
2785.510	-51.0	-36.0
4824.060	-41.7	-26,7

TABLE 10: CHANNEL 6

Frequency (MHz)	Spurious level (dBm)	FCC Margin (dB)
8.000	-28.8	-14.8
10.990	-28.5	-14.5
27.440	-37.0	-23.0
82.300	-37.6	-23.6
631.320	-19.6	-5.6
841.735	-31.7	-17.7
946.950	-52.0	-38.0
2815.510	-54.0	-40.0
4884.030	-36.1	-22.1

TABLE 11: CHANNEL 11

Frequency (MHz)	Spurious level (dBm)	FCC Margin (dB)
8.020	-41.0	-24.4
144.500	-48.0	-31.4
650.800	-28.5	-11.9
850.100	-38.7	-22.1
1880.000	-42.7	-26.1
2407.489	-57.0	-40.4
2440.940	-50.0	-33.4
2835.000	-59.0	-42.4
4922.000	-43.0	-26.4
4927.000	-57.0	-40.4

10 RADIATED EMISSIONS HARMONICS/SPURIOUS

Radiated Spurious Emissions applies to harmonics and spurious emissions that fall in the restricted and non-restricted bands. The restricted bands are listed in Section 15.205. The maximum permitted average field strength for the restricted band is listed in Section 15.209. A 2.4 GHz notch filter was used to attenuate the carrier so that the spectrum analyzer would not be overloaded. The insertion loss of the notch filter was added to the spurious level on the table below.

10.1 CISCO DIPOLE ANTENNA

TABLE 12: CHANNEL 1 (CISCO DIPOLE ANTENNA)

Frequency (MHz)	Test Detector	Antenna Polarity (H/V)	Turntable Azimuth (deg)	Antenna Height (m)	Analyzer Reading (dBµV)	Site Correction Factor (dB/m)	Level in (dBµV/m)	Limit in (dBµV/m)	Margin (dB)
2413.07	AV	V	90	1.5	98.5	8.9	107.4	Fundamental	
2413.07	PK	V	90	1.5	108.4	8.9	117.3	Fundamental	
2785.51	AV	V	95	1.5	37.0	9.0	46.0	54.0	-8
4824.33	AV	V	90	1.5	33.5		NF	54.0	

Average Measurement (AV: resolution bandwidth. =1 MHz, video bandwidth = 10 Hz; NF = noise floor
Peak Measurement (PK) = resolution bandwidth = 1 MHz, video bandwidth = 1 MHz
NF = Noise Floor

TABLE 13: CHANNEL 6 (CISCO DIPOLE ANTENNA)

Frequency (MHz)	Test Detector	Antenna Polarity (H/V)	Turntable Azimuth (deg)	Antenna Height (m)	Analyzer Reading (dBµV)	Site Correction Factor (dB/m)	Level in (dBµV/m)	Limit in (dBµV/m)	Margin (dB)
2442.97	AV	V	95	1.	98.7	8.9	107.6	Fundamental	
2442.97	PK	V	95	1.	108.8	8.9	117.7	Fundamental	
4884.13	AV	V	95	1.	34.7		NF	54.0	

Average Measurement (AV: resolution bandwidth. =1 MHz, video bandwidth = 10 Hz; NF = noise floor
Peak Measurement (PK) = resolution bandwidth = 1 MHz, video bandwidth = 1 MHz
NF = Noise Floor

TABLE 14: CHANNEL 11(CISCO DIPOLE ANTENNA)

Frequency (MHz)	Test Detector	Antenna Polarity (H/V)	Turntable Azimuth (deg)	Antenna Height (m)	Analyzer Reading (dBµV)	Site Correction Factor (dB/m)	Level in (dBµV/m)	Limit in (dBµV/m)	Margin (dB)
2462.9	AV	V	95	1.	98.5	7.5	106.0	Fundamental	
2462.9	PK	V	95	1.	108.3	7.5	115.8	Fundamental	
4925.8	AV	V	95	1.	33.4		NF	54.0	

Average Measurement (AV: resolution bandwidth. =1 MHz, video bandwidth = 10 Hz; NF = noise floor
Peak Measurement (PK) = resolution bandwidth = 1 MHz, video bandwidth = 1 MHz
NF = Noise Floor

TEST PERSONNEL:

Typed/Printed Name: Rachid SEHB **Date:** ***February 28, 2001***

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Suite 1400
Herndon, VA 20170
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10.2 DELL DIPOLE ANTENNA

TABLE 15: CHANNEL 1 (DELL DIPOLE ANTENNA)

Frequency (MHz)	Test Detector	Antenna Polarity (H/V)	Turntable Azimuth (deg)	Antenna Height (m)	Analyzer Reading (dBµV)	Site Correction Factor (dB/m)	Level in (dBµV/m)	Limit in (dBµV/m)	Margin (dB)
2372.13	AV	H	95	1.5	41.1	-2.2	38.9	54.0	-15.1
2372.13	PK	H	95	1.5	53.9	-2.2	51.7		
2375.13	AV	H	95	1.5	42.4	-2.2	40.2	54.0	-13.8
2375.13	PK	H	95	1.5	53.0	-2.2	50.8		
2383.63	AV	H	95	1.5	42.3	-2.2	40.1	54.0	-13.9
2383.63	PK	H	95	1.5	56.9	-2.2	54.7		
2413.07	AV	H	90	1.5	94.7	-2.2	92.5	Fundamental	
2413.07	PK	H	90	1.5	99.5	-2.2	97.3	Fundamental	
2439.00	AV	H	95	1.5	48.5	-2.2	46.3	72.5	-26.2
2439.00	PK	H	95	1.5	59.7	-2.2	57.5		
.2448.88	AV	H	95	1.5	44.8	-2.2	42.6	72.5	-29.9
2448.88	PK	H	95	1.5	56.2	-2.2	54.0		
2452.00	AV	H	95	1.5	44.2	-2.2	42.0	72.5	-30.5
2452.00	PK	H	95	1.5	57.5	-2.2	55.3		
4826.17	AV	H	100	1.5	34.5	8.5	43.0	54.0	-11.0
4826.17	PK	H	100	1.5	44.0	8.5	52.5		

Average Measurement (AV: resolution bandwidth. =1 MHz, video bandwidth = 10 Hz; NF = noise floor
Peak Measurement (PK) : resolution bandwidth = 1 MHz, video bandwidth = 1 MHz
NF = Noise Floor

TEST PERSONNEL:

Typed/Printed Name: Rachid SEHB **Date:** ***April 3, 2001***

TABLE 16: CHANNEL 6 (DELL DIPOLE ANTENNA)

Frequency (MHz)	Test Detector	Antenna Polarity (H/V)	Turntable Azimuth (deg)	Antenna Height (m)	Analyzer Reading (dBµV)	Site Correction Factor (dB/m)	Level in (dBµV/m)	Limit in (dBµV/m)	Margin (dB)
2406.28	AV	H	100	1.5	47.7	-2.2	45.5	73.3	-27.8
2406.28	PK	H	100	1.5	59.6	-2.2	57.4		
2410.00	AV	H	100	1.5	43.1	-2.2	40.9	73.3	-32.4
2410.00	PK	H	100	1.5	55.2	-2.2	50.0		
2416.50	AV	H	100	1.5	52.3	-2.2	50.1	73.3	-23.2
2416.50	PK	H	100	1.5	60.9	-2.2	58.7		
2443.25	AV	H	90	1.5	95.5	-2.2	93.3	Fundamental	
2443.25	PK		90		98.9	-2.2	96.7	Fundamental	
2467.75	AV	H	90	1.5	56.9	-2.2	54.7	73.3	-18.6
2467.75	PK	H	90	1.5	65.8	-2.2	63.6		
2470.63	AV	H	100	1.5	53.0	-2.2	50.8	73.3	-22.5
2470.63	PK	H	100	1.5	57.3	-2.2	55.1		
2479.88	AV	H	100	1.5	53.1	-2.2	50.9	73.3	-22.4
2479.88	PK	H	100	1.5	58.9	-2.2	56.7		
2489.88	AV	H	100	1.5	48.7	-2.2	46.5	54.0	-7.5
2489.88	PK	H	100	1.5	57.1	-2.2	54.9		
2511.75	AV	H	100	1.5	43.2	-2.2	41.0	73.3	-32.3
2511.75	PK	H	100	1.5	53.1	-2.2	51.9		
4886.50	AV	H	100	1.5	35.0	8.5	43.5	54.0	-10.5
4886.50	PK	H	100	1.5	54.0	8.5	62.5		

Average Measurement (AV: resolution bandwidth. =1 MHz, video bandwidth = 10 Hz; NF = noise floor
Peak Measurement (PK) = resolution bandwidth = 1 MHz, video bandwidth = 1 MHz
NF = Noise Floor

TEST PERSONNEL:

Typed/Printed Name: Rachid SEHB **Date:** ***April 3, 2001***

TABLE 17: CHANNEL 11 (DELL DIPOLE ANTENNA)

Frequency (MHz)	Test Detector	Antenna Polarity (H/V)	Turntable Azimuth (deg)	Antenna Height (m)	Analyzer Reading (dBμV)	Site Correction Factor (dB/m)	Level in (dBμV/m)	Limit in (dBμV/m)	Margin (dB)
2433.00	AV	H	100	1.5	42.4	-2.2	40.2	74.2	-34.0
2433.00	PK	H	100	1.5	57.2	-2.2	55.2		
2436.00	AV	H	100	1.5	43.4	-2.2	41.2	74.2	-33.0
2436.00	PK	H	100	1.5	54.5	-2.2	52.3		
2440.75	AV	H	100	1.5	47.8	-2.2	45.6	74.2	-28.6
2440.75	PK	H	100	1.5	56.2	-2.2	54.0		
2463.75	AV	H	95	1.5	96.4	-2.2	94.2	Fundamental	
2463.75	PK		95		99.2		97.0	Fundamental	
2487.88	AV	H	90	1.5	50.9	-2.2	48.7	54.	-5.3
2487.88	PK	H	90	1.5	61.3	-2.2	59.1		
2490.88	AV	H	100	1.5	48.8	-2.2	46.6	54.0	-7.4
2490.88	PK	H	100	1.5	60.7	-2.2	58.5		
2540.00	AV	H	100	1.5	44.8	-2.2	42.6	74.2	-31.6
2540.00	PK	H	100	1.5	58.4	-2.2	56.2		
2540.00	AV	H	100	1.5	33.4	8.5	41.9	54.0	-12.1
2540.00	PK	H	100	1.5	50.1	8.5	58.6		

Average Measurement (AV: resolution bandwidth. =1 MHz, video bandwidth = 10 Hz; NF = noise floor
Peak Measurement (PK) = resolution bandwidth = 1 MHz, video bandwidth = 1 MHz
NF = Noise Floor

TEST PERSONNEL:

Typed/Printed Name: Rachid SEHB **Date:** ***April 3, 2001***

10.3 DELL INVERTED F ANTENNA

TABLE 18: CHANNEL 1 (DELL INVERTED F ANTENNA)

Frequency (MHz)	Test Detector	Antenna Polarity (H/V)	Turntable Azimuth (deg)	Antenna Height (m)	Analyzer Reading (dBμV)	Site Correction Factor (dB/m)	Level in (dBμV/m)	Limit in (dBμV/m)	Margin (dB)
2375.25	AV	H	95	1.5	41.1	-2.2	38.9	54.0	-15.1
2375.25	PK	H	95	1.5	50.2	-2.2	48.0		
2380.00	AV	H	95	1.5	40.0	-2.2	37.8	54.0	-16.2
2380.00	PK	H	95	1.5	51.4	-2.2	49.2		
2383.50	AV	H	95	1.5	41.7	-2.2	39.5	54.0	-14.5
2383.50	PK	H	95	1.5	52.1	-2.2	49.9		
2386.50	AV	H	95	1.5	39.9	-2.2	37.7	54.0	-16.3
2386.50	PK	H	95	1.5	53.2	-2.2	51.0		
2413.07	AV	H	90	1.5	97.1	-2.2	94.9	Fundamental	
2413.07	PK	H	90	1.5	100.0	-2.2	97.8	Fundamental	
2449.00	AV	H	95	1.5	47.5	-2.2	45.3	74.9	-29.6
2449.00	PK	H	95	1.5	58.5	-2.2	56.3		
2451.88	AV	H	95	1.5	46.6	-2.2	44.4	74.9	-30.5
2451.88	PK	H	95	1.5	58.7	-2.2	56.5		
4826.14	AV	H	95	1.5	36.2	8.5	44.7	54.0	-9.3
4826.14	PK	H	95	1.5	50.0	8.5	58.5		

Average Measurement (AV: resolution bandwidth. =1 MHz, video bandwidth = 10 Hz; NF = noise floor
Peak Measurement (PK) = resolution bandwidth = 1 MHz, video bandwidth = 1 MHz
NF = Noise Floor

TEST PERSONNEL:

Typed/Printed Name: Rachid SEHB **Date:** ***April 3, 2001***

TABLE 19: CHANNEL 6 (DELL INVERTED F ANTENNA)

