

ENGINEERING TEST REPORT

WIRELESS LAN CARD

Model No: RL2400

FCC ID: NVF-RL2400

FCC PART 15, SUBPART C, PARA. 15.247
DIRECT SEQUENCE SPREAD SPECTRUM (DSSS) TRANSMITTERS
OPERATING IN THE FREQUENCY BAND FROM 2412 - 2462 MHz

UltraTech's FILE NO.: RLT-001FTX

TESTED FOR:

RADIO-LINK TECHNOLOGY COMPANY, LTD.
No. 19, Tien-Hsiang, Hsin-Ying Village
Miao-Li City, Taiwan, R.O.C.

TESTED BY:

UltraTech Engineering Labs Inc.
4181 Sladeview Crescent, Unit 33
Mississauga, Ontario
Canada L5L 5R2

PREPARED BY: Tri M. Luu, P.Eng.

DATE: Mar. 25, 1998

UltraTech

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EXHIBIT 1 - SUMMARY OF TEST RESULTS & GENERAL STATEMENT OF CERTIFICATION

FCC PARAGRAPH.	TEST REQUIREMENTS	COMPLIANCE (YES/NO)
15.247(a)(2)	Spectrum Bandwidth of a Direct Sequence Spread Spectrum System	Yes
15.247(b)	Maximum Peak Power	Yes
15.247(c)	RF Conducted Spurious Emissions at the Transmitter Antenna Terminal	Yes
15.247(c), 15.209 & 15.205	Transmitter Radiated Emissions	Yes
15.247(d)	Transmitted Power Density of a Direct Sequence Spread Spectrum System	Yes
15.247(e)	Processing Gain of Direct Sequence Spread Spectrum System	Yes
15.107, 15.109	AC Power Conducted Emissions & Radiated Emissions for Receiver and Digital Circuit Portions	Yes (Note 1)

Note 1: The digital circuits and receiver portion of the EUT has been tested and verified to comply with FCC Part 15, Subpart B, Class B Digital Devices and Radio Receivers (Class B Equivalent Limits). The engineering test report can be provided upon FCC requests.

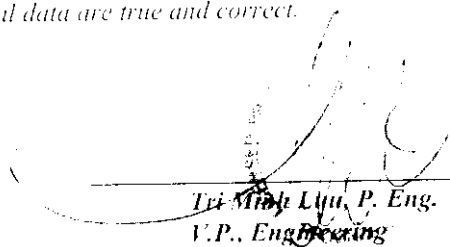
- Accredited by **ITI** (UK) Competent Body & **NVLAP** (USA) Accreditation Body
- Recognized/ Listed by **FCC** (USA), **Industry Canada** (Canada), **Austel** (Australia)
- All test results contained in this engineering test report are traceable to National Institute of Standards and Technology (**NIST**)

TESTIMONIAL AND STATEMENT OF CERTIFICATION

THIS IS TO CERTIFY:

- 1) THAT the application was prepared either by, or under the direct supervision of the undersigned.
- 2) THAT the measurement data supplied with the application was taken under my direction and supervision.
- 3) THAT the data was obtained on representative production units, representative.
- 4) THAT, to the best of my knowledge and belief, the facts set forth in the application and accompanying technical data are true and correct.

Certified by:



Tri-Ming Lhu, P. Eng.
V.P., Engineering

DATE: Mar. 25, 1998

EXHIBIT 2 - GENERAL INFORMATION

1.1. **Applicant**

RADIO-LINK TECHNOLOGY COMPANY, LTD.
No. 19, Tien-Hsiang, Hsin-Ying Village
Miao-Li City, Taiwan, R.O.C.

Applicant's Representative: Mr. Tang Young Chao

1.2. **Manufacturer**

RADIO-LINK TECHNOLOGY COMPANY, LTD.
No. 19, Tien-Hsiang, Hsin-Ying Village
Miao-Li City, Taiwan, R.O.C.

1.3. **Description of Equipment under Test**

PRODUCT NAME:	WIRELESS LAN CARD
SERIAL NUMBER:	Pre-production
TYPE OF EQUIPMENT:	DSSS Transmitters
OPERATING FREQ.:	2412 - 2462 MHz
NUMBER OF CHANNEL:	11
CHANNEL SPACING:	5 MHz
BANDWIDTH (6 dB OBW):	9 MHz minimum
POWER RATING:	46.8 miliWatts max.
ANTENNA GAIN:	2.15 dBi maximum / 0 dBi typical (internal integral part of the printed circuit board) Manufacturer: Toko, P/N: DAC2450CT1, Type: Ultra Miniature Size Dielectric Antenna Element.
EMISSION DESIGNATION:	Direct Sequence Spread Spectrum, 2 Mb/s data rate, DPSK
DUTY CYCLE:	Continuous
OSC. FREQUENCY(IES):	32.76 KHz, 22 MHz, 40MHz, 560 MHz (VCO), 2450 MHz (IF), 280 MHz (IF), Tx Local Osc.: Tx freq. - IF freq. (280 MHz)
INPUT SUPPLY:	Using DC Power from a laptop computer
ASSOCIATED DEVICES:	Not applicable
FCC ID:	NVF-RL2400
INTERFACE PORTS:	Not applicable

UltraTech Engineering Labs Inc.

4181 Sladerview Cres., Unit 33, Mississauga, Ontario, Canada L5L 5R2

UltraTech's File #: RL2-001FTX

Tel. #: 905-569-2550

Fax. #: 905-569-2480

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- Recognized / Listed by: **FCC** (USA), **Industry Canada** (Canada), **Austel** (Austroding)
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1.4. **Related Submittal(s)/Grant**

Not applicable.

1.5. **Test Methodology**

These tests were conducted on a sample of the equipment for the purpose of certification compliance with Code of Federal Regulations (CFR47-1991), Part 15, Subpart C, Para. 15.247, Direct Sequence Spread Spectrum Transmitters operating in the Frequency Band 2412 - 2462 MHz.

Both conducted and radiated emissions measurements were conducted in accordance with American National Standards Institute ANSI C63.4-1992 - American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 KHz to 40 GHz.

1.6. **Test Facility**

AC Powerline Conducted Emissions were performed in UltraTech's shielded room, 16'(L) by 12'(W) by 12'(H).

Radiated Emissions were performed at the UltraTech's 3-to-10 Meter Open Field Test Site (OFTS) situated in the Town of Oakville, province of Ontario.

The above sites have been calibrated in accordance with ANSI C63.4, and found to be in compliance with the requirements of Sec. 2.948 of the FCC Rules. The descriptions and site measurement data of the Oakville Open Field Test Site has been filed with FCC office (FCC File No.: 31040/SIT 1300B3) and Industry Canada office (Industry Canada File No.: IC2049). Last Date of Site Calibration: July 16, 1997.

The above test site is also filed with Interference Technology International Ltd (ITI - An EC Directive on EMC).

1.7. **Units of Measurements**

Measurements of conducted emissions are reported in units of dB referenced to one microvolt [dB(uV)].

Measurements of radiated emissions are reported in units of dB referenced to one microvolt per meter [dB(uV)/m] at the distance specified in the report, wherever it is applicable.

EXHIBIT 3 - SYSTEM TEST CONFIGURATION**1.8. Test System Details**

The following peripherals, FCC identifiers and types interconnecting cables were used with the EUT for testing:

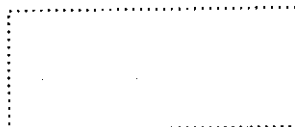
- (1) **EUT:** RADIO-LINK TECHNOLOGY COMPANY, LTD., WIRELESS LAN CARD, Model : RL2400, S/N: Pre-production
Power & I/O Cable: Not applicable.
- (2) **PERIPHERAL:** HP OmniBook Laptop Computer, Model HP OmniBook 5500 CS, FCC ID: B945500, S/N: TW63403246
I/O Cable: All I/O Cables were shielded
Power Supply Cable: Non-shielded
- (3) **PERIPHERAL:** Digital DEC Writer 1001 Parallel Printer, Model LJ100-AZ, S/N: OV44352056, FCC ID: EP8JP150
I/O CABLE: Shielded
POWER CABLE: Unshielded
- (4) **PERIPHERAL:** Kana Serial Modem, Model 2400EI, S/N: EI-9004777, FCC ID: GN23V4A2400EI
I/O Cable: Shielded
Power Supply Cable: Non-shielded

1.9. Block Diagrams Radiated Emission Measurements

4181 Sladeview Cres., Unit 33,
Mississauga, ON L5L 5R2

4181 Sladeview Cres., Unit 33,
Mississauga, ON L5L 5R2

Digital Writer 1001
Digital Printer
Model LJ100-AZ



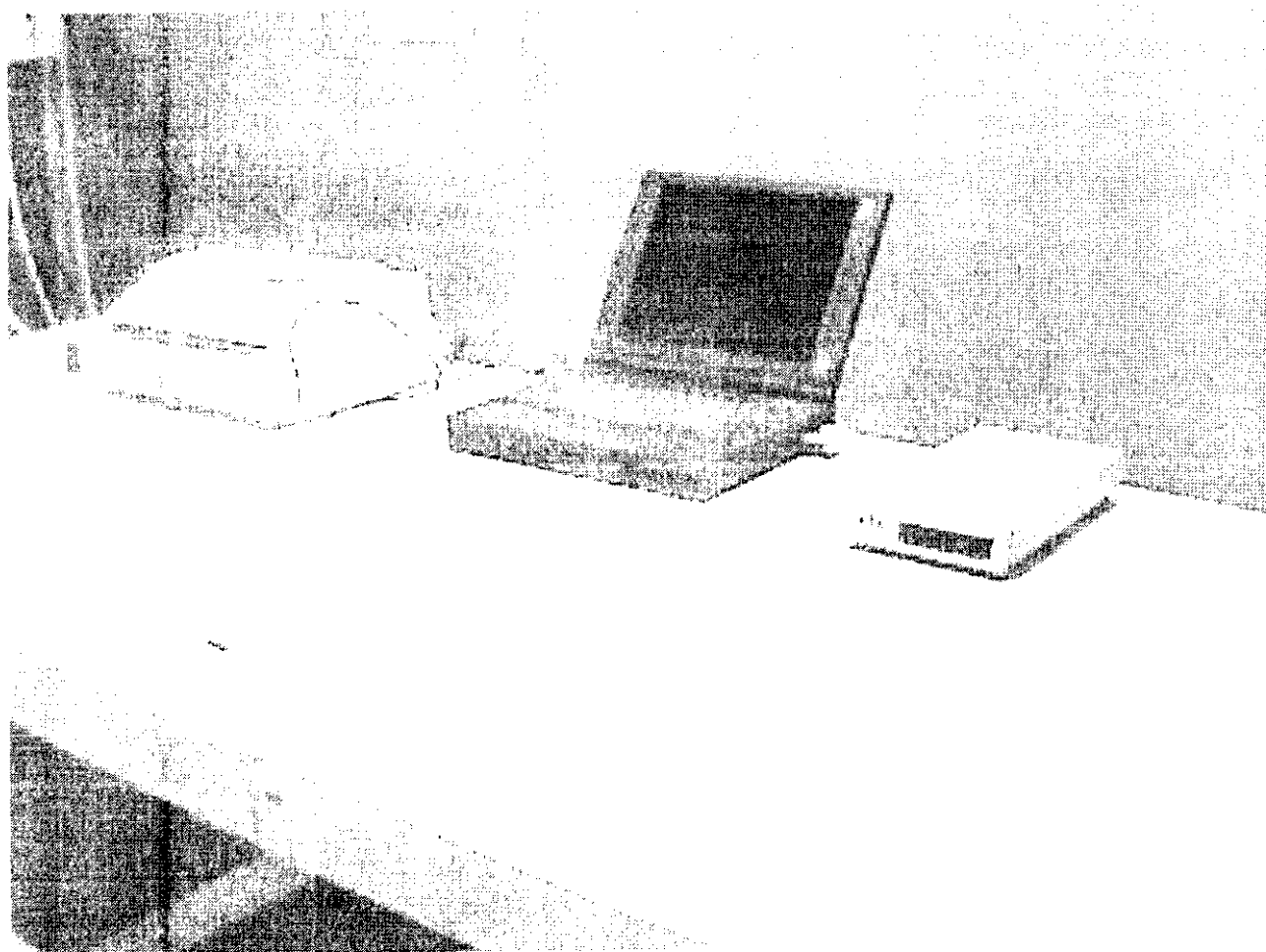
1999
10/10/99

Rev. 12/17/00-02

1.10. Photograph for RF Emission Measurements

Please refer to the attached photos.

**TEST SETUP FOR
AC POWER LINE CONDUCTED EMISSIONS MEASUREMENTS**
(tests were performed in the screen room)



- Accredited by **ITI** (UK), Competent Body & **NVLAP** (USA) Accreditation Body
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1.11. Justification

No deviation, in both configuration and operation manners, different from normal operation were required.

1.12. EUT Operating Condition

Software provided by RADIO-LINK TECHNOLOGY COMPANY, LTD. to set the EUT to transmit at lowest, middle and highest channel frequencies.

1.13. Special Accessories

No special accessories were required.

1.14. Equipment Modifications

To achieve compliance, the following change(s) were made by UltraTech's test house during compliance testing:

Not required.

- Accredited by: **ITI** (UK) Competent Body & **NVLAP** (USA) Accreditation Body
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EXHIBIT 4 - TEST DATA**1.15. 6 dB Bandwidth @ FCC CFR 47, Para 15.247(a)(2)****PRODUCT NAME:** WIRELESS LAN CARD, Model No.: RL2400**FCC REQUIREMENTS:**

For a direct sequence spread spectrum system, the minimum 6 dB bandwidth shall be at least 500 KHz.

CLIMATE CONDITION:

Standard Temperature and Humidity: 23°C and 53%

TEST EQUIPMENT:

- Advantest Spectrum Analyzer, Model R3271, S/N: 15050203

METHOD OF MEASUREMENTS:

The transmitter output was connected to the spectrum analyzer through an attenuator, the bandwidth of the fundamental frequency was measured with the spectrum analyzer using 100 KHz RBW, VBW = 100 KHz. The 6 dB bandwidth was measured and recorded.

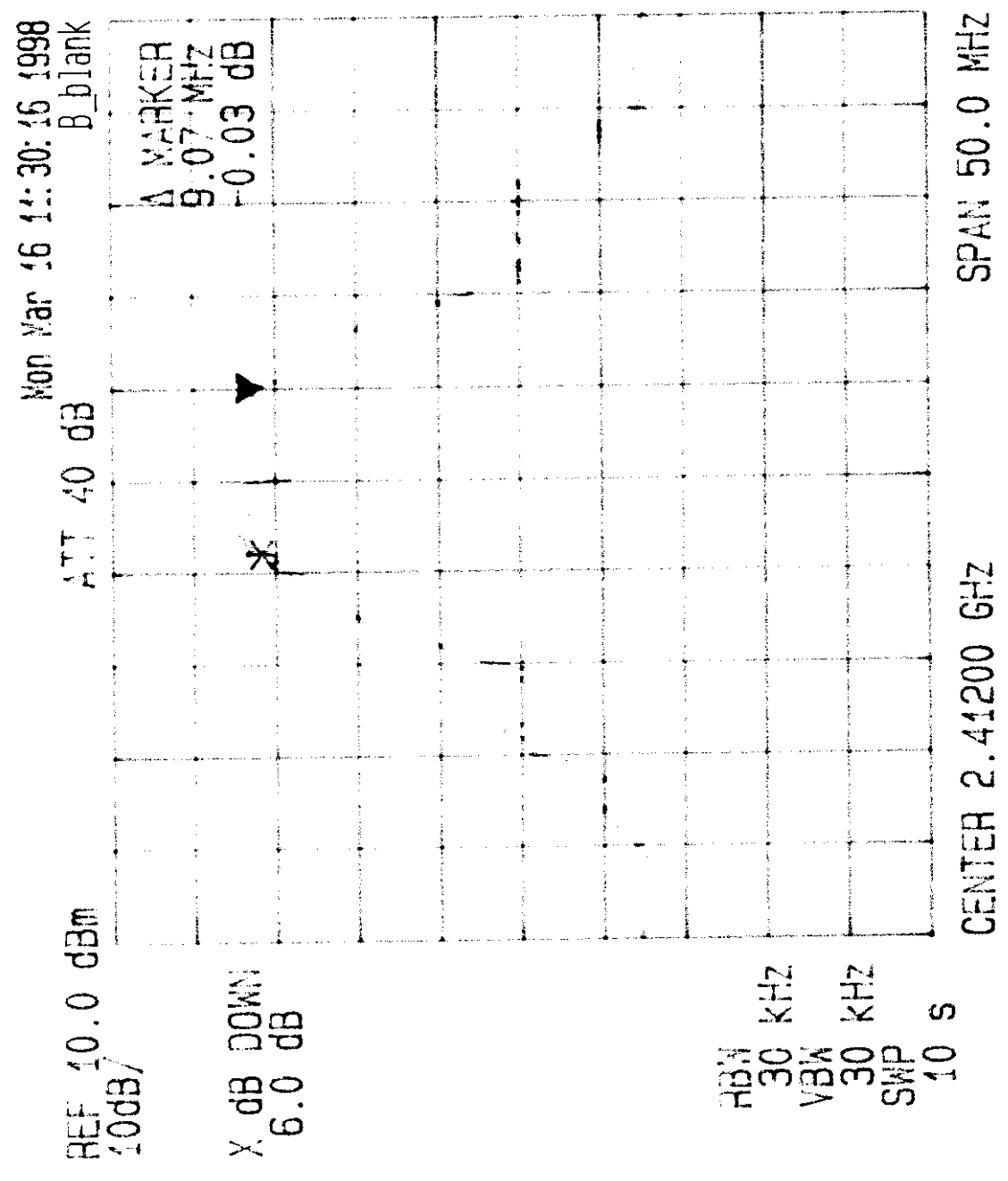
TEST ARRANGEMENT**TEST RESULTS:** Conforms.**TEST PERSONNEL:** Tri M. Luu, P.Eng.**DATE:** Mar. 16, 1998**MEASUREMENT DATA:**

CHANNEL FREQUENCY (MHz)	6 dB BANDWIDTH (MHz)	MINIMUM LIMIT (MHz)	PASS/FAIL
2412	9.1	0.5	PASS
2437	9.1	0.5	PASS
2462	9.0	0.5	PASS

- Accredited by **ITI** (UK), Competent Body & **NVLAP** (USA), Accreditation Body
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Channel #: 1, Tx Frequency: 2412 MHz, RF Power: 10.0 dBm
Modulation: DSSS (11 Mcbps/s, 2.0 Mb/s DPSK, 2 bits/symbol)

Date: Mar. 16/98
Tested by: Tm Fou

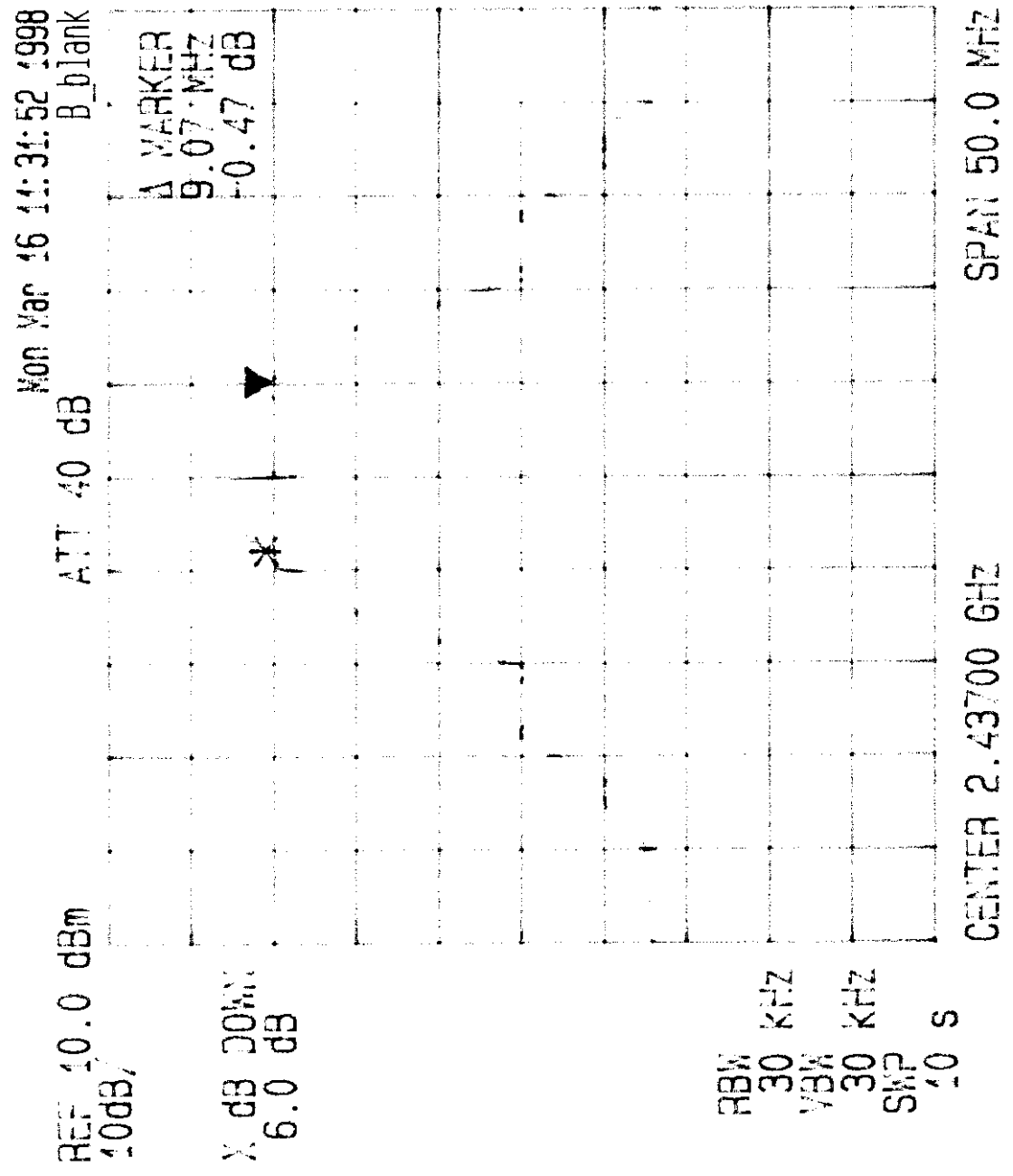




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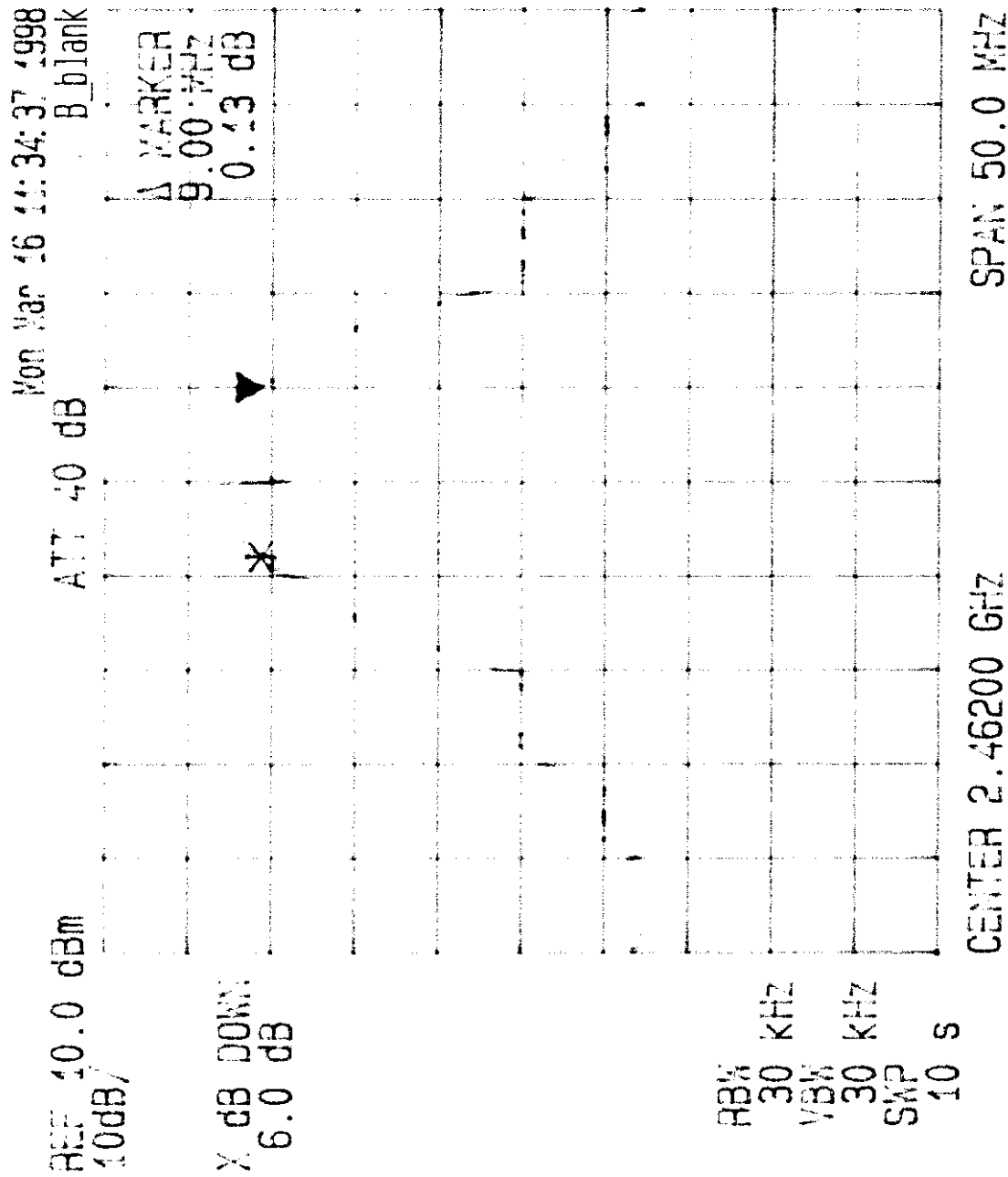
Date: Mar. 16/98
Tested by: Tri Lau

