

ENGINEERING TEST REPORT

ISP DIRECT INDOOR & OUTDOOR UNITS
Model No: 2401-01 (indoor) and 2401-02 (outdoor)

FCC ID: NUX-ISP2401

FCC PART 15, SUBPART C, PARA. 15.247
DIRECT SEQUENCE SPREAD SPECTRUM (DSSS) TRANSMITTERS
OPERATING IN THE FREQUENCY BAND FROM 2408.625 - 2464.875 MHz

UltraTech's FILE NO.: IAW-004FTX

TESTED FOR:

INTERAIR WIRELESS
485 Cayuga Road. P.O. Box 222
Buffalo, New York
USA, 14225-0222

TESTED BY:

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

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

DATE: Apr. 12, 1998

UltraTech

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1. 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) & 1.1310	Maximum Peak Power and RF Exposure Limits	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 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 A Digital Devices. 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 Minh Luu, P. Eng.
V.P., Engineering

DATE: Apr. 12, 1998

2. EXHIBIT 2 - GENERAL INFORMATION

2.1 *Applicant*

INTERAIR WIRELESS
485 Cayuga Road, P.O. Box 222
Buffalo, New York
USA, 14225-0222

Applicant's Representative: Mr. Dave Chauncey, Director RF Engineering

2.2 *Manufacturer*

INTERAIR WIRELESS
485 Cayuga Road, P.O. Box 222
Buffalo, New York
USA, 14225-0222

Applicant's Representative: Mr. Dave Chauncey, Director RF Engineering

2.3 *Description of Equipment under Test*

PRODUCT NAME:	ISP DIRECT INDOOR & OUTDOOR UNITS
SERIAL NUMBER:	Preproduction
TYPE OF EQUIPMENT:	DSSS Transmitters
POWER RATING:	160 mWatts
EMISSION DESIGNATION:	Direct sequence spread spectrum
DUTY CYCLE:	45% maximum
OSC. FREQUENCY(IES):	35 MHz (Rx IF), 70 MHz (Rx LO), 915 MHz (Tx IF), Tx Lo. Osc. = Tx Freq- 915 MHz.
INPUT SUPPLY:	AC 120 V 60Hz from Elpac external switching power supply, model WRI4232
OPERATING FREQ./ 6dB BANDWIDTH	2408.625 - 2464.875 MHz

The following table shows the characteristics of each channel frequency of the transmitter:

Channel No.	Channel Frequency	Modulation Bandwidth	Maximum 6dB Bandwidth (MHz)	Chips per Symbol	Data Rate (Mb/s)	Max. RF Output Power (miliWatts)	Highest gain Antenna Used (dBi)
1	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2	N/A	N/A	N/A	N/A	N/A	N/A	N/A
3	2408.625	Narrow	4.2	11	4.5	190	17
4	2411.4375	Medium	5.3	11	5.625	190	17
5	2417.0625	Medium	5.3	11	5.625	190	17
6	2419.875	Wide	10	11	11.25	190	17
7	2422.6875	Medium	5.3.0	11	5.625	190	17
8	2428.3125	Medium	5.3	11	5.625	190	17
9	2431.125	Wide	10	11	11.25	190	17
10	2433.9375	Medium	5.3	11	5.625	190	17
11	2439.5625	Medium	5.3	11	5.625	190	17
12	2442.3750	Wide	10.0	11	11.25	190	17
13	2445.1875	Medium	5.3	11	5.625	190	17
14	2450.8125	Medium	5.3	11	5.625	190	17
15	2453.625	Wide	10.0	11	11.25	190	17
16	2456.4375	Medium	5.3	11	5.625	190	17
17	2462.0625	Medium	5.3	11	5.625	190	17
18	2464.875	Narrow	4.2	11	4.5	190	17

For worst case of measurements the following channels were chosen to be tested: Narrow BW: 3 & 17, Medium BW: 4, 10 & 17, Wide BW: 6, 9 & 15.

ASSOCIATED DEVICES:

- (1) Elpac external switching power supply, model WRI4232, AC IN: AC 95 250 V, 47-63 Hz, 1.2A, DC OUT: +5V, +12V, -12 Vdc
- (2) One of the following antenna may be supplied with the InterAir ISP Direct System, the antenna is permanently secured to the ISP Direct Outdoor Unit using TNC connectors and heat shrink:

Selection Number	Description	Vendor	P/N	Gain (dBi)
1	1x1 Patch	Huber Suhner	64958022	8.5
2	3x3 Patch	Huber Suhner	65119522	16.5
3	1x10 Patch	Huber Suhner	65247322	16.5
4	Omni	Andrew	RT1N0F-024V-013A	13
5	Reflector	Conifer	18T-2400	17

The Conifer Reflector with the highest antenna gain from the above list is chosen to be tested with the InterAir ISP Direct System for the worst case.

- (3) The RF interconnecting cable between the InterAir ISP Direct Indoor and the Outdoor Units can be selected with one of the following:

Selection No.	Description	Vendor	Part No.	Length (ft)	Loss (dB)
1	0.4" Cable – WP	Times	LMR-400-DB	150	10.2
2	0.3" Cable	Times	LMR-300	100	10.4
3	0.24" Cable	Times	LMR-240	80	10.3
4	0.2" cable	Times	LMR-200	60	10.1
5	0.5" Cable – WP	Times	LMR-500-DB	200	11
6	0.6" Cable – WP	Times	LMR-600-DB	250	11
7	0.9" Cable – WP	Times	LMR-900-DB	400	12
8	0.25" Flex	MISC	RG-223/U	30	10.5

The above item # 8, 0.25" Flex, RG-223/U cable with shortest available length (30 ft) and lowest loss (10.5 dB), was used for testing and represents the worst case.

FCC ID: NUX-ISP2401

INTERFACE PORTS:

INDOOR UNIT:

- (1) LAN Port - RJ-45
- (2) Event In/Out (Sync) - BNC
- (3) Serial Port – DB9 (for factory uses only)
- (4) RF OUT - TNC. The RF OUT will not deliver any rf power if the indoor unit is not connected to the outdoor unit.

OUTDOOR UNIT:

- (1) RF-IN (TNC) (1) LAN Port - RJ-45
- (2) RF-OUT (TNC). Permanently attached to the antenna as one unique assembly. Heat shrink is used to secured the Outdoor Box's RF –OUT terminal to the Antenna, and the Outdoor Box is mounted on the antenna.

2.4 Related Submittal(s)/Grant

No applicable.

2.5 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 2408.625 - 2464.875 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.

2.6 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 3-10 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).

2.7 Units of Measurements

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

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

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

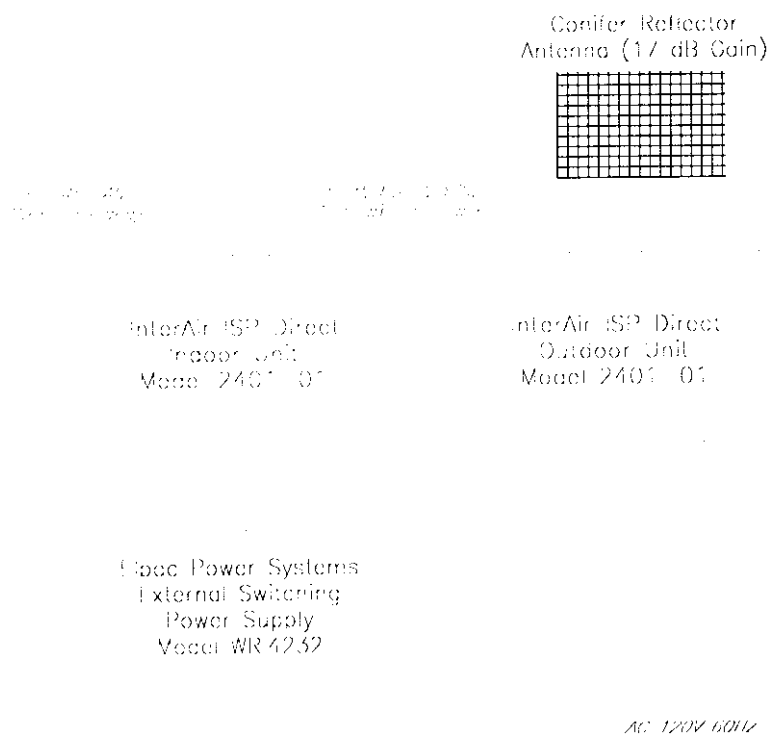
3. EXHIBIT 3 - SYSTEM TEST CONFIGURATION

3.1 Test System Details

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

- (1) **EUT:** INTERAIR WIRELESS, ISP DIRECT INDOOR & OUTDOOR UNITS, Model : 2401-01 (indoor) and 2401-02 (outdoor), S/N: Preproduction.
I/O Cable: All I/O cables were shielded except for the RJ-45 LAN cable
Power Supply Cable: Non-shielded AC cord and shielded DC out cable.
- (2) **ASSOCIATED MAXIMUM GAIN ANTENNA:** Conifer Reflector Antenna , P/N: 18T-2400, Gain: 17 dB.
I/O Cable: All I/O Cables were shielded
- (3) **ASSOCIATED SHORTEST & MINIMUM LOSS RF CABLE:** RG-223/U shielded cable, 0.25" flex, 30ft long minimum, 10.5 dB loss @ 2.45 GHz.

3.2 Block Diagrams for Conducted & Radiated Emission Measurements



3.4 **Justification**

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

3.5 **EUT Operating Condition**

Software provided by INTERAIR WIRELESS to set the EUT to transmit or receive at various channel frequencies.

3.6 **Special Accessories**

No special accessories were required.

3.7 **Equipment Modifications**

To achieve compliance with FCC 15.205 and 15.209 at the Transmitter local oscillator frequency (Tx Freq – 915 MHz), the following modifications were made by InterAir Wireless:

- a. The front and back plastic bezel with the Ni EMI coated edges were glued to the front and back metal plates using Conductive EMI adhesive.
- b. Metal shield boxes were installed at both sides (RF board and Digital Board) of the internal 40-Pin connector.
- c. EMI gasket/washer was installed between the RF and Digital printed circuit boards at the 40-Pin Connector.
- d. 2 mounting screws were added to secure the DC IN power jack to the back metal plate.

4. EXHIBIT 4 - TEST DATA

4.1 6 dB Bandwidth @ FCC 15.247(a)(2)

PRODUCT NAME: ISP DIRECT INDOOR & OUTDOOR UNITS, Model No.: 2401-01 (indoor) and 2401-02 (outdoor)

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:

- Ambient temperature: 23 °C
- Relative humidity: 43 %

POWER INPUT:

AC 120 V 60Hz from Elpac external switching power supply, model WRI4232.

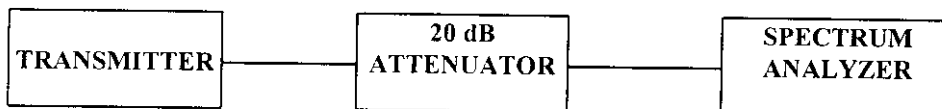
TEST EQUIPMENT:

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

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: Mr. Tri M. Luu, P.Eng.

DATE: Feb. 26 & Mar. 04, 1998

MEASUREMENT DATA:

Channel No.	Channel Frequency	Modulation Bandwidth	Data Rate (Mb/s)	Chips per Symbol	Measured 6dB Bandwidth (MHz)	FCC Limit (MHz)
3	2408.625	Narrow	4.5	11	4.2	0.5
4	2411.4375	Medium	5.625	11	5.0	0.5
6	2419.875	Wide	11.25	11	8.4	0.5
9	2431.125	Wide	11.25	11	10.0	0.5
10	2433.9375	Medium	5.625	11	5.2	0.5
15	2453.625	Wide	11.25	11	8.1	0.5
17	2462.0625	Medium	5.625	11	5.3	0.5
18	2464.875	Narrow	4.5	11	4.0	0.5

UltraTech Engineering Labs Inc.

UltraTech's File #: IAW-004FTX

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

Tel. #: 905-569-2550

Fax. #: 905-569-2480

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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**)



Engineering Labs Inc.

h/p

ISP DIRECT, MODEL 2401-01 (INDOOR) & 2401-02 (OUTDOOR)

Test Configuration #: 7, Tx Frequency: 2408.625 MHz, RF Power: 0.19 W
Modulation: DSSS, BW: NARROW (4.5 Mc/s), 11 chips/symbol, 0.818 Mbps DQPSK

Date: Feb 26/98
Tested by: Tin Luu

Channel #3

MARKER Δ
4.20 MHz
.23 dB

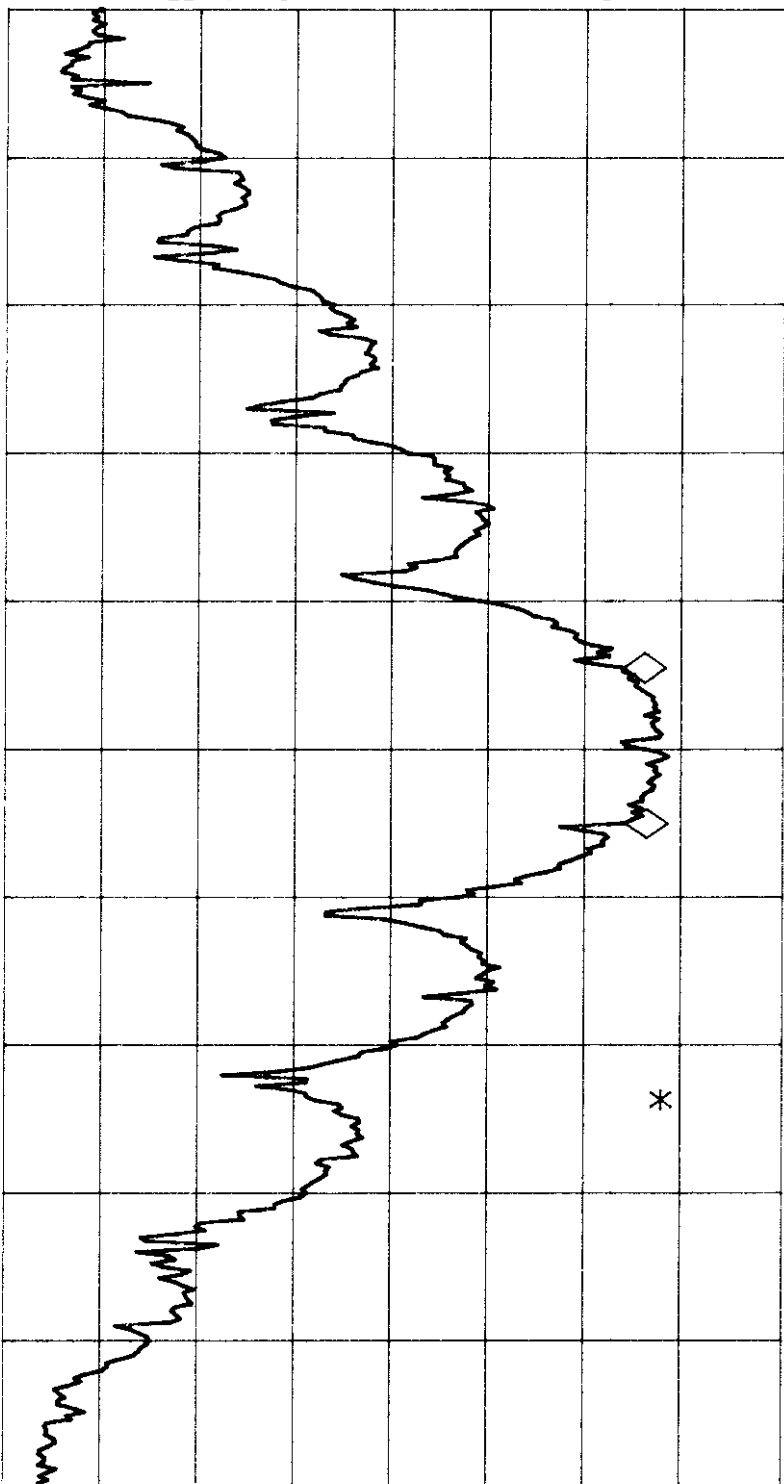
ACTV DET: PEAK
MEAS DET: PEAK QP AVG
MKR 4.20 MHz
.23 dB

No user
Menu

REF OFFST 20.0 dB
LOG REF 20.0 dBm

10
dB/
#ATN
10 dB

VA SB
SC FC
CORR



CENTER 2.40863 GHz
#IF BW 30 KHz

#AVG BW 300 KHz

SPAN 40.00 MHz
#SWP 50.0 sec



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ISP DIRECT, MODEL 2401-01 (INDOOR) & 2401-02 (OUTDOOR)
Test Configuration #: 4, Tx Frequency: 2411.4375 MHz, RF Power: 0.19 W
Modulation: DSSS, BW: MEDIUM (5.625 Mc/s), 11 chips/symbol, 1.023 Mbps DQPSK

Date: Feb. 26/98
Tested by: Tri Luu

MARKER Δ
2.50 MHz
-1.67 dB

Channel 44

ACTV DET: PEAK
MEAS DET: PEAK GP AVG

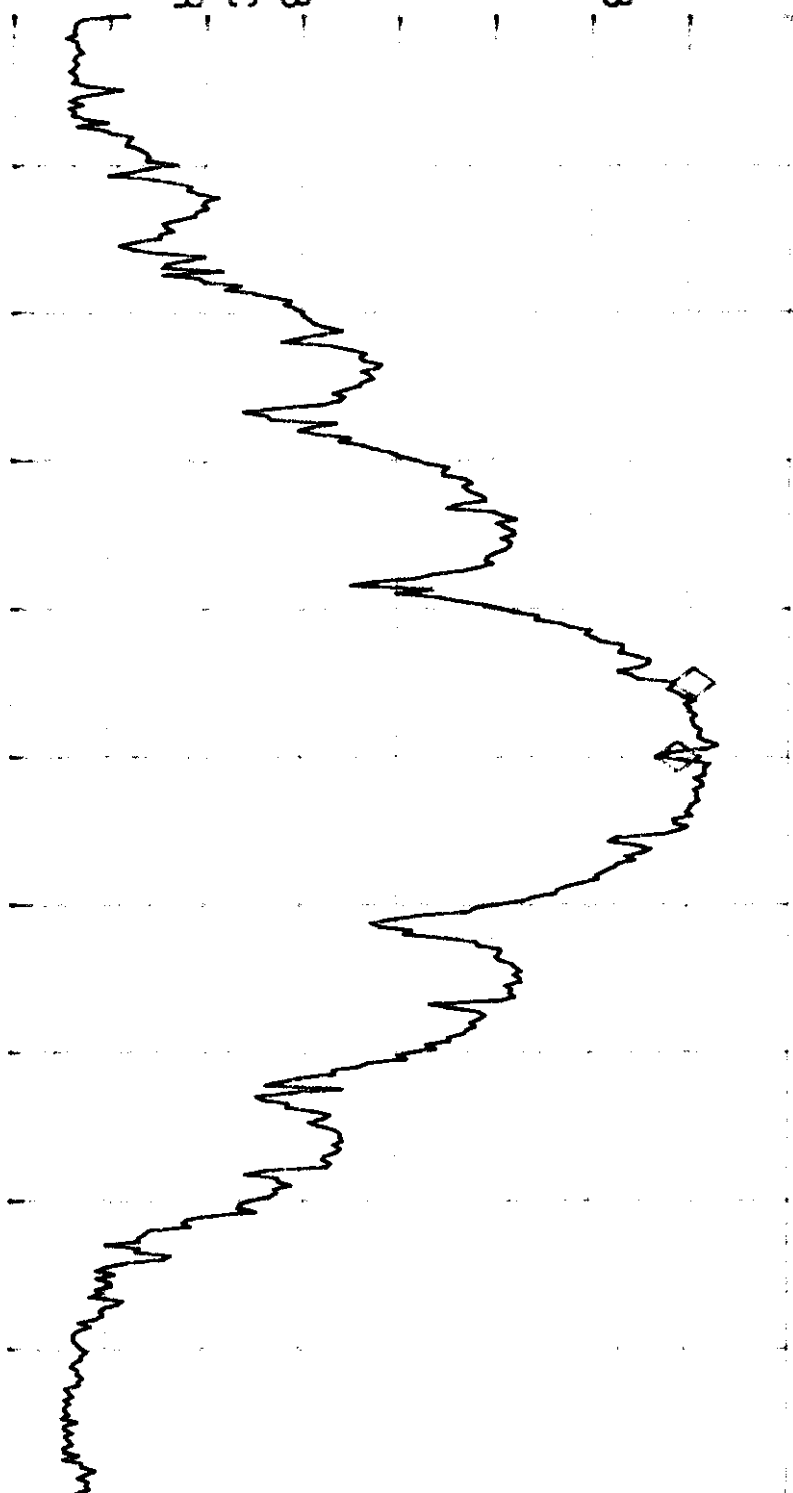
MKR 2.50 MHz
-1.67 dB

No user
Menu

REF OFFST 20.0 dB
LOG REF 15.0 dBm

10
dB/
#ATTN
10 dB

V/A SB
SC FC
CORR



CENTER 2.41144 GHz
#IF BW 30 KHz

#AVG BW 300 KHz

SPAN 50.00 MHz
#SWP 20.0 sec



h/p

ISP DIRECT, MODEL 2401-01 (INDOOR) & 2401-02 (OUTDOOR)
Test Configuration #: 241988, Tx Frequency: 2.41988 MHz, RF Power: 0.19 W
Modulation: DSSS, BW: WIDE (11.25 Mc/s), 11 chips/symbol, 2.045 Mbps DQPSK

Date: Feb. 26 /98
Tested by: Tri Luu

Channel #6.