Frequency (MHz)	Test Detector	Antenna Polarity (H/V)	Turntable Azimuth (deg)	Antenna Height (m)	Analyzer Reading (dBµV)	Site Correction Factor (dB/m)	Level in (dBµV/m)	Limit in (dBµV/m)	Margin (dB)
2394.25	AV	H	90	1.5	41.6	-2.2	39.4	74.0	-34.6
2394.25	PK	H	90	1.5	52.3	-2.2	50.1		
2402.80	AV	H	90	1.5	43.5	-2.2	41.3	74.0	-32.7
2402.80	PK	H	90	1.5	54.4	-2.2	52.2		
2407.06	AV	H	90	1.5	47.2	-2.2	45.0	74.0	-29.0
2407.06	PK	H	90	1.5	56.5	-2.2	54.3		
2412.88	AV	H	90	1.5	47.6	-2.2	45.4	74.0	-28.6
2412.88	PK	H	90	1.5	56.7	-2.2	54.5		
2416.50	AV	H	90	1.5	54.9	-2.2	52.7	74.0	21.3
2416.50	PK	H	90	1.5	67.7	-2.2	65.5		
2443.00	AV	H	100	1.5	96.2	-2.2	94.0	Fundamental	
2443.00	PK	H	100	1.5	99.7	-2.2	97.5	Fundamental	
2467.75	AV	H	90	1.5	56.4	-2.2	54.2	74.0	-19.8
2467.75	PK	H	90	1.5	62.5	-2.2	60.3		
2479.63	AV	H	90	1.5	48.7	-2.2	46.5	74.0	-27.5
2479.63	PK	H	90	1.5	51.4	-2.2	49.2		
2489.88	AV	H	90	1.5	44.8	-2.2	42.6	54.0	-11.4
2489.88	PK	H	90	1.5	51.8	-2.2	49.6		
4486.00	AV	AV	90	1.5	40.2	8.5	48.7	54.0	-5.3
4486.00	PK	PK	90	1.5	49.1	8.5	57.6		

Average Measurement (AV: resolution bandwidth. =1 MHz, video bandwidth = 10 Hz; NF = noise floor
Peak Measurement (PK) = resolution bandwidth = 1 MHz, video bandwidth = 1 MHz
NF = Noise Floor

TEST PERSONNEL:

Typed/Printed Name: Rachid SEHB **Date:** ***April 3, 2001***

TABLE 20: CHANNEL 11 (DELL INVERTED F ANTENNA)

Frequency (MHz)	Test Detector	Antenna Polarity (H/V)	Turntable Azimuth (deg)	Antenna Height (m)	Analyzer Reading (dBµV)	Site Correction Factor (dB/m)	Level in (dBµV/m)	Limit in (dBµV/m)	Margin (dB)
2433.58	AV	H	100	1.5	43.0	-2.2	40.8	71.5	-30.7
2433.58	PK	H	100	1.5	49.5	-2.2	47.3		
2440.88	AV	H	100	1.5	48.9	-2.2	46.7	71.5	-24.8
2440.88	PK	H	100	1.5	56.2	-2.2	54.0		
2463.75	AV	H	95	1.5	93.7	-2.2	91.5	Fundamental	
2463.75	PK	H	95	1.5	97.8	-2.2	95.6	Fundamental	
2487.75	AV	H	90	1.5	44.8	-2.2	42.6	54.0	-11.6
2487.75	PK	H	90	1.5	53.9	-2.2	51.7		
2490.50	AV	H	100	1.5	43.7	-2.2	41.5	54.0	-12.5
2490.50	PK	H	100	1.5	53.1	-2.2	50.9		
4927.50	AV	H	110	1.5	36.9	8.5	45.4	54.0	-8.5
4927.50	PK	H	110	1.5	45.0	8.5	53.5		

Average Measurement (AV: resolution bandwidth. =1 MHz, video bandwidth = 10 Hz; NF = noise floor
Peak Measurement (PK) = resolution bandwidth = 1 MHz, video bandwidth = 1 MHz
NF = Noise Floor

TEST PERSONNEL:

Typed/Printed Name: Rachid SEHB **Date:** ***April 3, 2001***

10.4 TOSHIBA CHIP ANTENNA

TABLE 21: CHANNEL 1 (TOSHIBA CHIP ANTENNA)

Frequency (MHz)	Test Detector	Antenna Polarity (H/V)	Turntable Azimuth (deg)	Antenna Height (m)	Analyzer Reading (dBµV)	Site Correction Factor (dB/m)	Level in (dBµV/m)	Limit in (dBµV/m)	Margin (dB)
2372.13	AV	H	90	1.5	38.6	-2.2	36.4	54.0	-17.6
2372.13	PK	H	90	1.5	45.0	-2.2	42.8		
2375.25	AV	H	90	1.5	39.6	-2.2	37.4	54.0	-16.6
2375.25	PK	H	90	1.5	44.2	-2.2	42.0		
2383.50	AV	H	90	1.5	41.0	-2.2	39.0	54.0	-15.0
2383.50	PK	H	90	1.5	51.4	-2.2	49.2		
2385.00	AV	H	95	1.5	40.0	-2.2	37.8	54.0	-16.2
2385.00	PK	H	95	1.5	51.0	-2.2	48.8		
2413.07	AV	H	90	1.5	96.7	-2.2	94.5	Fundamental	
2413.07	PK	H	90	1.5	98.7	-2.2	96.5	Fundamental	
2449.00	AV	H	90	1.5	40.5	-2.2	38.3	74.5	-36.2
2449.00	PK	H	90	1.5	50.9	-2.2	48.7		
2452.25	AV	H	90	1.5	40.2	-2.2	38.0	74.5	-36.5
2452.25	PK	H	90	1.5	45.7	-2.2	43.5		
2452.25	AV	H	90	1.5	33.3	8.5	41.8	54.0	-12.2
2452.25	PK	H	90	1.5	39.6	8.5	48.3		

Average Measurement (AV: resolution bandwidth. =1 MHz, video bandwidth = 10 Hz; NF = noise floor
Peak Measurement (PK) = resolution bandwidth = 1 MHz, video bandwidth = 1 MHz
NF = Noise Floor

TEST PERSONNEL:

Typed/Printed Name: Rachid SEHB **Date:** ***April 3, 2001***

TABLE 22: CHANNEL 6 (TOSHIBA CHIP ANTENNA)

Frequency (MHz)	Test Detector	Antenna Polarity (H/V)	Turntable Azimuth (deg)	Antenna Height (m)	Analyzer Reading (dBµV)	Site Correction Factor (dB/m)	Level in (dBµV/m)	Limit in (dBµV/m)	Margin (dB)
2406.00	AV	H	100	1.5	47.7	-2.2	45.5	73.3	-27.8
2406.00	PK	H	100	1.5	57.7	-2.2	55.5		
2410.00	AV	H	100	1.5	43.1	-2.2	40.9	73.3	-32.9
2410.00	PK	H	100	1.5	52.5	-2.2	50.3		
2416.50	AV	H	100	1.5	52.3	-2.2	50.1	73.3	-23.2
2416.50	PK	H	100	1.5	54.8	-2.2	52.6		
2443.88	AV	H	90	1.5	95.5	-2.2	93.3	Fundamental	
2443.88	PK	H	90	1.5	99.7	-2.2	97.5	Fundamental	
2470.88	AV	H	90	1.5	56.9	-2.2	54.7	73.3	-18.6
2470.88	PK	H	90	1.5	57.2	-2.2	55.0		
2479.00	AV	H	100	1.5	62.0	-2.2	50.8	73.3	-22.5
2479.00	PK	H	100	1.5	57.5	-2.2	55.3		
2482.00	AV	H	100	1.5	52.0	-2.2	49.8	73.3	-23.5
2482.00	PK	H	100	1.5	56.2	-2.2	54.0		
2489.80	AV	H	100	1.5	52.1	-2.2	50.9	54	-3.1
2489.80	PK	H	100	1.5	52.2	-2.2	50.0		
4887.76	AV	H	100	1.5	38.6	8.5	47.1	54	-6.9
4887.76	PK	H	100	1.5	44.0	8.5	52.5		

Average Measurement (AV: resolution bandwidth. =1 MHz, video bandwidth = 10 Hz; NF = noise floor
Peak Measurement (PK) = resolution bandwidth = 1 MHz, video bandwidth = 1 MHz
NF = Noise Floor

TEST PERSONNEL:

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TABLE 23: CHANNEL 11 (TOSHIBA CHIP ANTENNA)

Frequency (MHz)	Test Detector	Antenna Polarity (H/V)	Turntable Azimuth (deg)	Antenna Height (m)	Analyzer Reading (dBµV)	Site Correction Factor (dB/m)	Level in (dBµV/m)	Limit in (dBµV/m)	Margin (dB)
2433.25	AV	H	100	1.5	42.4	-2.2	40.2	73.7	-33.5
2433.25	PK	H	100	1.5	50.4	-2.2	48.2		
2436.13	AV	H	100	1.5	43.4	-2.2	41.2	73.7	-32.5
2436.13	PK	H	100	1.5	49.6	-2.2	51.8		
2440.88	AV	H	100	1.5	48.6	-2.2	46.4	73.7	-27.3
2440.88	PK	H	100	1.5	54.2	-2.2	52.0		
2462.76	AV	H	90	1.5	95.9	-2.2	93.7	Fundamental	
2462.76	PK	H	100	1.5	99.5	-2.2	97.3	Fundamental	
2483.38	AV	H	95	1.5	50.3	-2.2	48.1	73.7	-25.6
2483.38	PK	H	95	1.5	56.9	-2.2	54.7		
2487.88	AV	H	95	1.5	46.1	-2.2	43.9	54.0	-10.1
2487.88	PK	H	95	1.5	57.2	-2.2	55.0		
2490.63	AV	H	100	1.5	43.2	-2.2	41.0	54.0	-13.0
2490.63	PK	H	100	1.5	53.6	-2.2	51.4		
4925.52	AV	H	90	1.5	39.0	8.5	47.5	54.0	-6.5
4925.52	PK	H	90	1.5	50.5	8.5	59.0		

Average Measurement (AV: resolution bandwidth. =1 MHz, video bandwidth = 10 Hz; NF = noise floor
Peak Measurement (PK) = resolution bandwidth = 1 MHz, video bandwidth = 1 MHz
NF = Noise Floor

TEST PERSONNEL:

Typed/Printed Name: Rachid SEHB **Date:** ***April 3, 2001***

10.5 TOSHIBA INVERTED F ANTENNA

: TABLE 24 CHANNEL 1 (TOSHIBA INVERTED F ANTENNA)

Frequency (MHz)	Test Detector	Antenna Polarity (H/V)	Turntable Azimuth (deg)	Antenna Height (m)	Analyzer Reading (dBµV)	Site Correction Factor (dB/m)	Level in (dBµV/m)	Limit in (dBµV/m)	Margin (dB)
2272.25	AV	H	90	1.5	49.8	-2.2	47.6	54.0	-6.4
	PK	H	90	1.5	55.7	-2.2	53.5		
2372.38	AV	H	90	1.5	41.8	-2.2	39.6	54.0	-14.4
	PK	H	90	1.5	52.2	-2.2	50.0		
2375.38	AV	H	90	1.5	43.5	-2.2	41.3	54.0	-12.7
	PK	H	90	1.5	51.8	-2.2	49.6		
2380.00	AV	H	95	1.5	42.2	-2.2	40.0	54.0	-14.0
	PK	H	95	1.5	50.9	-2.2	48.7		
2386.38	AV	H	90	1.5	42.3	-2.2	40.1	54.0	13.9
	PK	H	90	1.5	51.2	-2.2	49.0		
2414.00	AV	H	90	1.5	96.9	-2.2	94.7	Fundamental	
	PK	H	90	1.5	100.4	-2.2	98.2	Fundamental	
2462.73	AV	H	90	1.5	42.5	-2.2	40.3	74.7	-34.4
	PK	H	90	1.5	51.2	-2.2	49.0		
2540.40	AV	H	90	1.5	41.7	-2.2	39.5	74.7	-35.2
	PK	H	90	1.5	51.0	-2.2	48.8		
2673.60	AV	H	90	1.5	43.1	-2.2	40.9	54.0	-13.1
	PK	H	90	1.5	51.2	-2.2	49.0		
4828.00	AV	H	90	1.5	33.5	8.5	42.0	54.0	-12.0
	PK	H	90	1.5	39.7	8.5	48.2		

Average Measurement (AV: resolution bandwidth. =1 MHz, video bandwidth = 10 Hz; NF = noise floor
Peak Measurement (PK) = resolution bandwidth = 1 MHz, video bandwidth = 1 MHz
NF = Noise Floor

TEST PERSONNEL:

Typed/Printed Name: Rachid SEHB **Date:** ***April 3, 2001***

: TABLE 25 CHANNEL 6 (TOSHIBA INVERTED F ANTENNA)

Frequency (MHz)	Test Detector	Antenna Polarity (H/V)	Turntable Azimuth (deg)	Antenna Height (m)	Analyzer Reading (dBµV)	Site Correction Factor (dB/m)	Level in (dBµV/m)	Limit in (dBµV/m)	Margin (dB)
2272.18	AV	H	100	1.5	52.4	-2.2	50.2	54.0	-3.8
	PK	H	100	1.5	61.2	-2.2	59.0		
2406.13	AV	H	100	1.5	52.7	-2.2	50.5	76.6	-26.1
	PK	H	100	1.5	62.2	-2.2	60.0		
2443.35	AV	H	100	1.5	98.8	-2.2	96.6	Fundamental	
	PK	H	100	1.5	102.2	-2.2	100.0	Fundamental	
2483.70	AV	H	90	1.5	53.9	-2.2	51.7	54.0	-2.3
	PK	H	90	1.5	62.2	-2.2	60.0		
4886.70	AV	H	90	1.5	40.0	8.5	48.5	54	-18.6
	PK	H	90	1.5	51.2	8.5	59.7		

Average Measurement (AV: resolution bandwidth. =1 MHz, video bandwidth = 10 Hz; NF = noise floor
Peak Measurement (PK) = resolution bandwidth = 1 MHz, video bandwidth = 1 MHz
NF = Noise Floor