Channel #: 6, Tx Frequency: 2.437 MHz, RF Power: 10 mW
Modulation: DSSS (11 Mcips/s, 2.0 Mb/s DPSK, 2 bits/symbol)



Channel #: 11, Tx Frequency: 24.02 MHz, RF Power: 4.7 mW
Modulation: DSSS (11 Mcchips/s, 2.0 Mb/s DPSK, 2 bits/symbol)

Date: Mar 16/98
Tested by: In Lau



1.16. Maximum Peak Output Power @ FCC 15.247(b) and RF Exposure Limit FCC 1.1310**PRODUCT NAME:** WIRELESS LAN CARD, Model No.: RL2400**FCC REQUIREMENTS:**

FCC 15.247(b):- Maximum peak output power of the transmitter shall not exceed 1 Watt. If the antenna of directional gain greater than 6 dBi are used, the power shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

FCC 1.1310:- The criteria listed in the following table shall be used to evaluate the environmental impact of human exposure to radiofrequency (RF) radiation as specified in 1.1307(b).

LIMITS FOR MAXIMUM PERMISSIBLE EXPOSURE (MPE)

Frequency Range (MHz)	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)	Power Density (mW/cm ²)	Average Time (minutes)
(A) Limits for Occupational/Control Exposures				
300-1500	...	...	F/300	6
1500-100,000	...	...	5	6
(B) Limits for General Population/Uncontrolled Exposure				
300-1500	...	...	F/1500	6
1500-100,000	...	...	1.0	30

F = Frequency in MHz

* - Plane-wave equivalent power density

CLIMATE CONDITION:

- Standard Temperature and Humidity: 23°C and 53%

POWER INPUT:

Using DC Power from a laptop computer.

TEST EQUIPMENT:

- HP RF Peak Power Meter, Model 8900, S/N: 2131A00124, Measuring Freq. Range: 01 - 18 GHz, 50 Ohm IN.
- HP RF Peak Power Sensor, Model 8481A, S/N: 2551A01965, Measuring Freq. Range: 0.1 - 18 GHz, 50 Ohm IN OUT
- Bird 20 dB Attenuator, 50 Ohm IN OUT

METHOD OF MEASUREMENTS:

FCC 47 CFR 1.1310 & OST Bulletin No. 65-October 1985

$$S = PG/4\pi r^2 = EIRP/4\pi r^2$$

Where: P: power input to the antenna in mW
 EIRP: Equivalent (effective) isotropic radiated power.
 S: power density mW/cm²
 G: numeric gain of antenna relative to isotropic radiator
 r: distance to centre of radiation in cm

FCC radio frequency exposure limits may be exceeded at distances closer than r cm from the antenna of this device

$$r = \sqrt{PG/4\pi S}$$

FCC radio frequency exposure limits may be exceeded at distances closer than r cm from the antenna of this device

TEST ARRANGEMENT

TEST RESULTS: Conforms.

TEST PERSONNEL: Tri M. Luu, P.Eng.

DATE: Mar. 16, 1998

MEASUREMENT DATA:PEAK POWER MEASUREMENT

ANTENNA GAIN: 2.15 dBi max / 0 dBi typical
(internal integral part of the printed circuit board)

**DIRECT POWER PEAK POWER MEASUREMENTS AT THE ANTENNA TERMINAL
WITH THE ANTENNA REPLACED BY A SMA CONNECTOR**

TRANSMITTER CHANNEL OUTPUT	FUNDAMENTAL FREQUENCY (MHz)	MEASURED PEAK TOTAL POWER (mW)	PEAK POWER LIMIT (mW)
1	2412	46.8	1000.0
6	2437	41.7	1000.0
11	2462	42.7	1000.0

Notes: The power measurements with respect to the field strength level measurement at 3 meters can not be properly performed as preferred by FCC since the maximum BW of the EMI receiver is 3 MHz while the 6dB BW of the transmitter RF output is 9.1 MHz; the power measurement using radiated emission measurement method will always show lower reading in 3 MHz BW.

RF EXPOSURE DISTANCE LIMITS: $r = (PG/411S)^{1/2}$
 $S=1\text{mW/cm}^2$, $G= 2.15 \text{ dB}$ or 1.64

TRANSMITTER CHANNEL OUTPUT	FUNDAMENTAL FREQUENCY (MHz)	MEASURED PEAK POWER (mWatts)	MINIMUM ALLOWABLE DISTANCE (r) FROM SKIN (Centi-Meter)
1	2412	46.8	2.5
6	2437	41.7	2.3
11	2462	42.7	2.4

Since the distance r is too small and the rf output power is too low, no RF exposure limit warning is required.

1.17. RF Conducted Emissions at the Transmitter Antenna Terminal, FCC CFR 47, Para. 15.247(c)

PRODUCT NAME: WIRELESS LAN CARD, Model No.: RL2400

FCC REQUIREMENTS:

In any 100 KHz bandwidth outside the operating frequency band, the radio frequency power that is produced by modulation products of the spreading sequence, the information sequence and the carrier frequency shall be at least 20 dB below that in any 100 KHz bandwidth within the band that contains the highest level of the desired power.

CLIMATE CONDITION:

Standard Temperature and Humidity: 23°C and 53%

POWER INPUT:

Using DC Power from a laptop computer.

TEST EQUIPMENT:

- Advantest Spectrum Analyzer, Model R3271, S/N: 15050203

METHOD OF MEASUREMENT:

A scan was made by using a spectrum analyzer with the detector function set to PEAK mode.

Set RBW = 100 KHz, VBW = 100 KHz.

FCC CFR 47, Para. 2.997 - Frequency spectrum to be investigated

The spectrum was investigated from the lowest radio generated in the equipment up to at least the 10th harmonic of the carrier frequency or to the highest frequency practicable in the present state of the art of measuring techniques, whichever is lower. Particular attention should be paid to harmonics and subharmonics of the carrier frequency. Radiation at the frequencies of multiplier stages should be checked. The amplitude of spurious emissions which are attenuated more than 20 dB below the permissible value need not be reported.

FCC CFR 47, Para. 2.991 - Spurious Emissions at Antenna Terminal

The radio frequency voltage or powers generated within the equipment and appearing on a spurious frequency shall be checked at the equipment output terminals when properly loaded with a suitable artificial antenna. Curves or equivalent data shall show the magnitude of the harmonic and other spurious emission that can be detected when the equipment is operated under the conditions specified in 2.989 as appropriate. The magnitude of spurious emissions which are attenuated more than 20 dB below the permissible value need not be specified.

TEST ARRANGEMENT

TEST RESULTS: Conforms.

TEST PERSONNEL: Tri M. Luu, P.Eng.

DATE: Mar. 17, 1998

- Accredited by **ITI** (UK) - Competent Body & **NVLAP** (USA) Accreditation Body
- Recognized/ Listed by **FCC** (USA), **Industry Canada** (Canada), **Austel** (Australia)
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MEASUREMENT DATASPURIOUS & HARMONIC EMISSIONS
AT THE TRANSMITTER ANTENNA TERMINALTEST CONFIGURATION

- The transmitter was coupled to the Spectrum Analyzer.
- The channel frequencies were established on the extreme edges (both upper and lower) and middle of the 2412 - 2462 MHz band at its full rated output power. The emissions was investigated up to the tenth harmonic of the fundamental emissions in each case, the measured level of the carrier was recorded and compared to the level of the emissions as required in Part 15.247(c)

Channel Frequency: 2412 MHz Full Rated Power: 46.8 mW		Power Level in 100 KHz BW: 3.6 dBm Limit = 3.6 dBm - 20 dB = -16.4 dBm		
FREQUENCY (MHz)	RF LEVEL (dBm)	LIMIT (dBm)	MARGIN (dB)	PASS/ FAIL
2412.0	3.6	--	--	--
2132.0	-36.0	-16.4	-19.6	PASS
2692.0	-52.6	-16.4	-36.2	PASS
4824.0	-66.7	-16.4	-50.3	PASS
No other significant emissions were found in the frequency range from 10 MHz to 25 GHz. Refer to attached plots for details				

Channel Frequency: 2437 MHz Full Rated Power: 41.7 mW		Power Level in 100 KHz BW: 2.6 dBm Limit = 2.6 dBm - 20 dB = -17.4 dBm		
FREQUENCY (MHz)	RF LEVEL (dBm)	LIMIT (dBm)	MARGIN (dB)	PASS/ FAIL
2437.0	-0.3	--	--	--
280.0	-53.8	-17.4	-36.4	PASS
2157.0	-35.0	-17.4	-16.6	PASS
2717.0	-51.2	-17.4	-33.8	PASS
4874.0	-61.5	-17.4	-44.1	PASS
No other significant emissions were found in the frequency range from 10 MHz to 25 GHz. Refer to attached plots for details				

Channel Frequency: 2462 MHz Full Rated Power: 42.7 mW		Power Level in 100 KHz BW: 2.9 dBm Limit = 2.9 dBm - 20 dB = -17.1 dBm		
FREQUENCY (MHz)	RF LEVEL (dBm)	LIMIT (dBm)	MARGIN (dB)	PASS/ FAIL
2462.0	-2.0	--	--	--
2182.0	-38.3	-17.1	-21.2	PASS
4924.0	-49.2	-17.1	-32.1	PASS
No other significant emissions were found in the frequency range from 10 MHz to 25 GHz. Refer to attached plots for details				

Channel #: 1 WIRELESS LAN CARD, MODEL RL2400
Tx Frequency: 2.412 MHz, RF Power: 14.5 mW
Modulation: DSSS (11 Mcips/st, 2.0 Mb/s DPSK, 2 bits/symbol)

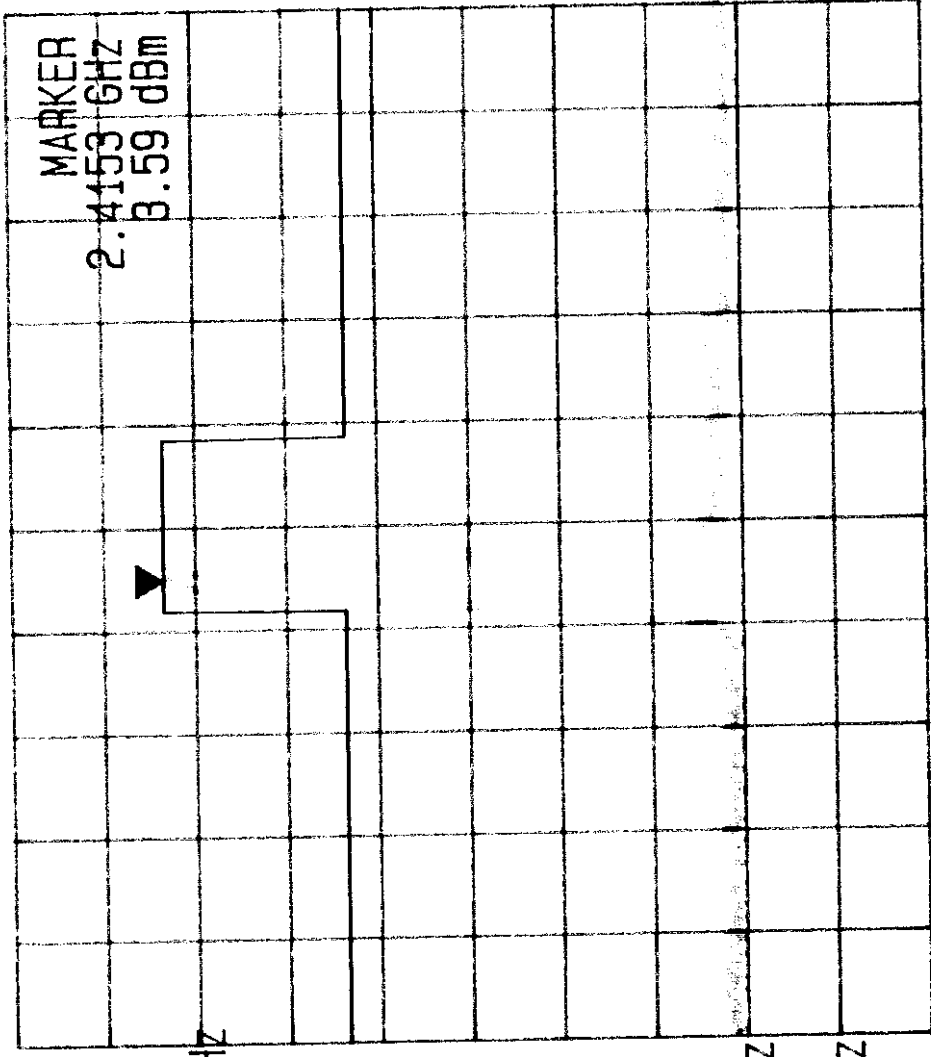
Date: Mar. 16/98
Tested by: Tri Lau

Mon Mar 16 10:18:15 1998
B blank

ATT 30 dB

REF 20.0 dBm
10dB/

MKR
2.4153 GHz



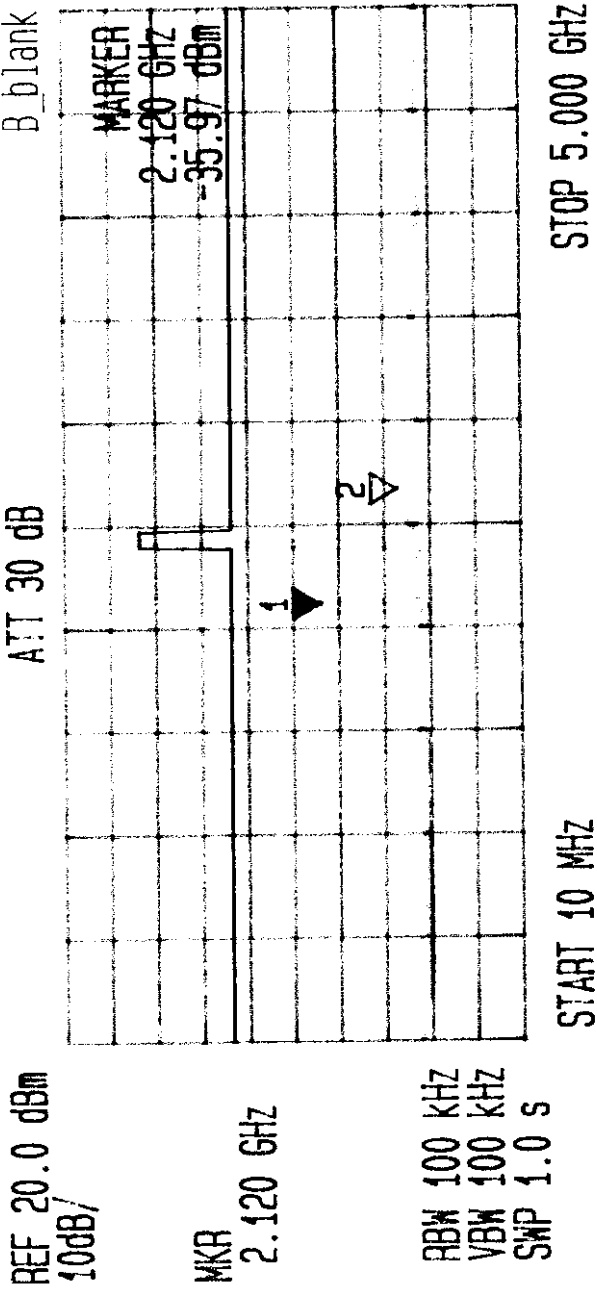
CENTER 2.4410 GHz
SPAN 500 MHz



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Channel #: / WIRELESS LAN CARD, MODEL RL2400
Tx Frequency: 2412 MHz, RF Power: 20.0 dBm
Modulation: DSSS (11 Mcbps/st, 2.0 Mb/s DPSK, 2 bits/symbol)

Date: Mar 16/98
Tested by: Tm Linn



*** Multi Marker List ***
2.120 GHz -35.97 dBm A
2.676 GHz -52.56 dBm A

- No. 1:
- No. 2:
- No. 3:
- No. 4:
- No. 5:
- No. 6:
- No. 7:
- No. 8:
- No. A:

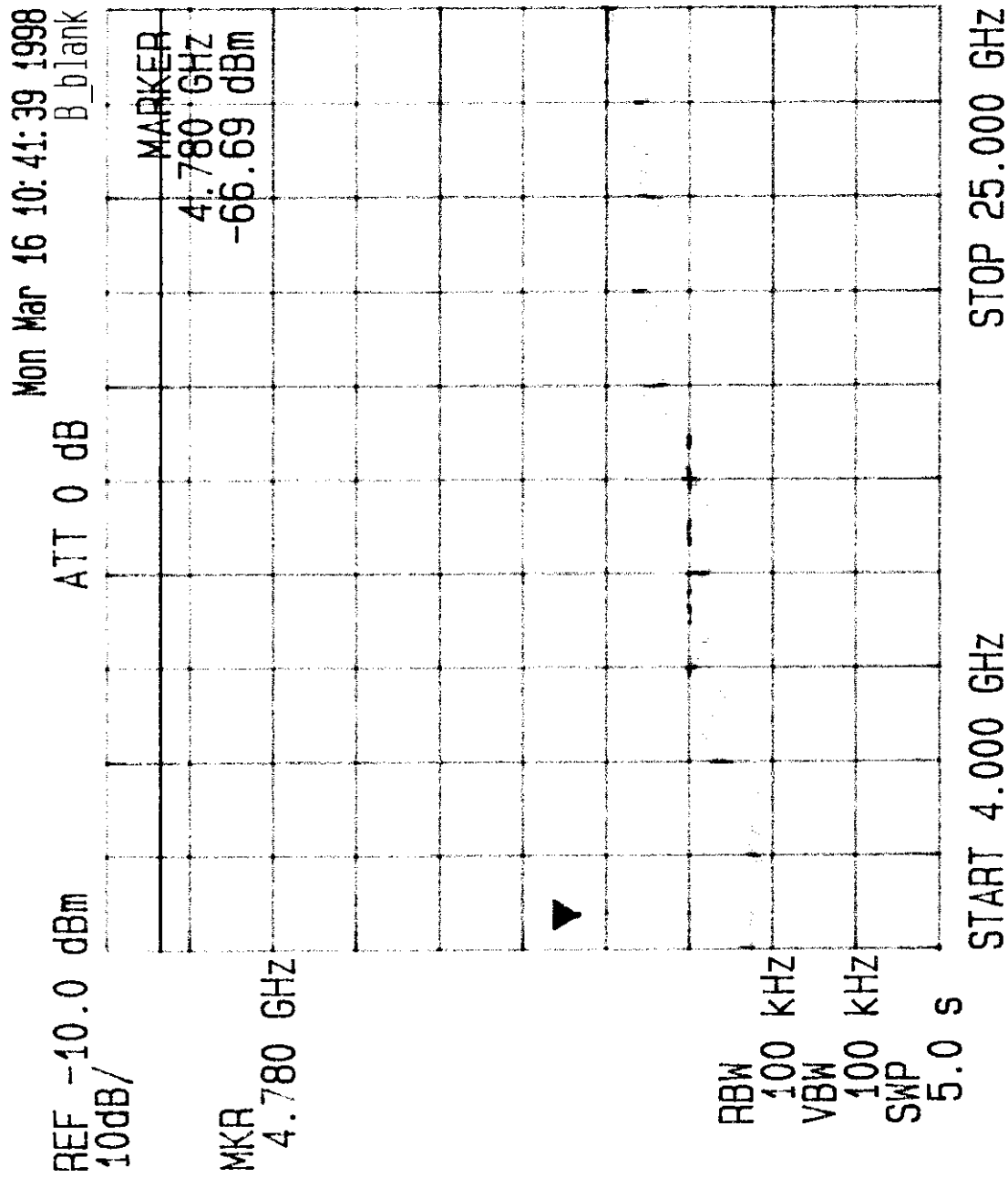


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WIRELESS LAN CARD, MODEL RL2400