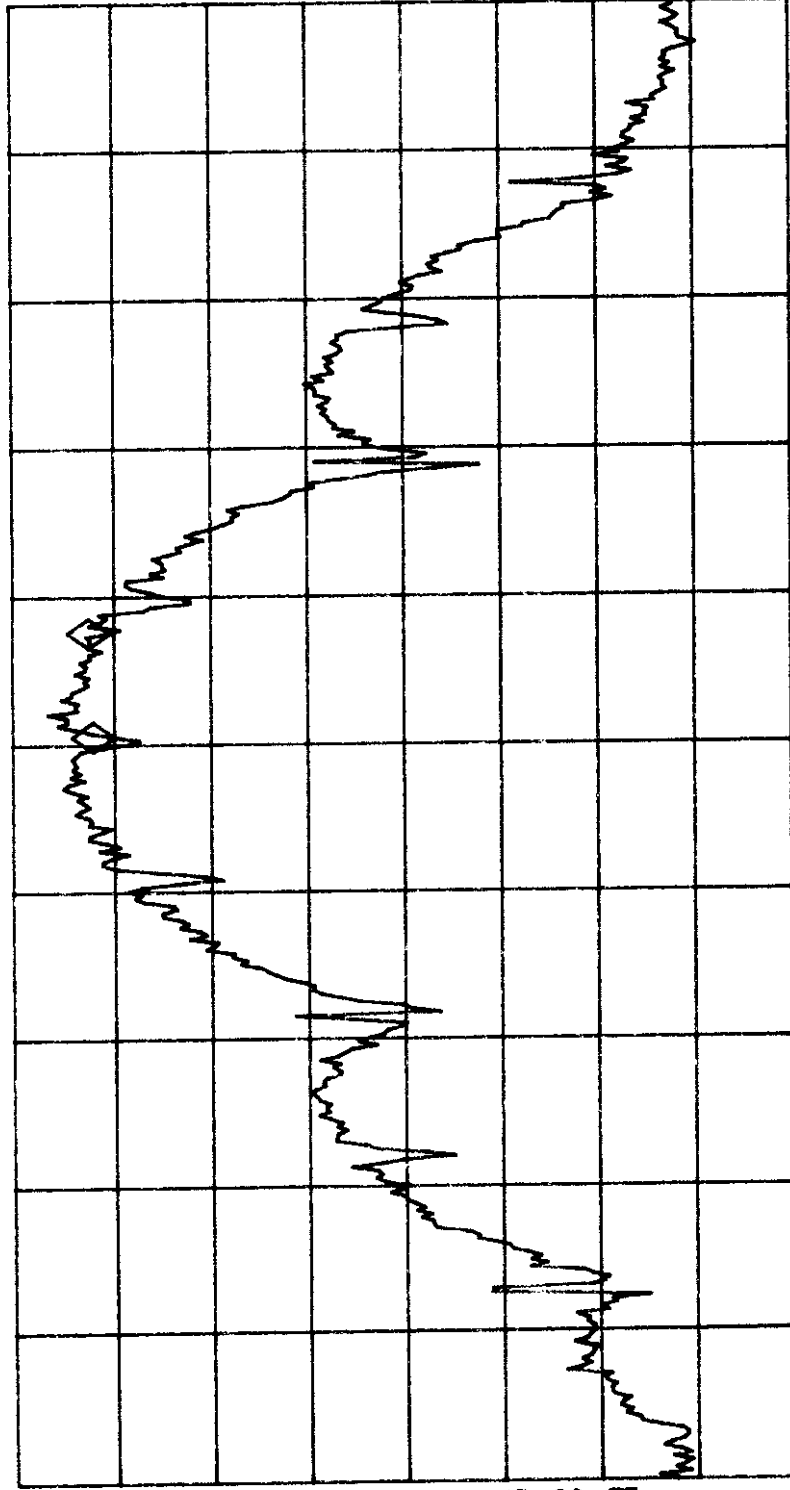
MARKER Δ
4.20 MHz
.48 dB

ACTV DET: PEAK
MEAS DET: PEAK QP AVG
MKR 4.20 MHz
.48 dB

No user
Menu

REF OFFST 20.0 dB
REF 10.0 dBm

LOG
10
dB/
#ATN
10 dB



VA SB
SC FC
CORR

CENTER 2.41988 GHz
#IF BW 30 KHz

#AVG BW 300 KHz
SPAN 60.00 MHz
SWP 200 msec

ISP DIRECT, MODEL 2401-01 (INDOOR) & 2401-02 (OUTDOOR)
Test Configuration #: 2, Tx Frequency: 2431.125 MHz, RF Power: 0.19 W
Modulation: DSSS, BW: WIDE (11.25 Mc/s), 11 chips/symbol, 2.045 Mbps DQPSK

Date: Feb. 16 /98
Tested by: Tri Lum

Channel # 4

MARKER Δ
4.95 MHz
-2.55 dB

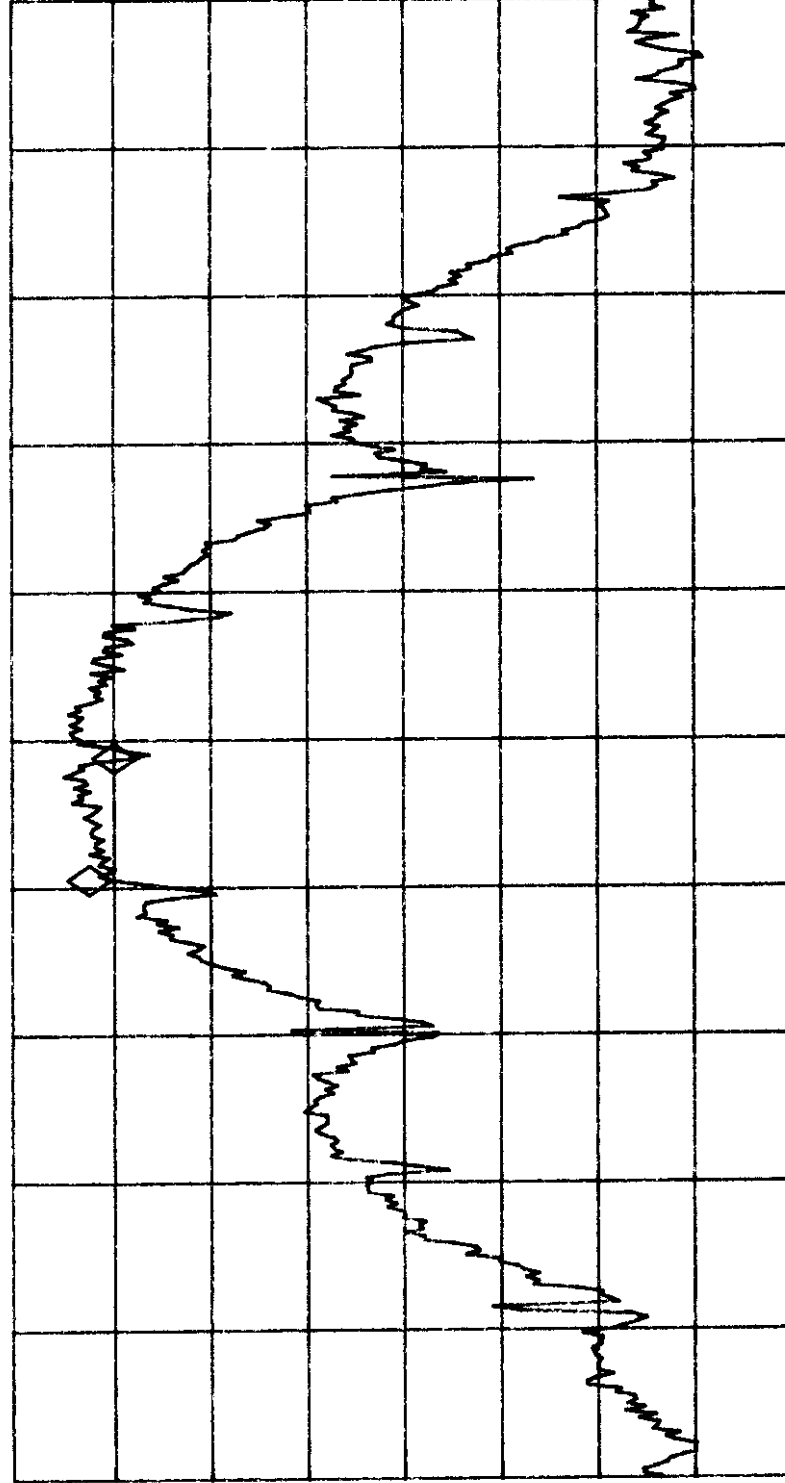
ACTV DET: PEAK
MEAS DET: PEAK QP AVG

No user
Menu

MKR 4.95 MHz
-2.55 dB

REF OFFST 20.0 dB
REF 10.0 dBm

LOG
10
dB/
#ATN
10 dB



VA SB
SC FC
CORR

CENTER 2.43188 GHz
#IF BW 30 KHz

#AVG BW 300 KHz
SPAN 60.00 MHz
SWP 200 msec



hp

Date: Feb. 26/98
Tested by: Tri Luu

ISP DIRECT, MODEL 2401-01 (INDOOR) & 2401-02 (OUTDOOR)

Test Configuration #: 5, Tx Frequency: 2433.9375 MHz, RF Power: 0.19 W
Modulation: DSSS, BW: MEDIUM (5.625 Mc/s), 11 chips/symbol, 1.023 Mbps DQPSK

Channel #10

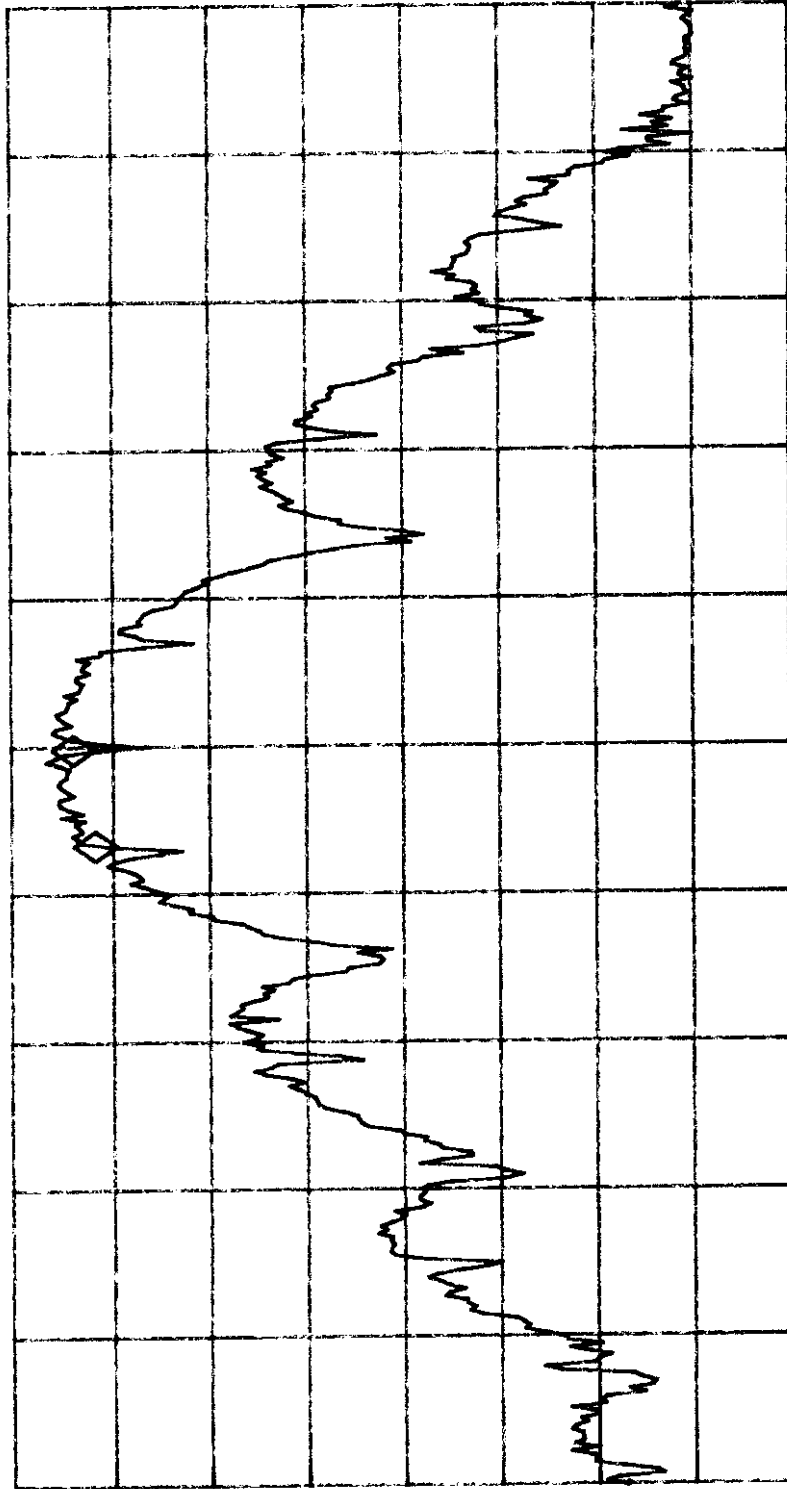
MARKER Δ
2.60 MHz
2.28 dB

ACTV DET: PEAK
MEAS DET: PEAK QP AVG
MKR 2.60 MHz
2.28 dB

No user
Menu

REF OFFST 20.0 dB
REF 10.0 dBm

LOG 10
dB/
#ATN
10 dB



VA SB
SC FC
CORR

CENTER 2.43394 GHz
#IF BW 30 KHz

SPAN 40.00 MHz
#SWP 15.0 sec
#AVG BW 300 KHz



hp

ISP DIRECT, MODEL 2401-01 (INDOOR) & 2401-02 (OUTDOOR)

Test Configuration #: 3, Tx Frequency: 2453.625 MHz, RF Power: 0.19 W
Modulation: DSSS, BW: WIDE (11.25 Mc/s), 11 chips/symbol, 2.045 Mbps DQPSK

Date: Feb. 26/98
Tested by: Tri Luu

MARKER Δ
4.05 MHz
1.49 dB

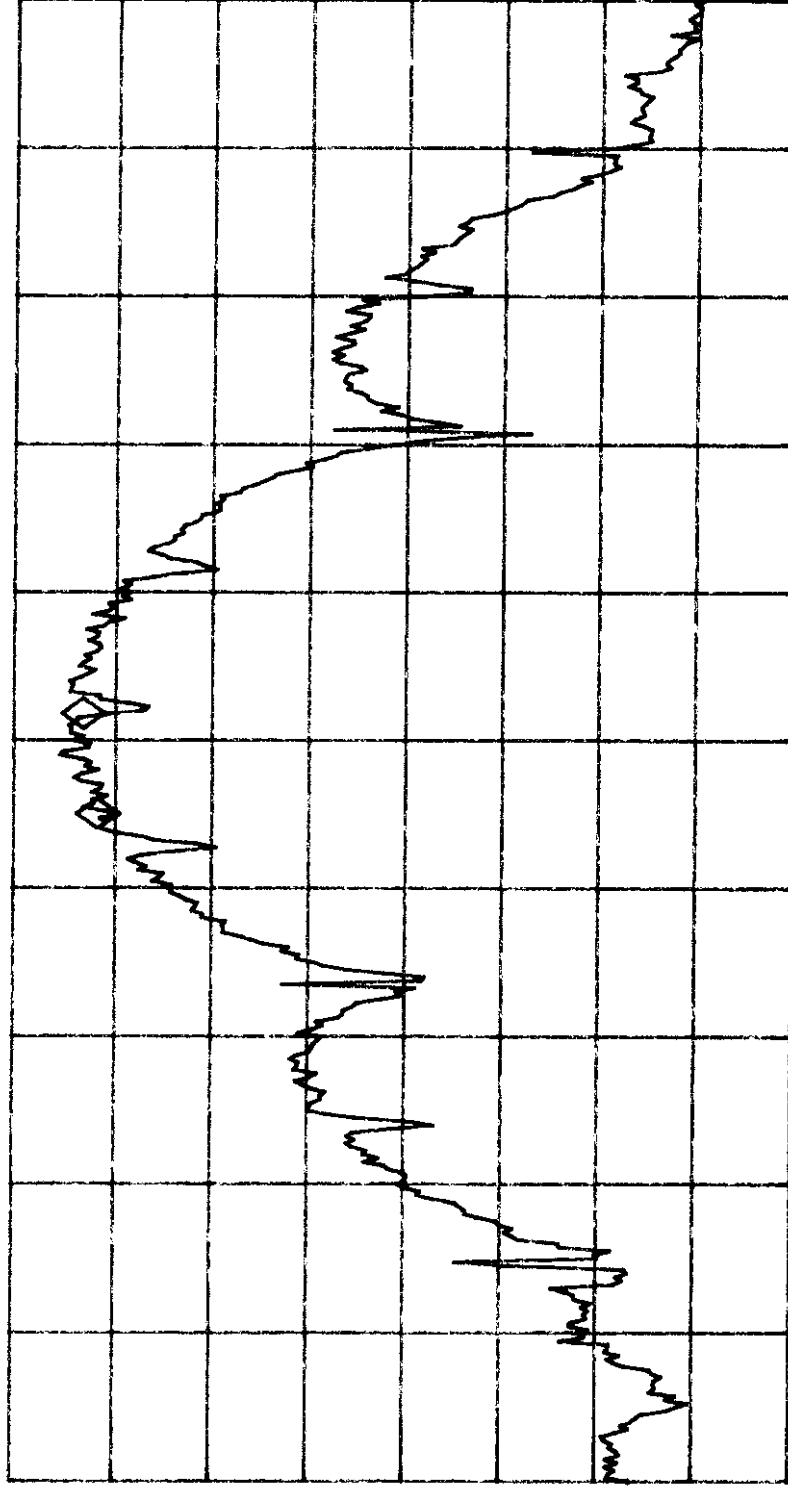
ACTV DET: PEAK
MEAS DET: PEAK QP AVG

MKR 4.05 MHz
1.49 dB

No user
Menu

REF OFFST 20.0 dB
REF 10.0 dBm

LOG 10
dB/
#ATN 10 dB



VA SB
SC FC
CORR

CENTER 2.45250 GHZ
#IF BW 30 KHZ

SPAN 60.00 MHz
SWP 200 msec

#AVG BW 300 KHZ



hp

Date: Mar. 04/98
Tested by: Tri Lam

ISP DIRECT, MODEL 2401-01 (INDOOR) & 2401-02 (OUTDOOR)
Channel #: 17, Tx Frequency: 2464.875 MHz, RF Power: 0.19 W
Modulation: DSSS, BW: MEDIUM (5.625 Mc/s), 11 chips/symbol, 1.023 Mbps DQPSK