TEST PERSONNEL:

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: TABLE 26 CHANNEL 11 (TOSHIBA INVERTED F ANTENNA)

Frequency (MHz)	Test Detector	Antenna Polarity (H/V)	Turntable Azimuth (deg)	Antenna Height (m)	Analyzer Reading (dBµV)	Site Correction Factor (dB/m)	Level in (dBµV/m)	Limit in (dBµV/m)	Margin (dB)
2272.50	AV	H	100	1.5	52.8	-2.2	50.6	54.0	-3.4
	PK	H	100	1.5	61.2	-2.2	59.0		
2406.35	AV	H	100	1.5	52.0	-2.2	49.8	75.5	-25.7
	PK	H	100	1.5	62.2	-2.2	60.0		
2433.04	AV	H	100	1.5	42.8	-2.2	40.6	75.5	-34.9
	PK	H	100	1.5	58.8	-2.2	56.6		
2436.48	AV	H	90	1.5	44.6	-2.2	42.4	75.5	-33.1
	PK	H	100	1.5	60.2	-2.2	58.0		
2440.74	AV	H	95	1.5	49.1	-2.2	46.9	75.5	-28.6
	PK	H	95	1.5	60.2	-2.2	58.0		
2463.98	AV	H	95	1.5	97.7	-2.2	95.5	Fundamental	
	PK	H	100	1.5	100.8	-2.2	98.6	Fundamental	
4927.96	AV	H	90	1.5	39.5	8.5	48.5	54.0	-5.5
	PK	H	90	1.5	50.5	8.5	59.0		

Average Measurement (AV: resolution bandwidth. =1 MHz, video bandwidth = 10 Hz; NF = noise floor
Peak Measurement (PK) = resolution bandwidth = 1 MHz, video bandwidth = 1 MHz
NF = Noise Floor

TEST PERSONNEL:

Typed/Printed Name: Rachid SEHB **Date:** ***April 3, 2001***

11 POWER SPECTRAL DENSITY TEST DATA

The Power spectral density per FCC 15.247(d) was measured from the antenna port of the EUT using a 50 ohm spectrum analyzer with the resolution bandwidth set at 3kHz, the video bandwidth set at 3kHz, and the sweep time set at 17 second. The spectral lines were resolved for the modulated carriers at 2.412GHz, 2.442GHz and 2.462GHz respectively. These levels are well below the +8 dBm limit. See power spectral density table below and the plots in Section 16 of this report.

TABLE 27: POWER SPECTRAL DENSITY

Channel	Power Spectral Density limit = +8dBm
1	-12.3
6	-11.6
11	-13.9

12 COMPLIANCE WITH THE RESTRICTED BAND EDGE TEST DATA

Compliance with the band edges was performed using the FCC's "Radiated Measurement at a Band Edge" guidance document. The final data derived below were from radiated measurements only. The data taken in this report represents the worst case at 11 MBPS. Data rates of 5.5MBPS, 2 MBPS and 1 MBPS were investigated and found to be in compliance. Both absolute and delta method were performed with the same results.

TABLE 28: RESTRICTED BAND EDGE

Band edge Measurement					
Antenna	**Channel Set to**	**Frequency tested MHz**	**Field Strength Level (dBµV/m)**	**FCC Limit (dBµV/m)**	**FCC Margin (dB)**
Cisco Dipole	1	2390.0	53.1	54.0	-0.9
	11	2483.5	53.9	54.0	-0.1
Dell Dipole	1	2390.0	41.4	54.0	-12.6
	11	2483.5	52.4	54.0	-1.6
Dell Inverted F	1	2390.0	40.4	54.0	-13.6
	11	2483.5	46.9	54.0	-7.1
Toshiba Chip	1	2390.0	37.9	54.0	-16.1
	11	2483.5	47.2	54.0	-6.8
Toshiba Inverted F	1	2390.0	39.8	54.0	-14.2
	11	2483.5	50.2	54.0	-3.8

13 RECEIVER TEST DATA

TABLE 29: RADIATED EMISSION (RECEIVER MODE)

Temperature: 47°F Humidity: 41%									
Emission Frequency (MHz)	Test Detector	Antenna Polarity (H/V)	Turntable Azimuth (deg)	Antenna Height (m)	Analyzer Reading (dBuV)	Site Correction Factor (dB/m)	Emission Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)
263.998	Qp	H	185	1.2	42.5	-13.5	29.0	46.0	-17.0
351.998	Qp	H	180	1.0	43.5	-11.4	32.1	46.0	-13.9
747.998	Qp	H	150	1.0	29.8	-4.5	25.3	46.0	-20.7
791.998	Qp	H	160	1.0	27.8	-3.7	24.1	46.0	-21.9
835.998	Qp	H	145	1.0	30.4	-3.4	27.0	46.0	-19.0
923.998	Qp	H	165	1.0	26.1	-2.4	23.7	46.0	-22.3

14 ANTENNA SPECIFICATIONS

14.1 CISCO DIPOLE ANTENNA

Electrical Specifications:

Model No.	LDK 102042
Frequency Range	2.4-2.5GHz
Bandwidth	100MHz
Gain	2.2dBi
V.S.W.R	<1.9
Radiation Pattern	Omni-Directional
Polarization	Vertical or Horizontal
Impedance	50ohms
Operating Temperature	

Electrical Specifications:

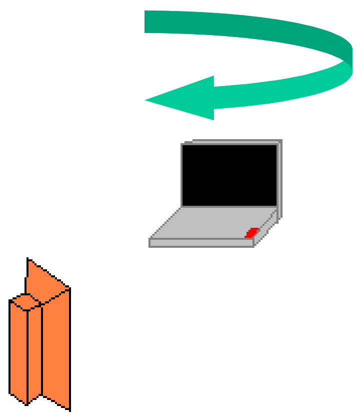
Dimension	N/A
Pulling Strength	N/A
Swivel Torque	N/A
Input Connector	

Setup:
Anechoic Chamber Measurements

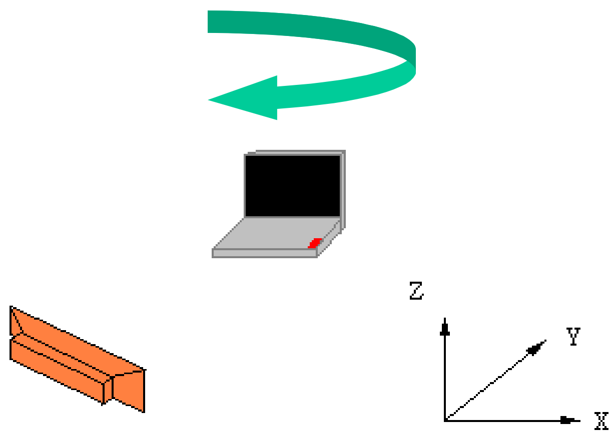
The anechoic chamber is a 3m absorber cone range with a fully automated turntable measurement system and software. Prior to conducting the DUT measurements, the range was calibrated with known gain horn antennas at the frequencies of 2.4GHz, 2.45GHz, and 2.5GHz to verify that the S21 gain settings were correct. This was done to make sure the gain measurements would give the correct absolute gain measurements of the antennas under test.

Four measurements we taken on each laptop for each of the antennas present in the laptop for the same three frequencies. The measurement planes are defined as the XY and YZ planes (the ZX plane was skipped due to time constraints), doing both a horizontal and vertical polarization measurements for each antenna. The antennas were placed on the turntable to match the level of the main beam from the measurement horn. Pictures of the setups are shown below:

XY plane, Horizontal Polarization

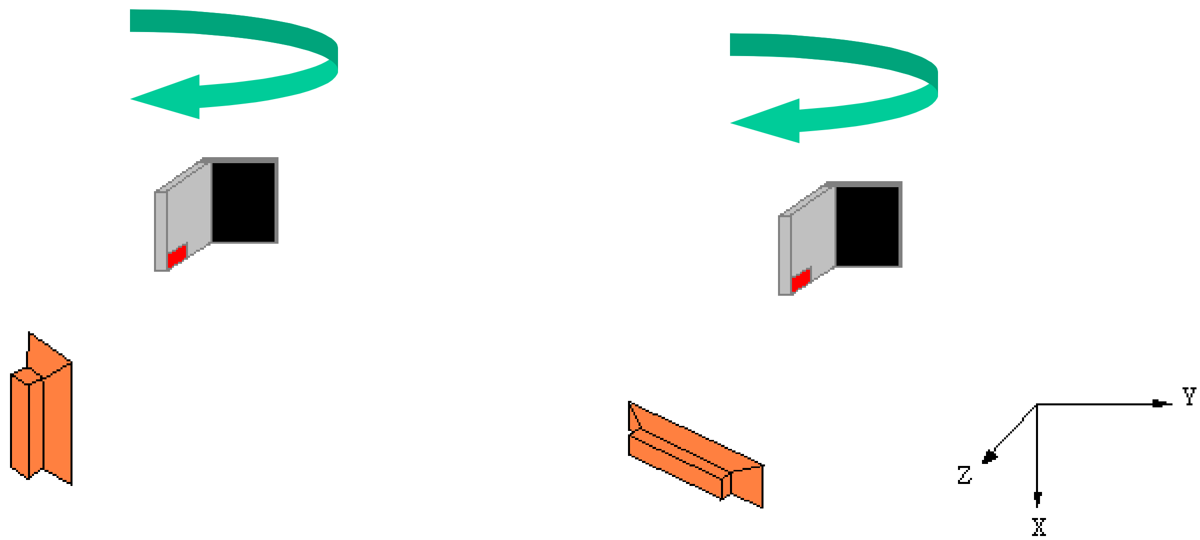


XY plane, Vertical Polarization



YZ plane, Horizontal Polarization YZ plane, Vertical Polarization

0 degrees is with the LCD directly facing the horn for both measurements.



Note that the full XY measurement is indicative of the antenna performance around the LCD as would be seen as the user rotates the laptop in an open position. For the YZ and ZX planes, only the –90 to +90 measurements are useful as the bottom of the laptop would be resting on a surface in actual use. Also, the YZ and ZX performance may vary depending on whether the desk surface is RF reflective (metal) or absorbive, so actual gain may vary somewhat depending on the user environment.

The following antenna characteristics were examined:

<u>The quality of the antenna match in the system</u>
The antenna system must be tuned to the correct band to get the optimum gain performance at the operating frequencies. The reflection coefficient S11 is used as a measure of the antennas ability to radiate at specific frequencies. It is desired to have a wide enough band antenna so it will be tuned over the entire operating band with some margin for slight tuning shifts. The figure of measure here is a S11 VSWR of less than 2:1 over the operating band, and a bandwidth of at least 100MHz for tuning shifts due to manufacturing tolerances.

<u>The gain of the antenna embedded in the system.</u>
The average gain of the antenna was compared with the average gain of the PCMCIA extended card antenna. The F-antenna performance in the card is a basic antenna performance benchmark for the required gain needed to get adequate RF coverage in the Orinoco system.

The average gain performance of the F-antennas is between –10dBi and –4dBi in each of the measurement planes, with an overall average gain around -1dBi to -6dBi when the card is in a laptop unit. Antennas with overall average gains in this range, give or take a dB or two, are deemed to have acceptable gain for the Orinoco system.

The peak gain is no greater than +1dBi for the F antennas based on previous Lucent documented test results. The upper gain limit on the embedded antennas is +2.5dBi to be able to use the certification work done on the mini-PCI card, as anything higher than this may require a full recertification effort.

<u>The omnidirectionality of the pattern</u>.
This is a measure of how constant the gain is as the antennas are rotated.

While statistical methods can be used to evalute this, a cursory look at the pattern plot can determine if the performance is acceptable. Omnidirectionality is difficult to control with electrically small antenna design, so the requirement of a less than 10dB difference between the average gain in the measurement plane and the maximum gain in the same plane is an acceptable goal. Omnidirectionality is important so that the user does not see large differences in SNR performance as the laptop is rotated around, which may lead them to believe there is a problem with the system.

<u>The polarization differences between the antennas.</u>
Some diversity scheme between the two antennas in a system is desired in order for the system to show 2-3dB performance improvements in fading at the cell fringes. One scheme is to use polarization diversity, where the antennas are designed to have a 90 degree polarization difference.

Polarization differences between the antennas are checked by orienting the transmitting horn in both HP and VP positions. Polarization diversity between two embedded antennas is most important in systems where the antennas are located closely together at fractions of an operating wavelength. Polarization can be rigorously computed through the use of formulas, but here, a simple inspection of the HP and VP measurements will show which polarization the design is leaning to. The higher the gain in a particular polarization, the more the antenna is polarized in that direction. For the small antennas, polarization will, in general, be somewhat chaotic and will be a combination of both HP and VP.

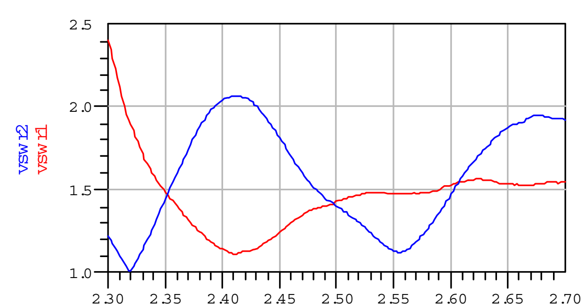
<u>The spacing of the antennas.</u>
In the case of laptop antennas, there is typically already the advantage of space diversity, another diversity scheme that can give comparable performance to polairization diversity. Space diversity simply means the antennas are spaced several wavelengths apart and are well isolated from each other. If this spacing condition is met, fulfilling the polarization diversity requirement is not as critical.