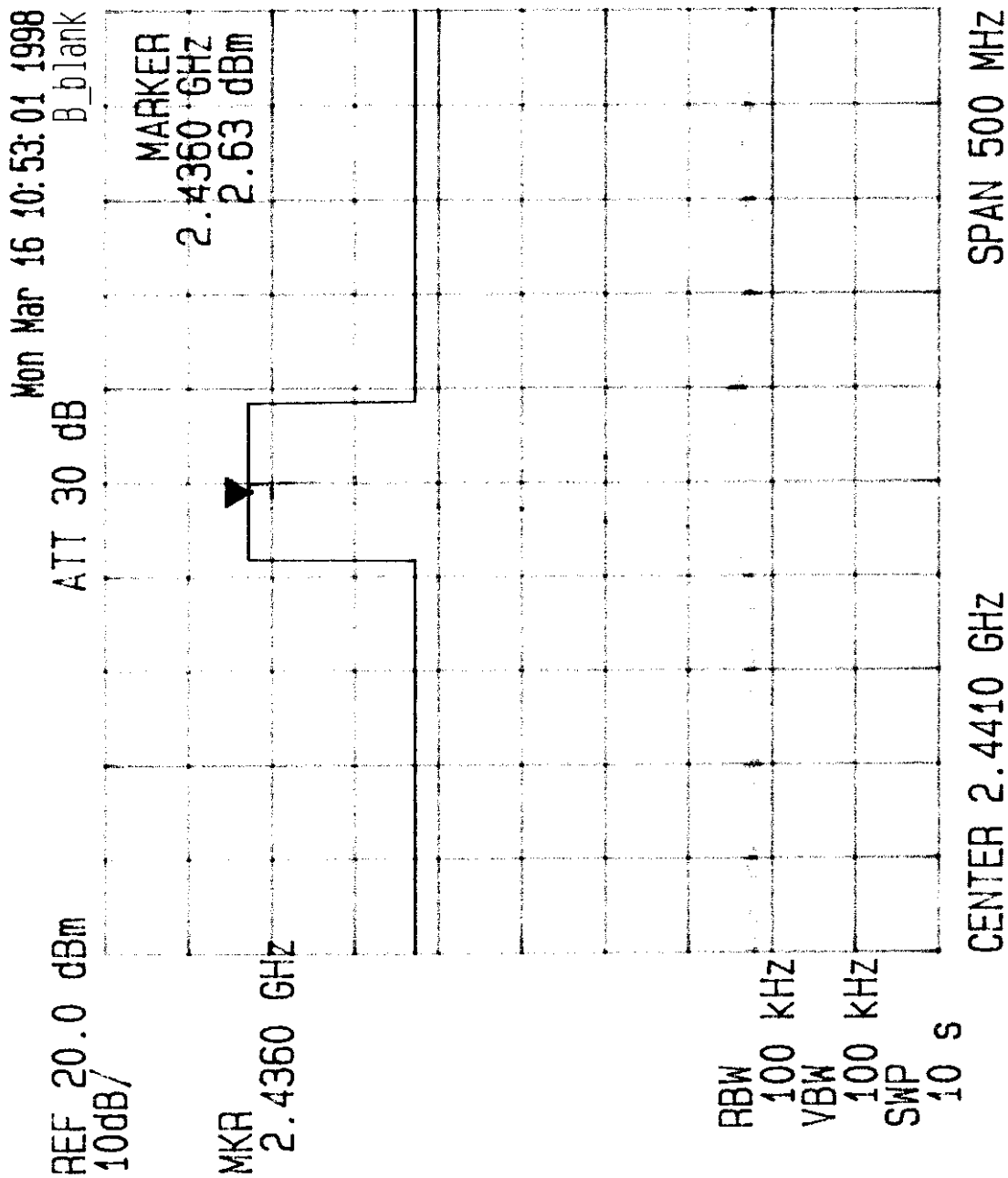
Channel #: 1, Tx Frequency: 2.412 MHz, RF Power: 10 dBm
Modulation: DSSS (11 Mcbps/s, 2.0 Mb/s DPSK, 2 bits/symbol)

Date: Mar. 16/98
Tested by: Tri Lau



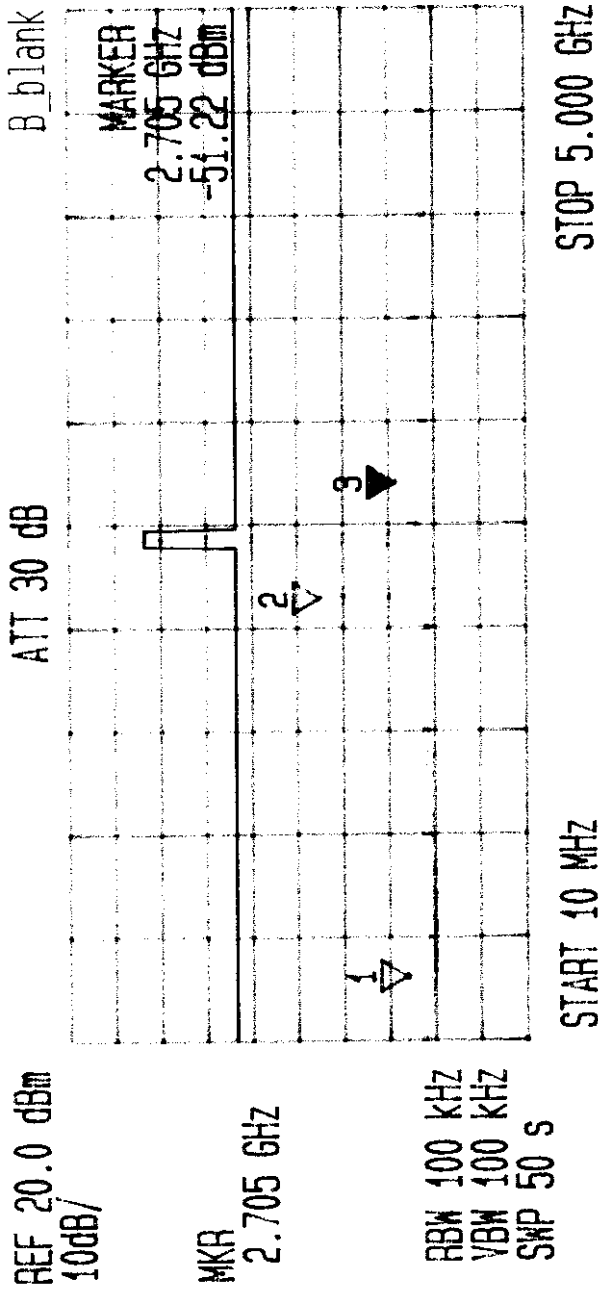
Channel #: 6, Tx Frequency: 2.437 MHz, RF Power: 10 mW
Modulation: DSSS (11 Mcips/s, 2.0 Mb/s DPSK, 2 bits/symbol)

Date: Mar 16/98
Tested by: Tri Lam



Channel #: 6 WIRELESS LAN CARD, MODEL RL2400
Tx Frequency: 2.437 MHz, RF Power: 41.7 mW
Modulation: DSSS (11 Mcbps/s, 2.0 Mb/s DPSK, 2 bits/symbol)

Date: Mar. 16/98
Tested by: Tri Lau



*** Multi Marker List ***

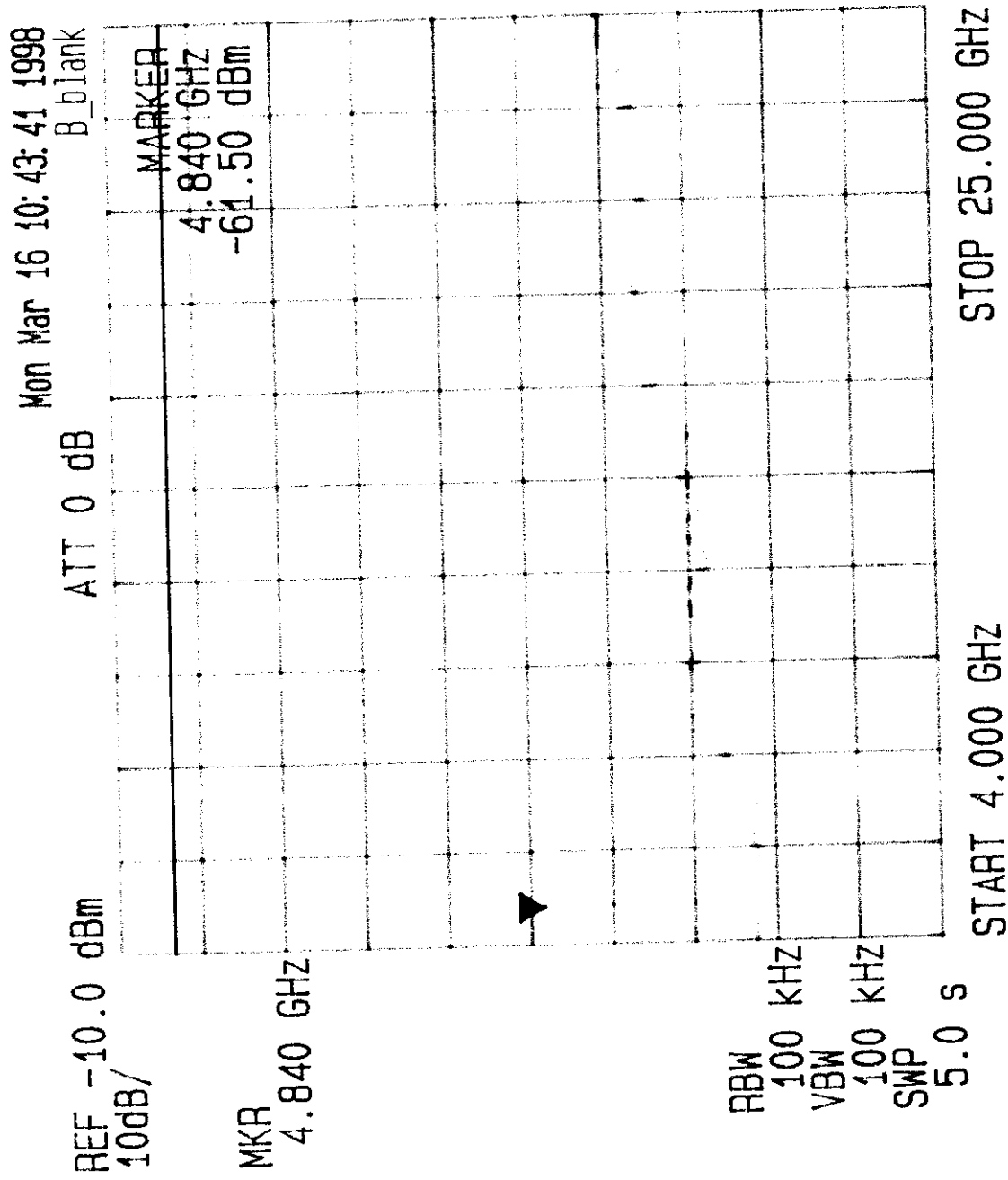
No.	Freq (MHz)	Power (dBm)	Marker
1	317	-53.75	A
2	2.149	-34.97	A
3	2.705	-51.22	A



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Channel #: 6 WIRELESS LAN CARD, MODEL RL2400
Tx Frequency: 2437 MHz, RF Power: 10.0 dBm
Modulation: DSSS (11 Mcips/st, 2.0 Mb/s DPSK, 2 bits/symbol)

Date: Mar 16/98
Tested by: Tri Lau

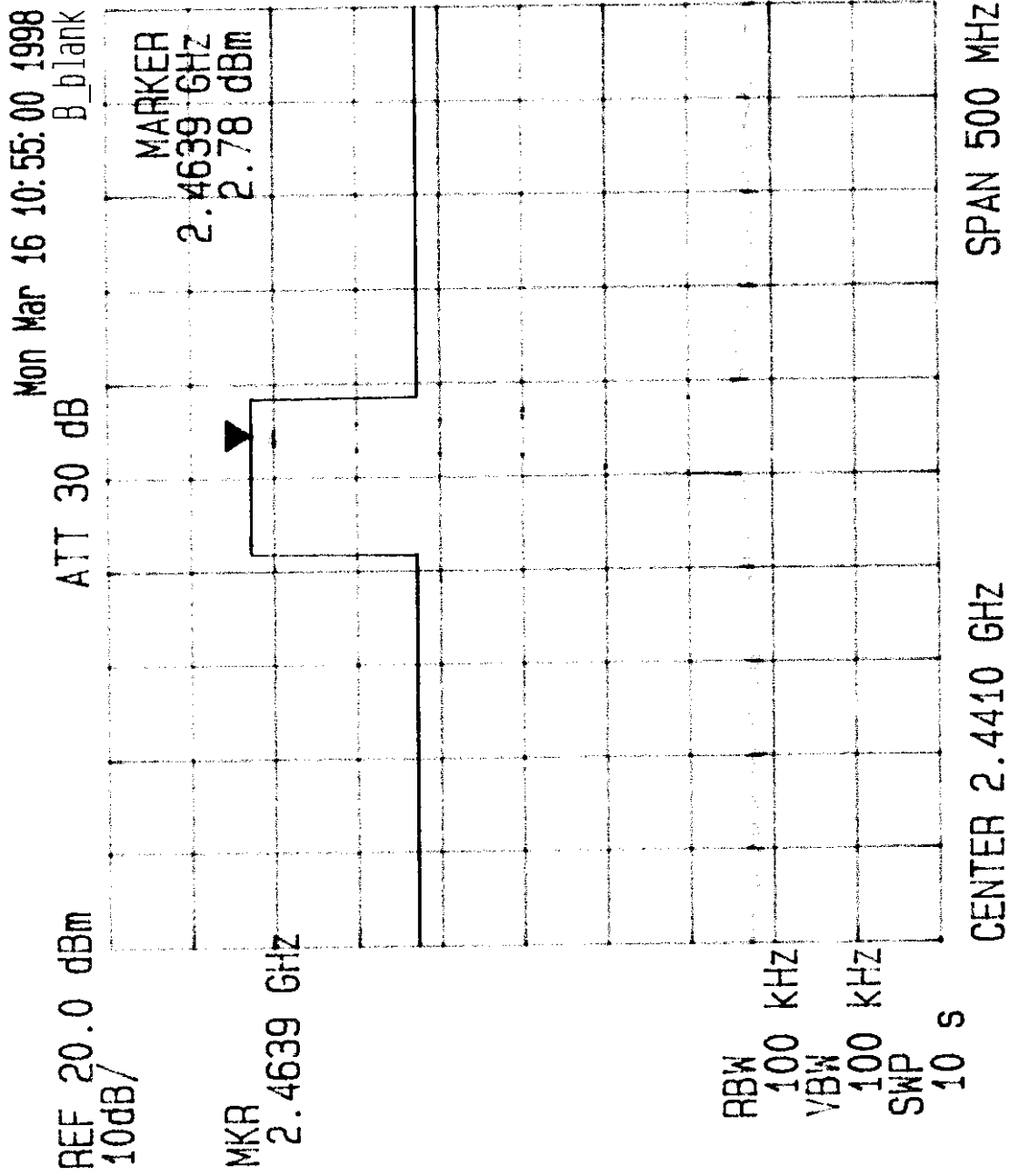


Channel #: 11

Modulation: DSSS (11 Mcips/st, 2.0 Mb/s DPSK, 2 bits/symbol)

WIRELESS LAN CARD, MODEL RL2400

Tx Frequency: 2.463 MHz, RF Power: 100 mW



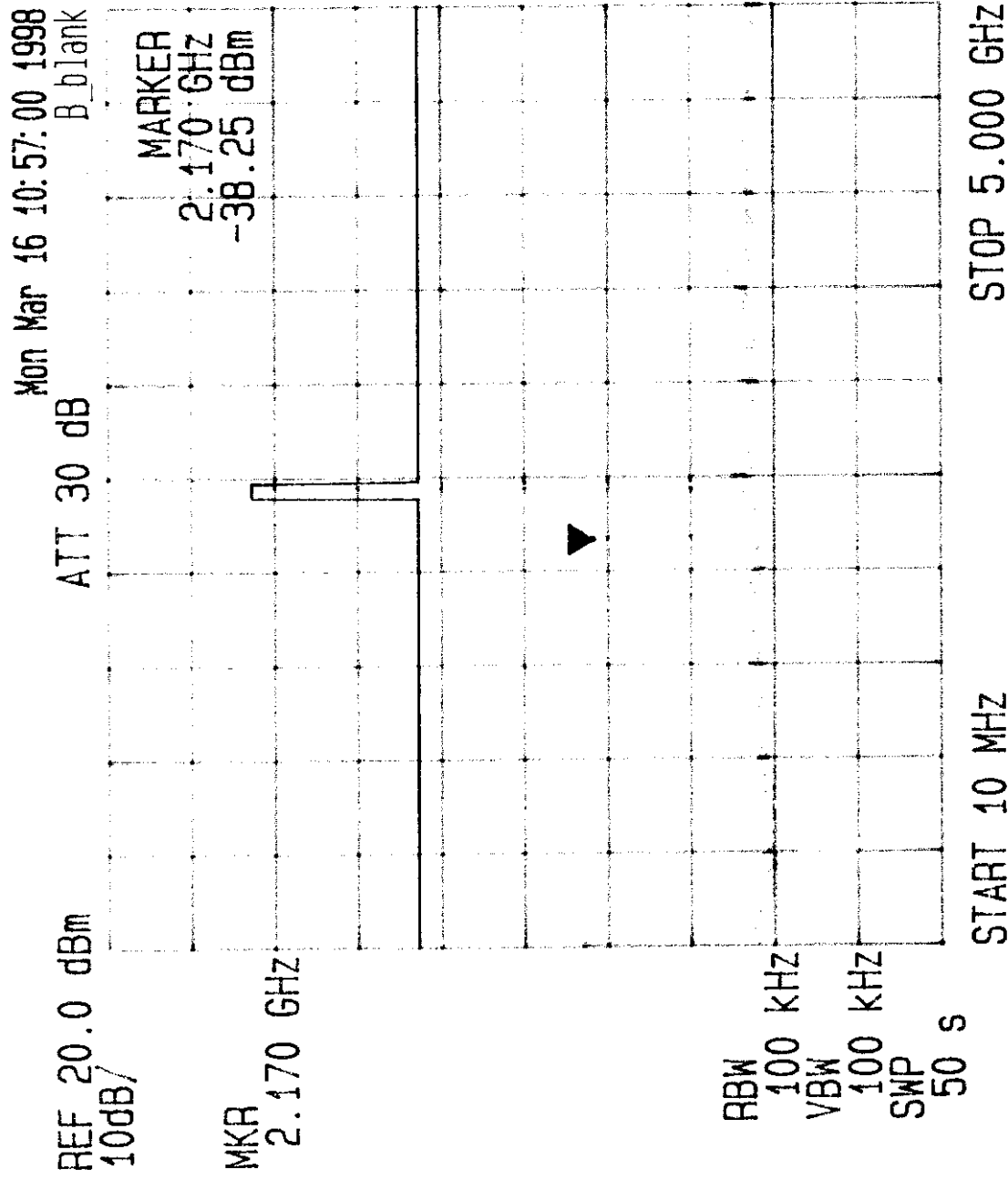


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WIRELESS LAN CARD, MODEL RL2400

Channel #: 11, Tx Frequency: 2.462 MHz, RF Power: 450 mW
Modulation: DSSS (11 Mcips/st, 2.0 Mb/s DPSK, 2 bits/symbol)

Date: Mar. 16/98
Tested by: Tin Lau



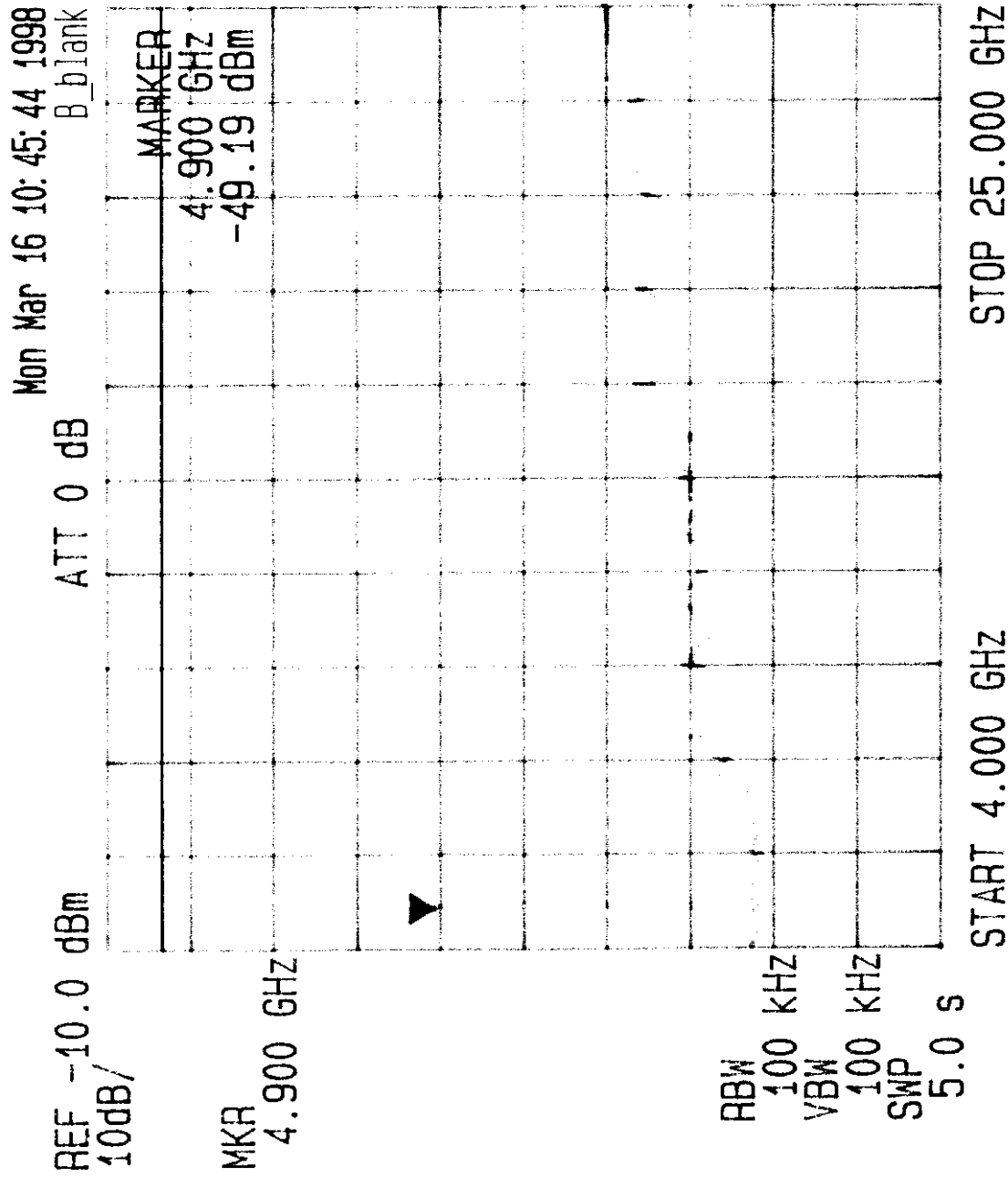


UltraTech
Engineering Labs Inc.

WIRELESS LAN CARD, MODEL RL2400

Channel #: 11, Tx Frequency: 2462 MHz, RF Power: 10 W
Modulation: DSSS (11 Mcips/st, 2.0 Mb/s DPSK, 2 bits/symbol)

Date: Mar. 16/98
Tested by: Tri Luu



1.18. Transmitter Radiated Emissions @ 3 Meters, FCC CFR 47, Para. 15.247(c), 15.209 & 15.205**PRODUCT NAME:** WIRELESS LAN CARD, Model No.: RL2400**FCC REQUIREMENTS:**

In any 100 KHz bandwidth outside the operating frequency band, the radio frequency power that is produced by modulation products of the spreading sequence, the information sequence and the carrier frequency shall be either at least 20 dB below that in any 100 KHz bandwidth within the band that contains the highest level of the desired power or shall not exceed the general levels specified in (a) 15.209(a), which lesser attenuation.