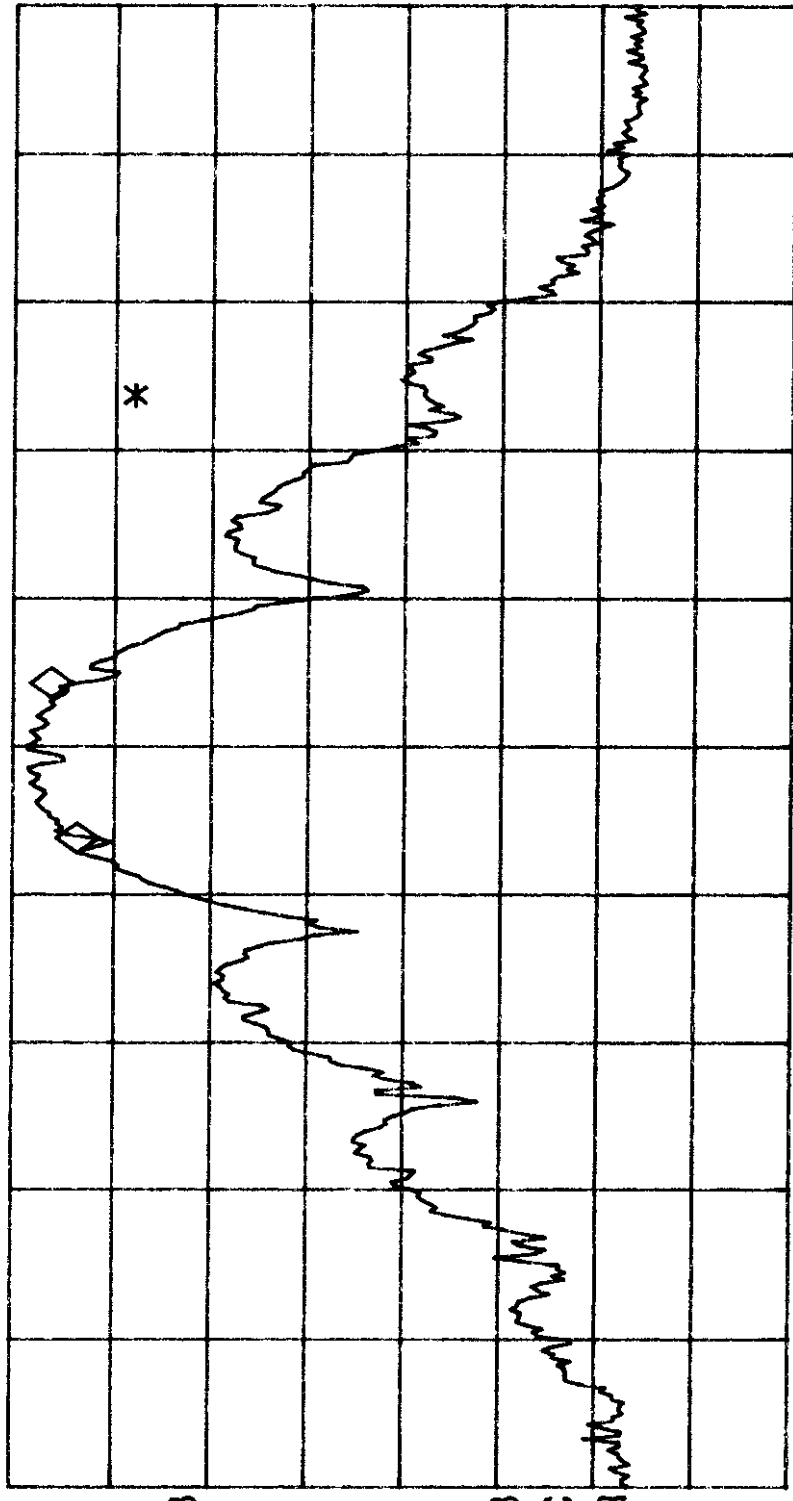
MARKER Δ
5.25 MHz
2.74 dB

ACTV DET: PEAK
MEAS DET: PEAK QP AVG
MKR 5.25 MHz
2.74 dB

No user
Menu

REF OFFST 20.0 dB
REF 10.0 dBm

LOG 10 dB/ ATN 10 dB



CENTER 2.46250 GHz
#IF BW 100 KHz
SPAN 50.00 MHz
#SWP 7.50 sec
#AVG BW 300 KHz

ISP DIRECT, MODEL 2401-01 (INDOOR) & 2401-02 (OUTDOOR)
Test Configuration #: 8, Tx Frequency: 2464.875 MHz, RF Power: 0.19 W
Modulation: DSSS, BW: NARROW (4.5 Mc/s), 11 chips/symbol, 0.818 Mbps DQPSK

hp

Channel #18

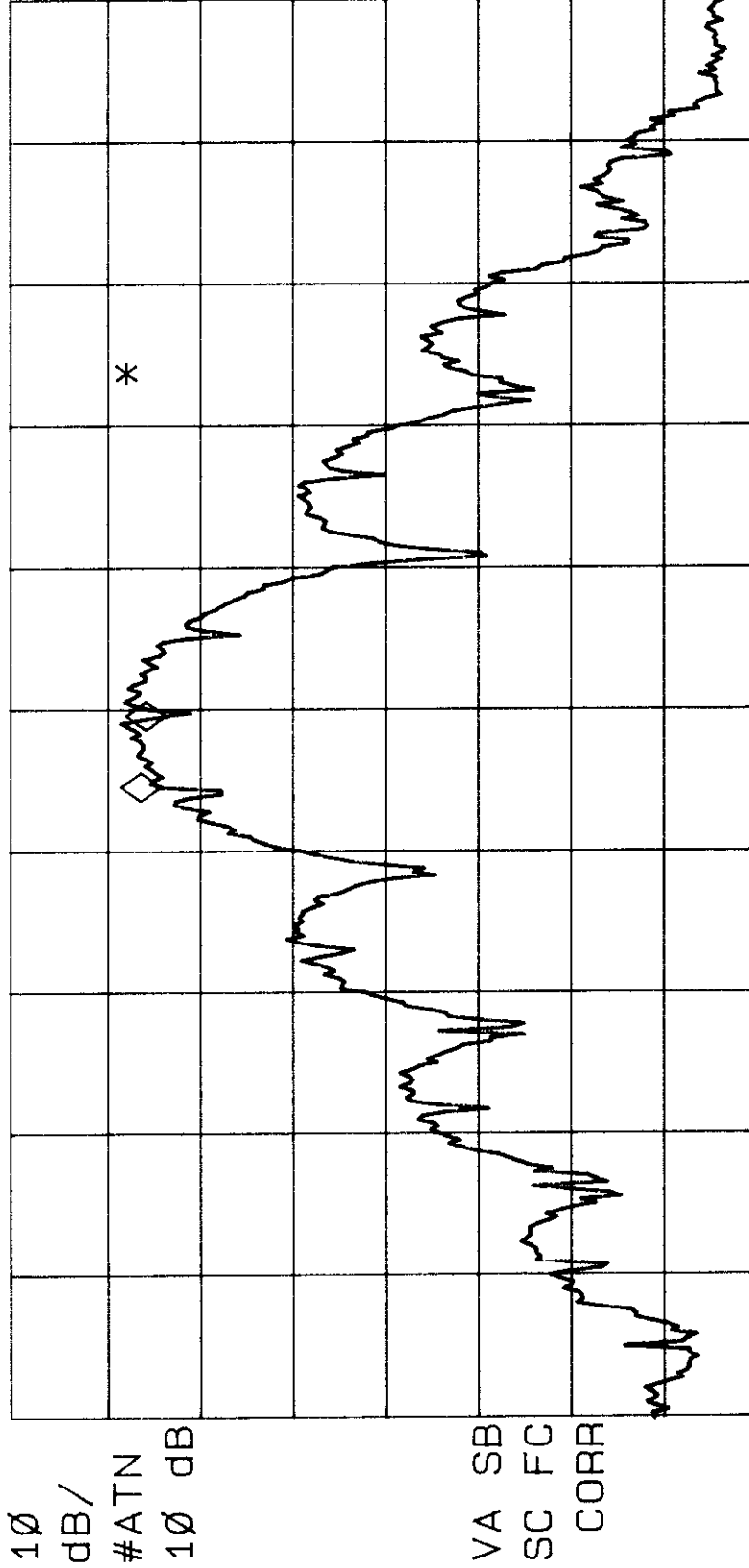
MARKER Δ
2.000 MHz
- .56 dB

ACTV DET: PEAK
MEAS DET: PEAK QP AVG
MKR 2.000 MHz
- .56 dB

No user
Menu

REF OFFST 20.0 dB
REF 20.0 dBm

LOG 10
dB/
#ATN
10 dB



CENTER 2.46488 GHz
#IF BW 30 KHz

#AVG BW 300 KHz
SPAN 40.00 MHz
#SWP 50.0 sec

4.2 Maximum Peak Output Power @ FCC 15.247(b) and RF Exposure Limit FCC 1.1310

PRODUCT NAME: ISP DIRECT INDOOR & OUTDOOR UNITS, Model No.: 2401-01 (indoor) and 2401-02 (outdoor)

FCC REQUIREMENTS:

FCC 15.247(b):- Maximum peak output power of the transmitter shall not exceed 1 Watt.

- (i) Systems operating in the 2400-2483.5 MHz band that used exclusively for fixed, point-to-point operations may employ transmitting antennas with directional gain greater than 6 dBi provided the maximum peak output power of the intentional radiator is reduce by 1 dB for every 3 dB that the directional gain of the antenna exceed 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:

- Ambient temperature: 23 °C
- Relative humidity: 43 %

POWER INPUT:

AC 120 V 60Hz from Elpac external switching power supply, model WRI4232.

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

METHOD OF MEASUREMENTS:

FCC @ 1.1310 & OST Bulletin No. 65-October 1985

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

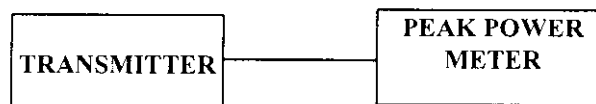
Where: P: power input to the antenna in mW
EIRP: Equivalent (effective) isotropic radiated power.
S: power density mW/cm²
G: numeric gain of antenna relative to isotropic radiator
r: distance to centre of radiation in cm

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: Mr. Tri M. Luu, P.Eng.

DATE: Feb. 26, 1998

MEASUREMENT DATA:**PEAK POWER MEASUREMENT**

Maximum Antenna Gain provided: 17 dBi

FCC Power Output Limit = 30 dBm – (17 dBi - 6 dBi)/3 = 29.3 dBm or 851 mWatts

Channel No.	Channel Frequency	Modulation Bandwidth	Data Rate (Mb/s)	Chips per Symbol	Measured Peak Power (mWatts)	FCC Limit (mWatts)
3	2408.625	Narrow	4.5	11	190	851
4	2411.4375	Medium	5.625	11	190	851
6	2419.875	Wide	11.25	11	190	851
9	2431.125	Wide	11.25	11	190	851
10	2433.9375	Medium	5.625	11	190	851
15	2453.625	Wide	11.25	11	190	851
17	2462.0625	Medium	5.625	11	190	851
18	2464.875	Narrow	4.5	11	190	851

Note: The power density or SAR tests were not applicable to this type of equipment. Since the transmitting antenna is located outdoor far away from the user (at least 30 ft away).

- 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**)

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

PRODUCT NAME: ISP DIRECT INDOOR & OUTDOOR UNITS, Model No.: 2401-01 (indoor) and 2401-02 (outdoor)

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:

- Ambient temperature: 23 °C
- Relative humidity: 43 %

POWER INPUT:

AC 120 V 60Hz from Elpac external switching power supply, model WRI4232.

TEST EQUIPMENT:

- Advantest Spectrum Analyzer, Model R3271, S/N: 15050203
- Bird 20 dB Attenuator, 50 Ohm IN/OUT
- Microphase Highpass Filter, P/N: CR220HIB, S/N: 1301, Cut-off Freq. 1.8 GHz. (Optional)

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.

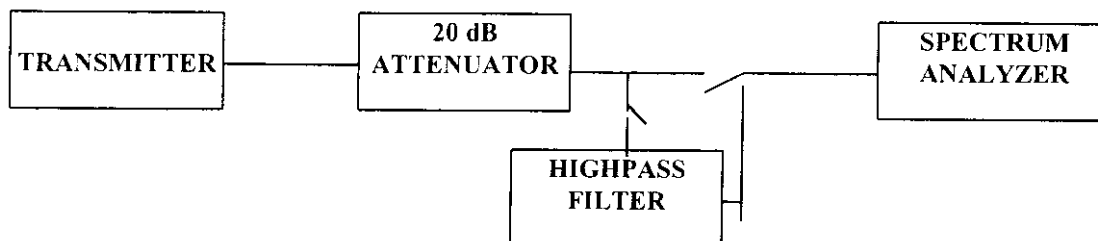
FCC CFR 47, Para. 2.997 - Frequency spectrum to be investigated

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 RESULTS: Conforms.

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

DATE: Feb. 26, 1998

- 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**)

MEASUREMENT DATA**SPURIOUS & HARMONIC EMISSIONS
AT THE TRANSMITTER ANTENNA TERMINAL****TEST CONFIGURATION**

- The transmitter was coupled to the Spectrum Analyzer through a 20 dB attenuator.
- The insertion loss between the transmitter output terminal and the spectrum analyzer was measured to be 20 dB
- The channel frequencies were established on the extreme edges (both upper and lower) and middle of the 2408.625 - 2464.875 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 #: 3, Frequency: 2408.625 MHz Full Rated Peak Power: 190 mW Modulation: DQPSK, narrow, 11 chips/symbol, Data Rate: 4.5 Mb/s, 2 bits/symbol			Power Level in 100 KHz BW: 9.7 dBm Limit = 9.7 dBm - 20 dB = -10.3 dBm		
FREQUENCY	RF LEVEL	EMI DETECTOR	LIMIT	MARGIN	PASS/
(MHz)	(dBm)	(dBm)	(dBm)	(dB)	FAIL
2408.6	9.7	Peak	--	--	PASS
451.0	-46.7	Peak	-10.3	-36.4	PASS
1498.0	-44.5	Peak	-10.3	-34.2	PASS
2374.0	-43.0	Peak	-10.3	-32.7	PASS
No other significant emissions were found in the frequency range from 10 MHz to 25 GHz. Refer to attached plots for details					

Channel #: 4, Frequency: 2411.4375 MHz Full Rated Peak Power: 190 mW Modulation: DQPSK, medium, 11 chips/symbol, Data Rate: 5.625 Mb/s, 2 bits/symbol			Power Level in 100 KHz BW: 9.1 dBm Limit = 9.1 dBm - 20 dB = -10.9 dBm		
FREQUENCY	RF LEVEL	EMI DETECTOR	LIMIT	MARGIN	PASS/
(MHz)	(dBm)	(dBm)	(dBm)	(dB)	FAIL
2411.4	9.1	Peak	--	--	PASS
451.0	-45.6	Peak	-10.9	-34.7	PASS
1496.4	-39.9	Peak	-10.9	-29.0	PASS
No other significant emissions were found in the frequency range from 10 MHz to 25 GHz. Refer to attached plots for details					

Channel #: 6, Frequency: 2419.875 MHz Full Rated Peak Power: 190 mW Modulation: DQPSK, wide, 11 chips/symbol, Data Rate: 11.25 Mb/s, 2 bits/symbol			Power Level in 100 KHz BW: 9.1 dBm Limit = 9.1 dBm - 20 dB = -10.9 dBm		
FREQUENCY (MHz)	RF LEVEL (dBm)	EMI DETECTOR (dBm)	LIMIT (dBm)	MARGIN (dB)	PASS/ FAIL
2419.9	9.1	Peak	--	--	PASS
1504.9	-38.6	Peak	-10.9	-27.7	PASS
2382.3	-38.7	Peak	-10.9	-27.8	PASS
2386.0	-41.8	Peak	-10.9	-30.9	PASS
No other significant emissions were found in the frequency range from 10 MHz to 25 GHz. Refer to attached plots for details					

Channel #: 9, Frequency: 2431.125 MHz Full Rated Peak Power: 190 mW Modulation: DQPSK, wide, 11 chips/symbol, Data Rate: 11.25 Mb/s, 2 bits/symbol			Power Level in 100 KHz BW: 8.7 dBm Limit = 8.7 dBm - 20 dB = -11.3 dBm		
FREQUENCY (MHz)	RF LEVEL (dBm)	EMI DETECTOR (dBm)	LIMIT (dBm)	MARGIN (dB)	PASS/ FAIL
2431.1	8.7	Peak	--	--	PASS
1516.1	-41.3	Peak	-11.3	-30.0	PASS
2396.5	-40.5	Peak	-11.3	-29.2	PASS
No other significant emissions were found in the frequency range from 10 MHz to 25 GHz. Refer to attached plots for details					

Channel #: 10, Frequency: 2433.9375 Full Rated Peak Power: 190 mW Modulation: DQPSK, medium, 11 chips/symbol, Data Rate: 5.625 Mb/s, 2 bits/symbol			Power Level in 100 KHz BW: 8.7 dBm Limit = 8.7 dBm - 20 dB = -11.3 dBm		
FREQUENCY (MHz)	RF LEVEL (dBm)	EMI DETECTOR (dBm)	LIMIT (dBm)	MARGIN (dB)	PASS/ FAIL
2433.9	8.7	Peak	--	--	PASS
2398.5	-45.4	Peak	-11.3	-34.1	PASS
No other significant emissions were found in the frequency range from 10 MHz to 25 GHz. Refer to attached plots for details					

Channel #: 15, Frequency: 2453.625 MHz Full Rated Peak Power: 190 mW Modulation: DQPSK, wide, 11 chips/symbol, Data Rate: 11.25 Mb/s, 2 bits/symbol			Power Level in 100 KHz BW: 8.9 dBm Limit = 8.9 dBm - 20 dB = -11.1 dBm		
FREQUENCY (MHz)	RF LEVEL (dBm)	EMI DETECTOR (dBm)	LIMIT (dBm)	MARGIN (dB)	PASS/ FAIL
2453.6	8.9	Peak	--	--	PASS
1538.6	-38.3	Peak	-11.1	-27.2	PASS
No other significant emissions were found in the frequency range from 10 MHz to 25 GHz. Refer to attached plots for details					

Channel #: 17, Frequency: 2462.0625 MHz Full Rated Peak Power: 190 mW Modulation: DQPSK, medium, 11 chips/symbol, Data Rate: 5.625 Mb/s, 2 bits/symbol			Power Level in 100 KHz BW: 8.6 dBm Limit = 8.6 dBm - 20 dB = -11.4 dBm		
FREQUENCY (MHz)	RF LEVEL (dBm)	EMI DETECTOR (dBm)	LIMIT (dBm)	MARGIN (dB)	PASS/ FAIL
2462.1	8.6	Peak	--	--	PASS
494.0	-48.7	Peak	-11.4	-37.3	PASS
1547.1	-45.5	Peak	-11.4	-34.1	PASS
No other significant emissions were found in the frequency range from 10 MHz to 25 GHz. Refer to attached plots for details					

Channel #: 18, Frequency: 2464.875 MHz Full Rated Peak Power: 190 mW Modulation: DQPSK, narrow, 11 chips/symbol, Data Rate: 4.5 Mb/s, 2 bits/symbol			Power Level in 100 KHz BW: 8.6 dBm Limit = 8.6 dBm - 20 dB = -11.4 dBm		
FREQUENCY (MHz)	RF LEVEL (dBm)	EMI DETECTOR (dBm)	LIMIT (dBm)	MARGIN (dB)	PASS/ FAIL
2464.875	9.5	Peak	--	--	PASS
No significant emissions were found in the frequency range from 10 MHz to 25 GHz. Refer to attached plots for details					



UltraTech
Engineering Labs Inc.

ISP DIRECT, MODEL 2401-01 (INDOOR) & 2401-02 (OUTDOOR)

Test Configuration #: 7, Tx Frequency: 2408.625 MHz, RF Power: 0.19 W
Modulation: DSSS, BW: NARROW (4.5 Mc/s), 11 chips/symbol, 0.818 Mbps DQPSK

Date: Feb. 26/98
Tested by: Tri Luu

HP

Channel # 3

SWEEP TIME
10.0 sec

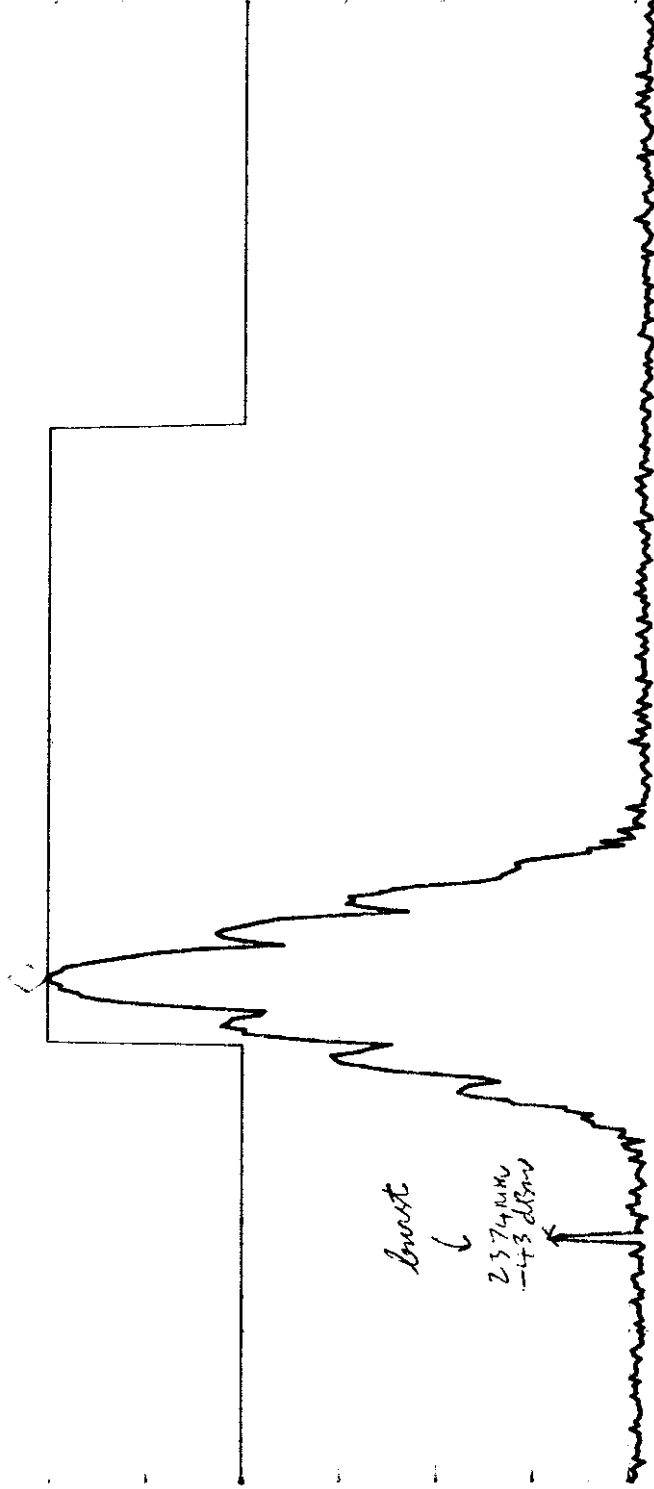
ACTV DET: PEAK
MEAS DET: PEAK GP AVG

No user
Menu

2.4090 GHz
9.67 dBm

REF OFFST 20.0 dB
LOG REF 20.0 dBm

10 dB,
#ATTN
10 dB



CENTER 2.4090 GHz
#IF BW 100 KHz #AVG BW 300 KHz SPAN 200.0 KHz
#SWP 10.0 sec



Date: Feb. 26/98
Tested by: Tri Lau

ISP DIRECT, MODEL 2401-01 (INDOOR) & 2401-02 (OUTDOOR)