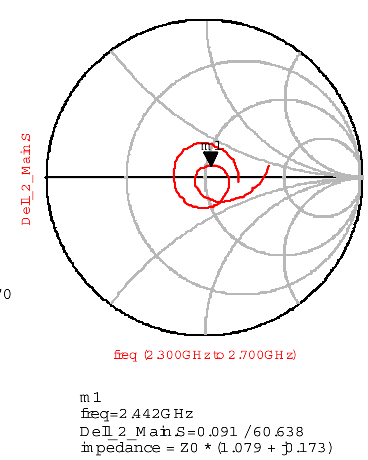
<u>The isolation between antennas.</u>
This can be a problem when the antennas are constrained to be close together. The desired isolation spec is S21 > 20dB. Since the two antennas are typically spaced far apart in these applications, the spec should not have a problem being met.

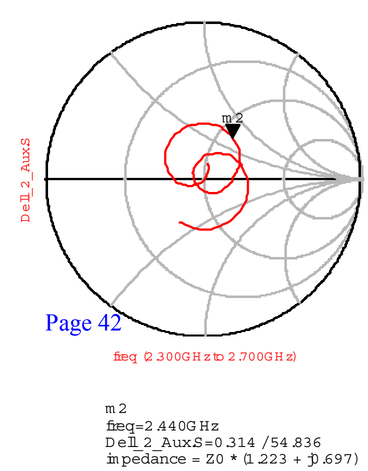
Office Environment Measurements
Test Results:

H2 Laptop

This laptop had both the main and auxilary antenna connected to a diversity switch. A bias T was used to operate the switch externally with a DC bias. Network analyzer measurements were done to check the tuning of the antennas and to make sure there was enough isolation to provide the space diversity requirements.







The aux antenna looked like it might be tuned slightly high, but it was close enough to be acceptable. The isolation between the antennas was greater than 20dB which is acceptable. The antennas were located on opposite sides of the unit, so space diversity between the antennas was adequately present.

Gain measurements on a similar laptop with the same antenna designs were previously taken by Foxconn on 7/00-8/00. A summary of the results they received as documented in their IEEE802.11 Test Report –2 document is shown below:

MAIN ANTENNA – Average Gain

(dBi)	2400 MHz	2450 MHz	2500 MHz
XY-OPEN-H	-11.71	-11.72	-12.40
XY-OPEN-V	-7.75	-9.10	-10.11
XY-OPEN-AVG.	-6.29	-7.21	-8.10
YZ-OPEN-H	-8.73	-8.31	-8.35
YZ-OPEN-V	-12.58	-14.11	-12.59
YZ-OPEN-AVG.	-7.23	-7.29	-6.96
XZ-OPEN-H	-11.67	-10.66	-11.66
XZ-OPEN-V	-6.94	-6.82	-7.52
XZ-OPEN-AVG.	-5.68	-5.32	-6.10
TOTAL AVG. GAIN	-6.35	-6.51	-6.98

AUX ANTENNA – Average Gain

(dBi)	2400 MHz	2450 MHz	2500 MHz
XY-OPEN-H	-12.31	-14.63	-17.08
XY-OPEN-V	-8.70	-9.82	-8.86
XY-OPEN-AVG.	-7.13	-8.58	-8.25
YZ-OPEN-H	-6.91	-8.17	-8.27
YZ-OPEN-V	-11.67	-11.85	-13.57
YZ-OPEN-AVG.	-5.66	-6.62	-7.14
XZ-OPEN-H	-9.35	-10.94	-10.11
XZ-OPEN-V	-8.28	-11.03	-8.62
XZ-OPEN-AVG.	-5.77	-7.97	-6.29
TOTAL AVG. GAIN	-6.14	-7.65	-7.15

The average gain numbers are calculated by summing all the linear gain measurements and dividing by 360, then converting back to dBi units.

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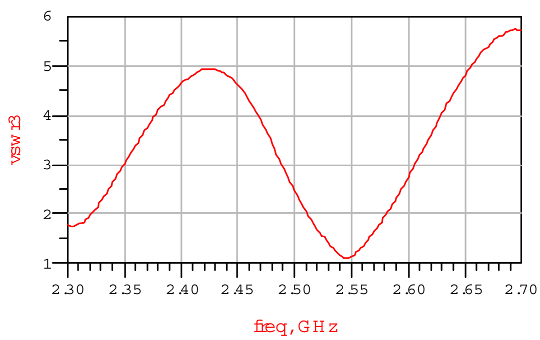
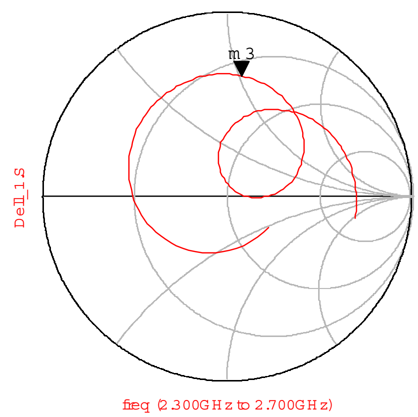
Dell L2 Laptop (Inspiron)

This laptop contained only one antenna due to space constraints, so there is no need to check the polarization or isolation of the system. The diversity scheme is therefore not used in this system. Network analyzer measurement data is shown below. This antenna also seemed to be tuned to 2.55 GHz, and needs some VSWR improvement in the 2.4-2.483GHz band.





m3
freq=2.440GHz
Dell_1.S=0.656 / 83.258
impedance = Z0 * (0.446 + j1.021)

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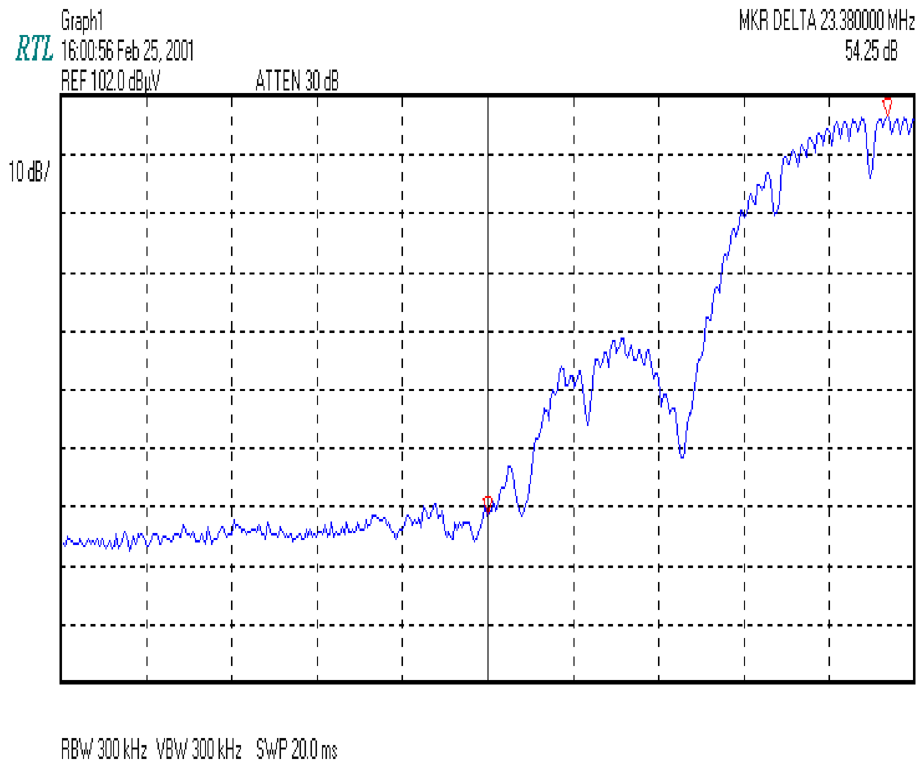
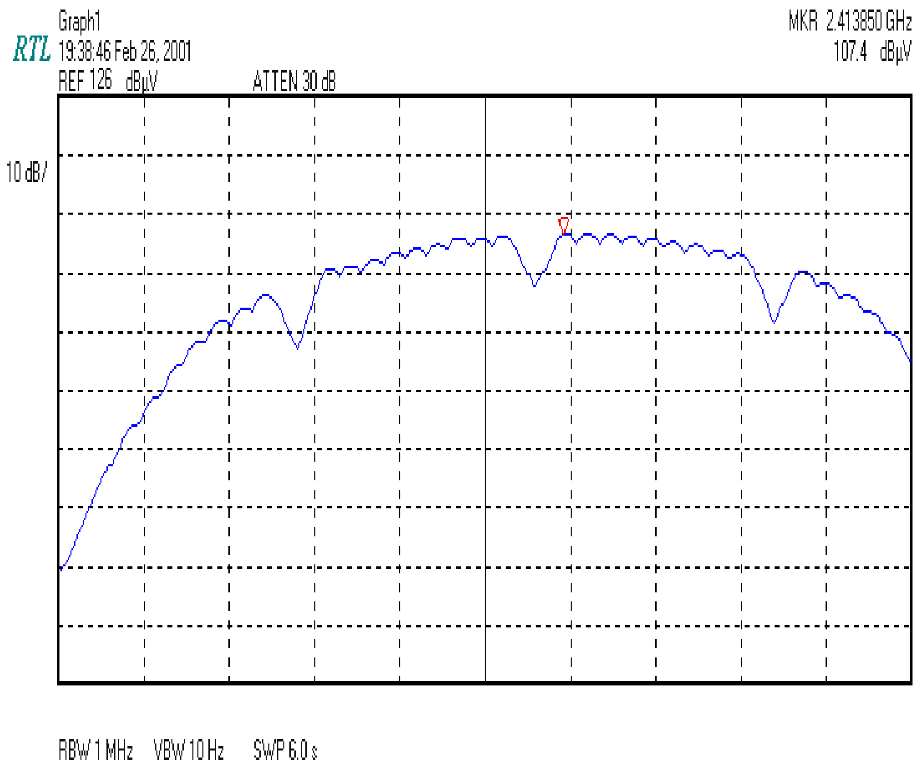
15 BANDEDGE PLOTS

PLOT 1: CHANNEL 1 CISCO DIPOLE ANTENNA 1MHZ/10HZ



PLOT 2: CHANNEL 1 CISCO DIPOLE ANTENNA



Note site factor entered into analyzer register for corrected final result.

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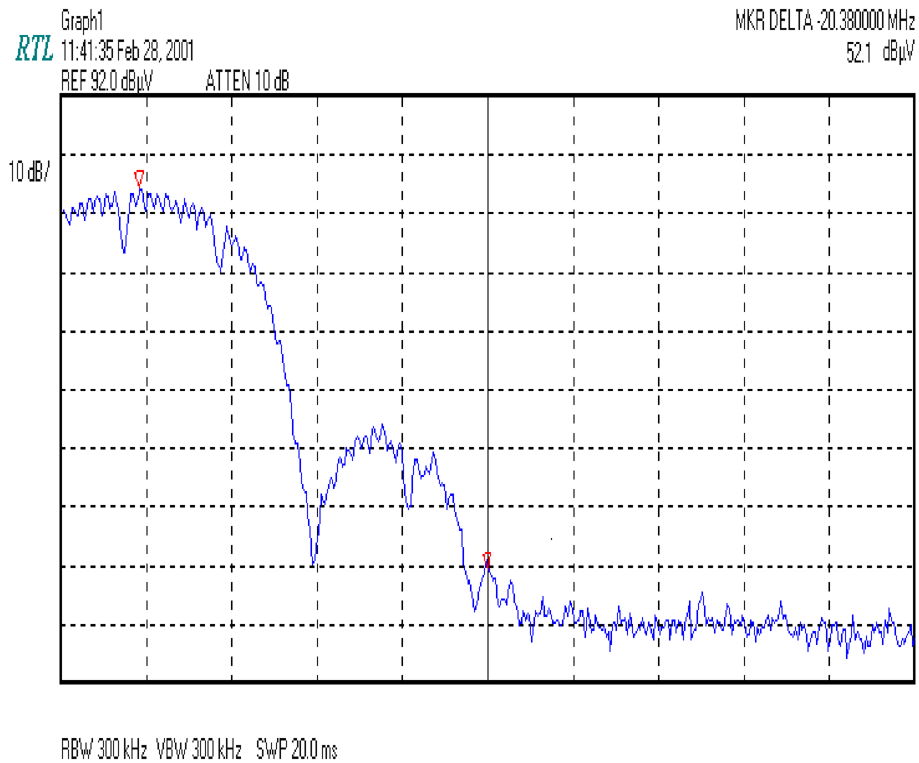
PLOT 3: CHANNEL 11 CISCO DIPOLEANTENNA