All other emissions inside restricted bands specified in (a) 15.205(a) shall not exceed the general radiated emission limits specified in (a) 15.209(a)

Remarks:

- Applies to harmonics/spurious emissions that fall in the restricted bands listed in Section 15.205. The maximum permitted average field strength is listed in Section 15.209.
- (a) FCC CFR 47, Para. 15.237(c) - The emission limits as specified above are based on measurement instrument employing an average detector. The provisions in (a) 15.35 for limiting peak emissions apply.

FCC CFR 47, Part 15, Subpart C, Para. 15.205(a) - Restricted Frequency Bands

MHz	MHz	MHz	GHz
0.090 - 0.110	162.0125 - 167.17	2310 - 2390	9.3 - 9.5
0.49 - 0.51	167.72 - 173.2	2483.5 - 2500	10.6 - 12.7
2.1735 - 2.1905	240 - 285	2655 - 2900	13.25 - 13.4
8.362 - 8.366	322 - 335.4	3260 - 3267	14.47 - 14.5
13.36 - 13.41	399.9 - 410	3332 - 3339	14.35 - 16.2
25.5 - 25.67	608 - 614	3345.8 - 3358	17.7 - 21.4
37.5 - 38.25	960 - 1240	3600 - 4400	22.01 - 23.12
73 - 75.4	1300 - 1427	4500 - 5250	23.6 - 24.0
108 - 121.94	1435 - 1626.5	5350 - 5460	31.2 - 31.8
123 - 138	1660 - 1710	7250 - 7750	36.43 - 36.5
149.9 - 150.05	1718.8 - 1722.2	8025 - 8500	Above 38.6
156.7 - 156.9	2200 - 2300	9000 - 9200	

FCC CFR 47, Part 15, Subpart C, Para. 15.209(a)
-- Field Strength Limits within Restricted Frequency Bands --

FREQUENCY (MHz)	FIELD STRENGTH LIMITS (microvolts/m)	DISTANCE (Meters)
0.009 - 0.490	2,400 F (KHz)	300
0.490 - 1.705	24,000 F (KHz)	30
1.705 - 30.0	30	30
30 - 88	100	3
88 - 216	150	3
216 - 960	200	3
Above 960	500	3

CLIMATE CONDITION:

Standard Temperature and Humidity: 23°C and 53%

POWER INPUT:

Using DC Power from a laptop computer.

TEST EQUIPMENT:

- **Spectrum Analyzer**, Advantest, Model R3271, S/N: 15050203, 100 Hz to 32 GHz)
- **Spectrum Analyzer**, Advantest, Model 3261A, SN 91720151, Input +25dBm max., 9KHz-2.6GHz, 50 Ohms, built-in Quasi-Peak Detector.
- **RF Preselector**, Advantest Model R3551, SN 92970002, 9KHz-1GHz, 50 Ohms input/output, input +25 dBm max. 30 dB gain.
- **Microwave Amplifier**, HP, Model 83017A, Frequency Range 1 to 26.5 GHz, 34-38 dBdB gain nominal.
- **Active Loop Antenna**, Emco, Model 6507, SN 8906-1167, Frequency Range 1 KHz - 30 MHz, @ 50 Ohms
- **Log Periodic/Bow-Tie Antenna**, Emco, Model 3143, SN 1029, 20 - 1000 MHz, @ 50 ohms.
- **Log Periodic Antenna**, A.H. Systems, Model SAS-200/518, SN 343, Frequency Range: 1 - 18 GHz, @ 50 Ohms.
- **Horn Antenna**, Emco, Model 3160-09, 18-26.5GHz

METHOD OF MEASUREMENTS:

Refer to ANSI 63.4-1992, Para. 8 for detailed radiated emissions measurement procedures.

Applies to harmonics spurious that fall in the restricted bands listed in Section 15.205. the maximum permitted average field strength is listed in Section 15.209. A Pre-Amp and highpass filter are used for this measurement.

For measurement below 1 GHz, set RBW = 100 KHz, VBW $\geq$ 100 KHz, SWEEP=AUTO.

For measurement above 1 GHz, set RBW = 1 MHz, VBW = 1 MHz (Peak) & VBW = 10 Hz (Average), SWEEP=AUTO.

If the emission is pulsed, modified the unit for continuous operation, then use the settings above for measurements, then correct the reading by subtracting the peak-average correction factor derived from the appropriate duty cycle calculation. See Section 15.35(b) and (c).

FCC CFR 47, Para. 2.997 - Frequency spectrum to be investigated

The spectrum was investigated from the lowest radio generated in the equipment up to at least the 10th harmonic of the carrier frequency or to the highest frequency practicable in the present state of the art of measuring techniques, whichever is lower. Particular attention should be paid to harmonics and subharmonics of the carrier frequency. Radiation at the frequencies of multiplier stages should be checked. The amplitude of spurious emissions which are attenuated more than 20 dB below the permissible value need not be reported.

FCC CFR 47, Para. 2.993 - Field Strength Spurious Emissions

- (a) Measurements was made to detect spurious emissions radiated directly from the cabinet, control circuits, power leads, or intermediate circuit elements under normal conditions of installation and operation. Curves or equivalent data were supplied showing the magnitude of each harmonic and other spurious emission. For this test, single sideband, independent sideband, and controlled carrier transmitters shall be modulated under the conditions specified in paragraph 2.989(c) as appropriate. For equipment operating on frequencies below 1 GHz, an Open Field Test is normally required, with the measuring instrument antenna located in the far field at all test frequencies. In event it is either impractical or impossible to make open field measurements (e.g. a broadcast transmitter installed in a building) measurement will be accepted of the equipment as installed. Such measurements must be accompanied by a description of the site where the measurements were made showing the location of any possible source of reflections which might distort the field strength measurements. Information submitted shall include the relative radiated power of each spurious emission with the reference to the rated power output of the transmitter, assuming all emissions are radiated from half-wave dipole antennas.
- (b) Measurements specified in paragraph (a) of this section shall be made for the following equipment:
- (1) Those in which the spurious emission are required to be 60 dB or more below the mean power of the transmitter.
 - (2) All equipment operating on frequencies higher than 25 MHz
 - (3) All equipment where the antenna is an integral part of, and attached directly to the transmitter.
 - (4) Other types of equipment as required, when deemed necessary by the Commission.

TEST RESULTS: Conforms.

TEST PERSONNEL: Tri M. Luu, P.Eng.

DATE: Mar. 18, 1998

MEASUREMENT DATA**RADIATED EMISSIONS MEASUREMENTS @ 3 METERS****TEST CONFIGURATION**

- This lowest, middle and highest channels were established at its full rated output power. The emissions were investigated from the lowest frequency generated by the transmitter up to the 10th harmonic of the fundamental emissions in each case, the measured level of the carrier was recorded and compared to the level of the emissions as required in Parts 15.247(c) or 15.209(a) whichever was applicable.
- For measuring radiated emissions at frequencies below 1 GHz, the Spectrum Analyzer was set as 100 KHz RBW, VBW $\geq$ RBW, SWEEP TIME: AUTO, PEAK DETECTOR.
- For measuring radiated emissions at frequencies above 1 GHz, the Spectrum Analyzer was set as 1 MHz RBW, 1 MHz VBW, SWEEP TIME: AUTO for PEAK measurements and 1 MHz RBW, 10 Hz VBW, SWEEP TIME: AUTO for AVERAGE measurements.
- The following measurements were the worst cases when the radiating antenna was placed in both horizontal and vertical polarization.
- The following **AVERAGE** rf levels were obtained from either Peak or Average readings added by the duty cycle correction factor. **DUTY CYCLE FACTOR = N/A (continuous)**

CHANNEL FREQUENCY TESTED: 2412 MHz**FULL RATED POWER: 46.8 mWatts**

FREQUENCY (MHz)	RF PEAK LEVEL (dBuV/m)	RF AVG LEVEL (dBuV/m)	ANTENNA PLANE (H/V)	LIMIT 15.209 (dBuV/m)	LIMIT 15.247 (dBuV/m)	MARGIN (dB)	PASS/ FAIL
560.00	29.5	26.1	V	46.0	81.0	-54.9	PASS
560.00	31.5	21.0	H	46.0	81.0	-60.0	PASS
840.00	19.6	11.7	V	46.0	81.0	-69.3	PASS
840.00	14.9	7.6	H	46.0	81.0	-73.4	PASS
1120.00	42.4	37.1	V	54.0	81.0	-16.9	**PASS
1120.00	42.8	36.8	H	54.0	81.0	-17.2	**PASS
1400.00	39.3	27.0	V	54.0	81.0	-27.0	**PASS
1400.00	38.7	26.9	H	54.0	81.0	-27.1	**PASS
2132.00	60.5	59.9	V	54.0	81.0	-21.1	PASS
2132.00	64.0	63.4	H	54.0	81.0	-17.6	PASS
2412.00	100.4	100.4	V	--	--	--	PASS
2412.00	101.0	101.0	H	--	--	--	PASS
4264.00	50.2	41.5	V	54.0	81.0	-12.5	** PASS
4264.00	50.9	45.3	H	54.0	81.0	-8.7	** PASS
6396.00	56.7	53.3	V	54.0	81.0	-27.7	PASS
6396.00	60.2	58.2	H	54.0	81.0	-22.8	PASS

No other significant emissions were found in the frequency range from 10 MHz to 25 GHz.

**** Emission within the restricted band specified in 15.205(a)**

CHANNEL FREQUENCY TESTED: 2437 MHz FULL RATED POWER: 41.7 mWatts							
FREQUENCY (MHz)	RF PEAK LEVEL (dBuV/m)	RF AVG LEVEL (dBuV/m)	ANTENNA PLANE (H/V)	LIMIT 15.209 (dBuV/m)	LIMIT 15.247 (dBuV/m)	MARGIN (dB)	PASS/ FAIL
560.00	29.5	26.1	V	46.0	81.0	-54.9	PASS
560.00	31.5	21.0	H	46.0	81.0	-60.0	PASS
840.00	19.6	11.7	V	46.0	81.0	-69.3	PASS
840.00	14.9	7.6	H	46.0	81.0	-73.4	PASS
1120.00	42.4	37.1	V	54.0	81.0	-16.9	**PASS
1120.00	42.8	36.8	H	54.0	81.0	-17.2	**PASS
1400.00	39.3	27.0	V	54.0	81.0	-27.0	**PASS
1400.00	38.7	26.9	H	54.0	81.0	-27.1	**PASS
2157.00	58.8	58.3	V	54.0	82.0	-23.7	PASS
2157.00	57.9	56.8	H	54.0	82.0	-25.2	PASS
2437.00	98.5	98.5	V	--	--	--	PASS
2437.00	102.0	102.0	H	--	--	--	PASS
4314.00	49.1	39.7	V	54.0	82.0	-14.3	**PASS
4314.00	50.9	45.2	H	54.0	82.0	-8.8	**PASS
6471.00	57.5	54.8	V	54.0	82.0	-27.2	PASS
6471.00	59.6	57.7	H	54.0	82.0	-24.3	PASS

No other significant emissions were found in the frequency range from 10 MHz to 25 GHz.

** Emission within the restricted band specified in 15.205(a)

CHANNEL FREQUENCY TESTED: 2462 MHz FULL RATED POWER: 42.7 mWatts							
FREQUENCY (MHz)	RF PEAK LEVEL (dBuV/m)	RF AVG LEVEL (dBuV/m)	ANTENNA PLANE (H/V)	LIMIT 15.209 (dBuV/m)	LIMIT 15.247 (dBuV/m)	MARGIN (dB)	PASS/ FAIL
560.00	29.5	26.1	V	46.0	81.0	-54.9	PASS
560.00	31.5	21.0	H	46.0	81.0	-60.0	PASS
840.00	19.6	11.7	V	46.0	81.0	-69.3	PASS
840.00	14.9	7.6	H	46.0	81.0	-73.4	PASS
1120.00	42.4	37.1	V	54.0	81.0	-16.9	**PASS
1120.00	42.8	36.8	H	54.0	81.0	-17.2	**PASS
1400.00	39.3	27.0	V	54.0	81.0	-27.0	**PASS
1400.00	38.7	26.9	H	54.0	81.0	-27.1	**PASS
2182.00	59.4	57.4	V	54.0	79.8	-22.4	PASS
2182.00	59.7	59.0	H	54.0	79.8	-20.8	PASS
2462.00	95.8	95.8	V	--	--	--	PASS
2462.00	99.8	99.8	H	--	--	--	PASS
4364.00	48.3	38.6	V	54.0	79.8	-15.4	**PASS
4364.00	49.2	39.4	H	54.0	79.8	-14.6	**PASS
6546.00	56.5	53.3	V	54.0	79.8	-26.5	PASS
6546.00	58.7	56.1	H	54.0	79.8	-23.7	PASS

No other significant emissions were found in the frequency range from 10 MHz to 25 GHz.

** Emission within the restricted band specified in 15.205(a)

UltraTech Engineering Labs Inc.

4181 Sladeview Cres., Unit 33, Mississauga, Ontario, Canada L5L 5R2

UltraTech's File #: RLT-001FTX

Tel. #: 905-569-2550

Fax. #: 905-569-2480

- Accredited by **ITI** (UK) / Competent Body & **NVLAP** (USA) Accreditation Body
- Recognized / Listed by **FCC** (USA), **Industry Canada** (Canada), **Austel** (Australia)
- All test results contained in this engineering test report are traceable to National Institute of Standards and Technology (**NIST**)



UltraTech
Engineering Labs Inc.

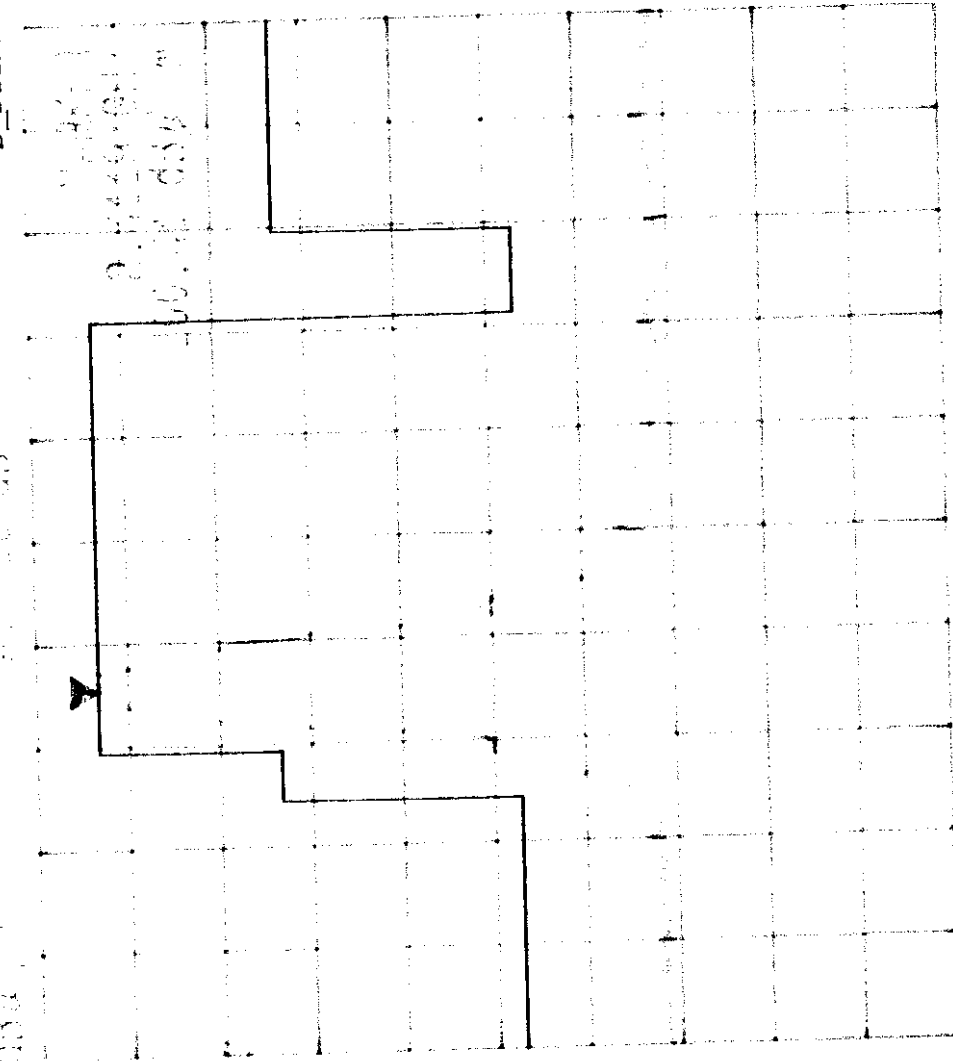
Channel #: _____, Tx Frequency: 2412 MHz, RF Power: _____ W
Modulation: DSSS (11 Mcbps/st, 2.0 Mb/s DPSK, 2 bits/symbol)

[illegible]

Antenna Polarization: Horizontal | |, Vertical | ∇

1000

Blank



44-38861-100

[illegible]

1997-1998

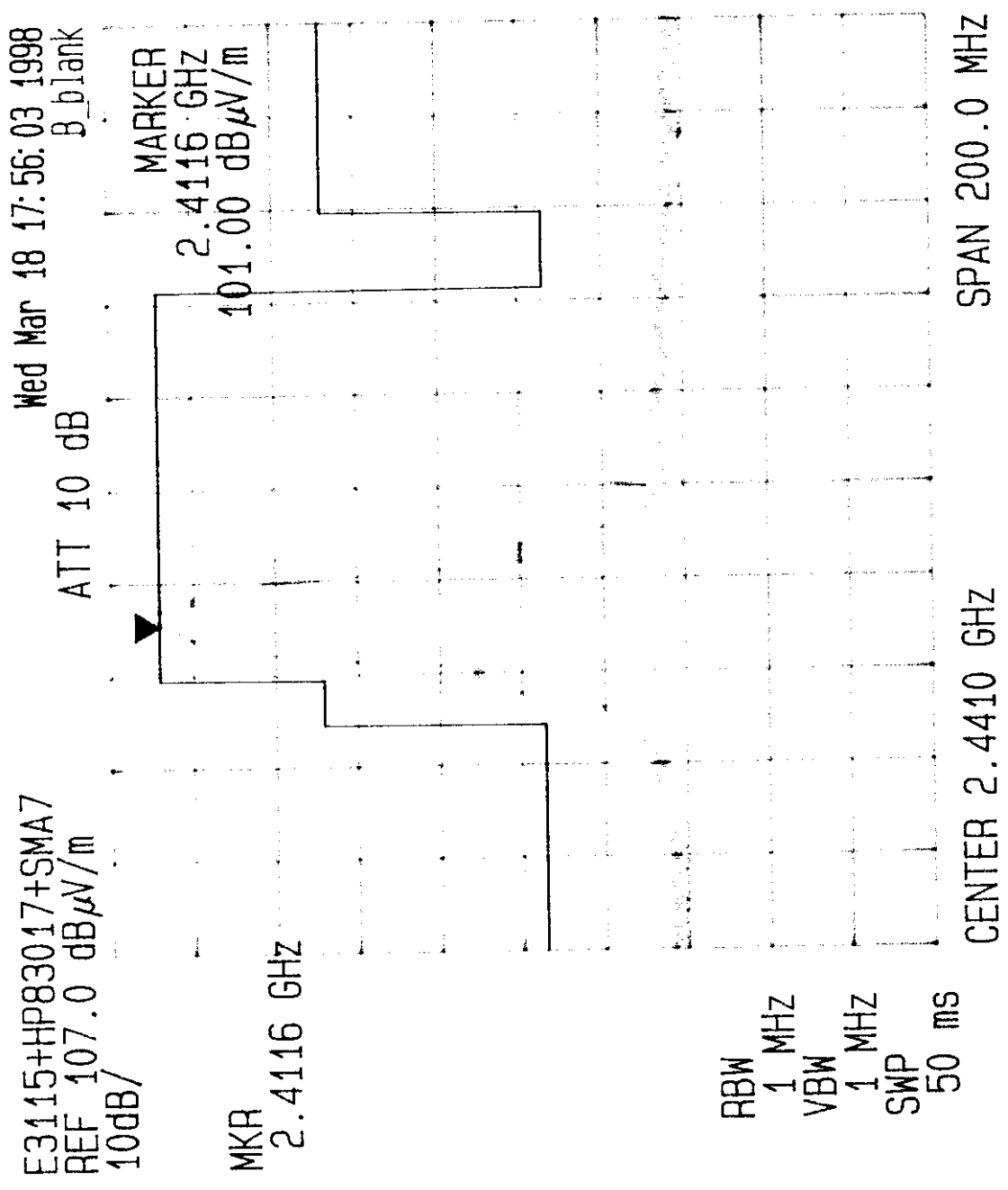
Date: Mar. 28 / 8 / 1988
Tested by: Tri Luu



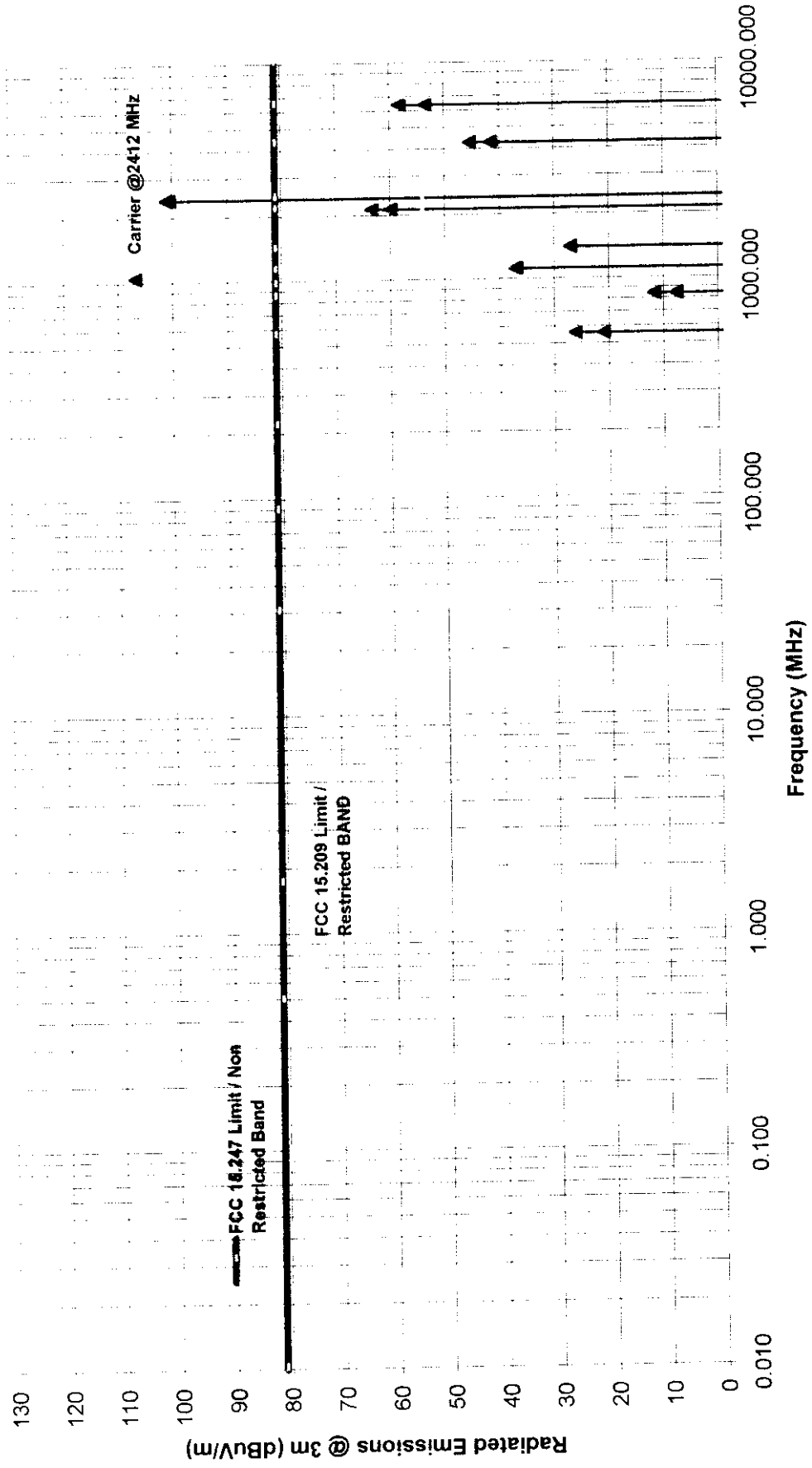
Date: Mar 18 1998
Tested by: Tim Liu

Channel #: 1 WIRELESS LAN CARD, MODEL RL2400
Tx Frequency: 2.4116 MHz, RF Power: 1 W
Modulation: DSSS (11 Mcbps/s, 2.0 Mb/s DPSK, 2 bits/symbol)