Test Configuration #: 7, Tx Frequency: 2408.625 MHz, RF Power: 0.19 W
Modulation: DSSS, BW: NARROW (4.5 Mc/s), 11 chips/symbol, 0.818 Mbps DQPSK

Channel #3

MARKER

2.498 GHz

-100.49 dBm

REF OFFSET 20.0 dB

LOG MAG 20.0 dBm

20

dB

#

20 dB

ACTV DET: PEAK

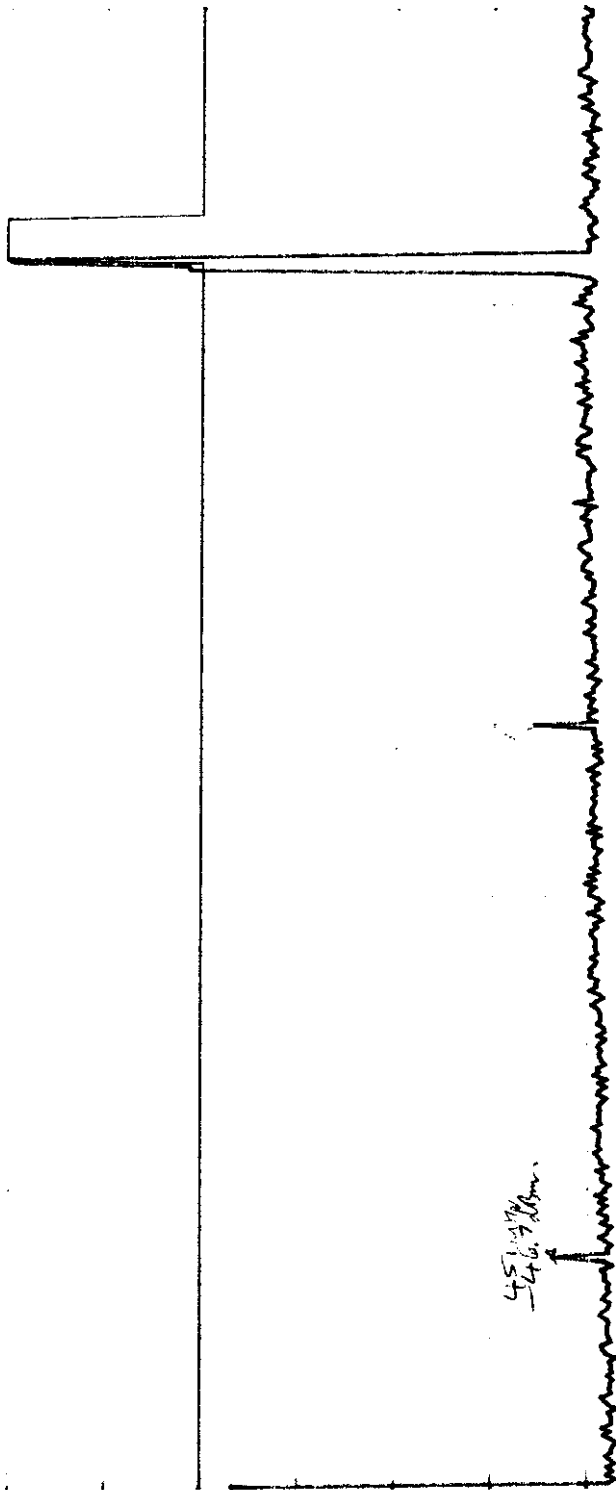
MEAS DET: PEAK QP AVG

PKW 2.498 GHz

-100.49 dBm

NO USER

REPU



START 20 MHz

#IF BW 200 KHz

#AVG BW 300 KHz

STOP 2.900 GHz

#SWP 30.0 sec

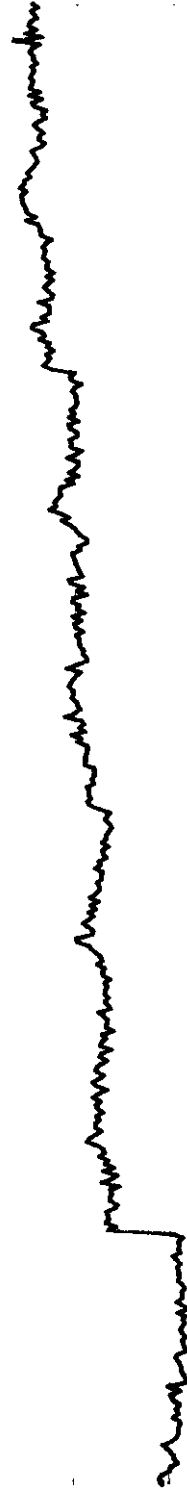


UltraTech
Engineering Labs Inc.

Date: Feb. 26/98
Tested by: Tri Lau

ISP DIRECT, MODEL 2401-01 (INDOOR) & 2401-02 (OUTDOOR)
Test Configuration #: 7, Tx Frequency: 2408.625 MHz, RF Power: 0.19 W
Modulation: DSSS, BW: NARROW (4.5 Mc/s), 11 chips/symbol, 0.818 Mbps DQPSK

Channel # 3





UltraTech
Engineering Labs Inc.

ISP DIRECT, MODEL 2401-01 (INDOOR) & 2401-02 (OUTDOOR)
Test Configuration #: 4, Tx Frequency: 2411.4375 MHz, RF Power: 0.19 W
Modulation: DSSS, BW: MEDIUM (5.625 Mc/s), 11 chips/symbol, 1.023 Mbps DQPSK

Date: Feb. 26/98
Tested by: Tri Lam

hp

MARKER
2.4110 GHZ
9.07 dBm

ACTV DET: PEAK
MEAS DET: PEAK QP AVG
MKR 2.4110 GHZ
9.07 dBm

Channel #4

REF OFFST 20.0 dB

LOG REF 20.0 dBm

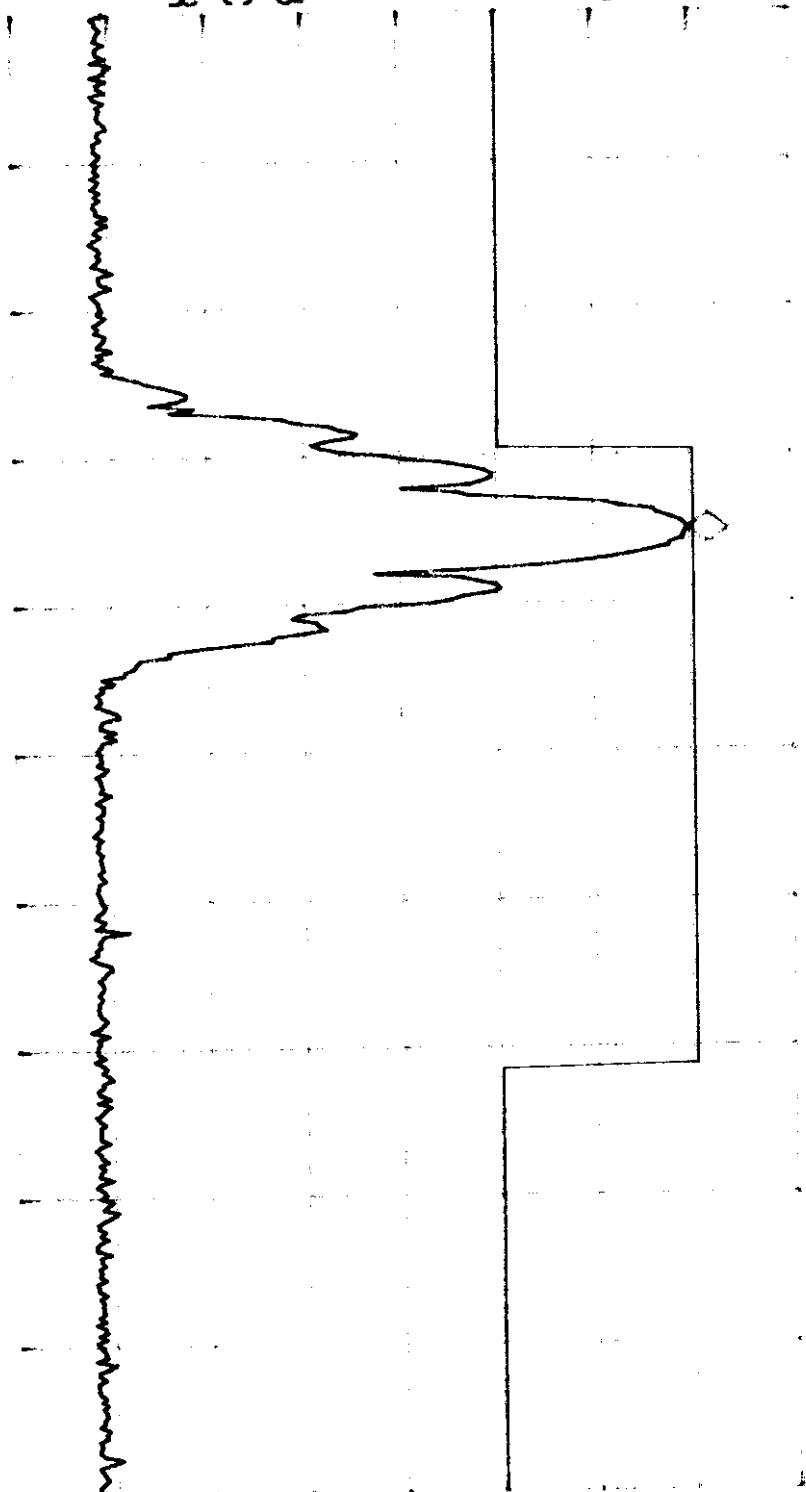
10

dB/

#ATTN

10 dB

VA SB-
SC FC
CORR



CENTER 2.4410 GHZ
#IF BW 100 KHz

#AVG BW 300 KHz

SPAN 200.0 MHz
#SWP 20.0 sec



UltraTech
Engineering Labs Inc.

hp

ISP DIRECT, MODEL 2401-01 (INDOOR) & 2401-02 (OUTDOOR)
Test Configuration #: 4, Tx Frequency: 2411.4375 MHz, RF Power: 0.19 W
Modulation: DSSS, BW: MEDIUM (5.625 Mc/s), 11 chips/symbol, 1.023 Mbps DQPSK

Date: Feb. 26/98
Tested by: Tri Lau

Channel # 4

MARKER

1.491 GHZ
-39.86 dBm

ACTV DET: PEAK

MEAS DET: PEAK QP AVG

MKR 1.491 GHZ
-39.86 dBm

No user
Menu

REF OFFST 20.0 dB

LOG REF 20.0 dBm

10

dB/

#ATN

10 dB

VA SB
SC FC
CORR

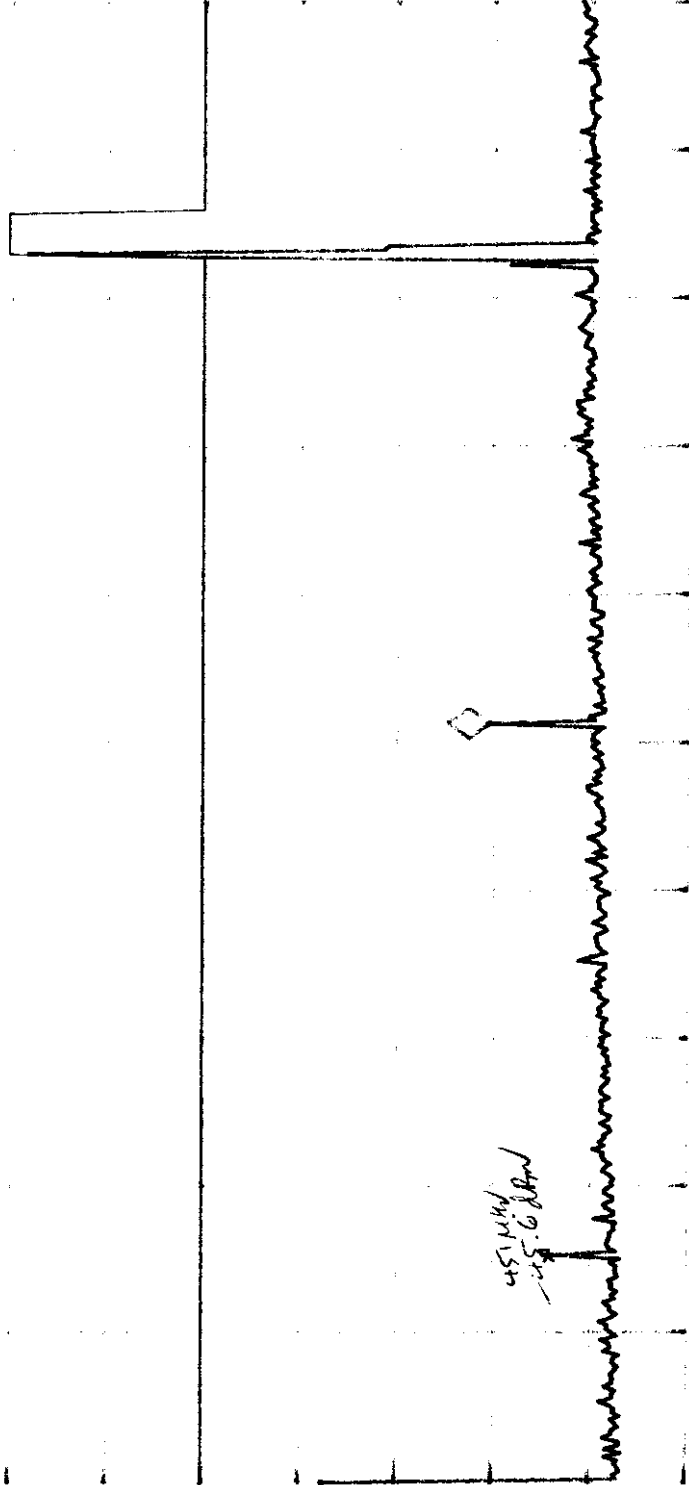
45.1 MHz
-39.86 dBm

START 10 MHz

#IF BW 100 KHZ

#AVG BW 300 KHZ

STOP 2.900 GHZ
#SWP 20.0 sec





UltraTech
Engineering Labs Inc.

ISP DIRECT, MODEL 2401-01 (INDOOR) & 2401-02 (OUTDOOR)
Test Configuration #: 4, Tx Frequency: 2411.4375 MHz, RF Power: 0.19 W
Modulation: DSSS, BW: MEDIUM (5.625 Mc/s), 11 chips/symbol, 1.023 Mbps DQPSK

Date: Feb. 26/98
Tested by: Tri Lau

h2

Channel #4

STOP
25.00 GHz

ACTV DET: PEAK
MEAS DET: PEAK QP AVG

No USER
Menu

MKR 23.90 GHz
-33.93 dBm

REF OFFST 20.0 dB
LOG REF 20.0 dBm

10
dB/
#ATTN
20 dB

*

VA SB
SC FC
CORR



START 2.90 GHz
#IF BW 100 KHz #AVG BW 300 KHz
STOP 25.00 GHz
#SWP 20.0 sec

ISP DIRECT, MODEL 2401-01 (INDOOR) & 2401-02 (OUTDOOR)
Test Configuration #: 1, Tx Frequency: 2419.875 MHz, RF Power: 0.19 W
Modulation: DSSS, BW: WIDE (11.25 Mc/s), 11 chips/symbol, 2.045 Mbps DQPSK

Channel #6

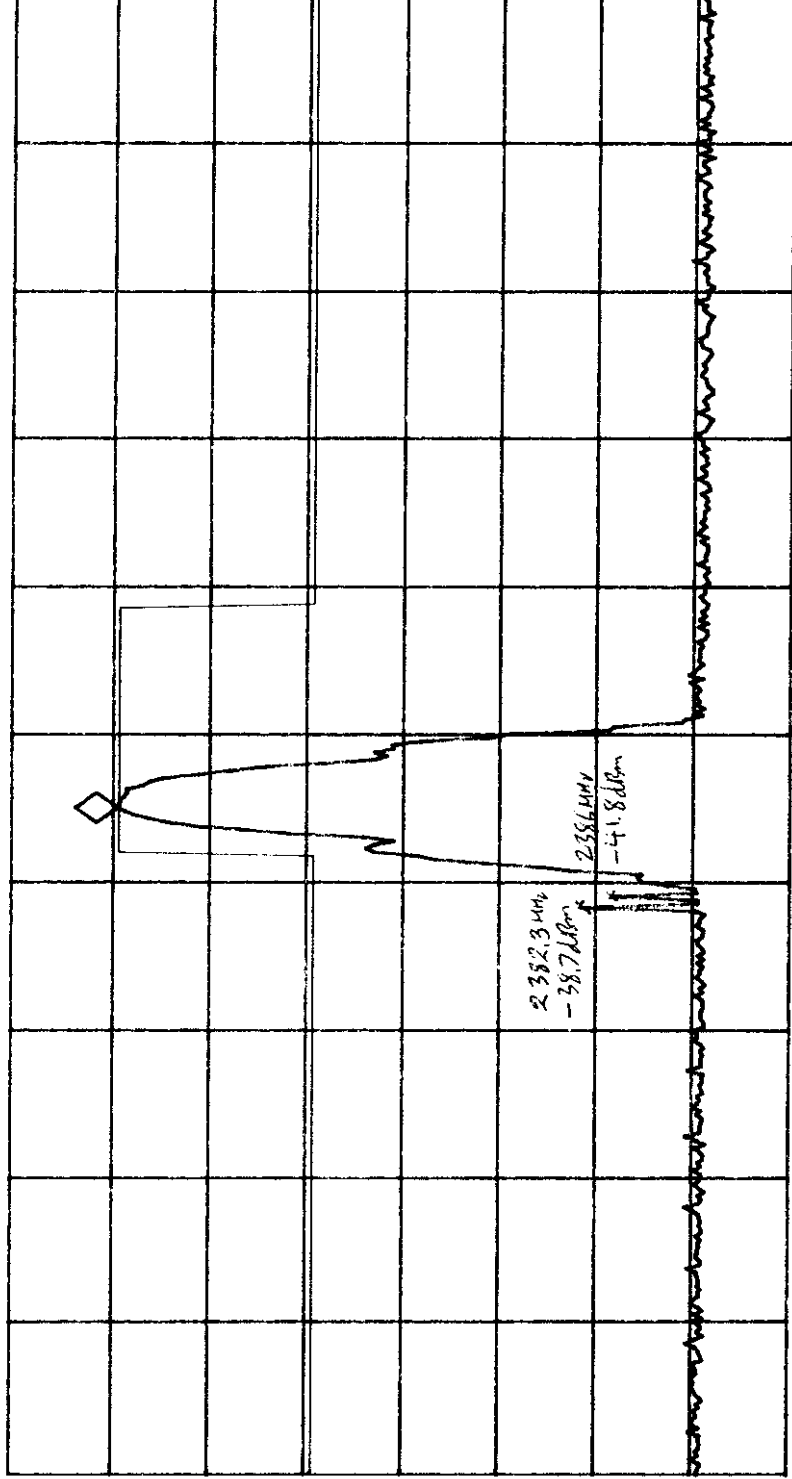
Date: Feb. 26 /98
Tested by: Tri Luu

ACTV DET: PEAK No user
MEAS DET: PEAK QP AVG Menu

MKR 2.4160 GHz
9.07 dBm

REF OFFST 20.0 dB
REF 20.0 dBm

LOG 10
dB /
#ATN
10 dB



CENTER 2.4410 GHz SPAN 500.0 MHz
#IF BW 100 KHZ #AVG BW 300 KHZ #SWP 100 sec



Date: Feb. 26 / 98
Tested by: Tri Lau

ISP DIRECT, MODEL 2401-01 (INDOOR) & 2401-02 (OUTDOOR)
Test Configuration #: / , Tx Frequency: 2419.875 MHz, RF Power: 0.19 W
Modulation: DSSS, BW: WIDE (11.25 Mc/s), 11 chips/symbol, 2.045 Mbps DQPSK

hp

Channel #6

MARKER

1.484 GHZ
-38.55 dBm

ACTV DET: PEAK
MEAS DET: PEAK QP AVG
MKR 1.484 GHZ
-38.55 dBm

No user
Menu

REF OFFST 20.0 dB

REF 20.0 dBm

LOG

10

dB/

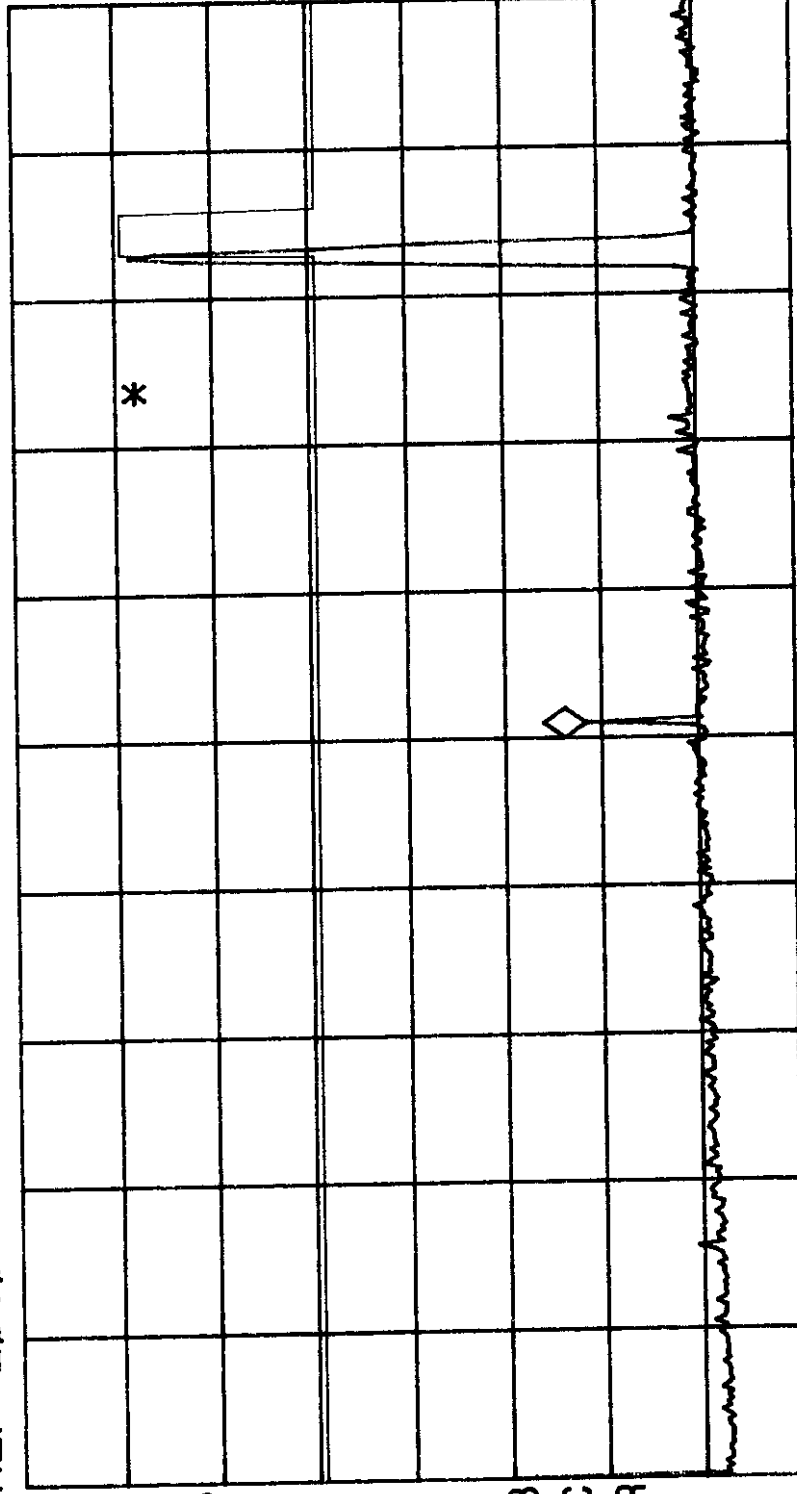
#ATN

10 dB

VA SB

SC FC

CORR



START 10 MHz

#IF BW 100 KHZ

#AVG BW 300 KHZ

STOP 2.900 GHZ

#SWP 100 sec



UltraTech
Engineering Labs Inc.