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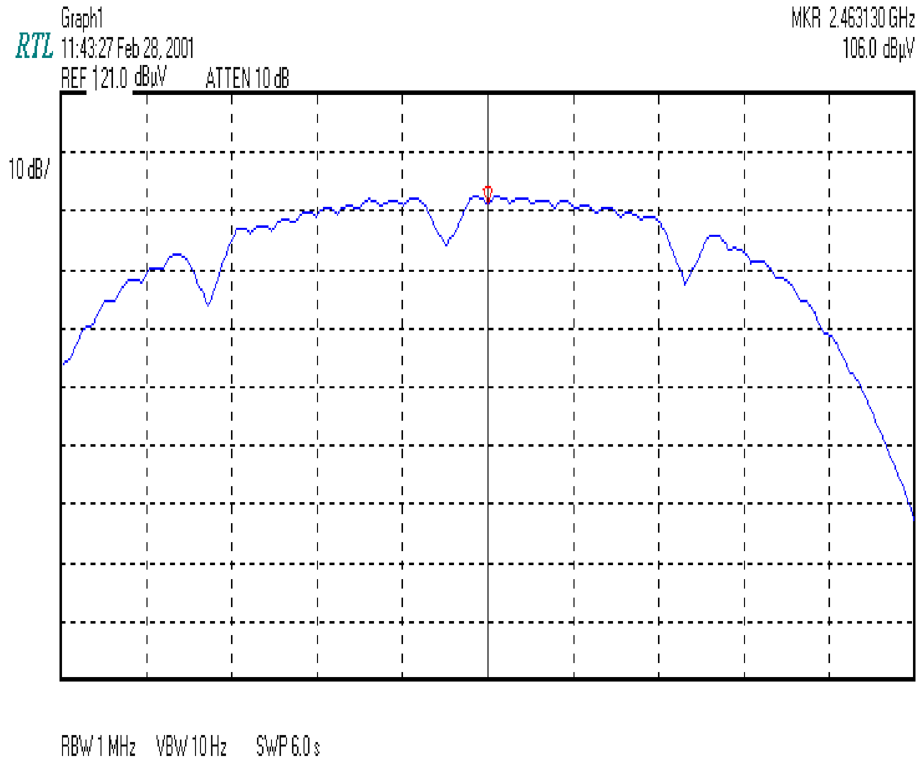
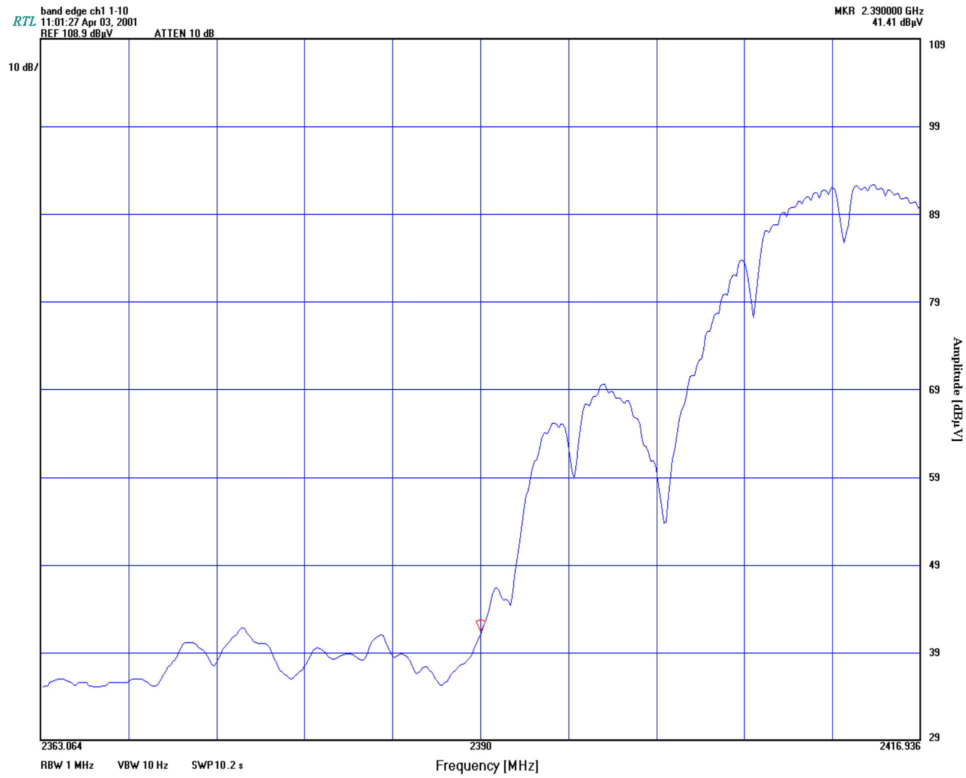
PLOT 4: CHANNEL 11 CISCO DIPOLE ANTENNA

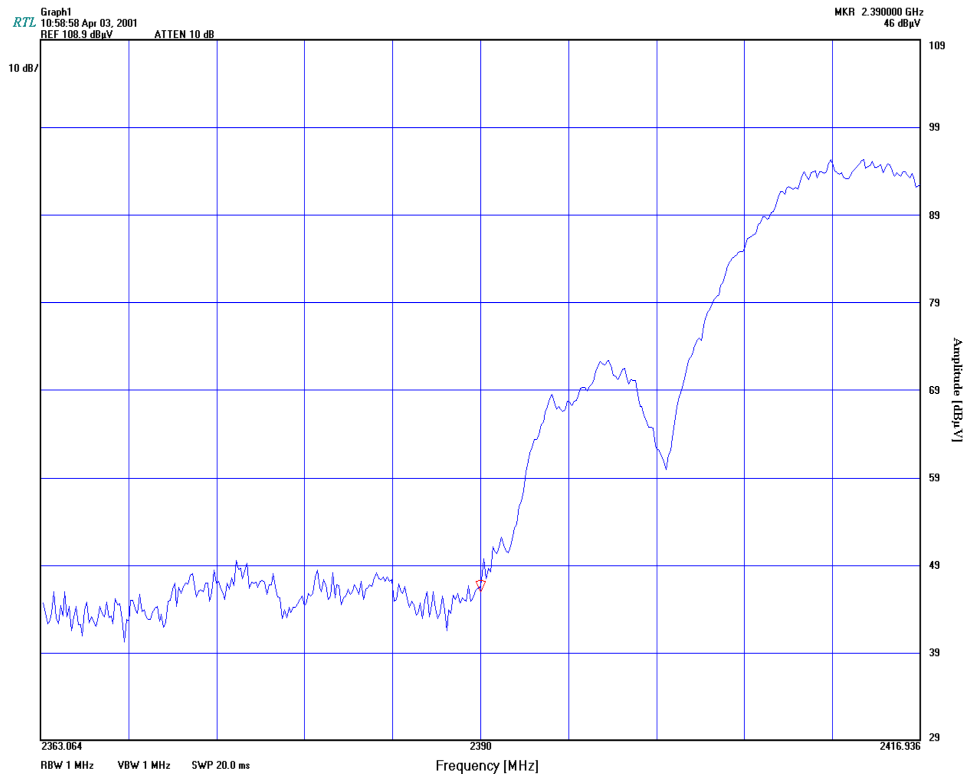


Note site factor entered into analyzer register for corrected final result.

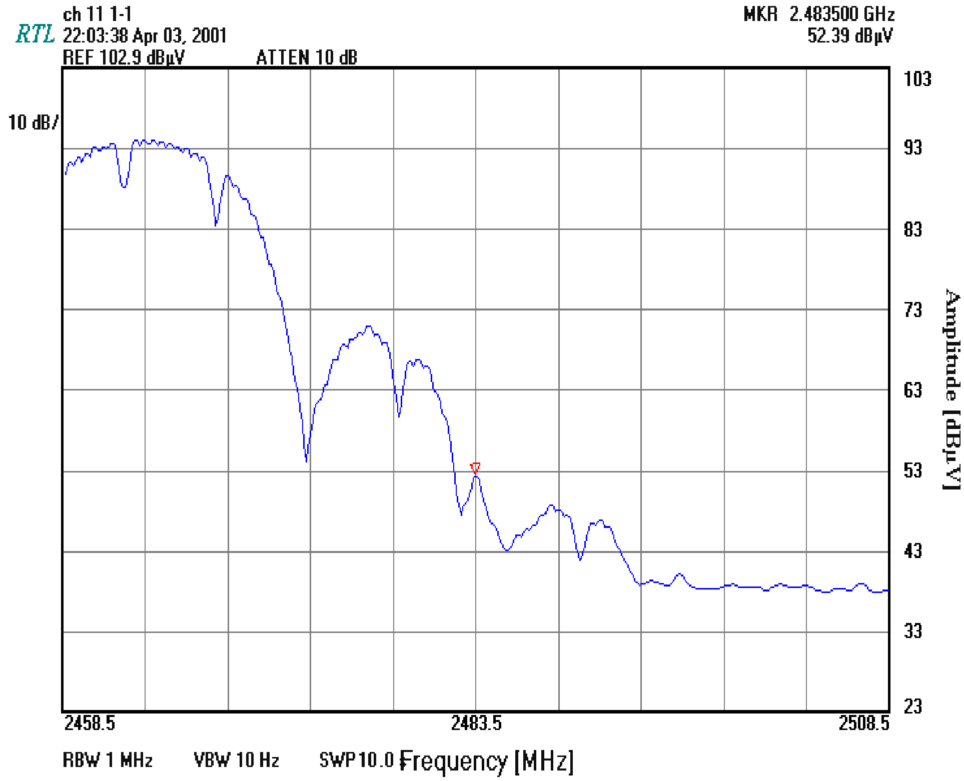
PLOT 5: CHANNEL 1 DELL DIPOLE ANTENNA 1MHZ/10HZ



PLOT 6 CHANNEL 1 DELL DIPOLE ANTENNA 1MHZ/1MHZ



PLOT 7   CHANNEL 11 DELL DIPOLE ANTENNA 1MHZ/10HZ



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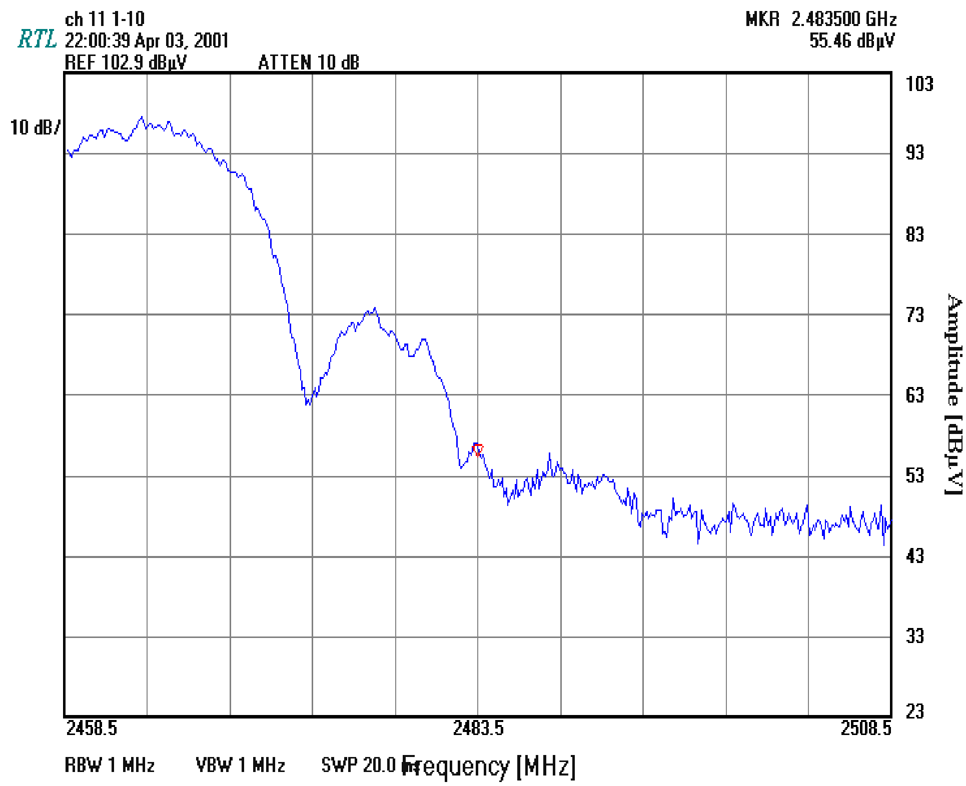
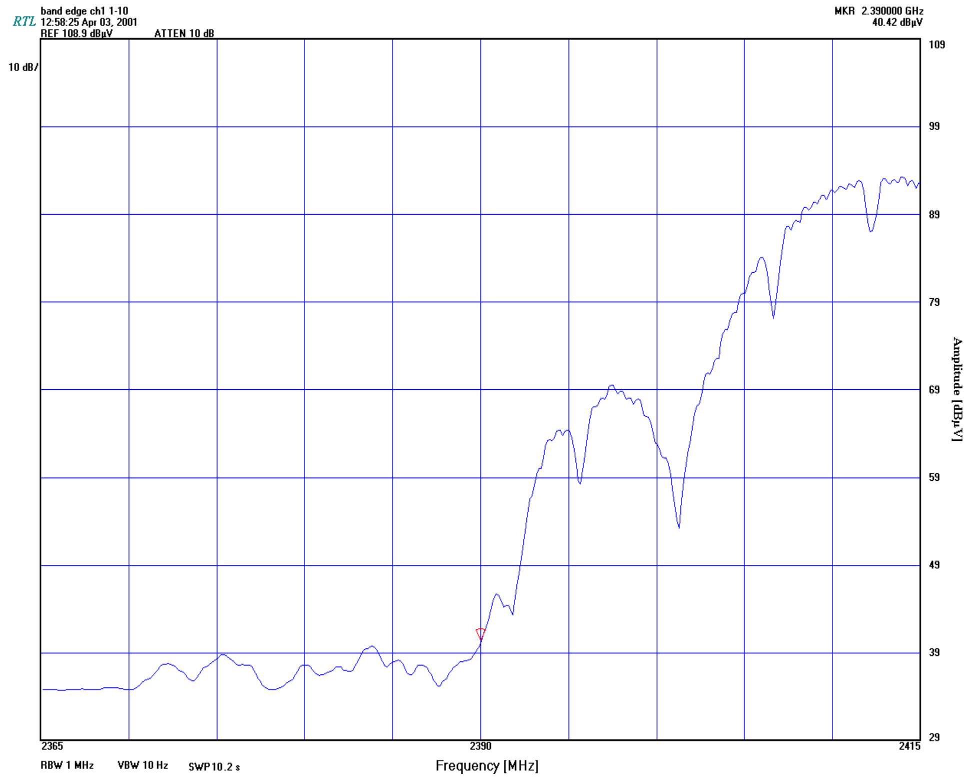
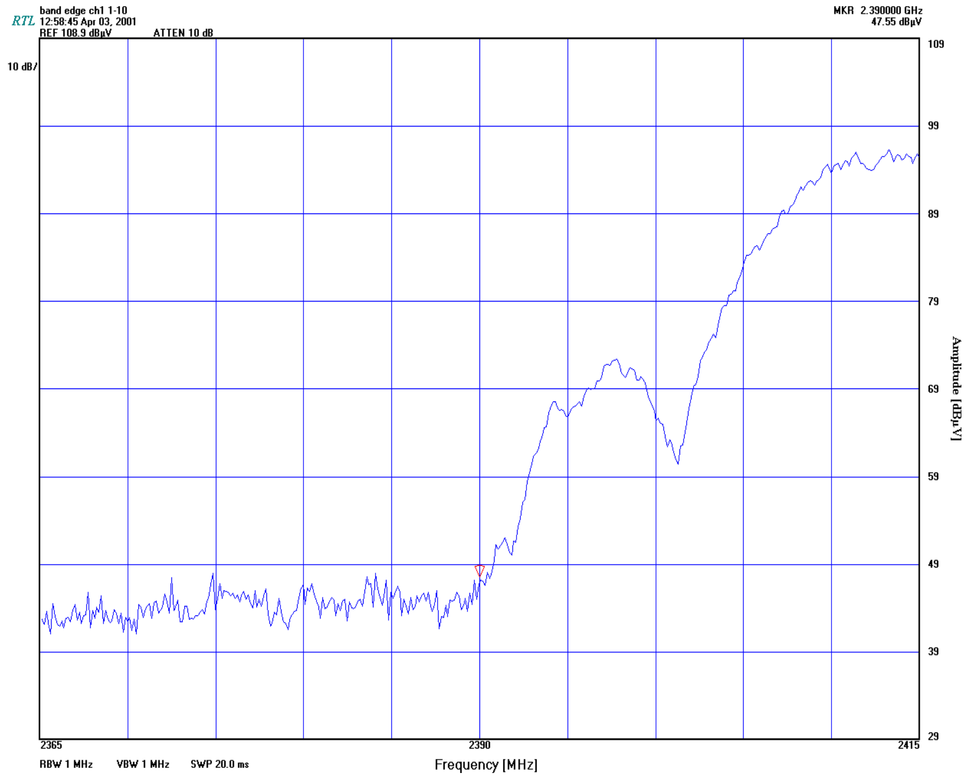
PLOT 8 CHANNEL 11 DELL DIPOLE ANTENNA 1MHZ/1MHZ