Antenna Polarization: Horizontal ☒ Vertical ☐



Transmitter Radiated Emissions Measurements at 3 Meter OFTS
RADIO-LINK TECHNOLOGY COMPANY, LTD.
WIRELESS LAN CARD, MODEL RL2400
Channel #1, TRANSMIT Freq.: 2412 MHz

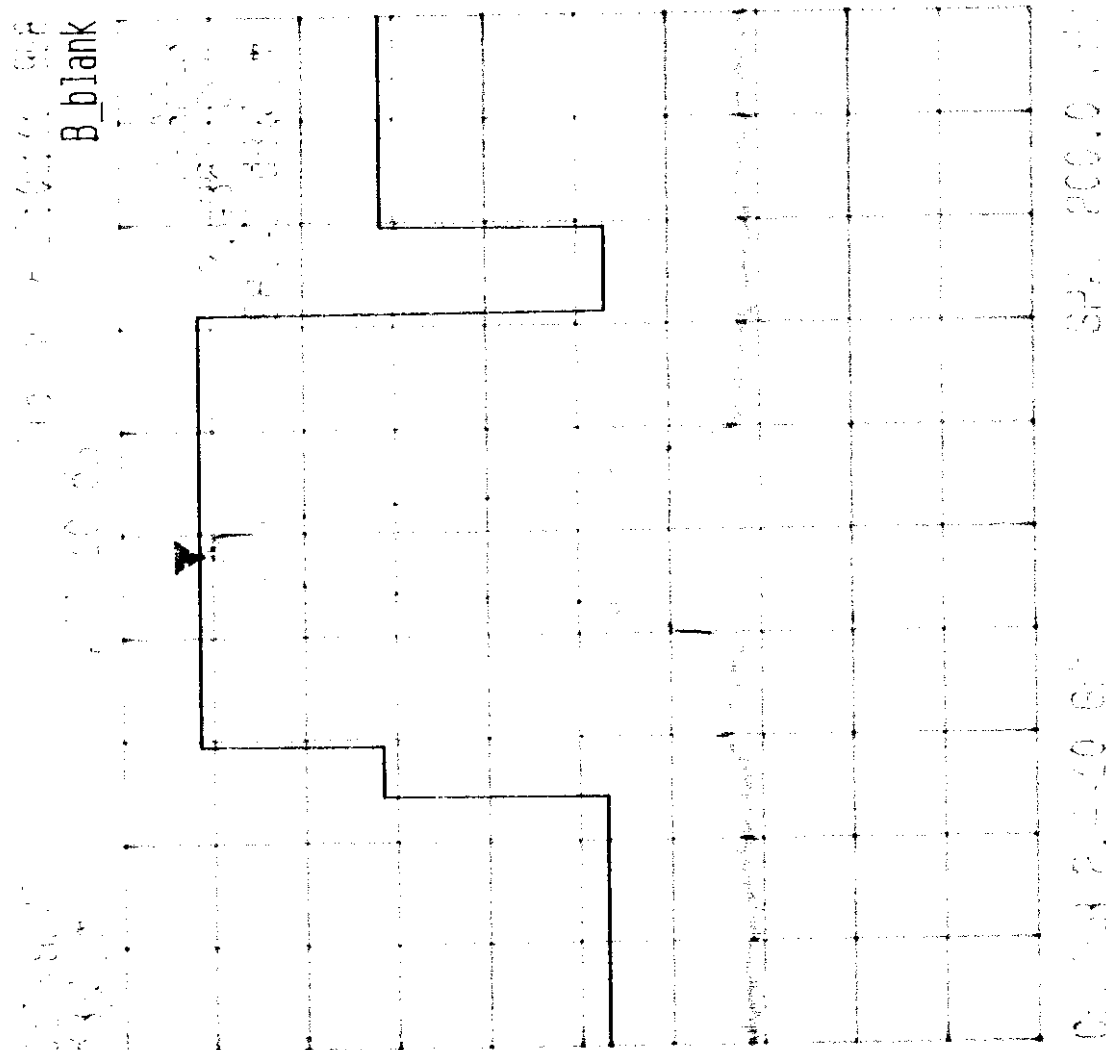




Channel #: 6, Tx Frequency: 2437 MHz, RF Power: _____ W
Modulation: DSSS (11 Mcbps/st, 2.0 Mb/s DPSK, 2 bits/symbol)

[illegible]

Antenna Polarization: Horizontal ☐, Vertical ☒



Date: Mar. 18 1998
Tested by: Tri Lam

Channel #: 6, Tx Frequency: 2.437 MHz, RF Power: 1 W
Modulation: DSSS (11 Mcbps/st, 2.0 Mb/s DPSK, 2 bits/symbol)

Date: Mar 18 1998
Tested by: Tri-Lan

Antenna Polarization: Horizontal | Vertical | |

ATT 10 dB

E3115+HP83017+SMA7
REF 107.0 dB μ V/m
10dB/

Wed Mar 18 17:43:08 1998

B_blank

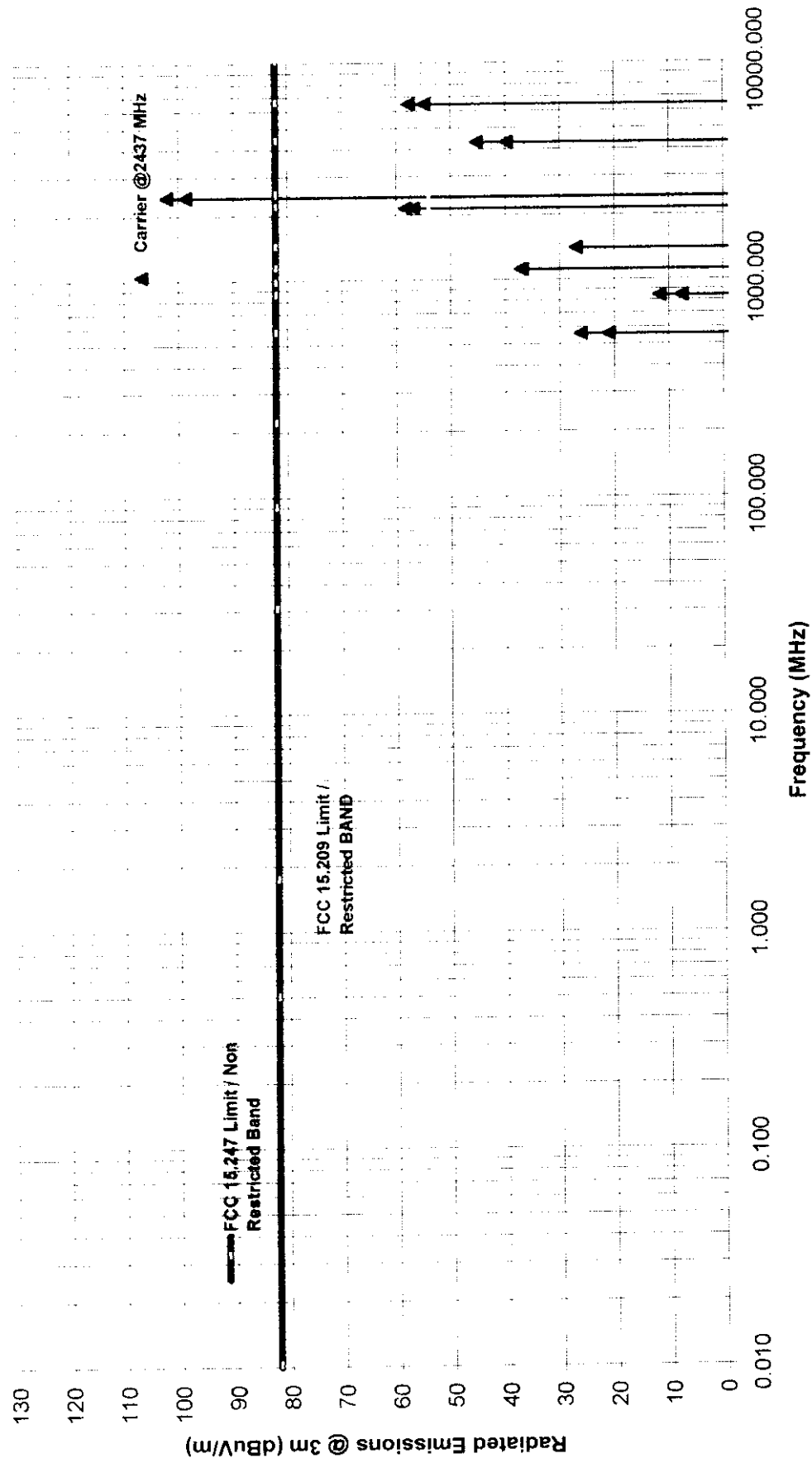
MARKER
2.4370 GHz
102.03 dB μ V/m

MKR
2.4370 GHz

RBW 1 MHz
VBW 1 MHz
SWP 50 ms

CENTER 2.4410 GHz
SPAN 200.0 MHz

Transmitter Radiated Emissions Measurements at 3 Meter OFTS
RADIO-LINK TECHNOLOGY COMPANY, LTD.
WIRELESS LAN CARD, MODEL RL2400
Channel #6, TRANSMIT Freq.: 2437 MHz





Channel #: 11 Tx Frequency: 2462 MHz, RF Power: 1 W
Modulation: DSSS (11 Mcbps/st, 2.0 Mb/s DPSK, 2 bits/symbol)

[illegible]

Antenna Polarization: Horizontal | |, Vertical | χ

E3115+HP83017+SMA7
REF 107.0 dB μ V/m
10dB/

Wed Mar 18 17:07:39 1998
B blank

100dB/

MARKER

2.4619 GHz

95.84 dBμV/m

MKB

MKR
2.4619 GHz

RBW 1 MHz
VBW 1 MHz
SWP 50 ms

CENTER 2.4410 GHZ
SPAN 200.0 MHZ

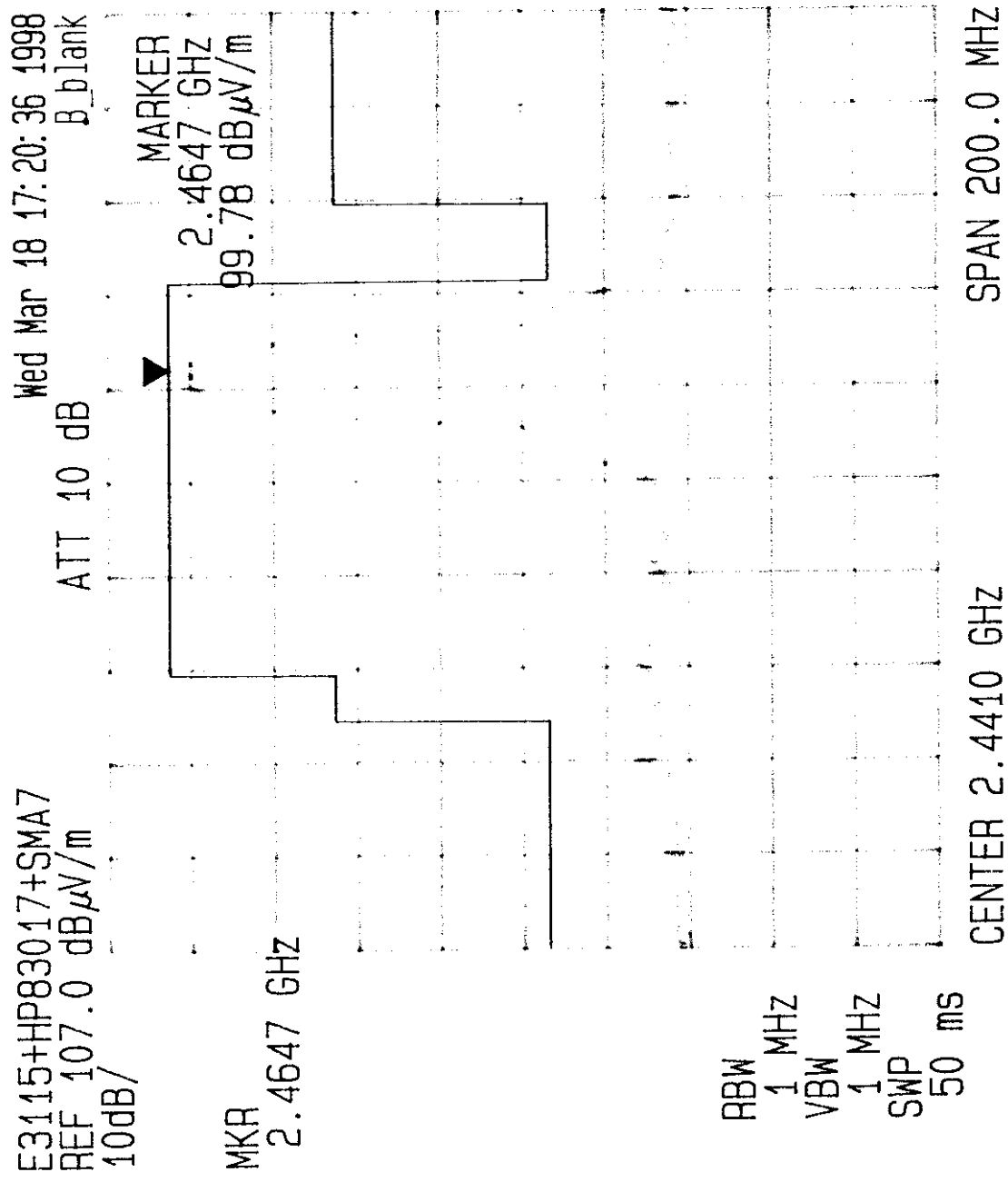
Channel #: 11, Tx Frequency: 2.462 MHz, RF Power: 100 mW
Modulation: DSSS (11 Mcbps/st, 2.0 Mb/s DPSK, 2 bits/symbol)

WIRELESS LAN CARD, MODEL RL2400

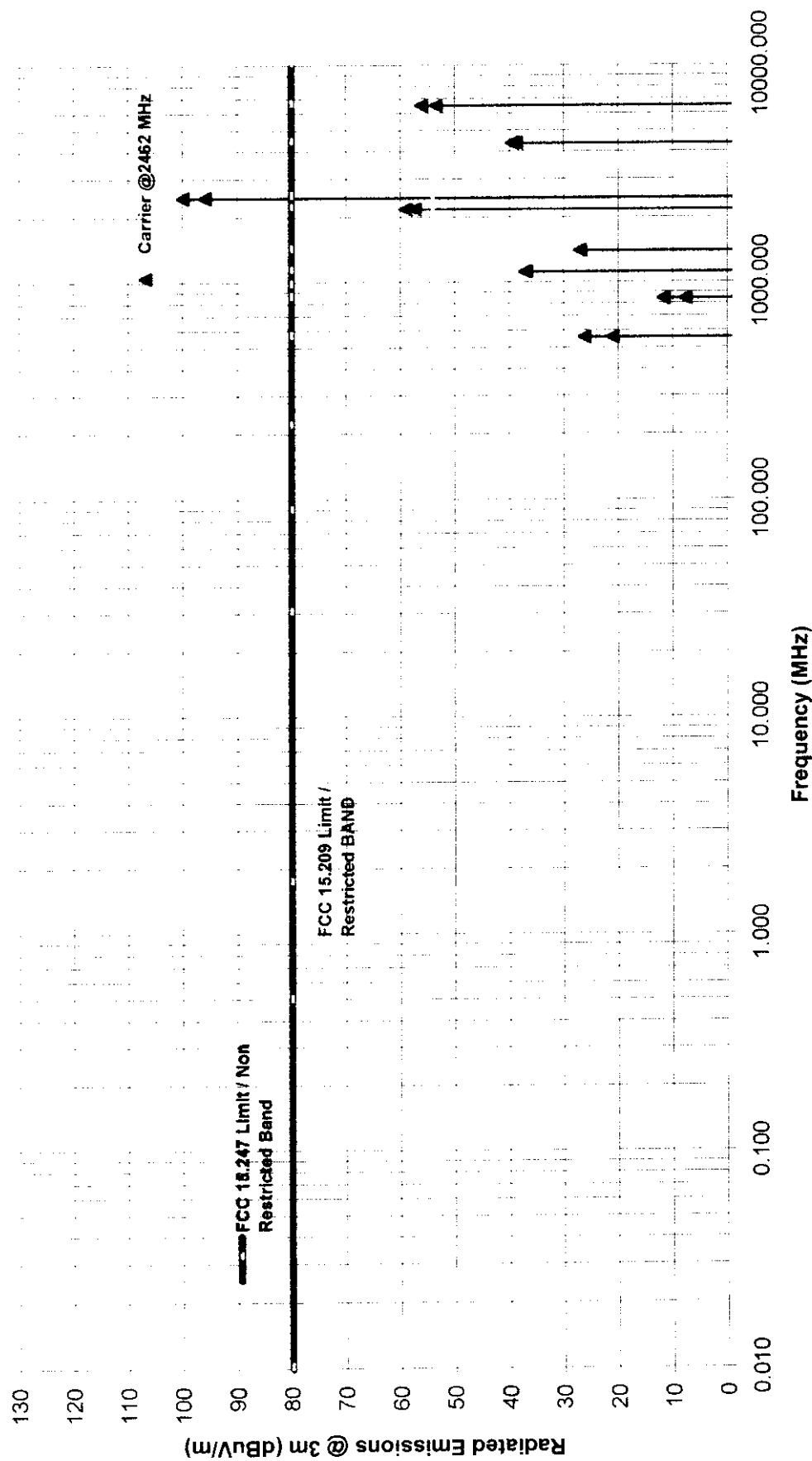
Date: Mar 18 / 98
Tested by: Tri Lam

Received Frequency: 2.4647 GHz

Antenna Polarization: Horizontal | Vertical | |



Transmitter Radiated Emissions Measurements at 3 Meter OFTS
RADIO-LINK TECHNOLOGY COMPANY, LTD.
WIRELESS LAN CARD, MODEL RL2400
Channel #11, TRANSMIT Freq.: 2462 MHz



1.19. Transmitted Power Density of a Direct Sequence Spread Spectrum System, FCC CFR 47, Para. 15.247(d)

PRODUCT NAME: WIRELESS LAN CARD, Model No.: RL2400

FCC REQUIREMENTS:

For a direct sequence system, the transmitted power density average over any 1 second interval shall not be greater than 8 dBm in any 3 KHz bandwidth within this band.

CLIMATE CONDITION:

Standard Temperature and Humidity: 23°C and 53%

POWER INPUT:

Using DC Power from a laptop computer.

TEST EQUIPMENT:

- Advantest Spectrum Analyzer, Model R3271, S/N: 15050203
- Bird 20 dB Attenuator, 50 Ohm IN/OUT

METHOD OF MEASUREMENT:

A scan was made by using a spectrum analyzer with the detector function set to NORMAL mode.

Locate and zoom in on emission peak(s) within the passband. Set RBW = 3 KHz, VBW $\geq$ RBW, Sweep $\geq$ SPAN 3 KHz. For example, a span of 1.5 MHz, the sweep should be $1.6 \times 10^6 / 3.0 \times 10^3 = 500$ seconds. The measured peak level must be no greater than +8 dBm.

- For devices with spectrum line spacing greater than 3 KHz no change is required.
- For devices with spectrum line spacing equal to or less than 3 KHz, the resolution bandwidth must be reduced below 3 KHz until the individual lines in the spectrum are resolved. The measurement data must then be normalized to 3 KHz by summing the power of all the individual spectral lines within 3 KHz band (in linear power units) to determine compliance.
- If the spectrum line spacing cannot be resolved on the available spectrum analyzer, the noise density function on most modern conventional spectrum analyzer will directly measure the noise power density normalized to 1 Hz noise power bandwidth. Add 30 dB for correction to 3 KHz.
- Should all the above fail or any controversy develop regarding accuracy of measurement, the Laboratory will use HP 89440A Vector Signal Analyzer for final measurement unless a clear showing can be made for a further alternate.

TEST ARRANGEMENT



TEST RESULTS: Conforms.

TEST PERSONNEL: Tri M. Luu, P.Eng.