hp

ISP DIRECT, MODEL 2401-01 (INDOOR) & 2401-02 (OUTDOOR)
Test Configuration #: 1, Tx Frequency: 2419.875 MHz, RF Power: 0.19 W
Modulation: DSSS, BW: WIDE (11.25 Mc/s), 11 chips/symbol, 2.045 Mbps DQPSK

Date: Feb. 26 /98
Tested by: Yi Luu

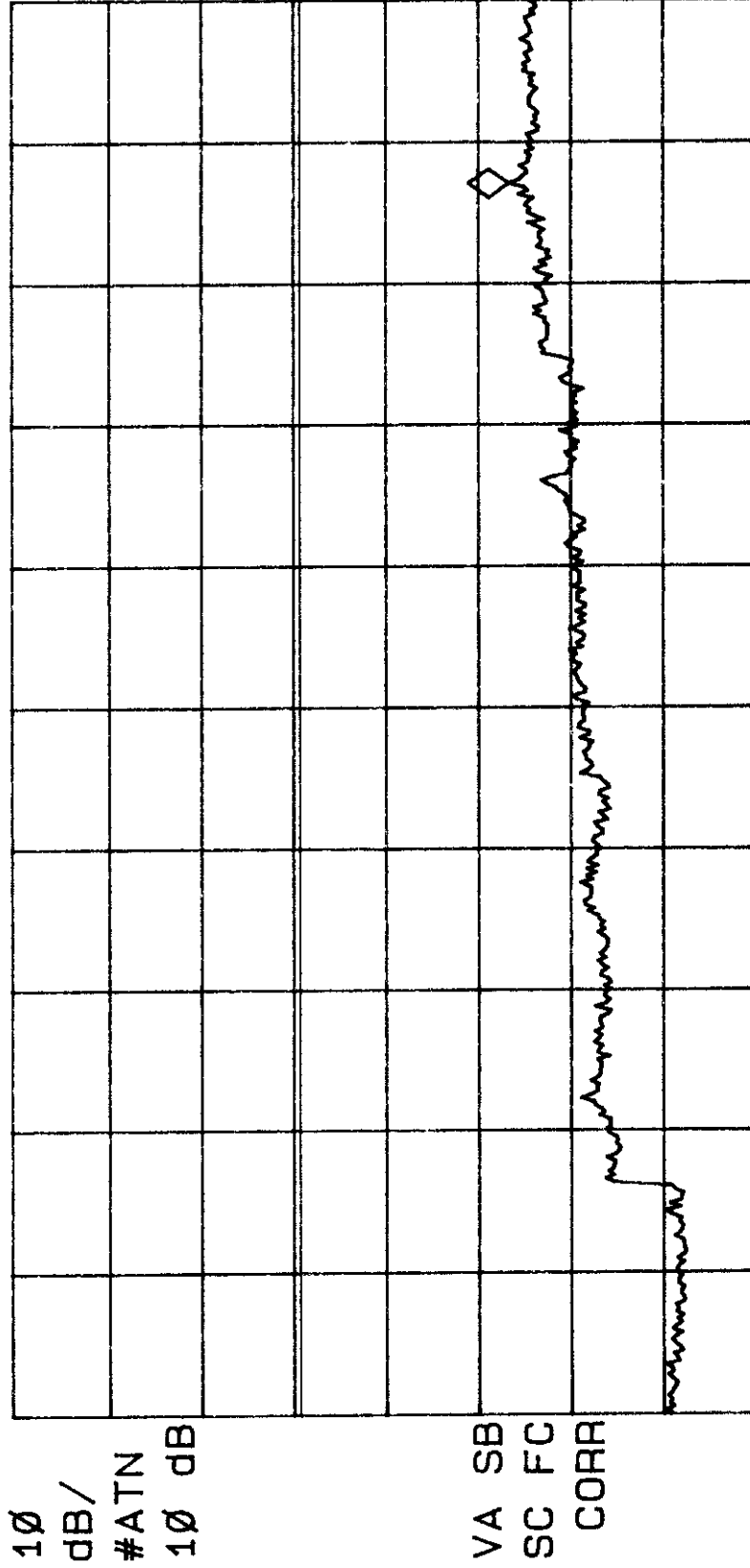
Channel #6.

ACTV DET: PEAK No user
MEAS DET: PEAK QP AVG Menu

MKR 22.13 GHz
-33.51 dBm

REF OFFST 20.0 dB

LOG REF 20.0 dBm



START 2.90 GHz

#IF BW 100 KHz

#AVG BW 300 KHz

STOP 25.00 GHz

SWP 6.63 sec



hp

ISP DIRECT, MODEL 2401-01 (INDOOR) & 2401-02 (OUTDOOR)
Test Configuration #: 2, Tx Frequency: 2431.135 MHz, RF Power: 0.19 W
Modulation: DSSS, BW: WIDE (11.25 Mc/s), 11 chips/symbol, 2.045 Mbps DQPSK

Date: Feb. 26 /98
Tested by: Tri Lou

Channel #1

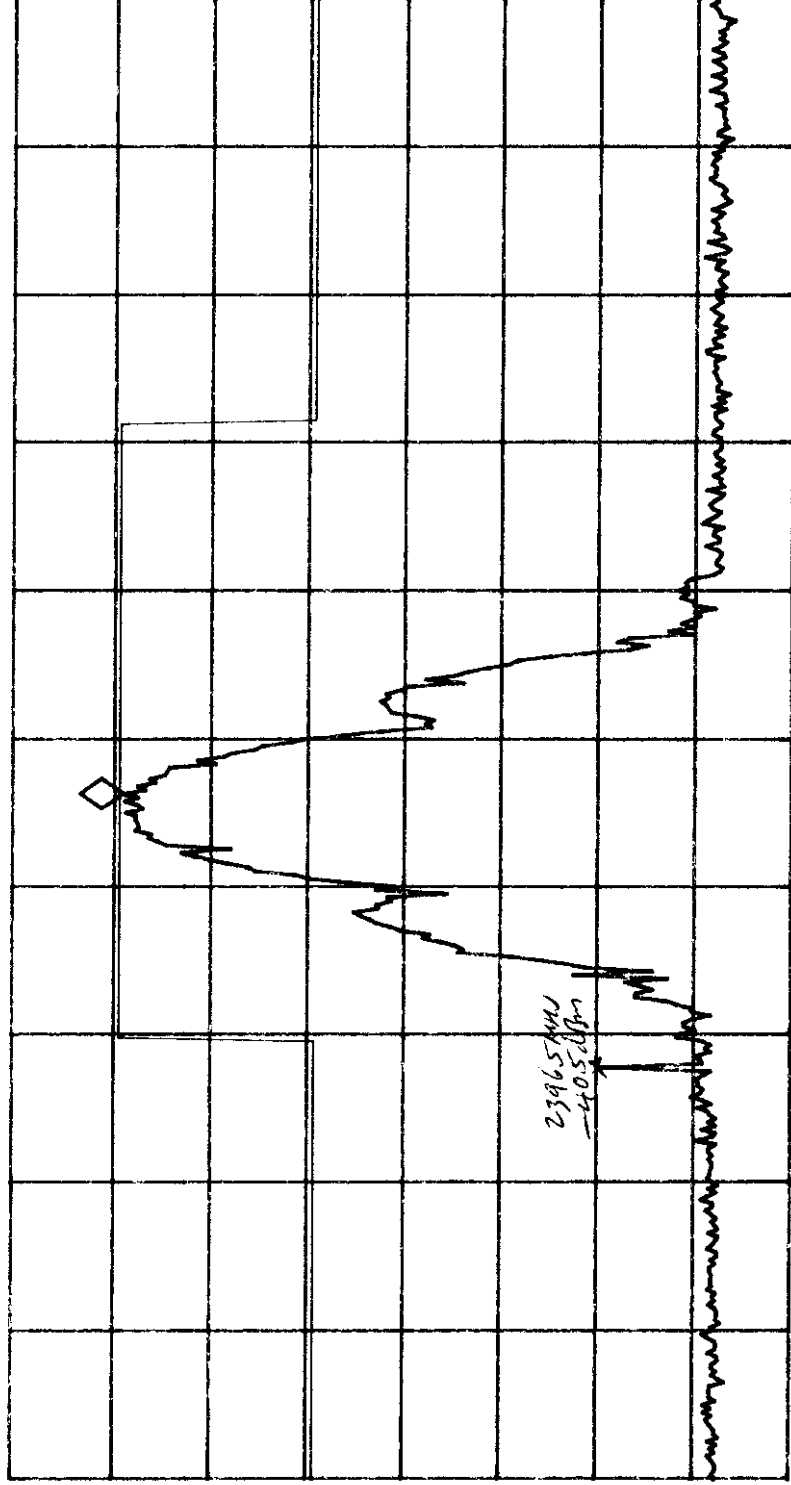
REF LEVEL
20.0 dBm

ACTV DET: PEAK
MEAS DET: PEAK QP AVG
MKR 2.4335 GHz
8.65 dBm

No user
Menu

REF OFFST 20.0 dB
REF 20.0 dBm

LOG
10
dB/
#ATN
10 dB



VA SB
SC FC
CORR

CENTER 2.4410 GHz
#IF BW 100 KHz
#AVG BW 300 KHz
SPAN 200.0 MHz
SWP 60.0 msec



hp

ISP DIRECT, MODEL 2401-01 (INDOOR) & 2401-02 (OUTDOOR)
Test Configuration #: 2431.13 MHz, RF Power: 0.19 W
Modulation: DSSS, BW: WIDE (11.25 Mc/s), 11 chips/symbol, 2.045 Mbps DQPSK

Date: Feb. 26 /98
Tested by: Tri Lau

Channel #4

MARKER

1.513 GHz
-41.31 dBm

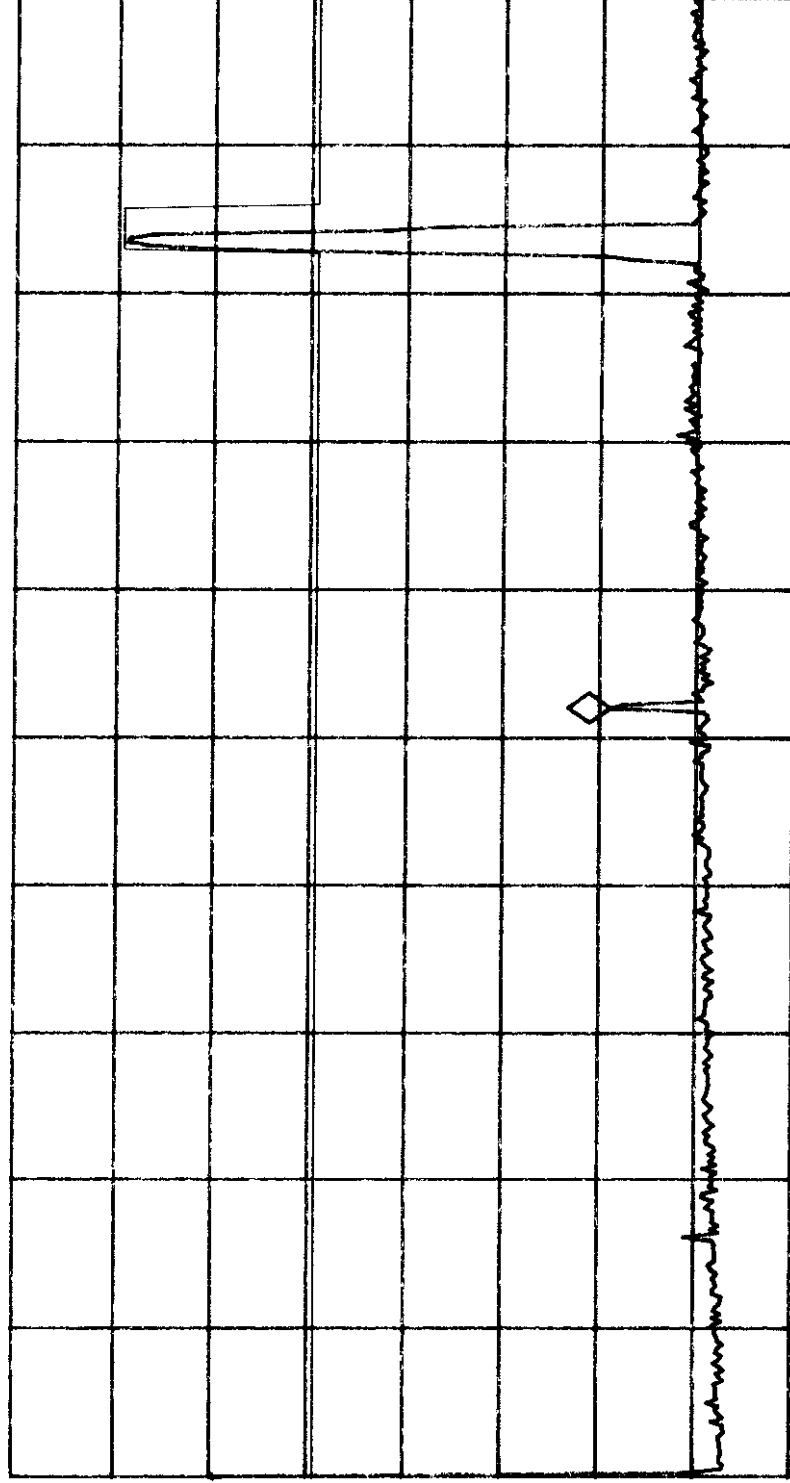
ACTV DET: PEAK

No user
Menu

MEAS DET: PEAK QP AVG
MKR 1.513 GHz
-41.31 dBm

REF OFFST 20.0 dB
REF 20.0 dBm

LOG 10
dB/
#ATN
10 dB



VA SB
SC FC
CORR

START 10 MHz

#IF BW 100 KHz

#AVG BW 300 KHz

STOP 2.900 GHz
#SWP 10.0 sec



hp

ISP DIRECT, MODEL 2401-01 (INDOOR) & 2401-02 (OUTDOOR)
Test Configuration #: 2, Tx Frequency: 2431.125 MHz, RF Power: 0.19 W
Modulation: DSSS, BW: WIDE (11.25 Mc/s), 11 chips/symbol, 2.045 Mbps DQPSK

Date: Feb. 26 /98
Tested by: Tri Luu

Channel #4

START

2.90 GHz

ACTV DET: PEAK

MEAS DET: PEAK QP AVG

No user
Menu

MKR 21.91 GHz
-33.81 dBm

REF OFFST 20.0 dB

REF 20.0 dBm

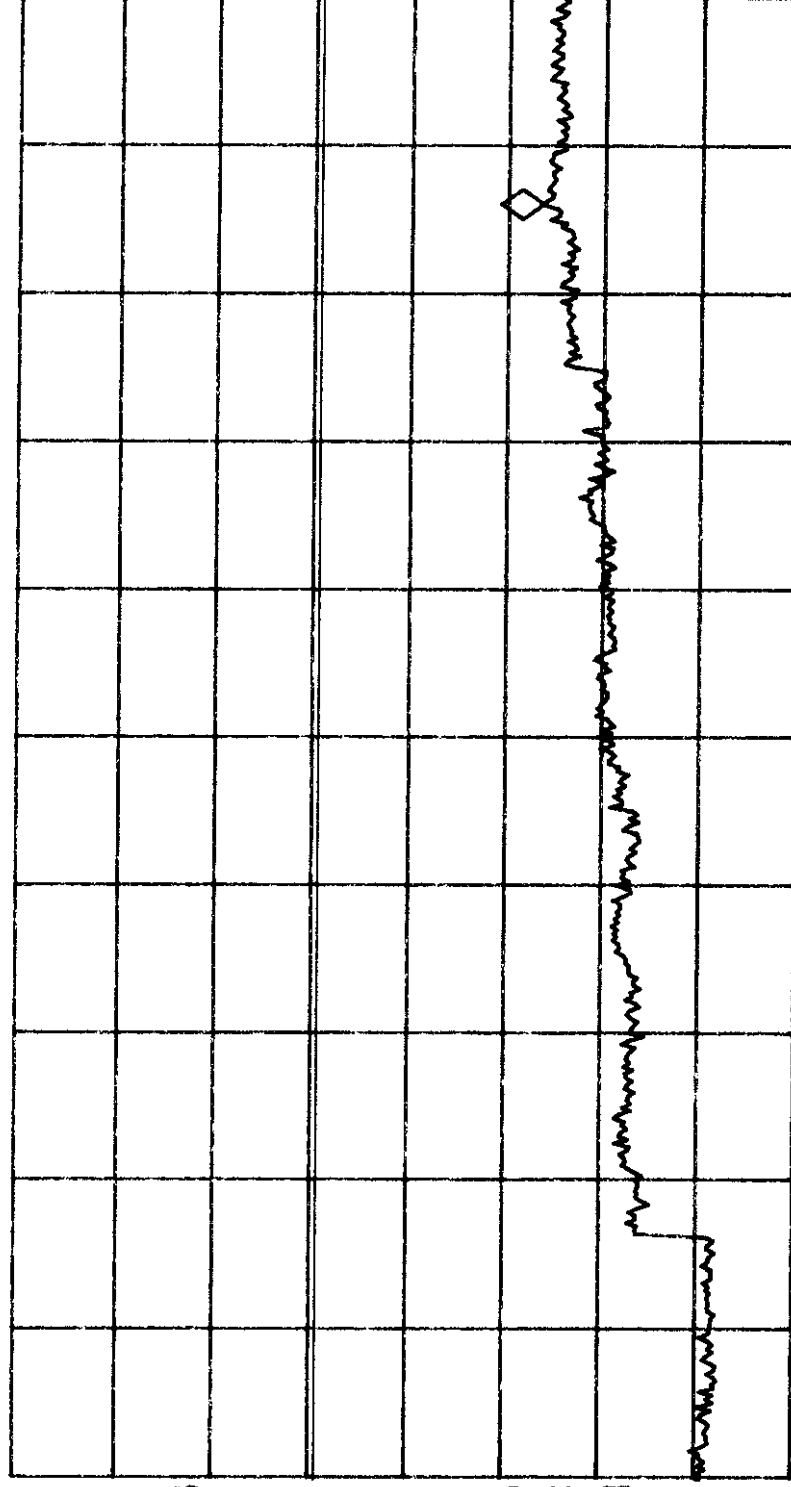
LOG

10

dB/

#ATN

10 dB



VA SB

SC FC

CORR

START 2.90 GHz

#IF BW 100 KHz

#AVG BW 300 KHz

STOP 25.00 GHz

#SWP 10.0 sec



Date: Feb. 26/98
Tested by: Tri Luu

ISP DIRECT, MODEL 2401-01 (INDOOR) & 2401-02 (OUTDOOR)
Test Configuration #: 5, Tx Frequency: 2433.9375 MHz, RF Power: 0.19 W
Modulation: DSSS, BW: MEDIUM (5.625 Mc/s), 11 chips/symbol, 1.023 Mbps DQPSK