PLOT 9 CHANNEL 1 DELL INVERTED F ANTENNA 1MHZ/10HZ



PLOT 10 CHANNEL 1 DELL INVERTED F ANTENNA 1MHZ/1MHZ



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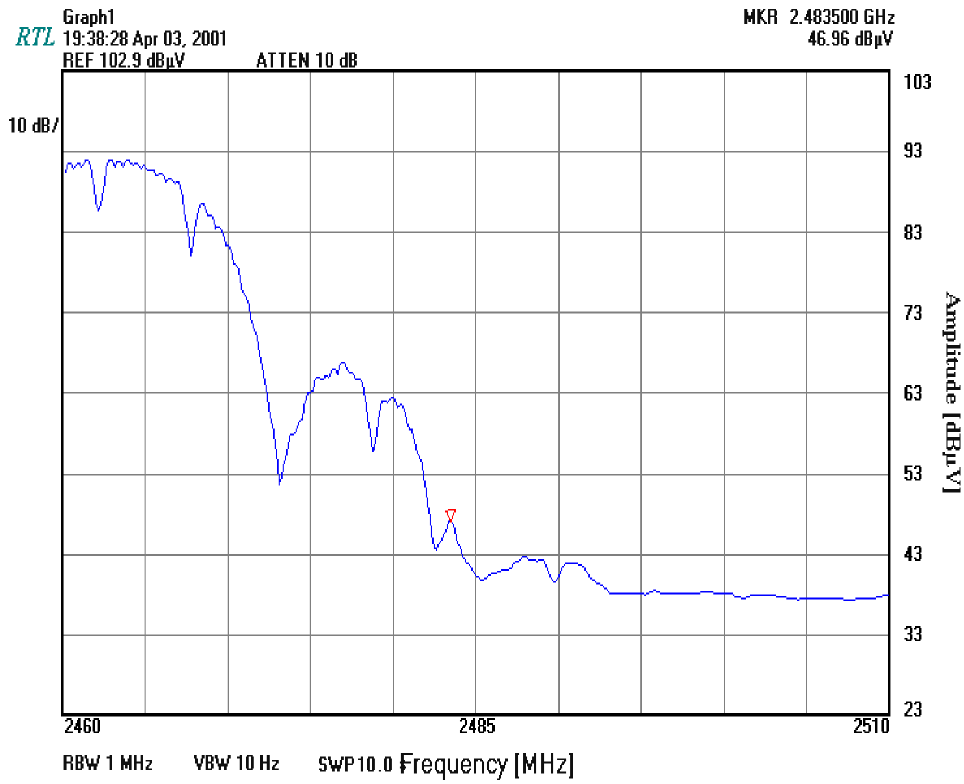
PLOT 11 CHANNEL 11 DELL INVERTED F ANTENNA 1MHZ/10HZ



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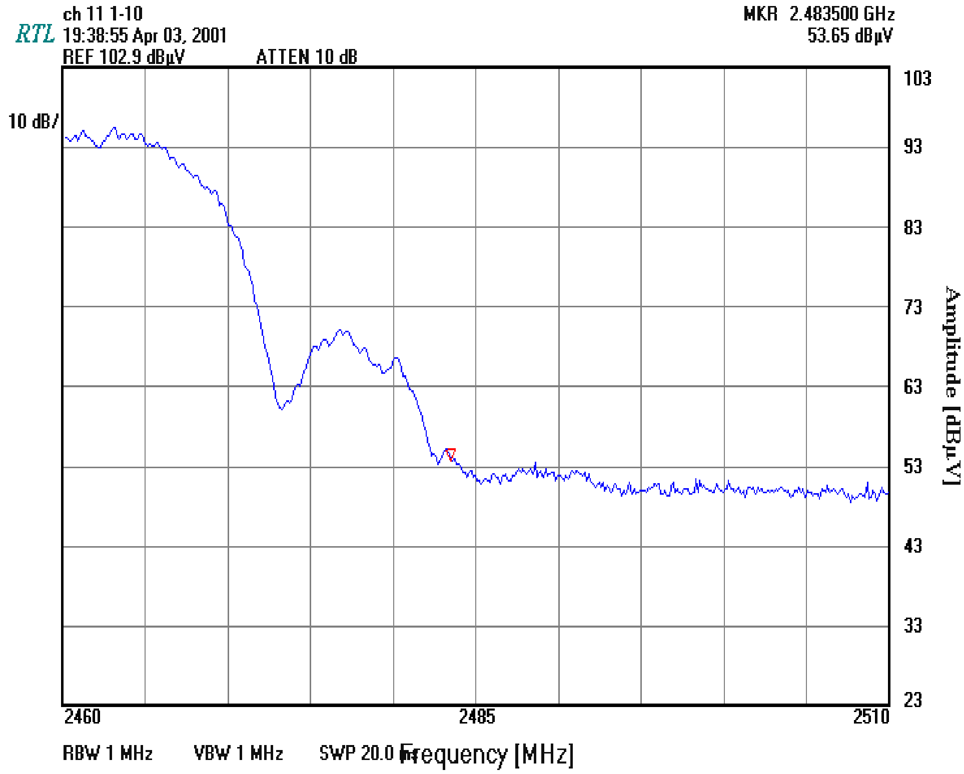
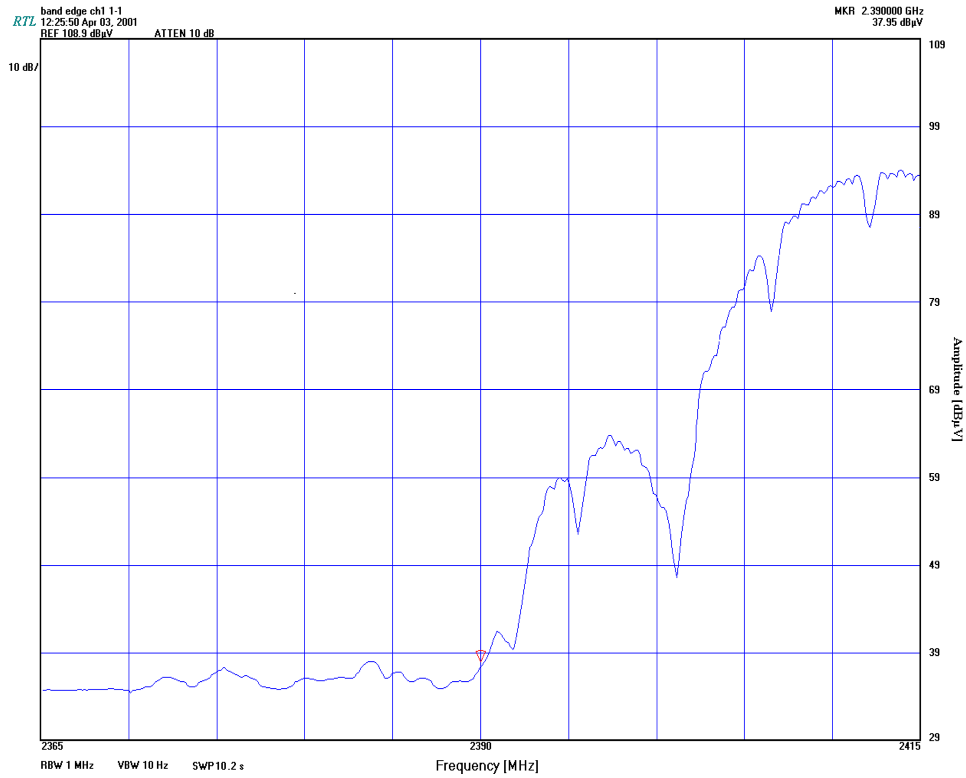
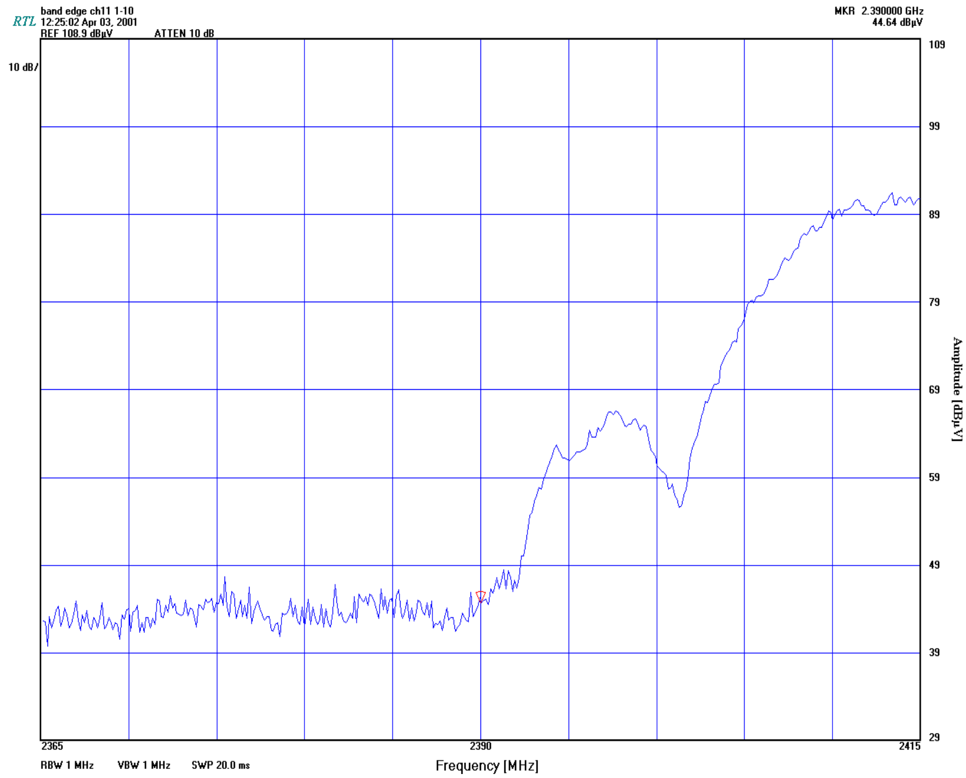
PLOT 12 CHANNEL 11 DELL INVERTED F ANTENNA 1MHZ/1MHZ