DATE: Mar. 16, 1998

MEASUREMENT DATA:

TEST CONFIGURATION

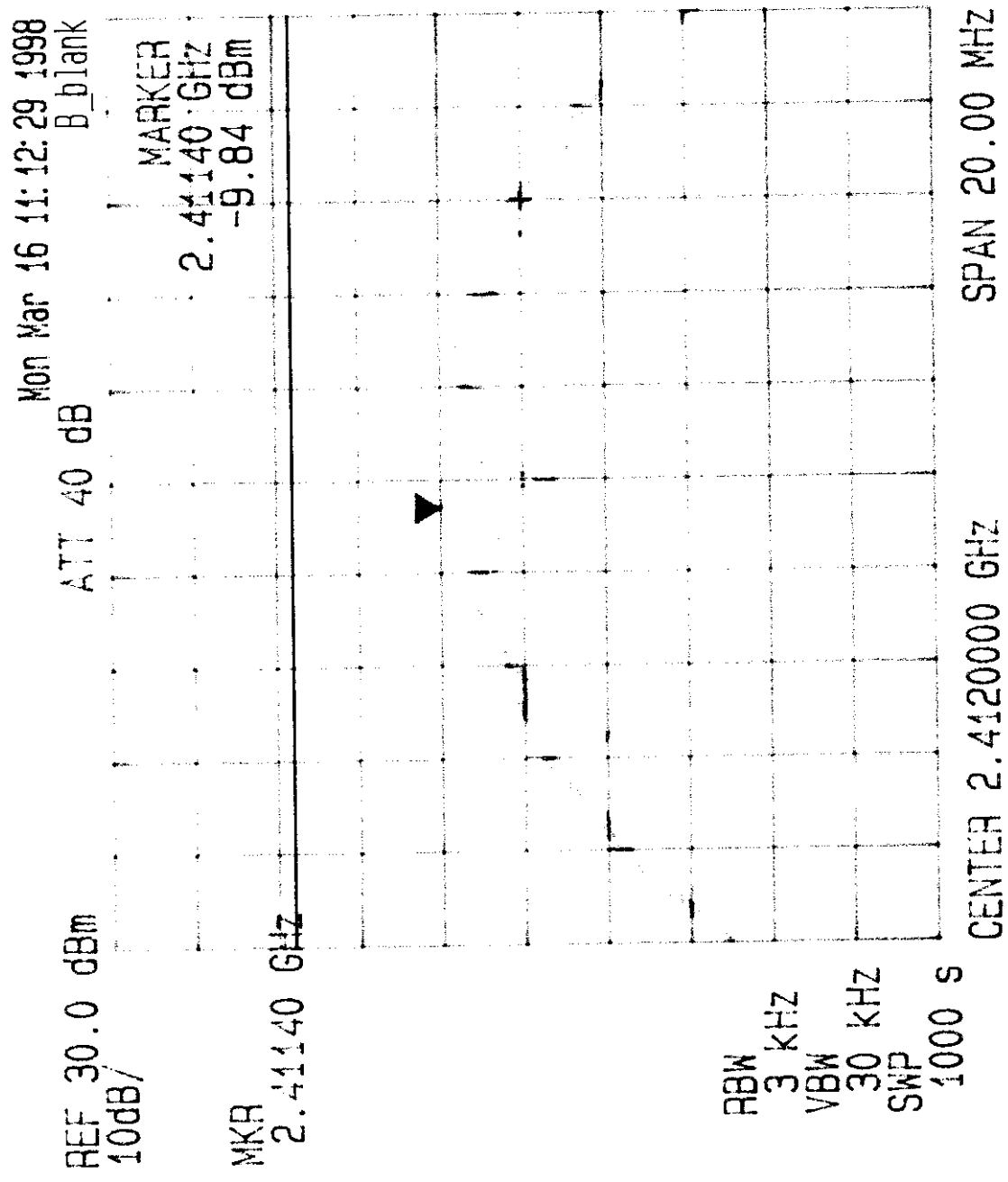
- The transmitter was coupled to the Spectrum Analyzer.
- The channel frequencies were established on the extreme edges (both upper and lower) and middle of the 2412 - 2462 MHz band at its full rated output power. The emissions was investigated up to the tenth harmonic of the fundamental emissions in each case, the measured level of the carrier was recorded and compared to the level of the emissions as required in Part 15.247(d)

CHANNEL NUMBER	CHANNEL FREQUENCY (MHz)	RF POWER LEVEL IN 3 KHz BW (dBm)	LIMIT (dBm)	MARGIN (dB)	COMMENTS (PASS/FAIL)
1	2412	-9.8	8.0	-17.8	PASS
6	2437	-10.9	8.0	-18.9	PASS
11	2462	-10.6	8.0	-18.6	PASS



Channel #: 1, Tx Frequency: 2.412 MHz, RF Power: 400 mW
Modulation: DSSS (11 Mcchips/s, 2.0 Mb/s DPSK, 2 bits/symbol)

Date: Jan 10/98
Tested by: Tri Lau



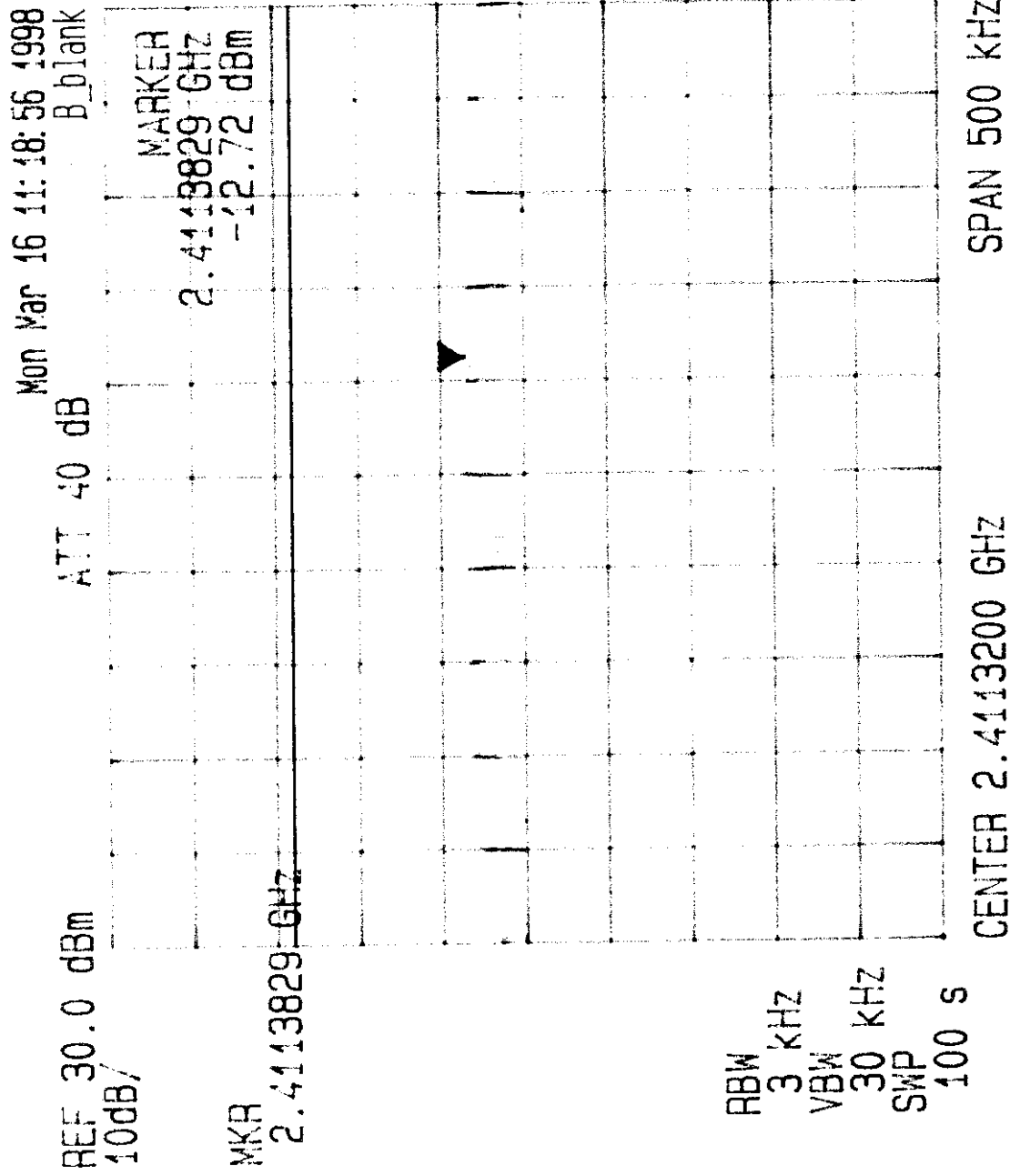


UltraTech
Engineering Labs Inc.

WIRELESS LAN CARD, MODEL RL2400

Channel #: 1, Tx Frequency: 2.412 MHz, RF Power: 16.5 mW
Modulation: DSSS (11 Mcbps/s, 2.0 Mb/s DPSK, 2 bits/symbol)

Date: Mar 16/98
Tested by: Tri Lau

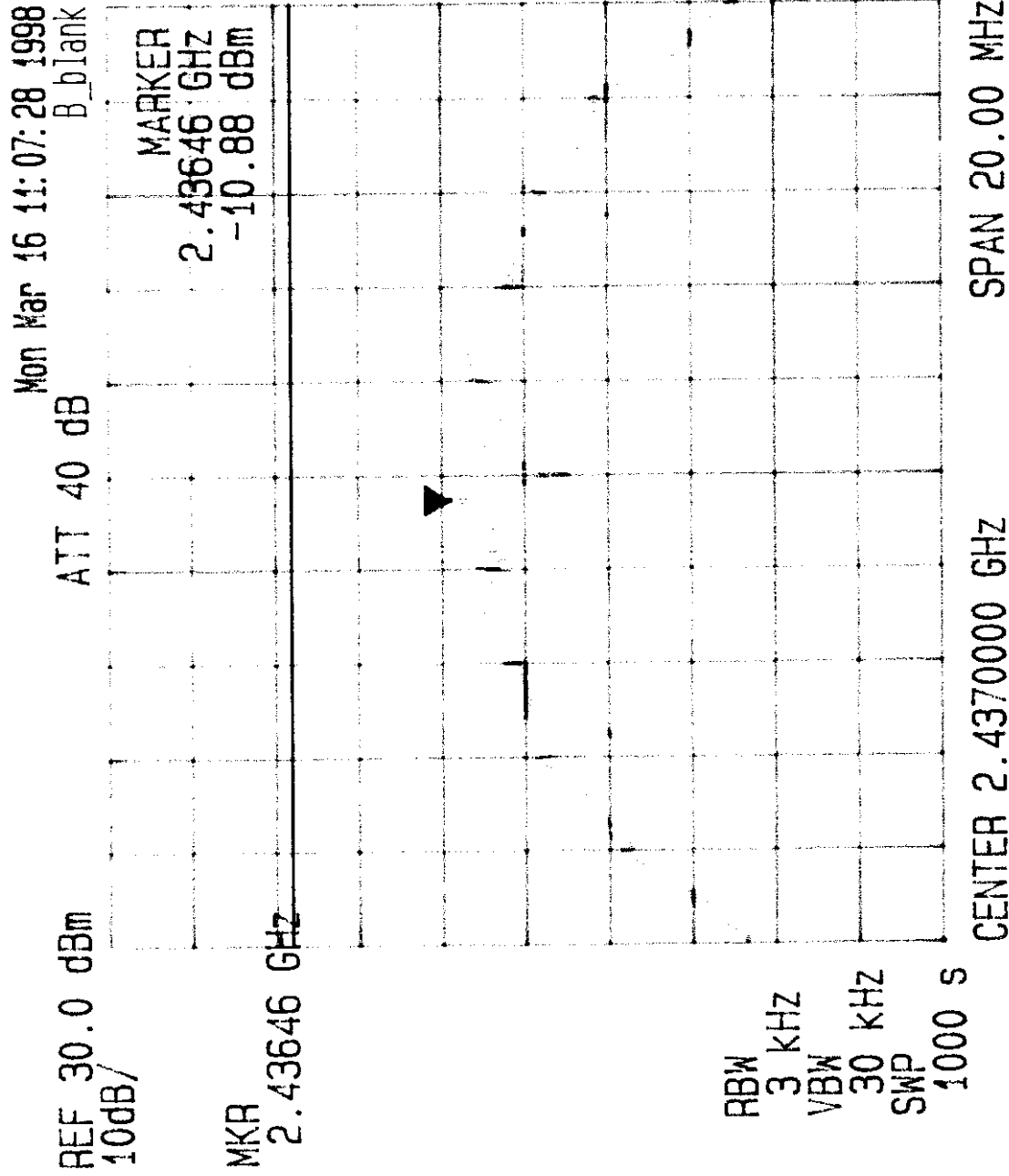




Engineering Labs Inc.

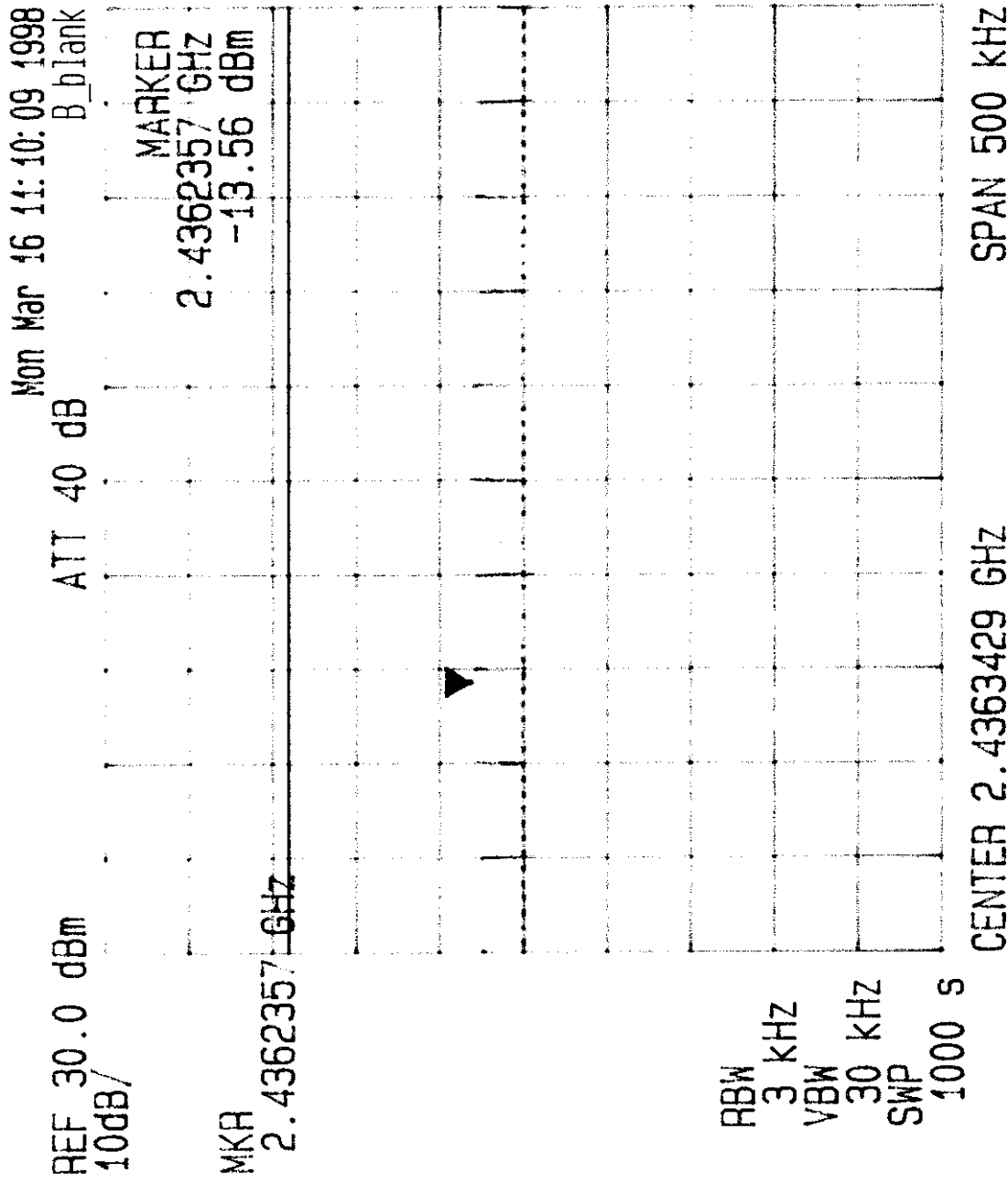
Channel #: 6 WIRELESS LAN CARD, MODEL RL2400
Tx Frequency: 2.437 MHz, RF Power: 41.7 mW
Modulation: DSSS (11 Mcips/st, 2.0 Mb/s DPSK, 2 bits/symbol)

Date: Mar. 16/98
Tested by: Tri Lau



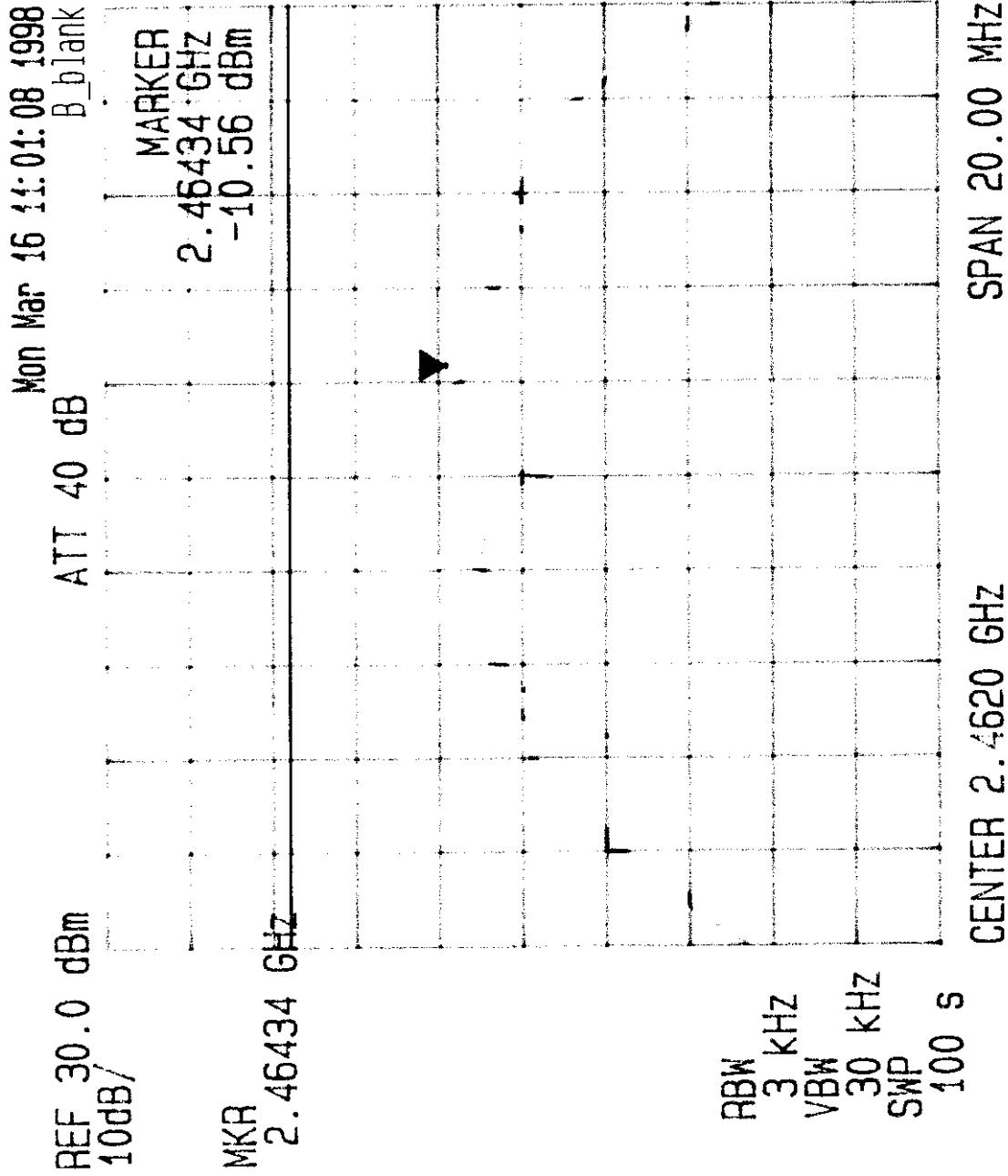
Channel #: 6 WIRELESS LAN CARD, MODEL RL2400
Tx Frequency: 2437 MHz, RF Power: 41.7 mW
Modulation: DSSS (11 Mcbps/s, 2.0 Mb/s DSSS, 2 bits/symbol)

Date: Mar 16/98
Tested by: Tri Lun



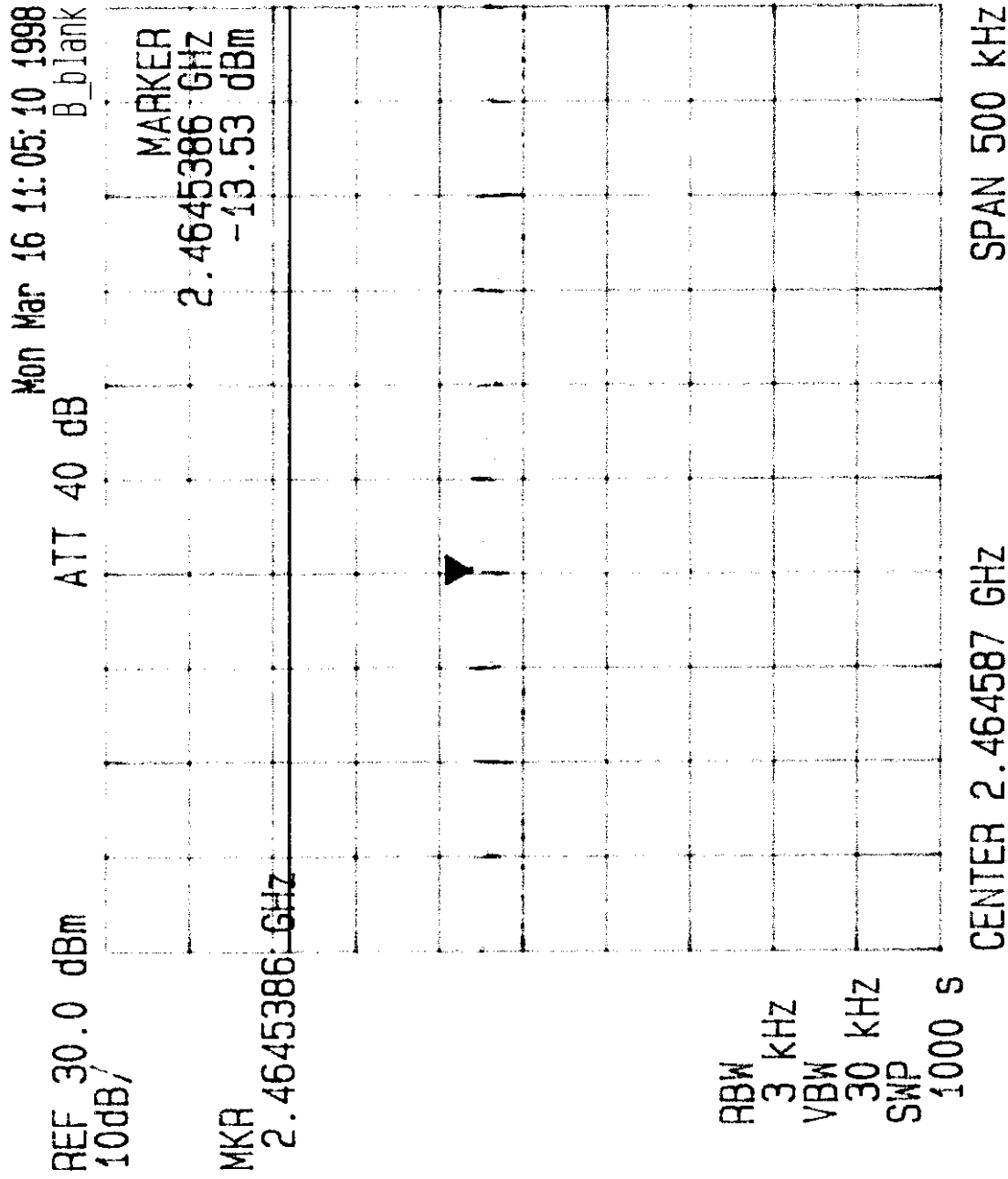
Channel #: 11 WIRELESS LAN CARD MODEL RL2400
Tx Frequency: 2.462 MHz, RF Power: 513 mW
Modulation: DSSS (11 Mcips/s, 2.0 Mb/s DPSK, 2 bits/symbol)

Date: Mar 16/98
Tested by: Tri Lau



Channel #: 11, Tx Frequency: 2.462 MHz, RF Power: 51.3 mW
Modulation: DSSS (11 Mcips/st, 2.0 Mb/s DPSK, 2 bits/symbol)

Date: Mar. 16/98
Tested by: Tri Luu



1.20. Processing Gain of A Direct Sequence Spread Spectrum, FCC CFR 47, Para. 15.247(e)**PRODUCT NAME:** WIRELESS LAN CARD, Model No.: RL2400**FCC REQUIREMENTS:**

The processing gain of a direct sequence system shall be at least 10 dB. The processing gain shall be determined from the ratio in dB of the signal-to-noise ratio with the system spreading code turned off to the signal-to-noise ratio with the system spreading code turned on, as measured at the demodulated output of the receiver.