hp

Channel #10

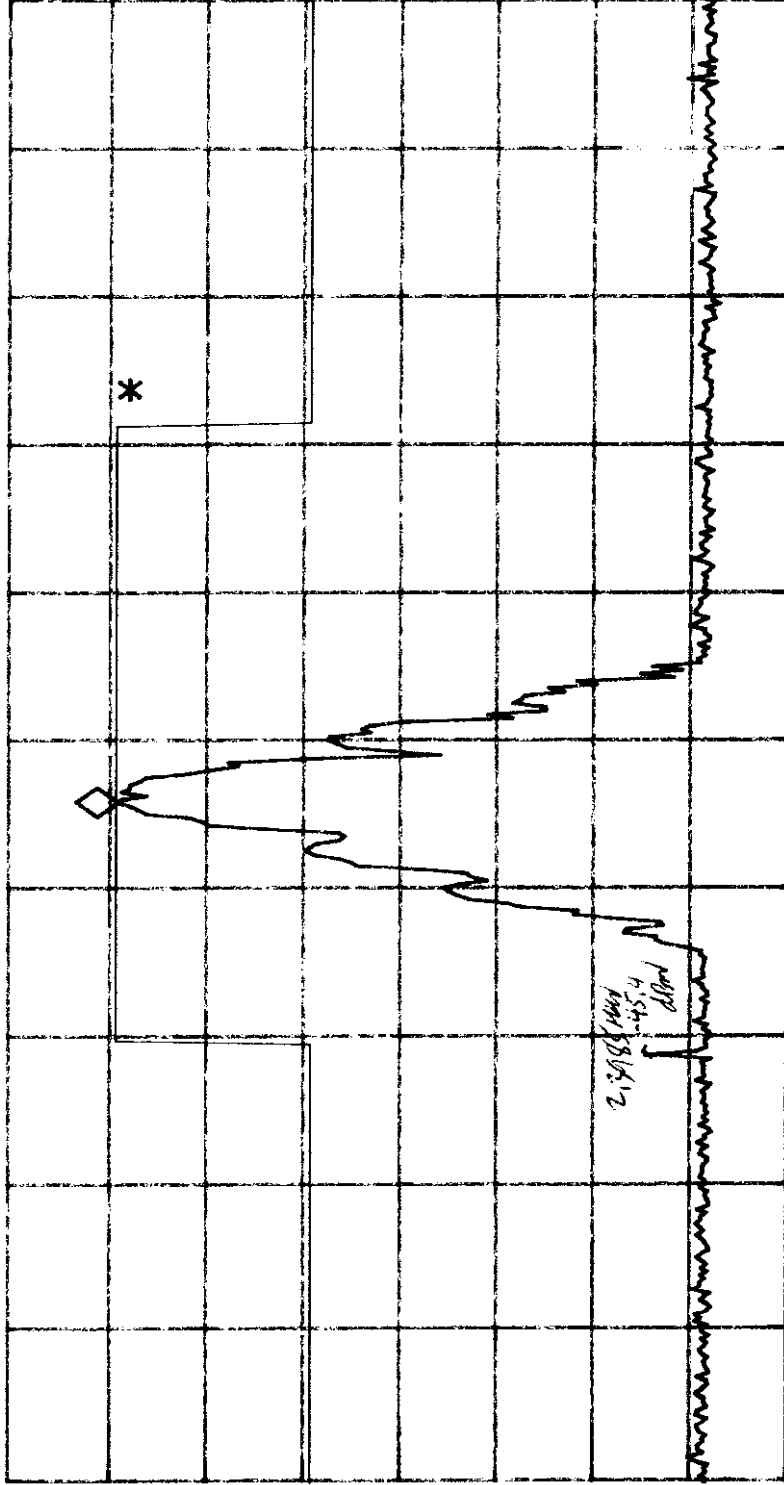
SWEPTIME
30.0 sec

ACTV DET: PEAK
MEAS DET: PEAK QP AVG
MKR 2.4325 GHz
8.65 dBm

No user
Menu

REF OFFST 20.0 dB
REF 20.0 dBm

LOG 10
dB/
#ATN
10 dB



VA SB
SC FC
CORR

CENTER 2.4410 GHz
IF BW 120 KHZ
#AVG BW 300 KHZ
SPAN 200.0 MHZ
#SWP 30.0 sec



UltraTech
Engineering Labs Inc.

ISP DIRECT, MODEL 2401-01 (INDOOR) & 2401-02 (OUTDOOR)

Test Configuration #: 5, Tx Frequency: 2433.9375 MHz, RF Power: 0.19 W
Modulation: DSSS, BW: MEDIUM (5.625 Mc/s), 11 chips/symbol, 1.023 Mbps DQPSK

Date: Feb. 26/98
Tested by: Tri Luu

hp

Channel #10

MARKER

2.394 GHz

-43.33 dBm

ACTV DET: PEAK

MEAS DET: PEAK QP AVG

MKR 2.394 GHz

-43.33 dBm

No user

Menu

REF OFFST 20.0 dB

REF 20.0 dBm

LOG

10

dB/

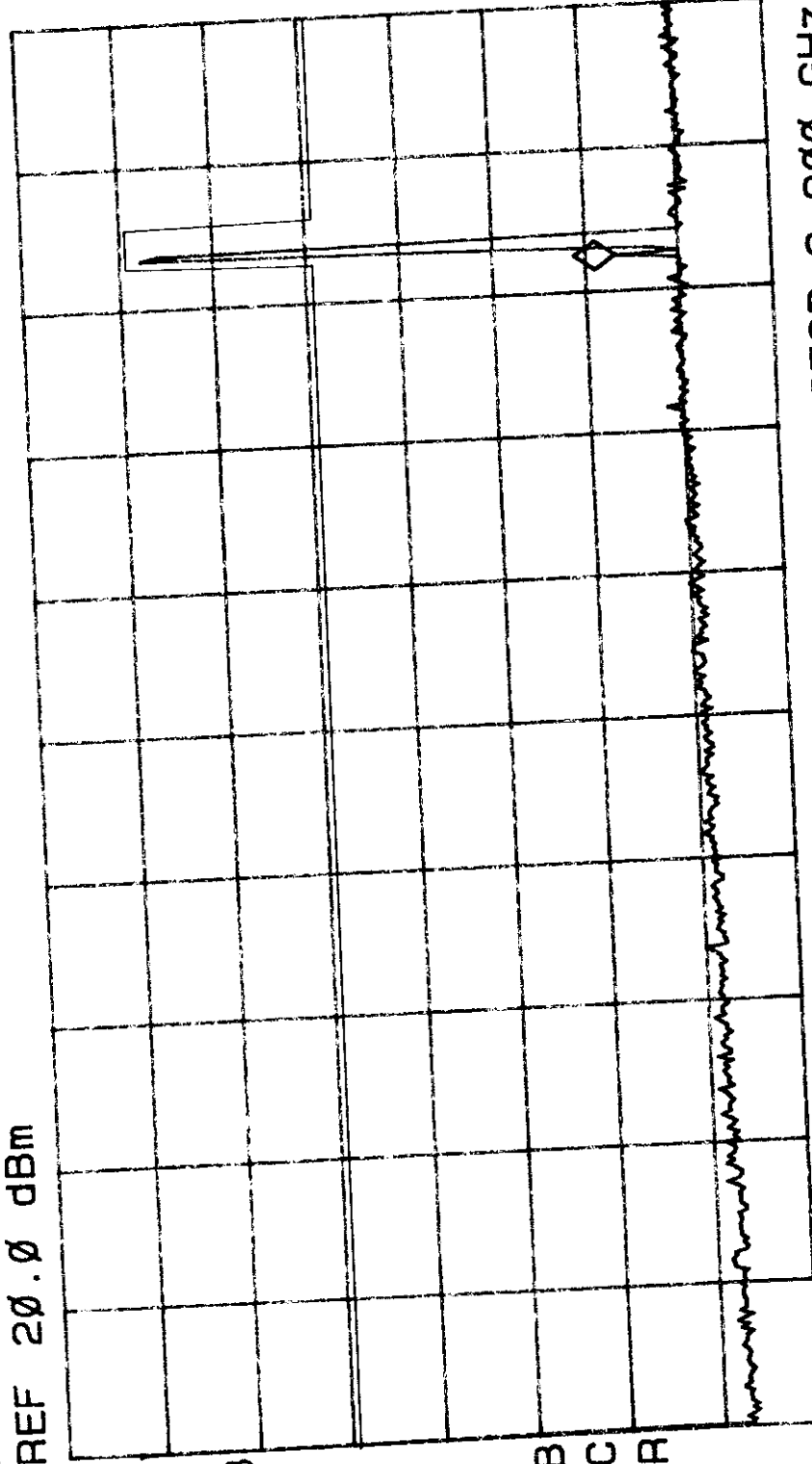
#ATN

10 dB

VA SB

SC FC

CORR



START 10 MHz

IF BW 120 KHz

#AVG BW 300 KHz

STOP 2.900 GHz

#SWP 30.0 sec



hp

ISP DIRECT, MODEL 2401-01 (INDOOR) & 2401-02 (OUTDOOR)

Test Configuration #: 5, Tx Frequency: 2433.9375 MHz, RF Power: 0.19 W

Modulation: DSSS, BW: MEDIUM (5.625 Mc/s), 11 chips/symbol, 1.023 Mbps DQPSK

Date: Feb. 26/98
Tested by: Tri Lau

Channel #10

STOP
25.00 GHz

ACTV DET: PEAK

No user
Menu

MEAS DET: PEAK QP AVG

MKR 22.07 GHz
-33.94 dBm

REF OFFST 20.0 dB

REF 20.0 dBm

LOG

10

dB/

#ATN

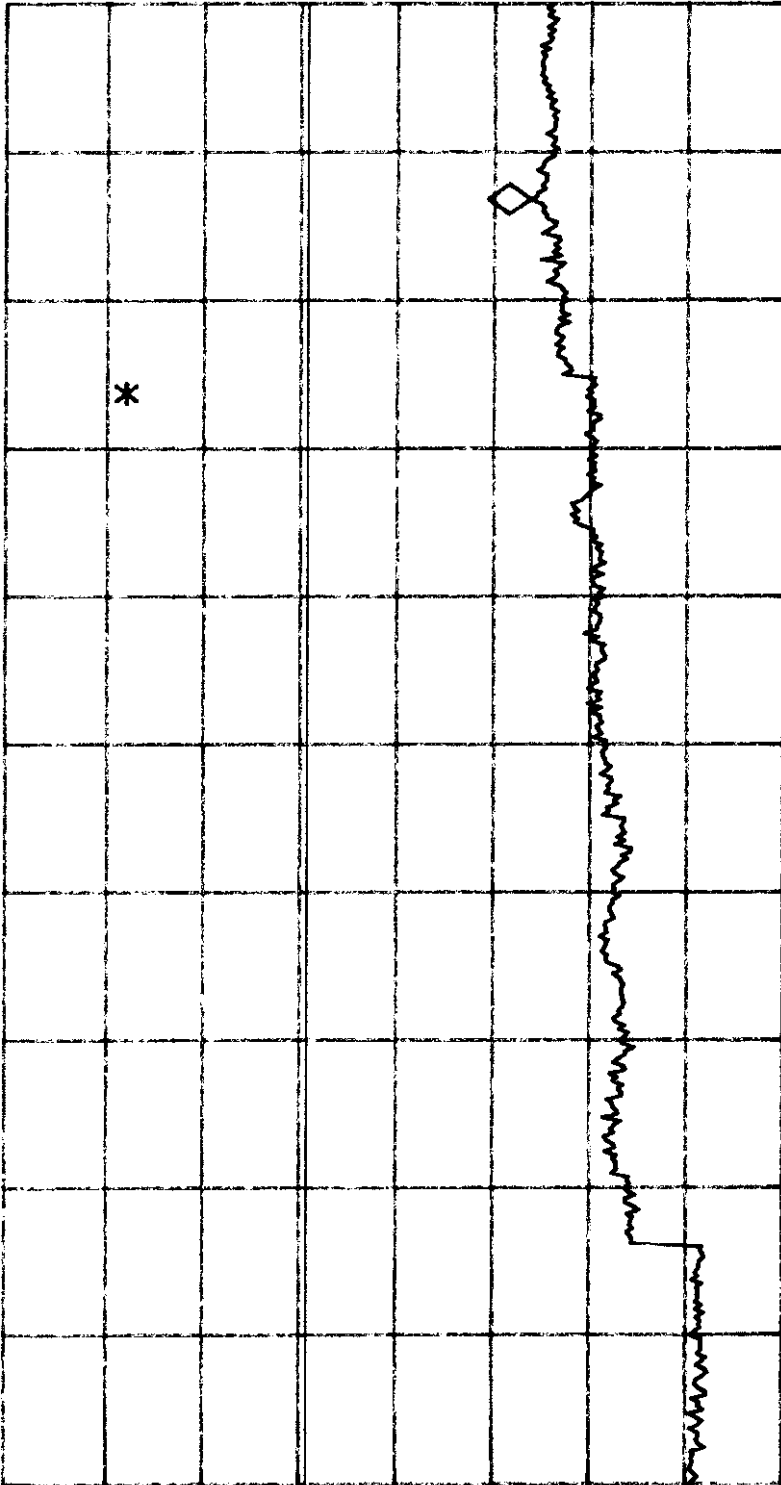
10 dB

*

VA SB

SC FC

CORR



START 2.90 GHz

IF BW 120 kHz

#AVG BW 300 kHz

STOP 25.00 GHz

#SWP 30.0 sec



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hp

ISP DIRECT, MODEL 2401-01 (INDOOR) & 2401-02 (OUTDOOR)

Test Configuration #: 3, Tx Frequency: 2453.625 MHz, RF Power: 0.19 W
Modulation: DSSS, BW: WIDE (11.25 Mc/s), 11 chips/symbol, 2.045 Mbps DQPSK

Date: Feb. 26/98
Tested by: Tin Lau

Channel # 15

SPAN

200.0 MHz

ACTV DET: PEAK

No user

MEAS DET: PEAK QP AVG

Menu

MKR 2.4525 GHz

8.86 dBm

REF OFFST 20.0 dB

REF 20.0 dBm

LOG

10

dB/

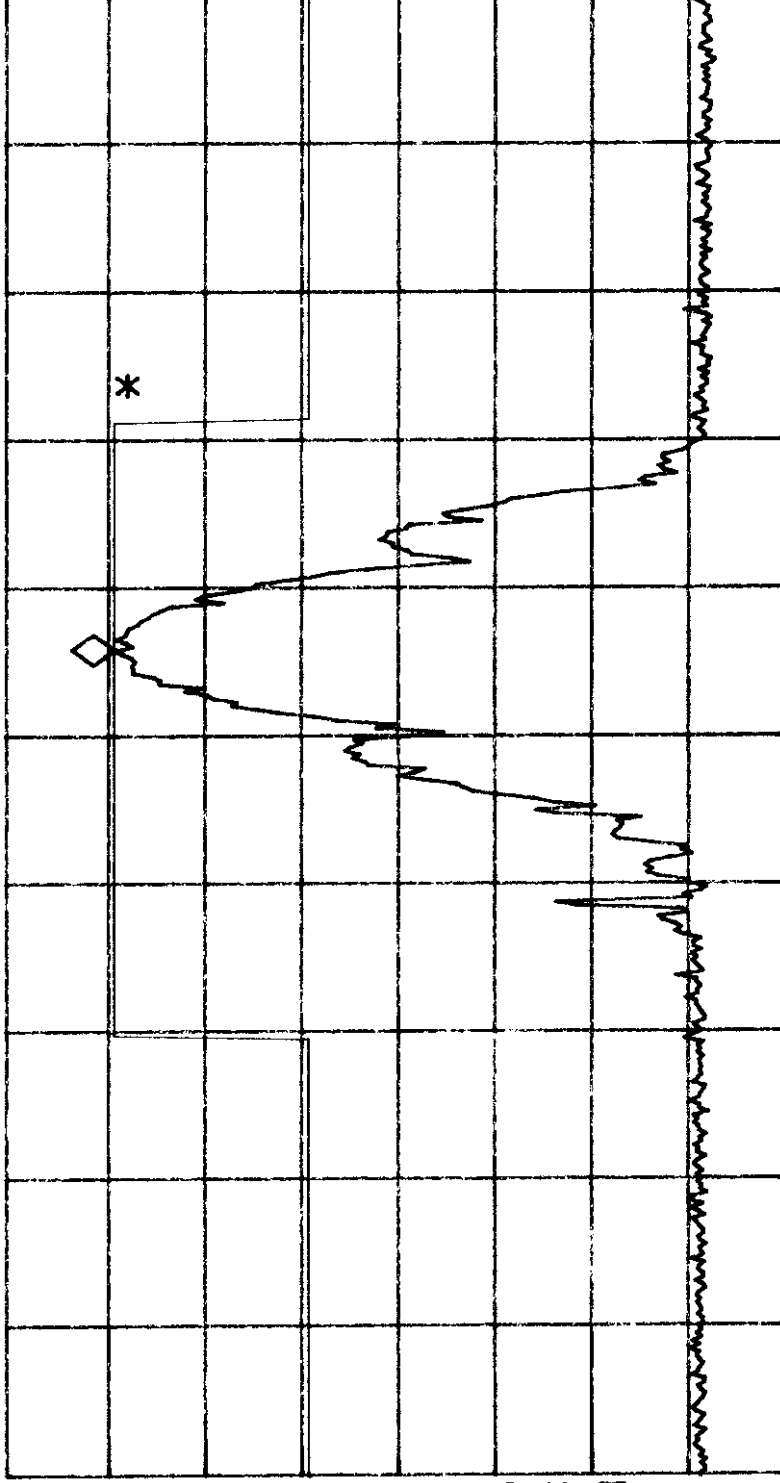
#ATN

10 dB

VA SB

SC FC

CORR



CENTER 2.4410 GHz

#IF BW 100 kHz

#AVG BW 300 kHz

SPAN 200.0 MHz

#SWP 30.0 sec



ISP DIRECT, MODEL 2401-01 (INDOOR) & 2401-02 (OUTDOOR)
Test Configuration #: 3, Tx Frequency: 2453.625 MHz, RF Power: 0.19 W
Modulation: DSSS, BW: WIDE (11.25 Mc/s), 11 chips/symbol, 2.045 Mbps DQPSK