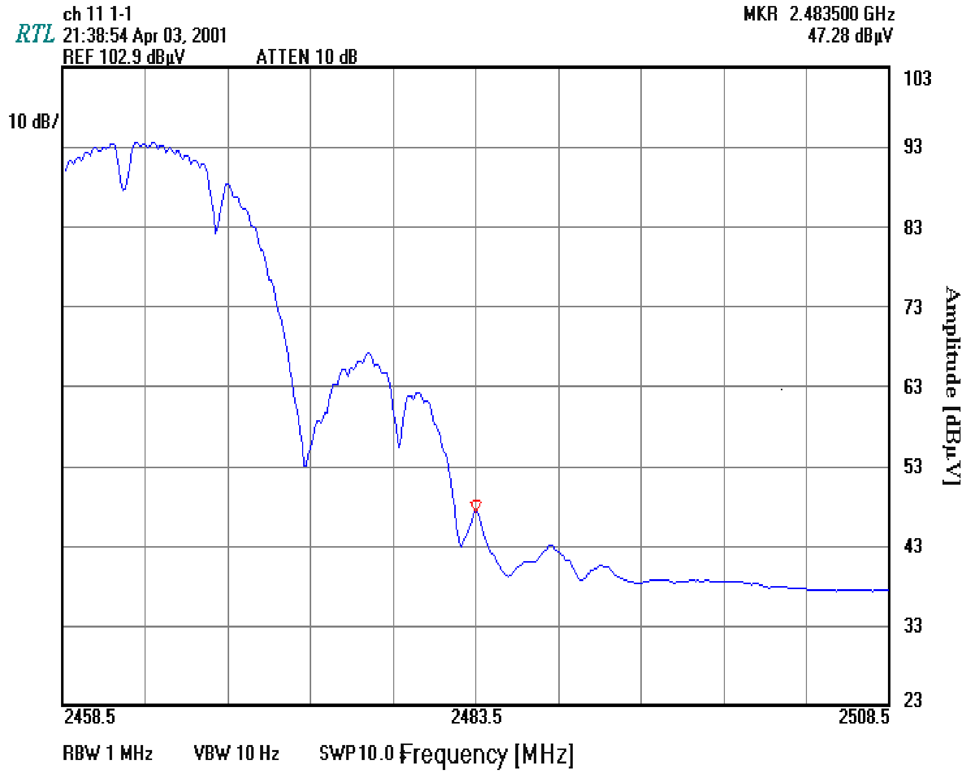
PLOT 13 CHANNEL 1 TOSHIBA CHIP ANTENNA 1MHZ/10HZ



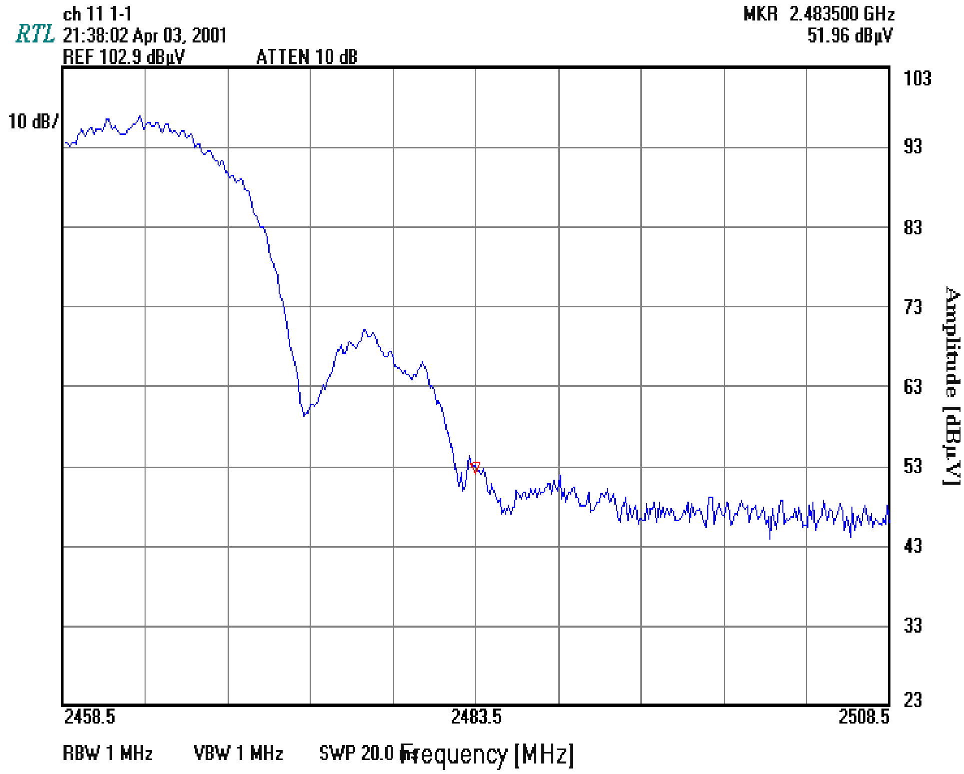
PLOT 14 CHANNEL 1 TOSHIBA CHIP ANTENNA 1MHZ/1MHZ



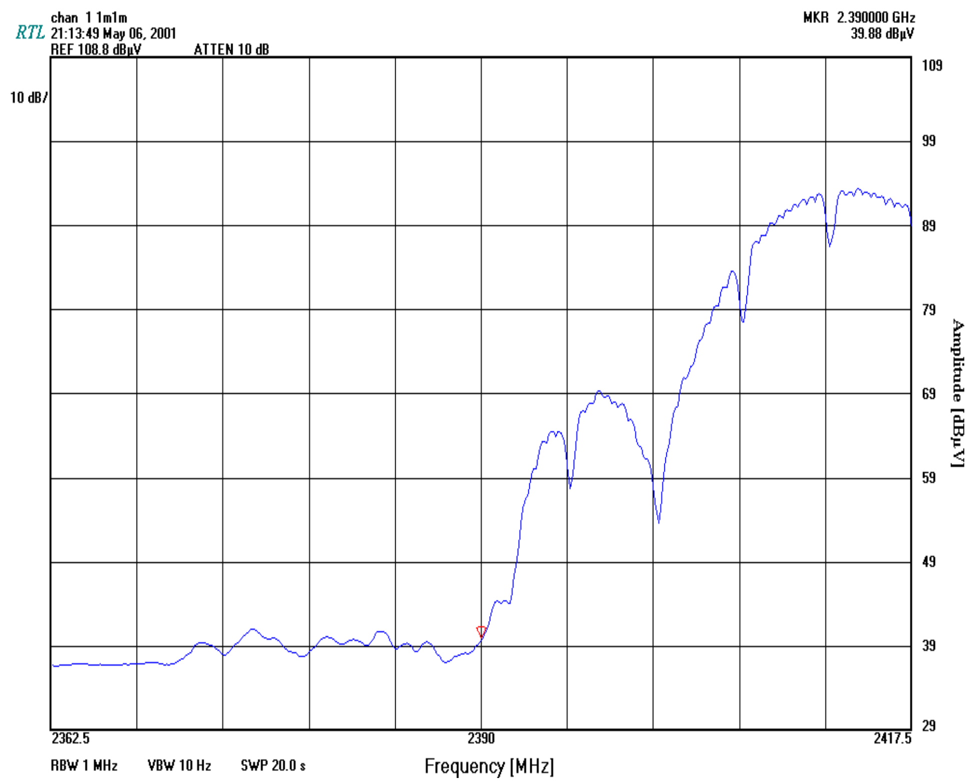
PLOT 15 CHANNEL 11 TOSHIBA CHIP ANTENNA 1MHZ/10HZ



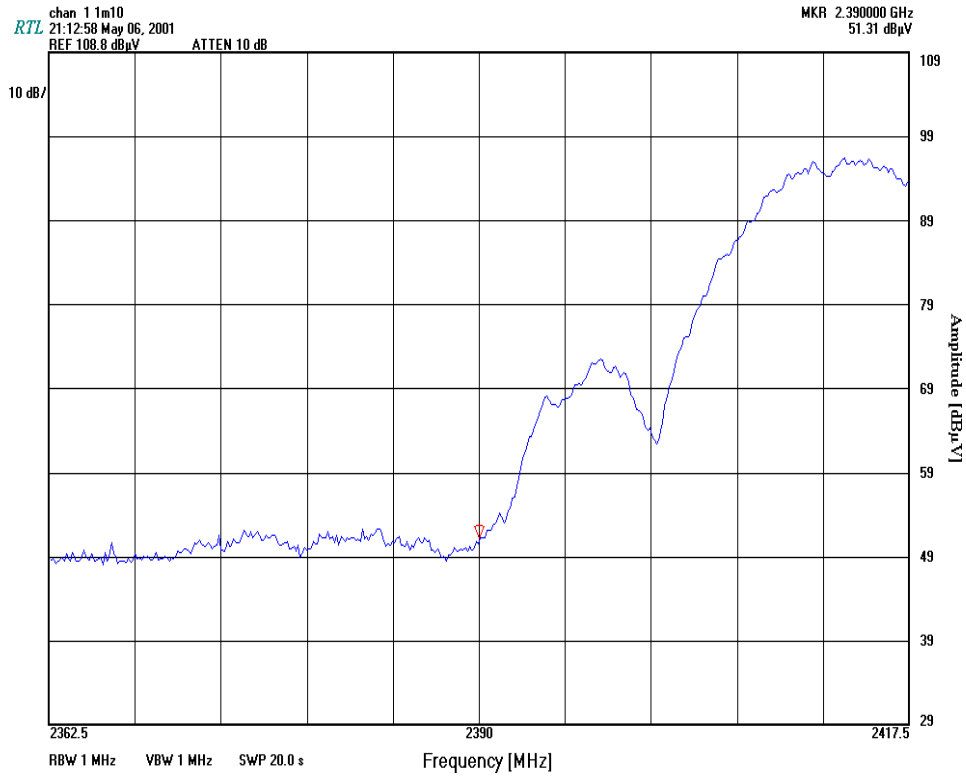
PLOT 16 CHANNEL 11 TOSHIBA CHIP ANTENNA 1MHZ/1MHZ



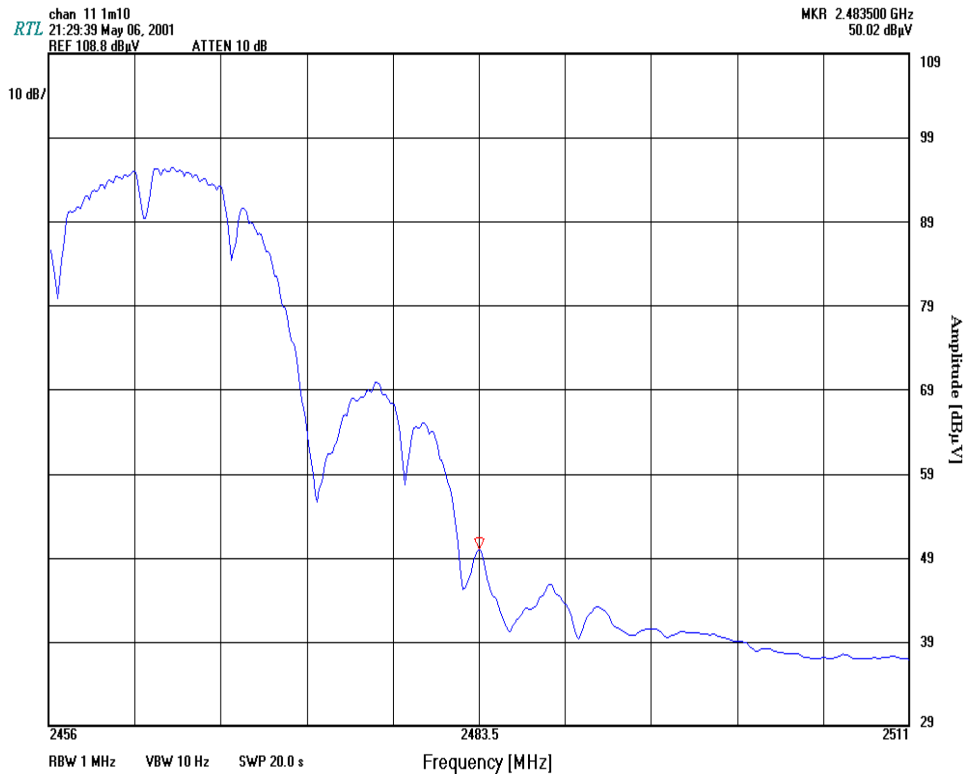
PLOT 17 CHANNEL 1 INVERTED F TOSHIBA ANTENNA 1MHZ/10HZ



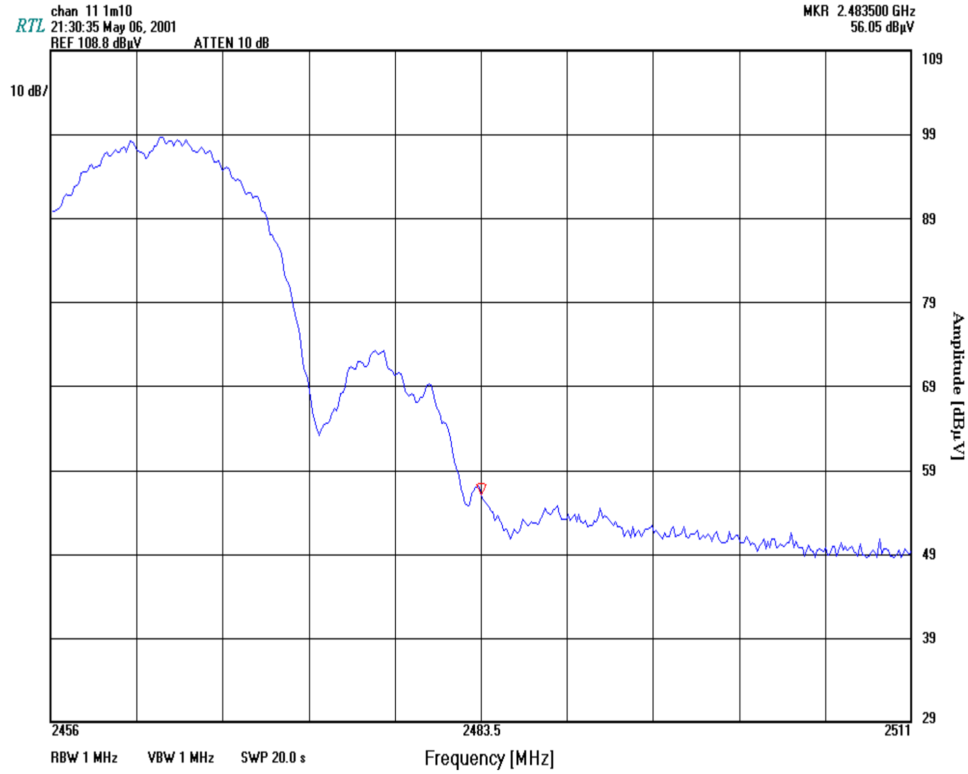
PLOT 18 CHANNEL 1 INVERTED F TOSHIBA ANTENNA 1MHZ/1MHZ