CLIMATE CONDITION:

Standard Temperature and Humidity: 23°C and 53%

POWER INPUT:

Using DC Power from a laptop computer.

TEST EQUIPMENT:

- Advantest Spectrum Analyzer, Model R3271, S.N: 15050203
- 3dB & 40 dB Attenuators, 50 Ohm IN/OUT
- Fluke RF Signal Generator, Model 6061A, Freq. range: 10 KHz - 1050 MHz.
- HP 8900 RF Peak Power Meter, Measuring Frequency Range: 100 MHz - 18 GHz.
- Bert Fireberd 4000 Communication Analyzer

METHOD OF MEASUREMENT:- Jamming Margin Method

The processing gain may be measured using the CW jamming margin method. Figure 1 shows the test configuration. The test consists of stepping a signal generator in 50 KHz increments across the passband of the system. At each point, the generator level required to produce the recommended Bit Error Rate (BER) is recorded. This level is jammer level. The output power of the transmitting unit is measured at the same point. The Jammer to Signal (J/S) ratio is then calculated. Discard the worst 20% of the J/S data points. The lowest remaining J/S ratio is used when calculating the Process Gain.

The signal to noise ratio for an ideal differentially coherent detection of a differentially encoded DPSK receiver can be derived from the Bit Error Probability (Pb) versus Signal-to-Noise ratio. See attached plot for detailed information.

For measurement of the (S/N), we use the Pb of 1.0×10^{-5} minimum.

Ref.: Viterbi, A.J. Principles of Coherent Communications (New York: McGraw-HILL 1966), Pg. 207

Using equation (1) shown above, calculate the signal to noise ratio required for your chosen BER. This value and the measured J/S ratio are used in the following equation to calculate the Process Gain (Gp) of the system.

$$G_p = (S/N)_{0+M_j+L_{sys}}$$

Where:

WIRELESS LAN CARD, Model RL2400**FCC ID: NVF-RL2400**

(S/N)₀: Theoretical signal to noise ratio required to maintain the normal operation just before the BER appears. In real measurements the maximum error of 0.001 is allowed in an ideal system using their modulation scheme with all codes turned off (i.e. no spreading or processing gain).

M_j: Maximum jammer to Signal Ratio that recorded at the detected BER.

L_{sys}: System losses such as non-ideal synchronization, tracking circuitry, non-optimal baseband receiver filtering and etc... These losses can be in excess of 3 dB for each transmitter and receiver pair. For the purpose of this processing gain calculation we assume a L_{sys} at its minimum value of 3 dB.

Ref.: Dixon, R. Spread Spectrum Systems. (New York: Wiley, 1984), Chapter 1.

TEST RESULTS: Conforms.

TEST PERSONNEL: Tri M. Luu, P.Eng.

DATE: Mar. 17, 1998

MEASUREMENT DATA:

Theoretical Process Gain = $\frac{11 \text{ Mcips/symbol}}{(2 \text{ Mb/s})/(2 \text{ bits/symbol})}$ = 11 numeric or 10.4 dB

- Accredited by: **ITI** (UK) Competent Body & **NVLAP** (USA) Accreditation Body
- Recognized/ Listed by: **FCC** (USA), **Industry Canada** (Canada), **Austel** (Australia)
- All test results contained in this copy may test report are traceable to National Institute of Standards and Technology (**NIST**)

- $(S/N)_0$: Refer to attached curves, BER versus $(S/N)_0$ for Differential Coherent Detection of Differentially Encoded DPSK
- Processing gain $G_p = (S/N)_0 + L_{sys} - M_j = (S/N)_0 + 2 + M_j$

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- All test results contained in this engineering test report are traceable to National Institute of Standards and Technology (**NIST**)

Test Method Employed: Jamming Margin

SIG. GEN. FREQ. (MHz) Differential	BER xexp-5 Coherent	(S/N) _o (dB) Detection	L _{sys} (dB) of Diff. Encoded	Sig. Gen. Total Peak Power @ Rx (dBm) DPSK	Transmitter Total Peak Power @ Rx (dBm)	Jammer to Signal Ratio Mj (dB)	Processing Gain (dB)
Fc - 1.00	1.2	10.0	2.0	-2.2	-3.3	1.1	13.1
Fc - 0.95	0.8	9.2	2.0	-2.5	-3.3	0.8	12.0
Fc - 0.90	0.8	9.2	2.0	-3.4	-3.3	-0.1	11.1
Fc - 0.85	1.5	10.0	2.0	-3.5	-3.3	-0.2	11.8
Fc - 0.80	1.5	10.0	2.0	-3.8	-3.3	-0.5	11.5
Fc - 0.75	1.6	9.9	2.0	-3.3	-3.3	0.0	11.9
Fc - 0.70	2.4	9.8	2.0	-3.4	-3.3	-0.1	11.7
Fc - 0.65	1.6	9.9	2.0	-3.9	-3.3	-0.6	11.3
Fc - 0.60	1.2	10.0	2.0	-4.1	-3.3	-0.8	11.2
Fc - 0.55	1.2	10.0	2.0	-3.6	-3.3	-0.3	11.7
Fc - 0.50	1.0	9.2	2.0	-3.7	-3.3	-0.4	10.8
Fc - 0.45	1.2	10.0	2.0	-3.2	-3.3	0.1	12.1
Fc - 0.40	1.8	9.9	2.0	-2.9	-3.3	0.4	12.3
Fc - 0.35	1.3	10.0	2.0	-2.9	-3.3	0.4	12.4
Fc - 0.30	1.5	10.0	2.0	-4.1	-3.3	-0.8	11.2
Fc - 0.25	1.6	9.9	2.0	-4.1	-3.3	-0.8	11.1
Fc - 0.20	1.2	10.0	2.0	-3.9	-3.3	-0.6	11.4
Fc - 0.15	1.2	10.0	2.0	-3.7	-3.3	-0.4	11.6
Fc - 0.10	1.2	10.0	2.0	-3.7	-3.3	-0.4	11.6
Fc - 0.05	1.2	10.0	2.0	-3.5	-3.3	-0.2	11.8
Fc	1.3	10.0	2.0	-3.1	-3.3	0.2	12.2
Fc + 0.05	1.5	10.0	2.0	-3.2	-3.3	0.1	12.1
Fc + 0.10	1.8	9.9	2.0	-3.0	-3.3	0.3	12.2
Fc + 0.15	0.9	9.2	2.0	-2.8	-3.3	0.5	11.7
Fc + 0.20	1.9	9.9	2.0	-2.7	-3.3	0.6	12.5
Fc + 0.25	1.2	10.0	2.0	-2.9	-3.3	0.4	12.4
Fc + 0.30	1.8	9.9	2.0	-2.3	-3.3	1.0	12.9
Fc + 0.35	1.2	9.2	2.0	-2.9	-3.3	0.4	11.6
Fc + 0.40	1.8	9.9	2.0	-2.2	-3.3	1.1	13.0
Fc + 0.45	1.2	10.0	2.0	-1.9	-3.3	1.4	13.4
Fc + 0.50	1.5	10.0	2.0	-1.7	-3.3	1.6	13.6
Fc + 0.55	1.2	10.0	2.0	-1.4	-3.3	1.9	13.9
Fc + 0.60	1.2	10.0	2.0	-0.9	-3.3	2.4	14.4
Fc + 0.65	1.8	9.9	2.0	-0.4	-3.3	2.9	14.8
Fc + 0.70	1.8	9.9	2.0	-1.0	-3.3	2.3	14.2
Fc + 0.75	1.2	9.2	2.0	-1.1	-3.3	2.2	13.4
Fc + 0.80	2.3	9.8	2.0	-1.6	-3.3	1.7	13.5
Fc + 0.85	2.4	9.8	2.0	-1.9	-3.3	1.4	13.2
Fc + 0.90	1.2	10.0	2.0	-1.9	-3.3	1.4	13.4
Fc + 0.95	1.9	9.2	2.0	-1.9	-3.3	1.4	12.6
Fc + 1.0	1.9	9.9	2.0	-1.9	-3.3	1.4	13.3
THEORETICAL PROCESS GAIN : 10.4dB				MIN. MEASURED PROCESSING GAIN: 10.8 dB			

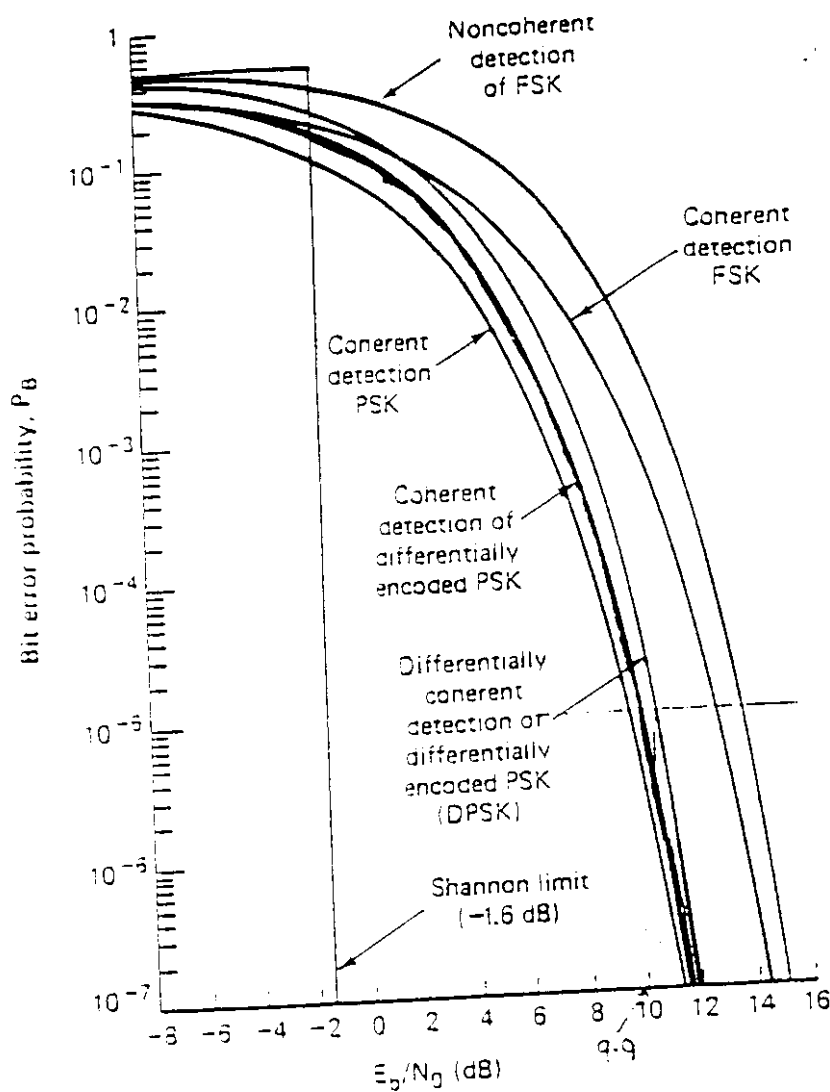


Figure 3.22 Bit error probability for several types of binary systems.

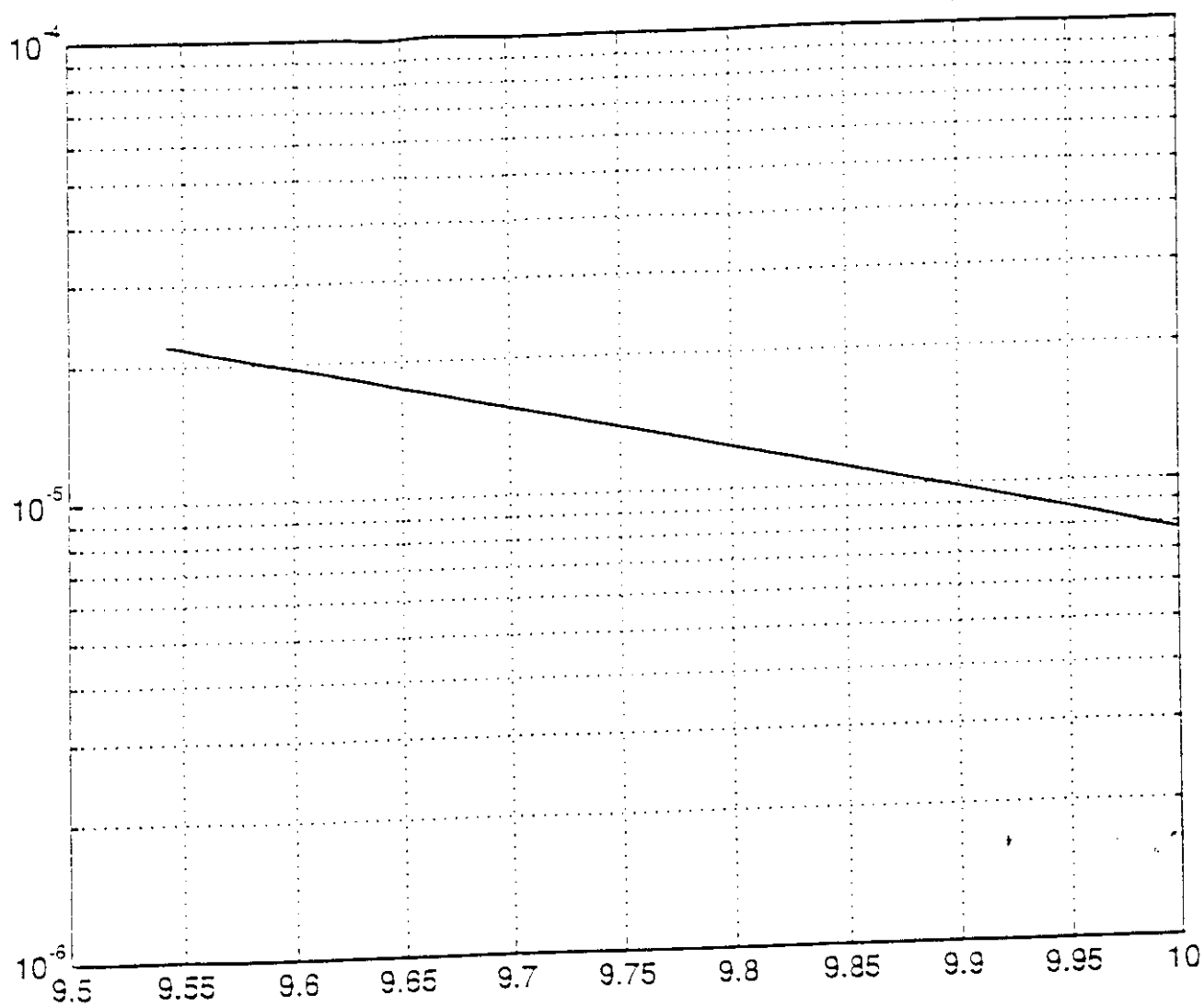
3.7.2 Probability of Bit Error for Coherently Detected Differentially Encoded PSK

Channel waveforms sometimes experience inversion: for example, when using a coherent reference generated by a phase-locked loop (see Chapter 8), one may have phase ambiguity. If the carrier phase were reversed in a DPSK modulation application, what would be the effect on the message? The only effect would be an error in the bit during which inversion occurred or the bit just after inversion, since the message information is encoded in the similarity or difference between adjacent symbols. The similarity or difference quality remains unchanged if the carrier is inverted. Sometimes, systems are *differentially encoded and coherently detected*, simply to avoid these phase ambiguities.

The probability of bit error for coherently detected, differentially encoded PSK is given by [7]

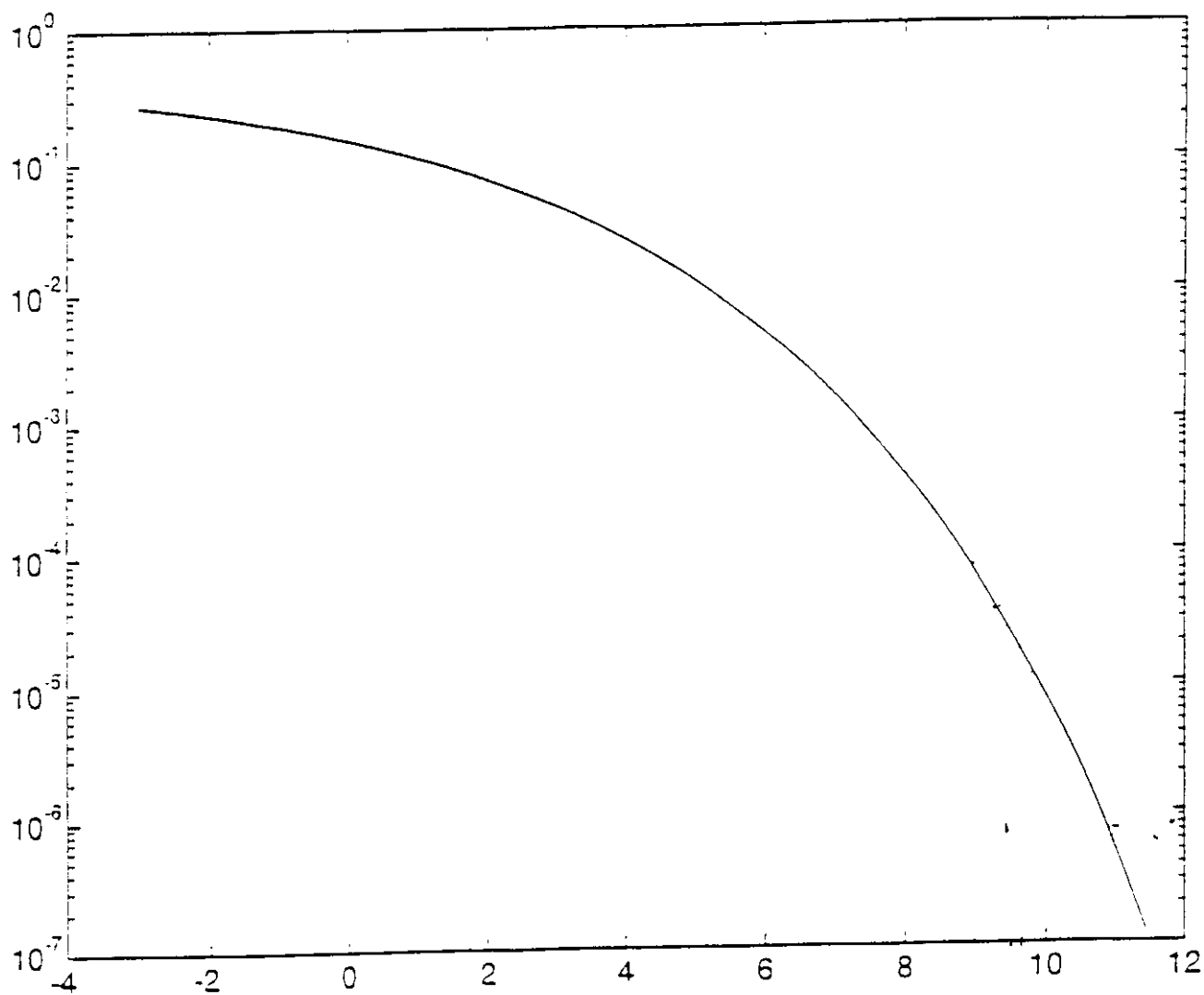
$$P_B = 2Q\left(\sqrt{\frac{2E_b}{N_0}}\right) \left[1 - Q\left(\sqrt{\frac{2E_b}{N_0}}\right)\right]$$

BER



$$\left(\frac{E_b}{N_0} \right) \text{ dB}$$

BER



$$\left(\frac{E_b}{N_0}\right) \text{ dB}$$

1.21. AC Powerline Conducted Emissions, FCC CFR 47, Para. 15.107(a)

PRODUCT NAME: WIRELESS LAN CARD, Model No.: RL2400

NAME OF TEST: AC Powerline Conducted Emissions.

FCC LIMIT:

The RF voltage conducted back onto the public utility lines shall not exceed 250 uV or 48.0 dBuV measured from 450 KHz to 30 MHz.

CLIMATE CONDITION:

Standard Temperature and Humidity: 23 °C and 53%

POWER INPUT:

Using DC Power from a laptop computer.

TEST EQUIPMENT:

- Advantest R3271 Spectrum Analyzer, Frequency Range: 100Hz-26.5GHz, with built-in Peak, Quasi-Peak and Average Detectors.
- HP 11947A Transient Limiter, HP, Model 11947A, Frequency Range: 9KHz-200MHz, Attenuation: 10dB.
- HP 7475 Plotter
- EMCO 3825/2 LISN, Frequency Range: 9KHz-200MHz
- RF Shielded Enclosure (12x16x12 feet)

METHOD OF MEASUREMENTS:

Refer to ANSI C63.4-1992.

TEST RESULTS: Conforms.

TEST PERSONNEL: Tri M. Luu, P.Eng.

DATE: Mar. 27, 1998

MEASUREMENT DATAAC POWER-LINE CONDUCTED EMISSIONSREMARKS

- All rf emissions from 450 KHz to 30 MHz were scanned, and eight highest emission levels were recorded. See attached plots.
- P: Peak Detector, 10 KHz RBW, VBW $\geq$ RBW
- Q: CISPR QUASI-PEAK, 9 KHz RBW, VBW $\geq$ RBW
- QP/BB: for broadband emission (QP level - AVG level > 6 dB); the recorded level was QP level less 13 dB.

FREQUENCY (MHz)	RF LEVEL (dBuV)	RECEIVER DETECTOR (P/QP/AVG)	QP/NB LIMIT (dBuV)	QP/BB LIMIT (dBuV)	MARGIN (dB)	PASS/ FAIL	LINE TESTED (L1/L2)
0.514	25.9	QP	48.0	61.0	-22.1	PASS	L1
9.500	36.4	QP	48.0	61.0	-11.6	PASS	L1
10.300	36.5	QP	48.0	61.0	-24.5	PASS	L1
16.900	32.7	QP	48.0	61.0	-15.3	PASS	L1
11.700	36.1	QP	48.0	61.0	-24.9	PASS	L1
0.830	19.9	QP	48.0	61.0	-41.1	PASS	L2
9.800	33.7	QP	48.0	61.0	-14.3	PASS	L2
10.200	33.4	QP	48.0	61.0	-27.6	PASS	L2
16.300	30.9	QP	48.0	61.0	-17.1	PASS	L2

POWER-LINE CONDUCTED EMISSIONS MEASUREMENTS

Engineering Labs Inc.