Date: Feb. 26/98
Tested by: Tri Luu

hp

Channel #15

MARKER

1.542 GHZ

-38.33 dBm

ACTV DET: PEAK

MEAS DET: PEAK QP AVG

MKR 1.542 GHZ

-38.33 dBm

No user
Menu

REF OFFST 20.0 dB

REF 20.0 dBm

LOG

10

dB/

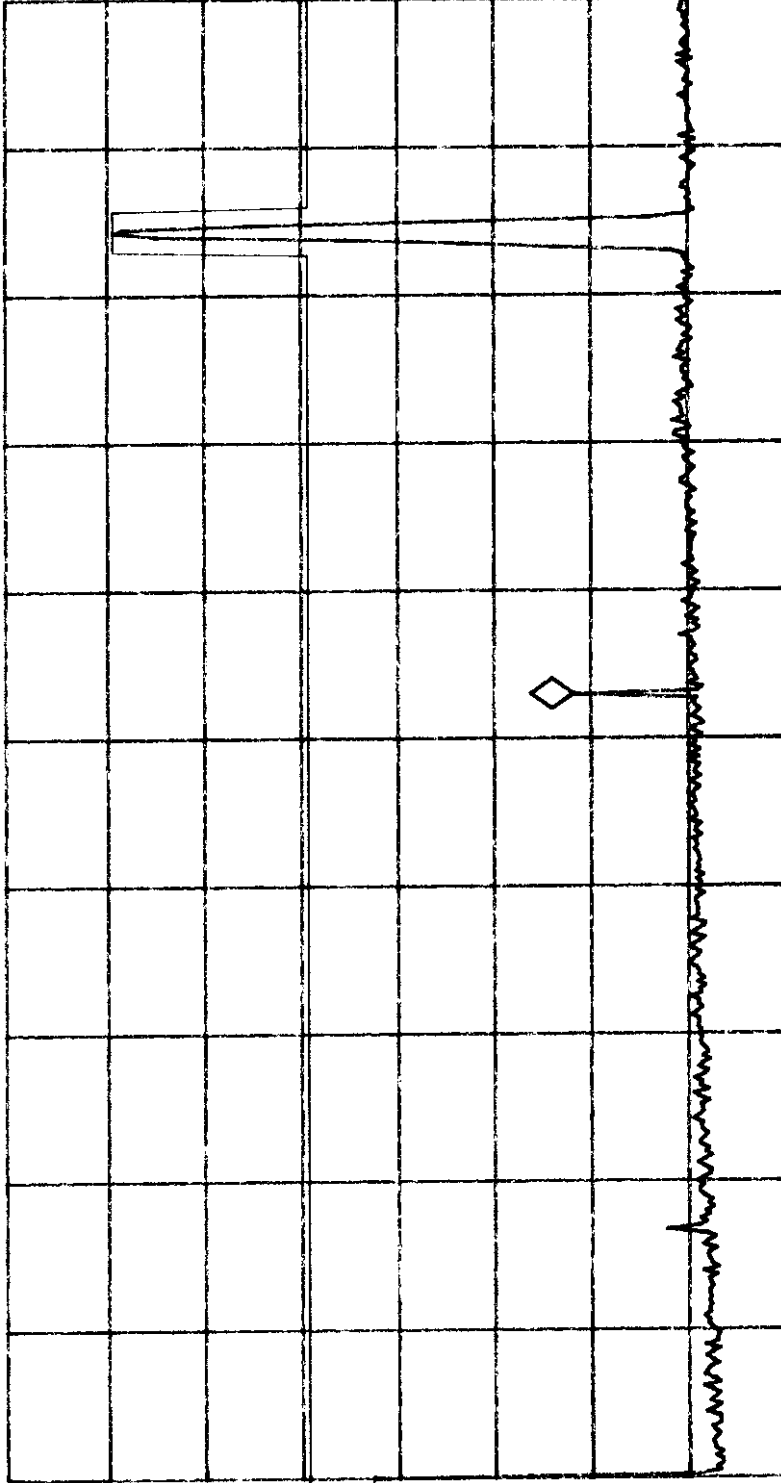
#ATN

10 dB

VA SB

SC FC

CORR



START 10 MHz

#IF BW 100 KHZ

#AVG BW 300 KHZ

STOP 2.900 GHZ

#SWP 30.0 sec



Date: Feb. 26/98
Tested by: Tri Luan

ISP DIRECT, MODEL 2401-01 (INDOOR) & 2401-02 (OUTDOOR)
Test Configuration #: 3, Tx Frequency: 2453.625 MHz, RF Power: 0.19 W
Modulation: DSSS, BW: WIDE (11.25 Mc/s), 11 chips/symbol, 2.045 Mbps DQPSK

hp

Channel #15

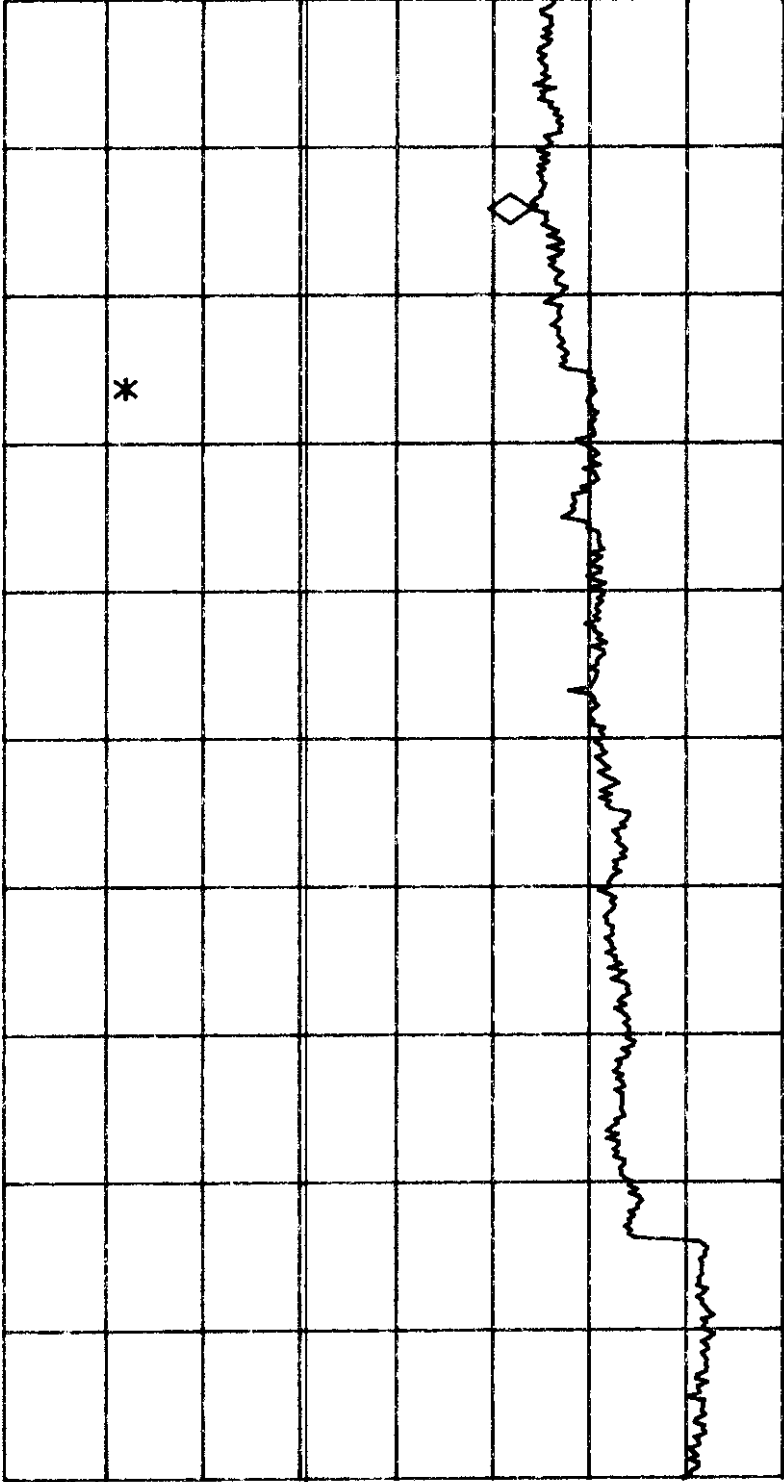
START
2.90 GHZ

ACTV DET: PEAK
MEAS DET: PEAK QP AVG
No user
Menu

MKR 21.85 GHZ
-34.14 dBm

REF OFFST 20.0 dB
REF 20.0 dBm

LOG
10
dB/
#ATN
10 dB



VA SB
SC FC
CORR

START 2.90 GHZ
#IF BW 100 KHZ
#AVG BW 300 KHZ
STOP 25.00 GHZ
#SWP 10.0 sec

SPAN
200.0 MHz

ACTV DET: PEAK

MEAS DET: PEAK QP AVG
MKR 2.4635 GHz
8.56 dBm

MARKER
→ HIGH

MARKER
→ CF

NEXT
PEAK

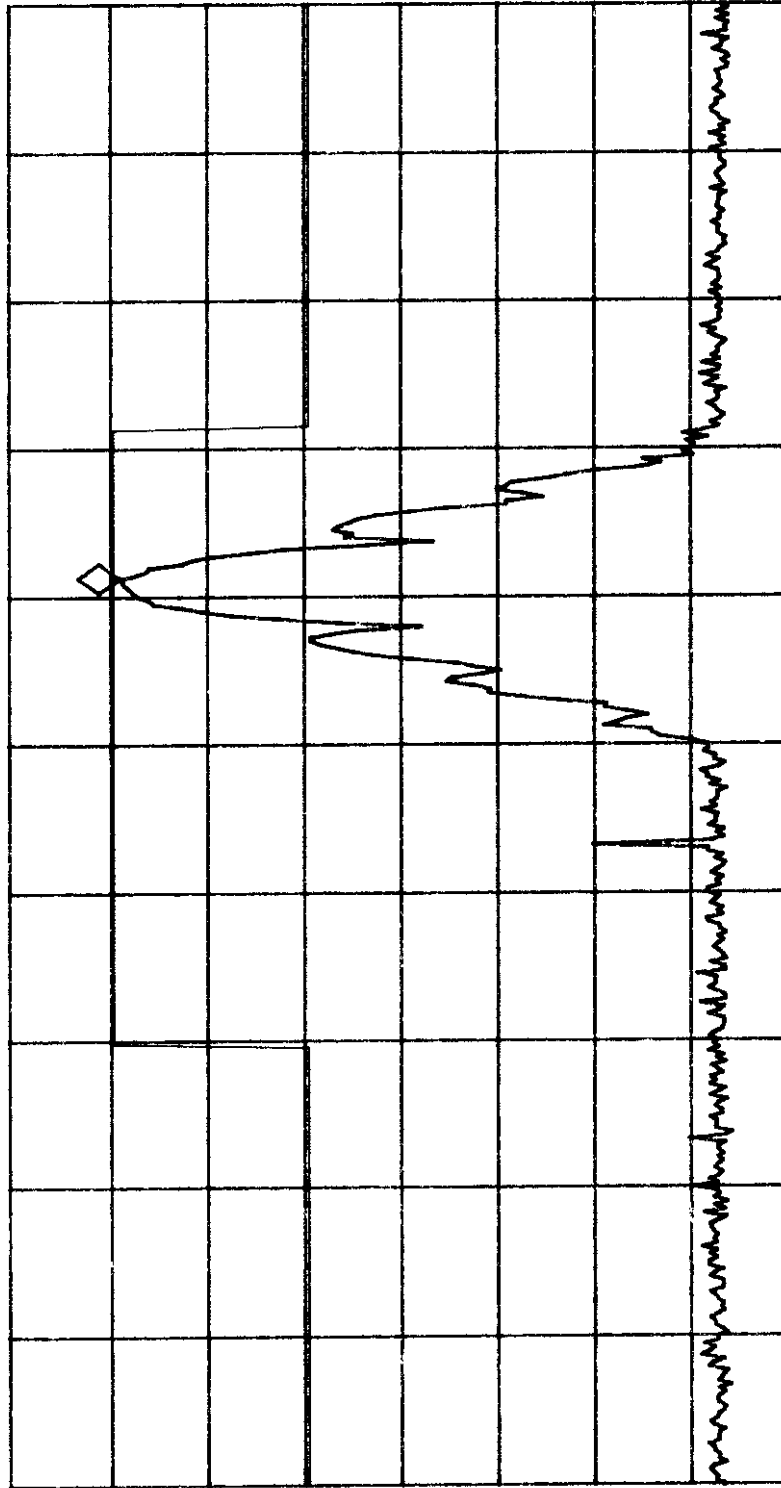
NEXT PK
RIGHT

NEXT PK
LEFT

MORE
1 of 3

REF OFFST 20.0 dB
REF 20.0 dBm

LOG
10
dB/
ATN
10 dB



VA SB
SC FC
CORR

CENTER 2.4410 GHz SPAN 200.0 MHz
#IF BW 100 KHz #AVG BW 300 KHz SWP 60.0 msec



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ISP DIRECT, MODEL 2401-01 (INDOOR) & 2401-02 (OUTDOOR)
Channel #: 17, Tx Frequency: 2464.875 MHz, RF Power: 0.19 W
Modulation: DSSS, BW: MEDIUM (5.625 Mc/s), 11 chips/symbol, 1.023 Mbps DQPSK

Date: Mar. 04/98
Tested by: Tri Lau

hp

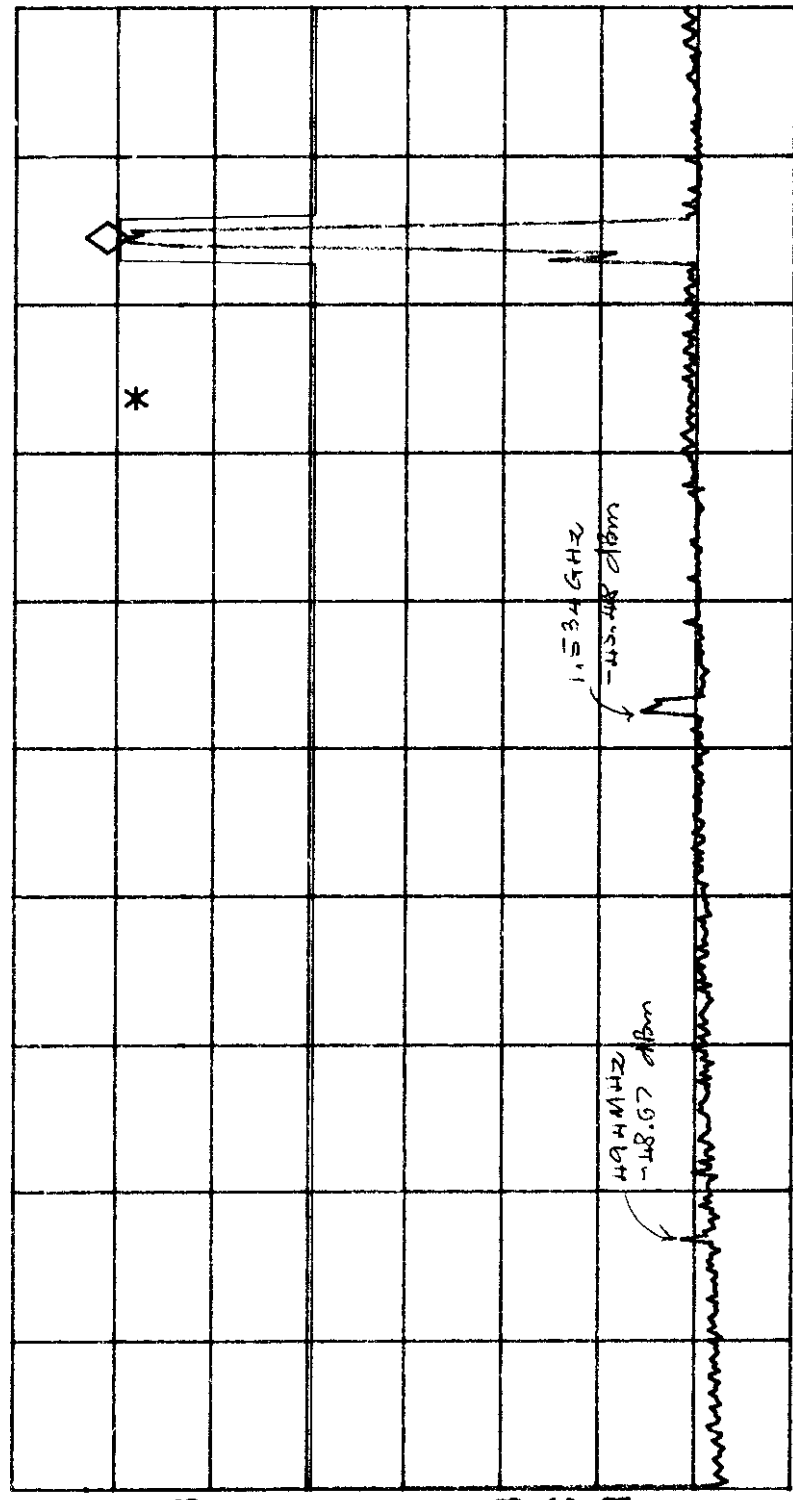
SWEPTIME
100 sec

ACTV DET: PEAK
MEAS DET: PEAK QP AVG
MKR 2.452 GHz
8.37 dBm

No user
Menu

REF OFFST 20.0 dB
REF 20.0 dBm

LOG
10
dB/
ATN
10 dB



VA SB
SC FC
CORR

START 10 MHz
#IF BW 100 KHZ
#AVG BW 300 KHZ
STOP 2.900 GHz
#SWP 100 sec

ISP DIRECT, MODEL 2401-01 (INDOOR) & 2401-02 (OUTDOOR)
Channel #: 17, Tx Frequency: 2464.875 MHz, RF Power: 0.19 W
Modulation: DSSS, BW: MEDIUM (5.825 Mc/s), 11 chips/symbol, 1.023 Mbps DQPSK

hp

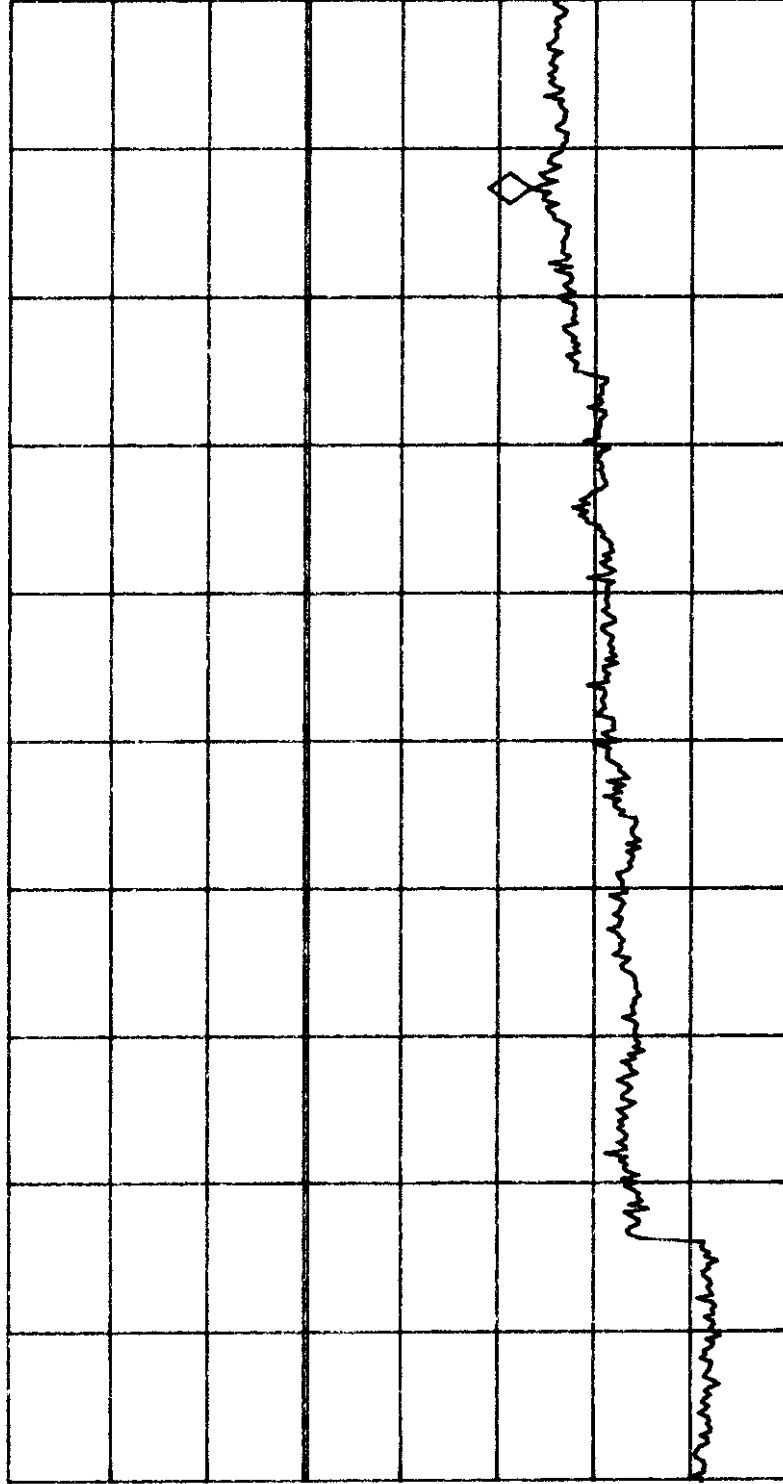
SWEPTIME
7.50 sec

ACTV DET: PEAK
MEAS DET: PEAK QP AVG
MKR 22.18 GHZ
-33.49 dBm

No user
Menu

REF OFFST 20.0 dB
REF 20.0 dBm

LOG
10
dB/
ATN
10 dB



START 2.90 GHZ
#IF BW 100 KHZ
#AVG BW 300 KHZ
STOP 25.00 GHZ
#SWP 7.50 sec



hp

ISP DIRECT, MODEL 2401-01 (INDOOR) & 2401-02 (OUTDOOR)

Test Configuration #: 8, Tx Frequency: 2464.875 MHz, RF Power: 0.19 W
Modulation: DSSS, BW: NARROW (4.5 Mc/s), 11 chips/symbol, 0.818 Mbps DQPSK