PLOT 19 CHANNEL 11 INVERTED F TOSHIBA ANTENNA 1MHZ/10HZ

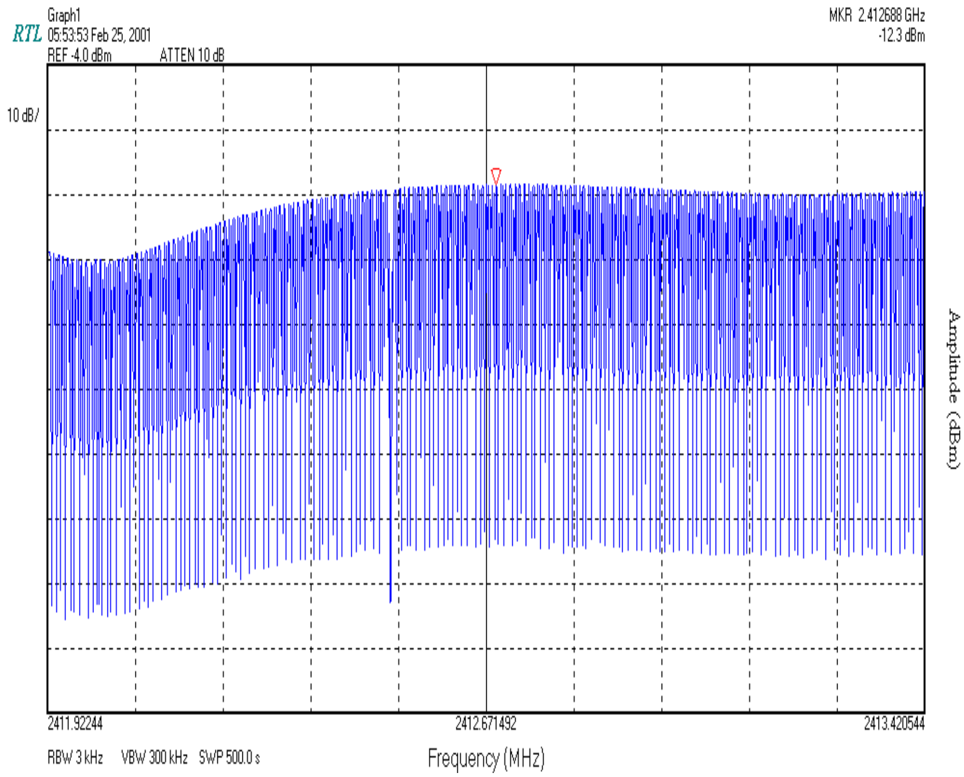


PLOT 20 CHANNEL 11 INVERTED F TOSHIBA ANTENNA 1MHZ/1MHZ

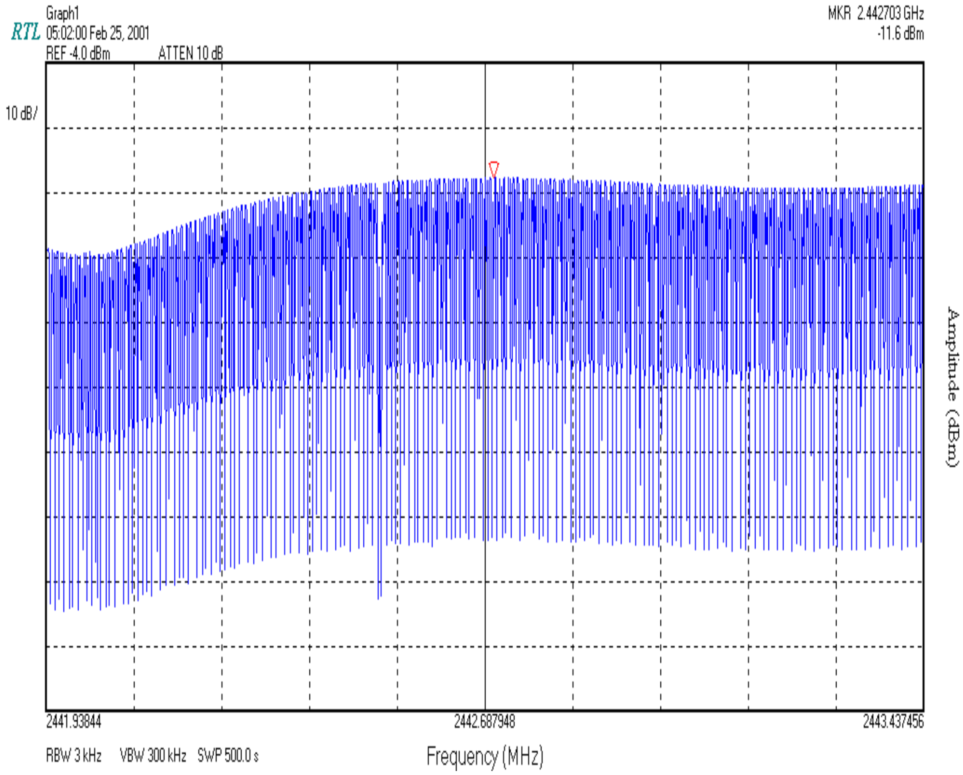


16 SPECTRAL DENSITY PLOTS

PLOT 21: CHANNEL 1



PLOT 22: CHANNEL 6



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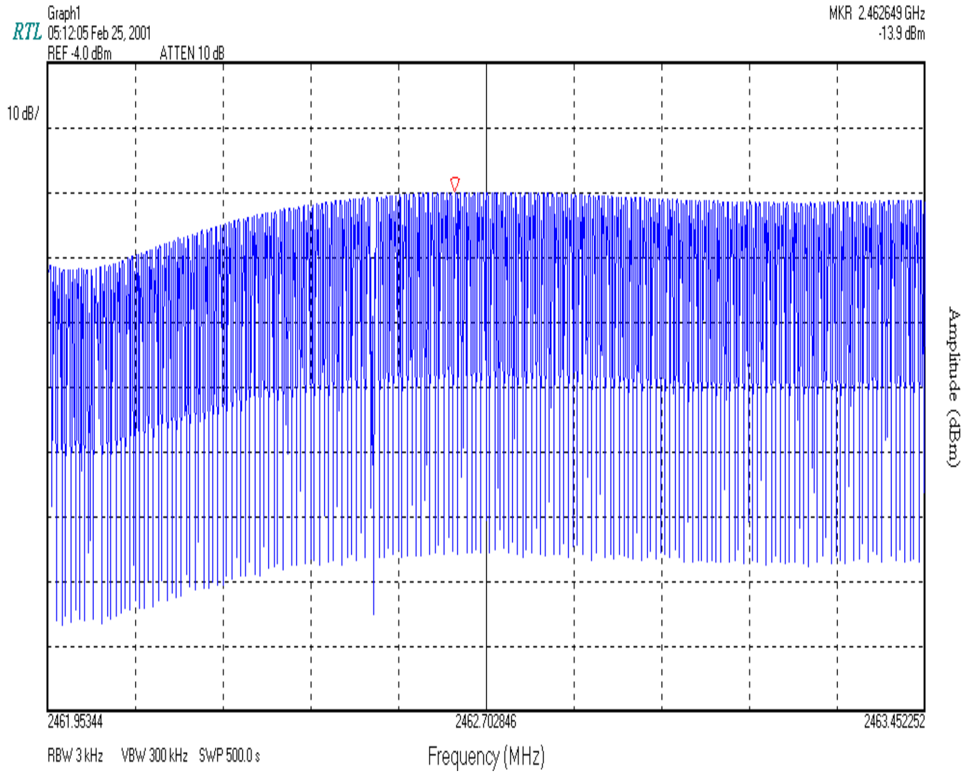
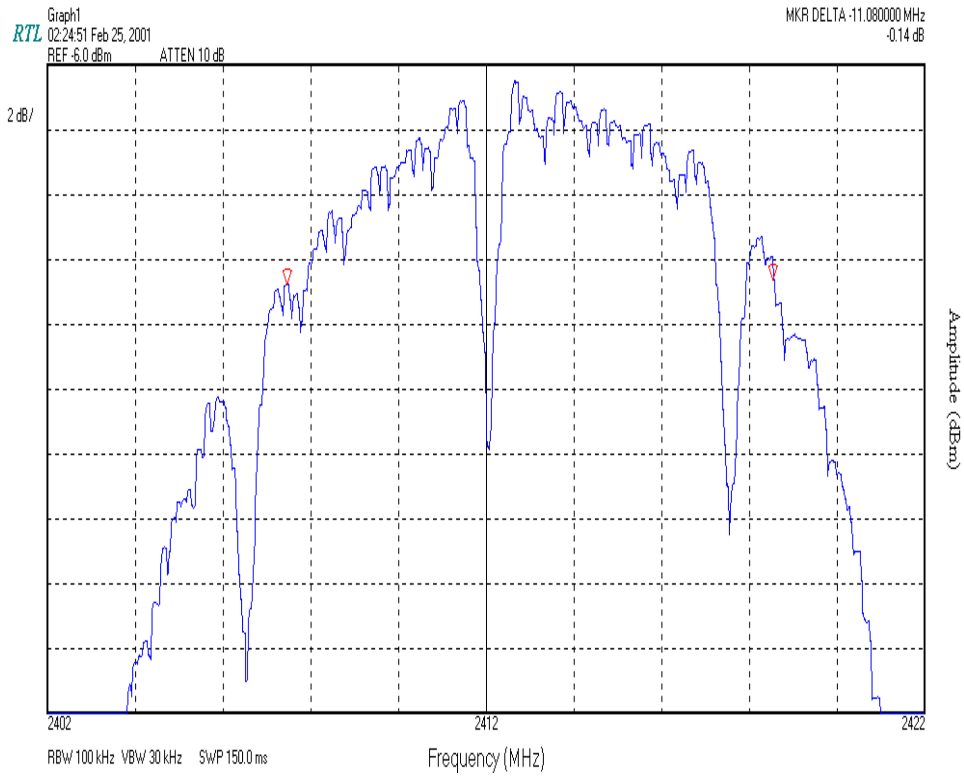
PLOT 23: CHANNEL 11



17 6dB PLOTS

PLOT 24: CHANNEL 1



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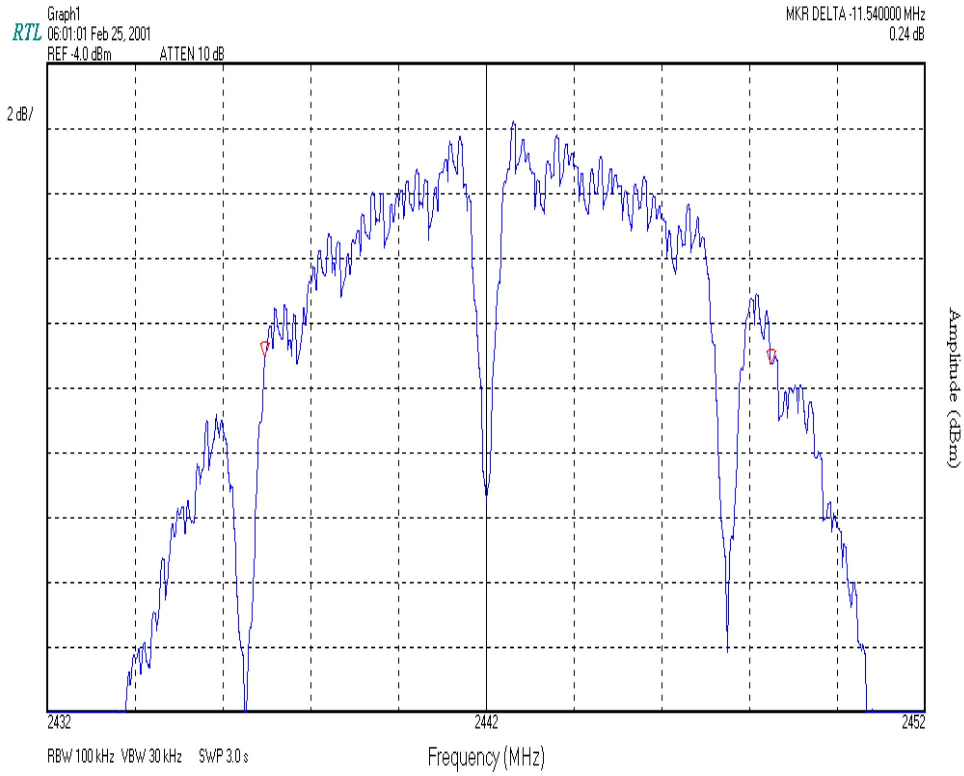
PLOT 25: CHANNEL 6



PLOT 26: CHANNEL 11