APPLICANT: RADIO LINK TECHNOLOGY
 PRODUCT: WIRELESS LAN CARD
 MODEL: RL2400

EMI Detector: [1] Peak [4] Quasi Peak [5] Average Temp.: 23 °C, Humidity: 47 %
 Line Tested: 1, Input Voltage: 120V, Tested by: phillips Test Date: Aug 27, 1998
 Comments:

Signal	Freq (MHz)	PK Amp	QP Amp	AV Amp	GPAL1	MARKER
1	0.514240	30.2	25.9	21.0	-22.1	→ HIGH
2	9.498775	39.2	36.4	32.7	-11.6	
3	10.341875	39.4	36.5	32.8	-11.6	
4	16.911313	36.6	32.7	26.2	-15.3	MARKER
5	11.668800	39.1	36.1	31.7	-11.9	→ CF

START
450 KHZ

ACTV DET: PEAK

MEAS DET: PEAK QP AVG

MKR 11.73 MHz
36.56 dBμV

NEXT

PEAK

LOG REF 80.0 dBμV

10

dB/

ATN

10 dB

NEXT PK

RIGHT

NEXT PK

LEFT

VA SB

SC FC

ACORR

MORE

1 of 3

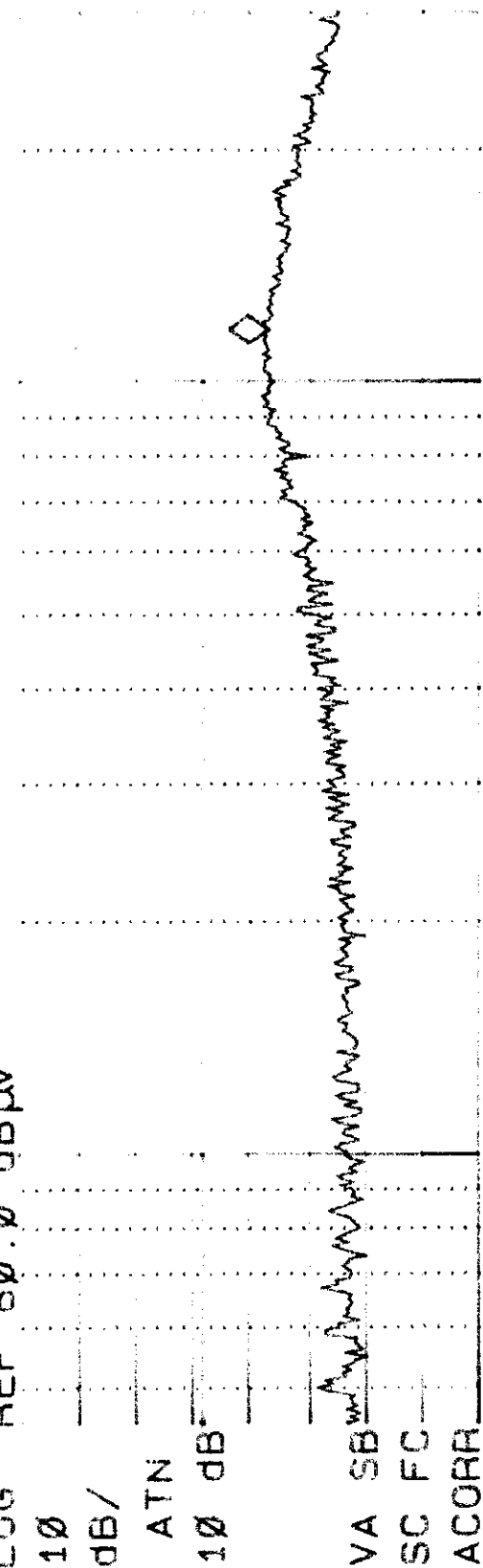
START 450 KHZ

IF BW 9.0 KHZ

AVG BW 30 KHZ

STOP 30.00 MHz

SWP 1.33 sec



POWER-LINE CONDUCTED EMISSIONS MEASUREMENTS

Engineering Labs Inc.

APPLICANT:

PRODUCT:

MODEL:

WIRELESS LAN CARD
R62400

EMI Detector: [] Peak [] Quasi Peak [] Average
Line Tested: 12, Input Voltage: 120V
Comments:

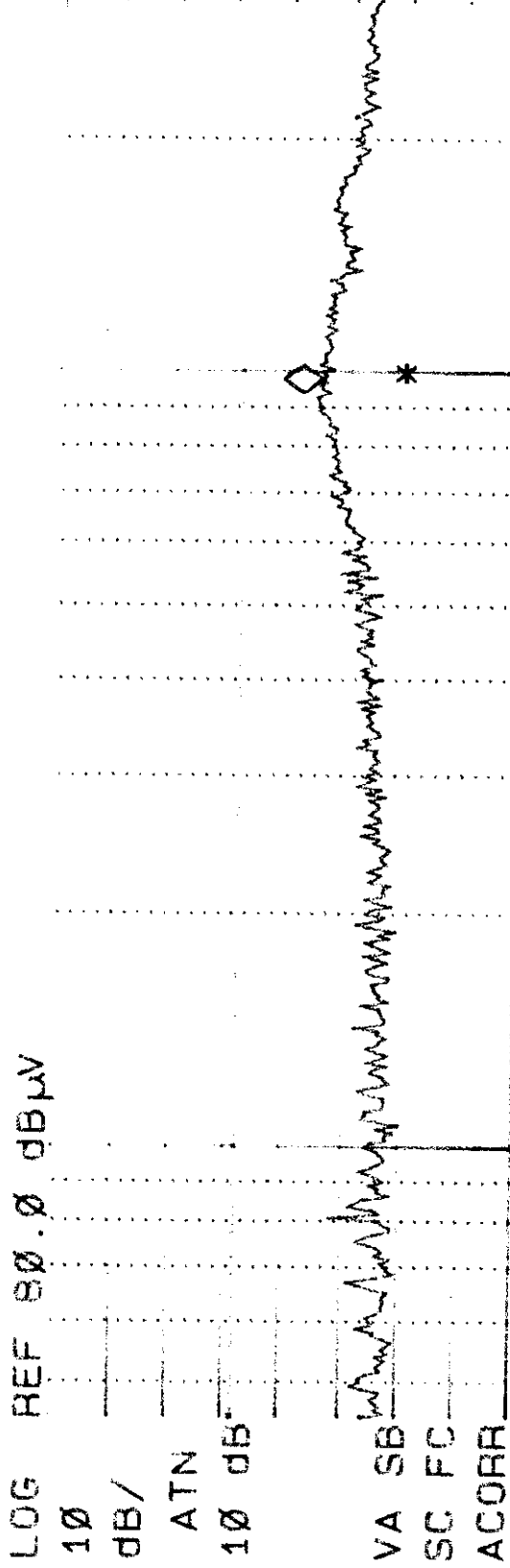
Temp.: 23 °C, Humidity: 47 %
Tested by: PLUCKS Test Date: 11/19/97

Signal	Freq (MHz)	PK Amp	QP Amp	AV Amp	QPA1	No	User
1	0.832450	25.0	19.9	13.7	-28.1		
2	9.821225	36.7	33.7	30.8	-14.3		
3	10.243625	36.9	33.4	29.3	-14.6		
4	16.328075	34.4	30.9	25.6	-17.1		

SIGNAL NUMBER

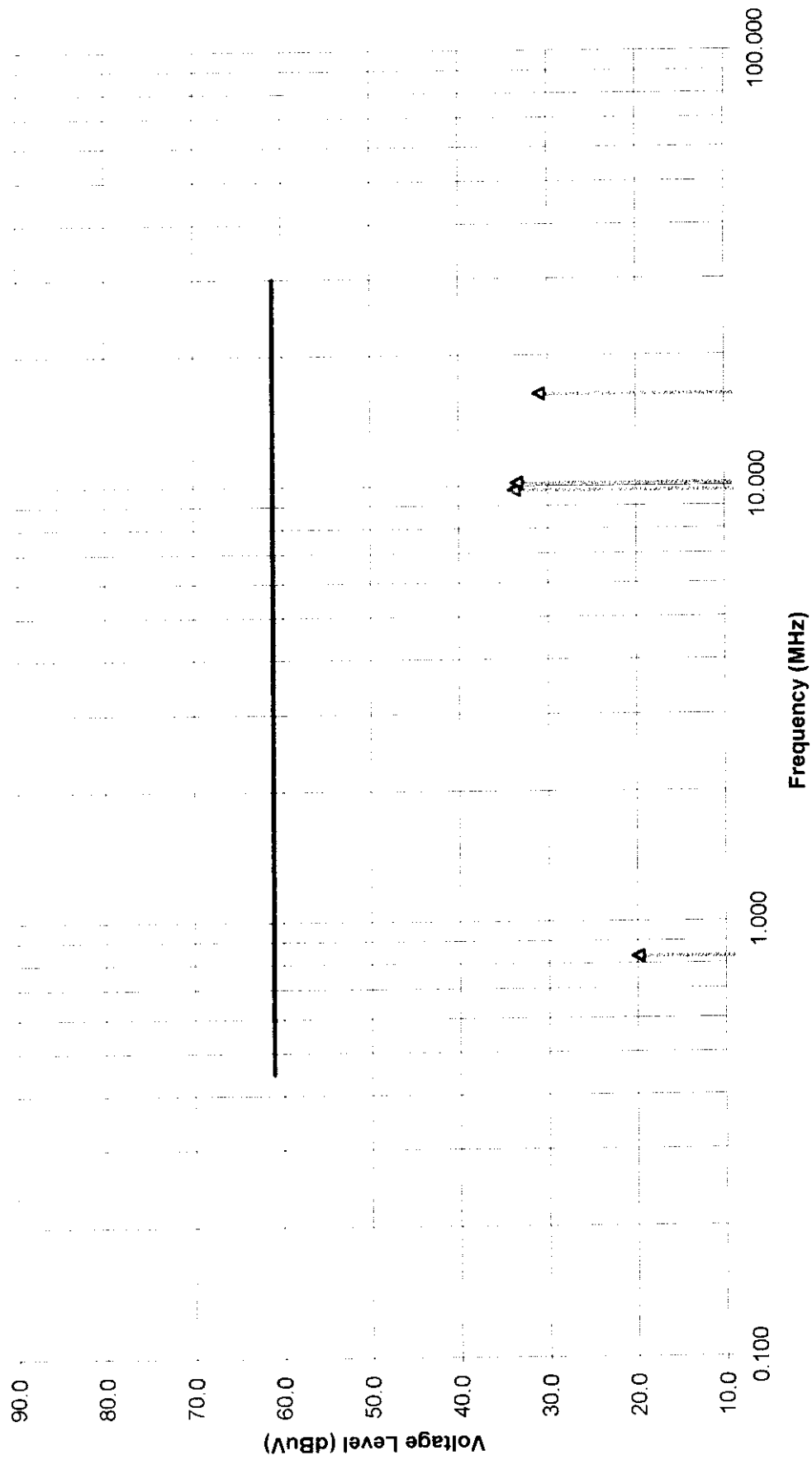
2

ACTV DET: PEAK
MEAS DET: PEAK QP AVG
MKR 9.81 MHz
34.23 dBμV



START 450 KHZ
IF BW 9.0 KHZ
AVG BW 30 KHZ
STOP 30.00 MHz
SWP 1.33 sec

AC Conducted Emissions - Line #2 (Neutral)
RADIO-LINK TECHNOLOGY COMPANY, LTD.
WIRELESS LAN CARD, MODEL RL2400



AC Conducted Emissions - Line #1 (Hot)
RADIO-LINK TECHNOLOGY COMPANY, LTD.
WIRELESS LAN CARD, MODEL RL2400

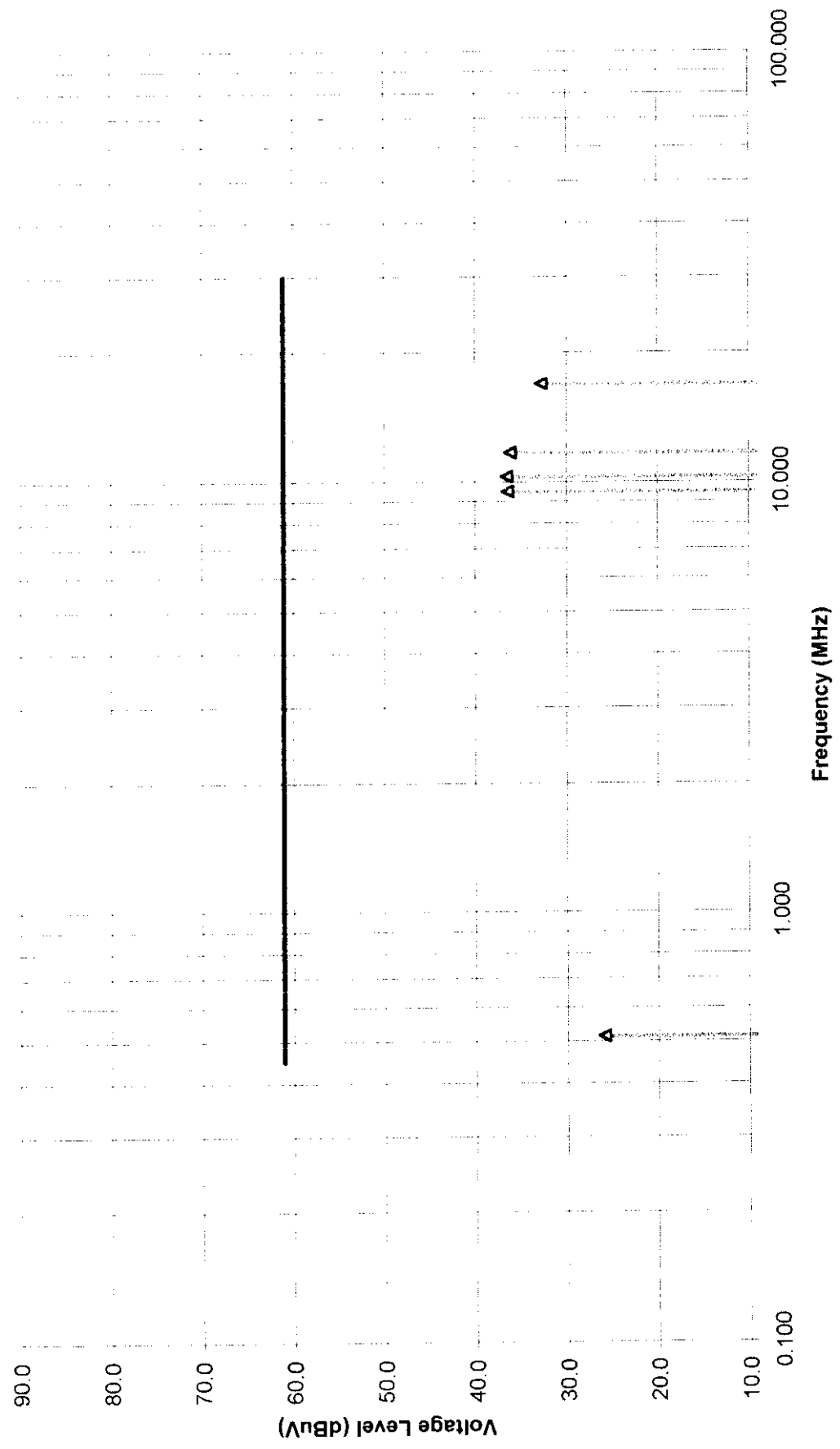


EXHIBIT 5 - GENERAL TEST PROCEDURES**1.22. AC Powerline Conducted Emissions Measurements - General Test Method**

- AC Powerline Conducted Emissions were performed in the shielded room, 16'(L) by 12'(W) by 12'(H).
- Conducted power-line measurements were made over the frequency range from 450 KHz to 30 MHz to determine the line-to-ground radio noise voltage which was conducted from the EUT power-input terminals that were directly connected to a public power network.
- The EUT normally received power from another device that connects to the public utility ac power lines, measurements would be made on that device with the EUT in operation to ensure that the device continues to comply with the appropriate limits while providing the EUT with power.
- If the EUT was operates only from internal or dedicated batteries, with no provisions for connection to the public utility ac power lines, ac power-line conducted measurements are not required.
- Table-top devices were placed on a platform of nominal size 1 m by 1.5m raised 80 cm above the conducting ground plane.
- The EUT current-carrying power lead, except the ground (safety) lead, was individually connected through a LISN to the power source. All unused 50-Ohm connectors of the LISN was terminated in 50-ohm when not connected to the measuring instruments.
- The line cord of the EUT connected to one LISN which was connected to the measuring instrument. Those power cords for the units of devices not under measurement were connected to a separate multiple ac outlets. Drawings and photographs of typically conducted emission test setups were shown in the Test Report. Each current-carrying conductor of the EUT shall be individually tested.
- The EUT was normally operated with a ground (safety) connection, the EUT was connected to the ground at the LISN through a conductor provided in the lead from the ac power mains to the LISN.
- The excess length of the power cord was folded back and forth in an 8-shape on a wooden strip with a vertical prong located on the top of the LISN case.
- The EUT was set-up in its typical configuration and operated in its various modes as described in 3.2 of the test report.
- A preliminary scan was made by using spectrum analyzer system with the detector function set to PEAK mode (10 KHz RBW, VBW $\geq$ RBW), frequency span 450KHz-30MHz.
- The maximum conducted emission for a given mode of operation was found by using the following step-by-step procedure:

- Step1. Monitor the frequency range of interest at a fixed EUT azimuth.
- Step2. Manipulate the system cables and peripheral devices to produce highest amplitude signal relative to the limit. Note the amplitude and frequency of the suspect signal.
- Step3. The effects of various modes of operation is examined. This is done by varying equipment operation modes as step 2 is being performed.
- Step4. After completing step 1 through 3, record EUT and peripheral device configuration, mode of operation, cable configuration, signal levels and frequencies for final test.

- Each highest signal level at the maximized test configuration was zoomed in a small frequency span on the spectrum analyzer's display (the manipulation of cables and peripheral devices and EUT operation modes might have to be repeated to obtain the highest signal level with the spectrum analyzer set to PEAK detector mode 10 KHz RBW and VBW $\geq$ RBW). The spectrum analyzer was then set to CISPR QUASI-PEAK detector mode (9 KHz RBW, 1 MHz VBW) and the final highest RF signal level and frequency was record.
- **Broad-band ac Powerline conducted emissions:-** If the EUT exhibits ac Powerline conducted emissions that exceed the limit with the instrument set to the quasi-peak mode, then measurements should be made in the average mode. If the amplitude measured in the quasi-peak mode is at least 6 dB higher than the amplitude measured in the average mode, the level measured in quasi peak mode may be reduced by 13 dB before comparing it to the limit.

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- Recognized/Listed by **FCC** (USA), **Industry Canada** (Canada), **Austel** (Australia)
- All test results contained in this engineering test report are traceable to National Institute of Standards and Technology (**NIST**)

1.23. Electrical Field Radiated Emissions Measurements - General Test Method

- The radiated emission measurements were performed at the UltraTech's 3 Meter Open Field Test Site (OFTS) situated in the Town of Oakville, province of Ontario. The Attenuation Characteristics of OFTS have been filed to FCC.
- Radiated emissions measurements were made using the following test instruments:
 - 1) Calibrated EMCO active loop antenna in the frequency range from 10 KHz to 1 MHz
 - 2) Calibrated EMCO biconilog antenna in the frequency range from 30 MHz to 2000 MHz.
 - 3) Calibrated A.H. Systems log periodic antenna in the frequency range above 1000 MHz (1GHz - 18 GHz).
 - 4) Horn Antennas:
 - a) Horn Antenna, Emco, Model 3160-09, 18-26.5GHz
 - b) Horn Antenna, Emco, Model 3160-10, 26.5-40GHz
 - c) Mixer, Tektronix, P/N 118-0098-00, 18-26.5GHz
 - d) Mixer, Tektronix, P/N 119-0098-00, 26.5-40GHz
 - e) Mixer, HP, P/N R3434A, 12.4-18GHz
 - f) Mixer, HP, P/N R3434B, 18-26.5GHz
 - g) Mixer, HP, P/N R3434C, 26.5-40GHz
 - 5) Calibrated Advantest spectrum analyzer and pre-selector/pre-amplifier. In general, the spectrum analyzer would be used as follows:
 - The rf electric field levels were measured with the spectrum analyzer set to PEAK detector (1 KHz RBW and 1 KHz VBW for frequency below 30 MHz, 100 KHz RBW and VBW $\geq$ RBW for Frequency below 1 GHz and 1 MHz RBW and 1 MHz VBW for frequency greater than 1 GHz).
 - If any rf emission was observed to be a broadband noise, the spectrum analyzer's CISPR QUASI-PEAK detector (120 KHz RBW and 1MHz VBW) was then set to measure the signal level.
 - If the signal being measured was narrowband and the ambient field was broadband, the bandwidth of the spectrum analyzer was reduced.
- The EUT was set-up in its typical configuration and operated in its various modes as described in 3.2 of the test report.
- The frequencies of emissions was first detected. Then the amplitude of the emissions was measured at the specified measurement distance using required antenna height, polarization, and detector characteristics.
- During this process, cables and peripheral devices were manipulated within the range of likely configuration.
- For each mode of operation required to be tested, the frequency spectrum was monitored. Variations in antenna heights (from 1 meter to 4 meters above the ground plane), antenna polarization (horizontal plane and vertical plane), cable placement and peripheral placement (each variable within bounds specified elsewhere) were explored to produce the highest amplitude signal relative to the limit.

The maximum radiated emission for a given mode of operation was found by using the following step-by-step procedure:

Step1: Monitor the frequency range of interest at a fixed antenna height and EUT azimuth.

Step2: Manipulate the system cables to produce highest amplitude signal relative to the limit. Note the amplitude and frequency of the suspect signal.

- Step3: Rotate the EUT 360 degrees to maximize the suspected highest amplitude signal. If the signal or another at a different frequency is observed to exceed the previously noted highest amplitude signal by 1 dB or more, go back to the azimuth and repeat Step 2. Otherwise, orient the EUT azimuth to repeat the highest amplitude observation and proceed.
- Step4: Move the antenna over its full allowed range of travel (1 to 4 meters) to maximize the suspected highest amplitude signal. If the signal or another at a different frequency is observed to exceed the previously noted highest amplitude signal by 1 dB or more, return to Step 2 with the highest amplitude observation and proceed.
- Step5: Change the polarization of the antenna and repeat Step 2 through 4. Compare the resulting suspected highest amplitude signal with that found for the other polarization. Select and note the higher of the two signals. This signal is termed the highest observed signal with respect to the limit for this EUT operational mode.
- Step6: The effects of various modes of operation is examined. This is done by varying the equipment modes as steps 2 through 5 are being performed.
- Step7: After completing steps 1 through 6, record the final highest emission level, frequency, antenna polarization and detector mode of the measuring instrument.

- Accredited by **ITI** (UK) Competent Body & **NVLAP** (USA) Accreditation Body
- Recognized / Listed by **FCC** (USA), **Industry Canada** (Canada), **Austel** (Australia)
- All test results contained in this engineering test report are traceable to National Institute of Standards and Technology (**NIST**)

Calculation of Field Strength:

The field strength is calculated by adding the calibrated 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
	RA	=	Receiver/Analyzer Reading
	AF	=	Antenna Factor
	CF	=	Cable Attenuation Factor
	AG	=	Amplifier Gain

Example: If a receiver reading of 60.0 dBuV is obtained, the antenna factor of 7.0 dB/m and cable factor of 1.0 dB are added, and the amplifier gain of 30 dB is subtracted. The actual field strength will be:

Field Level in dBuV/m = $60 + 7.0 + 1.0 - 30 = 38.0$ dBuV/m.

Field Level in uV/m = $10^{(38/20)} = 79.43$ uV/m.

Notes: The frequency and amplitude of at least six highest conducted emissions relative to the limit are recorded unless such emissions are more than 20 dB below the limit. If less than six emissions are within 20dB of the limit, the background or receiver noise level shall be reported at representative frequencies.