Date: Feb. 26/98
Tested by: Tri Lau

Channel #18

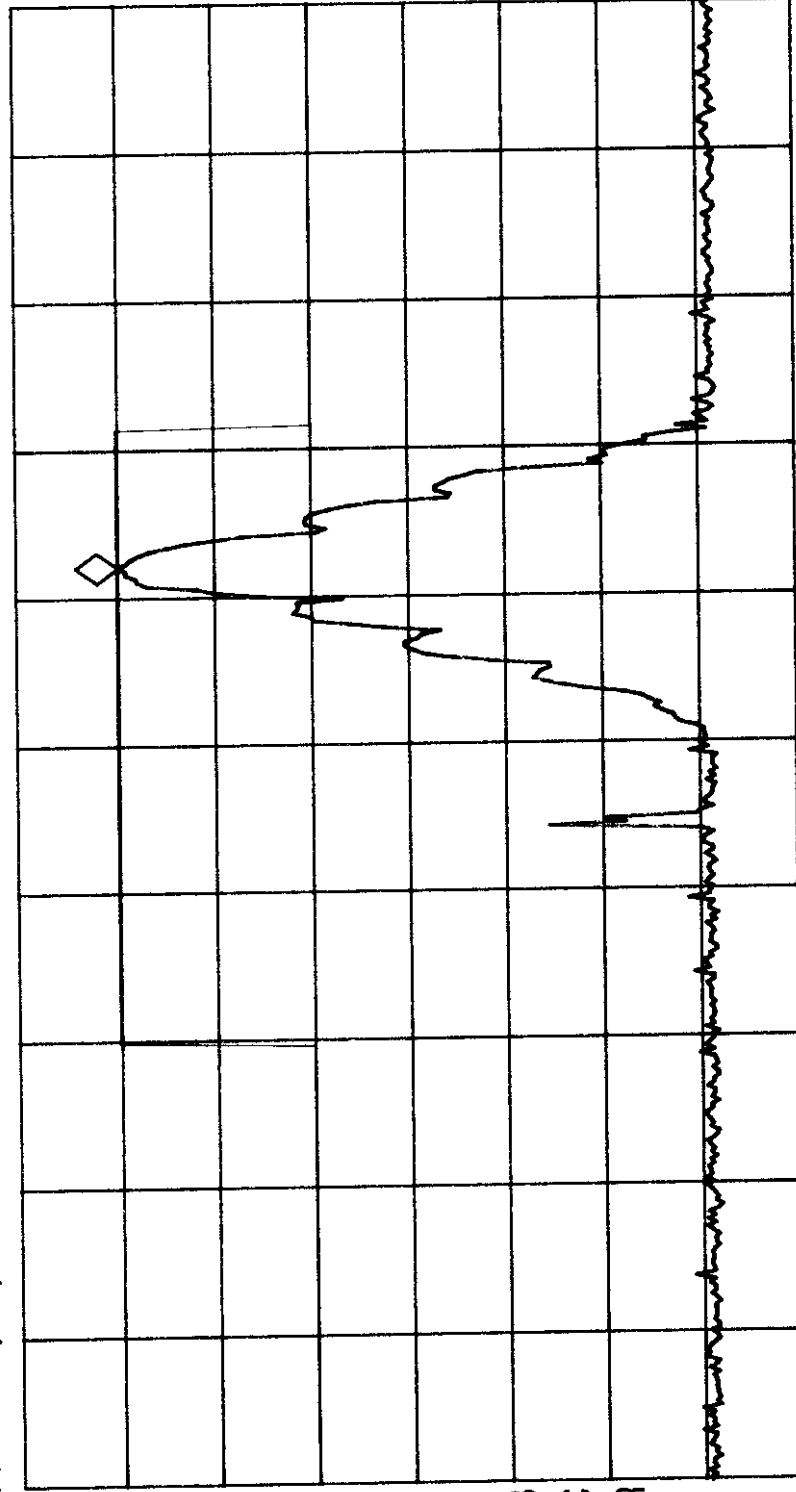
SWEPTIME
20.0 sec

ACTV DET: PEAK
MEAS DET: PEAK QP AVG
MKR 2.4650 GHz
9.51 dBm

No user
Menu

REF OFFST 20.0 dB
REF 20.0 dBm

LOG
10
dB/
#ATN
10 dB



CENTER 2.4410 GHz
#IF BW 100 kHz
SPAN 200.0 MHz
#SWP 20.0 sec
#AVG BW 300 kHz



ISP DIRECT, MODEL 2401-01 (INDOOR) & 2401-02 (OUTDOOR)
Test Configuration #: 8, Tx Frequency: 2464.875 MHz, RF Power: 0.19 W
Modulation: DSSS, BW: NARROW (4.5 Mc/s), 11 chips/symbol, 0.818 Mbps DQPSK

Date: Feb. 26/98
Tested by: Tri Luu

hp

Channel #18

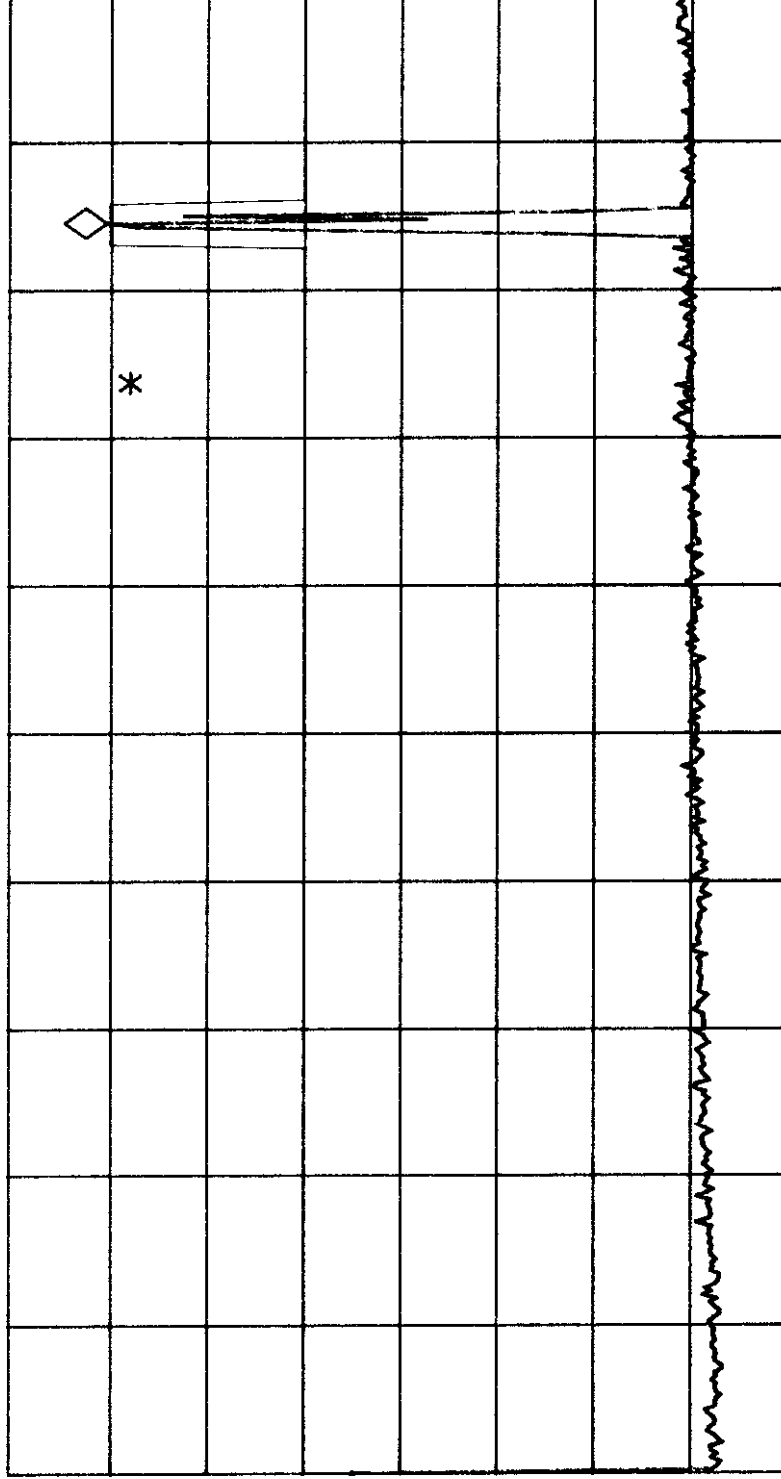
MARKER
2.452 GHz
10.00 dBm

ACTV DET: PEAK
MEAS DET: PEAK QP AVG
MKR 2.452 GHz
10.00 dBm

No user
Menu

REF OFFST 20.0 dB
REF 20.0 dBm

LOG
10
dB/
#ATN
10 dB



VA SB
SC FC
CORR

START 10 MHz
#IF BW 100 KHz
STOP 2.900 GHz
#SWP 100 sec
#AVG BW 300 KHz



hp

ISP DIRECT, MODEL 2401-01 (INDOOR) & 2401-02 (OUTDOOR)
Test Configuration #: 8, Tx Frequency: 2464.875 MHz, RF Power: 0.19 W
Modulation: DSSS, BW: NARROW (4.5 Mc/s), 11 chips/symbol, 0.818 Mbps DQPSK

Date: Feb. 26/98
Tested by: Tri Lam

Channel #18

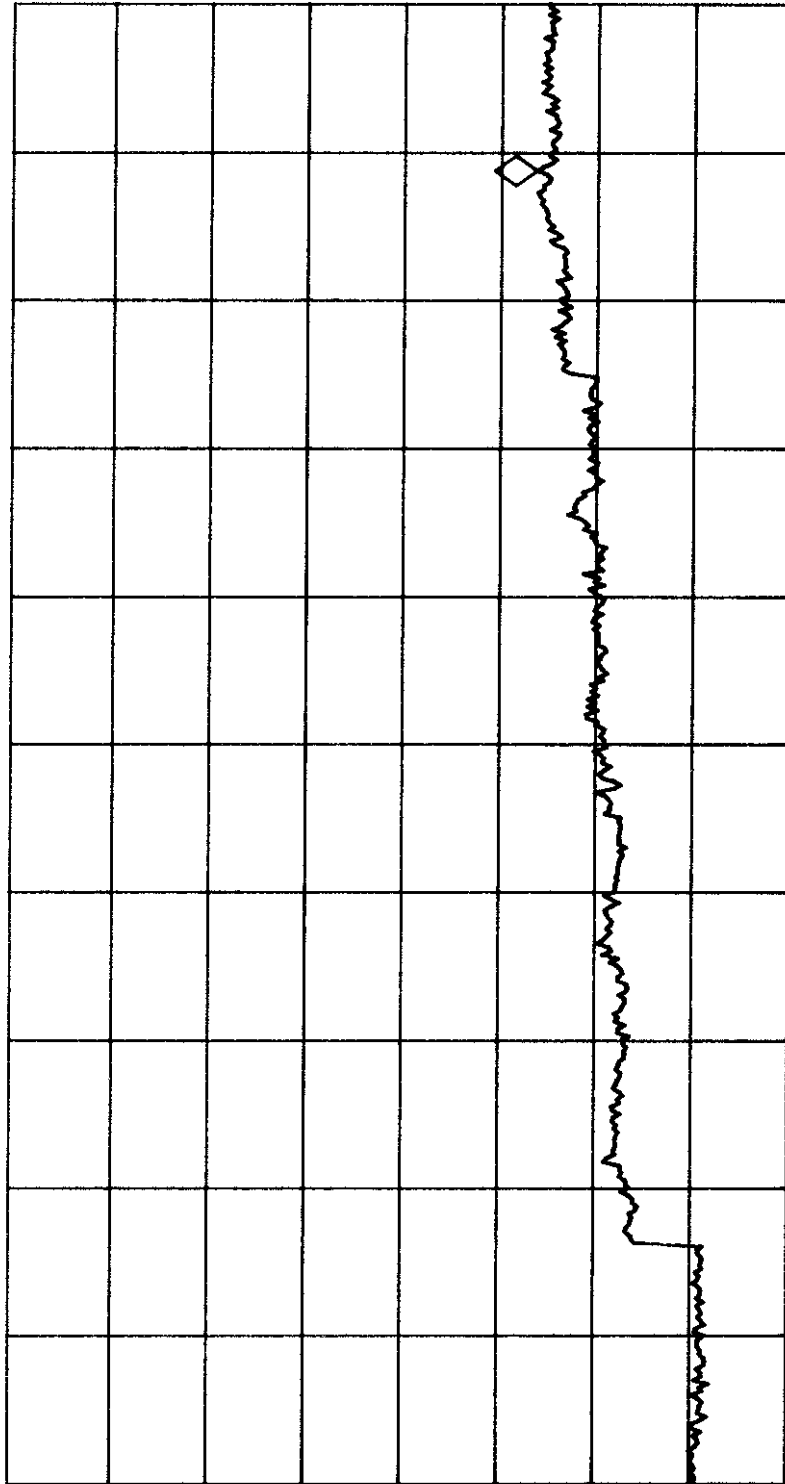
SWEPTIME
20.0 sec

ACTV DET: PEAK
MEAS DET: PEAK QP AVG
MKR 22.51 GHz
-33.85 dBm

No user
Menu

REF OFFST 20.0 dB
REF 20.0 dBm

LOG
10
dB/
#ATN
10 dB



VA SB
SC FC
CORR

START 2.90 GHz
#IF BW 100 kHz
STOP 25.00 GHz
#SWP 20.0 sec
#AVG BW 300 kHz

4.4 Transmitter Radiated Emissions @ 3 Meters, FCC CFR 47, Para. 15.247(c), 15.209 & 15.205

PRODUCT NAME: ISP DIRECT INDOOR & OUTDOOR UNITS, Model No.: 2401-01 (indoor) and 2401-02 (outdoor)

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 @ 15.209(a), which lesser attenuation.

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

UltraTech Engineering Labs Inc.

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UltraTech's File #: IAW-004FTX

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**)

CLIMATE CONDITION:

Standard Temperature and Humidity:

- Ambient temperature: 23 °C
- Relative humidity: 43 %

POWER INPUT:

AC 120 V 60Hz from Elpac external switching power supply, model WRI4232.

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 22 GHz, 30dB 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
- **Horn Antenna**, Emco, Model 3160-10, 26.5-40GHz
- **Mixer**, Tektronix, P/N 118-0098-00, 18-26.5GHz
- **Mixer**, Tektronix, P/N 119-0098-00, 26.5-40GHz

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: Mr. Tri M. Luu, P.Eng.

DATE: Mar. 04-05, 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** = $20\text{LOG}_{10}(0.45) = -6.9 \text{ dB}$

Channel #: 3, Frequency: 2408.625 MHz Full Rated Peak Power: 190 mW Modulation: DQPSK, narrow, 11 chips/symbol, Data Rate: 4.5 Mb/s, 2 bits/symbol				Power Level in 1 MHz BW: 116.2 dBuV/m Limit = 116.2dBuV/m - 20dB = 96.2 dBuV/m			
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
2408.63	116.2	109.3	V	--	--	--	--
2408.63	109.1	102.2	H	--	--	--	--
1493.00	53.2	45.4	V	54.0	96.2	-8.6	PASS
1493.00	52.8	43.9	H	54.0	96.2	-10.1	PASS
2384.50	66.4	45.2	V	54.0	96.2	-8.8	PASS
2986.00	37.9	25.4	V	54.0	96.2	-70.8	PASS
2986.00	33.2	26.3	H	54.0	96.2	-69.9	PASS
4816.00	56.5	34.5	V	54.0	96.2	-19.5	PASS
4816.00	56.1	34.3	H	54.0	96.2	-19.7	PASS
No other significant emissions were found in the frequency range from 10 MHz to 25 GHz. Refer to attached plots for details							

* FCC Limit @ 15.209 was applied for frequency fell within restricted band @ 15.205

- 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**)

Channel #: 4, Frequency: 2411.4375 MHz Full Rated Peak Power: 190 mW Modulation: DQPSK, medium, 11 chips/symbol, Data Rate: 5.625 Mb/s, 2 bits/symbol				Power Level in 1 MHz BW: 118.9 dBuV/m Limit = 118.9dBuV/m - 20dB = 98.9 dBuV/m			
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
2411.44	118.9	112.0	V	--	--	--	PASS
2411.44	110.9	104.0	H	--	--	--	PASS
1496.00	54.4	44.7	V	54.0	98.9	-9.3	PASS *
1496.00	54.7	44.8	H	54.0	98.9	-9.2	PASS *
2992.00	34.7	22.5	V	54.0	98.9	-76.4	PASS
2992.00	35.5	24.0	H	54.0	98.9	-74.9	PASS
4488.00	44.4	33.8	V	54.0	98.9	-20.2	PASS *
4488.00	43.2	32.1	H	54.0	98.9	-21.9	PASS *
4822.00	55.4	34.8	V	54.0	98.9	-19.2	PASS *
4822.00	53.5	33.0	H	54.0	98.9	-21.0	PASS *
No other significant emissions were found in the frequency range from 10 MHz to 25 GHz. Refer to attached plots for details							

* FCC Limit @ 15.209 was applied for frequency fell within restricted band @ 15.205

Channel #: 6, Frequency: 2419.875 MHz Full Rated Peak Power: 190 mW Modulation: DQPSK, wide, 11 chips/symbol, Data Rate: 11.25 Mb/s, 2 bits/symbol				Power Level in 1 MHz BW: 116.4 dBuV/m Limit = 116.4dBuV/m - 20dB = 96.4 dBuV/m			
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
2419.88	116.4	109.5	V	--	--	--	--
2419.88	108.8	101.9	H	--	--	--	--
1504.00	55.6	46.4	V	54.0	96.4	-7.6	PASS *
1504.00	48.7	40.4	H	54.0	96.4	-13.6	PASS *
3008.00	38.0	28.3	V	54.0	96.4	-68.1	PASS
3008.00	36.1	24.1	H	54.0	96.4	-72.3	PASS
4512.00	43.3	34.4	V	54.0	96.4	-19.6	PASS *
4512.00	41.8	30.2	H	54.0	96.4	-23.8	PASS *
4838.00	55.2	34.6	V	54.0	96.4	-19.4	PASS *
4838.00	50.1	30.7	H	54.0	96.4	-23.3	PASS *
No other significant emissions were found in the frequency range from 10 MHz to 25 GHz. Refer to attached plots for details							

* FCC Limit @ 15.209 was applied for frequency fell within restricted band @ 15.205

- 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**)

Channel #: 15, Frequency: 2453.625 MHz Full Rated Peak Power: 190 mW Modulation: DQPSK, wide, 11 chips/symbol, Data Rate: 11.25 Mb/s, 2 bits/symbol				Power Level in 1 MHz BW: 117.3 dBuV/m Limit = 117.3dBuV/m - 20dB = 97.3 dBuV/m			
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
2453.63	117.3	110.4	V	--	--	--	--
2453.63	106.9	100.0	H	--	--	--	--
1538.00	54.8	44.2	V	54.0	97.3	-9.8	PASS *
1538.00	35.6	27.8	H	54.0	97.3	-26.2	PASS *
3076.00	47.8	40.2	V	54.0	97.3	-57.1	PASS
3076.00	44.1	36.3	H	54.0	97.3	-61.0	PASS
4614.00	39.3	28.3	V	54.0	97.3	-25.7	PASS *
4614.00	41.8	33.5	H	54.0	97.3	-20.5	PASS *
4906.00	55.4	32.9	V	54.0	97.3	-21.1	PASS *
4906.00	59.1	33.7	H	54.0	97.3	-20.3	PASS *
No other significant emissions were found in the frequency range from 10 MHz to 25 GHz. Refer to attached plots for details							

* FCC Limit @ 15.209 was applied for frequency fell within restricted band @ 15.205

Channel #: 17, Frequency: 2462.0625 MHz Full Rated Peak Power: 190 mW Modulation: DQPSK, medium, 11 chips/symbol, Data Rate: 5.625 Mb/s, 2 bits/symbol				Power Level in 1 MHz BW: 117.8 dBuV/m Limit = 117.8dBuV/m - 20dB = 97.8 dBuV/m			
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
2462.06	117.8	110.9	V	--	--	--	--
2462.06	110.8	103.9	H	--	--	--	--
1547.00	54.4	45.3	V	54.0	97.8	-8.7	PASS *
1547.00	52.9	43.6	H	54.0	97.8	-10.4	PASS *
3094.00	45.0	37.1	V	54.0	97.8	-60.7	PASS
3094.00	39.3	30.8	H	54.0	97.8	-67.0	PASS
4924.00	55.9	35.7	V	54.0	97.8	-18.3	PASS *
4924.00	42.6	40.9	H	54.0	97.8	-13.1	PASS *
No other significant emissions were found in the frequency range from 10 MHz to 25 GHz. Refer to attached plots for details							

* FCC Limit @ 15.209 was applied for frequency fell within restricted band @ 15.205

- 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**)

Channel #: 18, Frequency: 2464.875 MHz Full Rated Peak Power: 190 mW Modulation: DQPSK, narrow, 11 chips/symbol, Data Rate: 4.5 Mb/s, 2 bits/symbol				Power Level in 1 MHz BW: 117.1 dBuV/m Limit = 117.1dBuV/m - 20dB = 97.1 dBuV/m			
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
1549.00	52.1	43.1	V	54.0	97.1	-10.9	PASS *
1549.00	52.7	44.6	H	54.0	97.1	-9.4	PASS *
2464.88	117.1	110.2	V	54.0	97.1	--	--
2464.88	110.8	103.9	H	54.0	97.1	--	--
3098.00	44.0	36.2	V	54.0	97.1	-60.9	PASS
3098.00	41.9	34.1	H	54.0	97.1	-63.0	PASS
4647.00	40.1	30.4	V	54.0	97.1	-23.6	PASS *
4647.00	41.4	32.5	H	54.0	97.1	-21.5	PASS *
4928.00	47.1	40.2	V	54.0	97.1	-13.8	PASS *
4928.00	39.3	27.4	H	54.0	97.1	-26.6	PASS *
No other significant emissions were found in the frequency range from 10 MHz to 25 GHz. Refer to attached plots for details							

* FCC Limit @ 15.209 was applied for frequency fell within restricted band @ 15.205



Date: Mar. 04/98
Tested by: Tri Luu

HP

09: 39: 31 OCT 24, 1997 10: 53: 46 OCT 24, 1997

ISP DIRECT, MODEL 2401-01 (INDOOR) & 2401-02 (OUTDOOR)
Channel #: 3, Tx Frequency: 2408.625 MHz, RF Power: 0.19 W
Modulation: DSSS, BW: NARROW (4.5 Mc/s), 11 chips/symbol, 0.818 Mbps DQPSK

Transmitter Radiated
Emissions @ 3m

Antenna Polarization: *VERTICAL*

IF BANDWIDTH

1.0 MHz

ACTV DET: PEAK

MEAS DET: PEAK QP AVG

No user
Menu

MKR 2.4085 GHz
116.19 dBμV

REF OFFST 20.0 dB

REF 127.0 dBμV

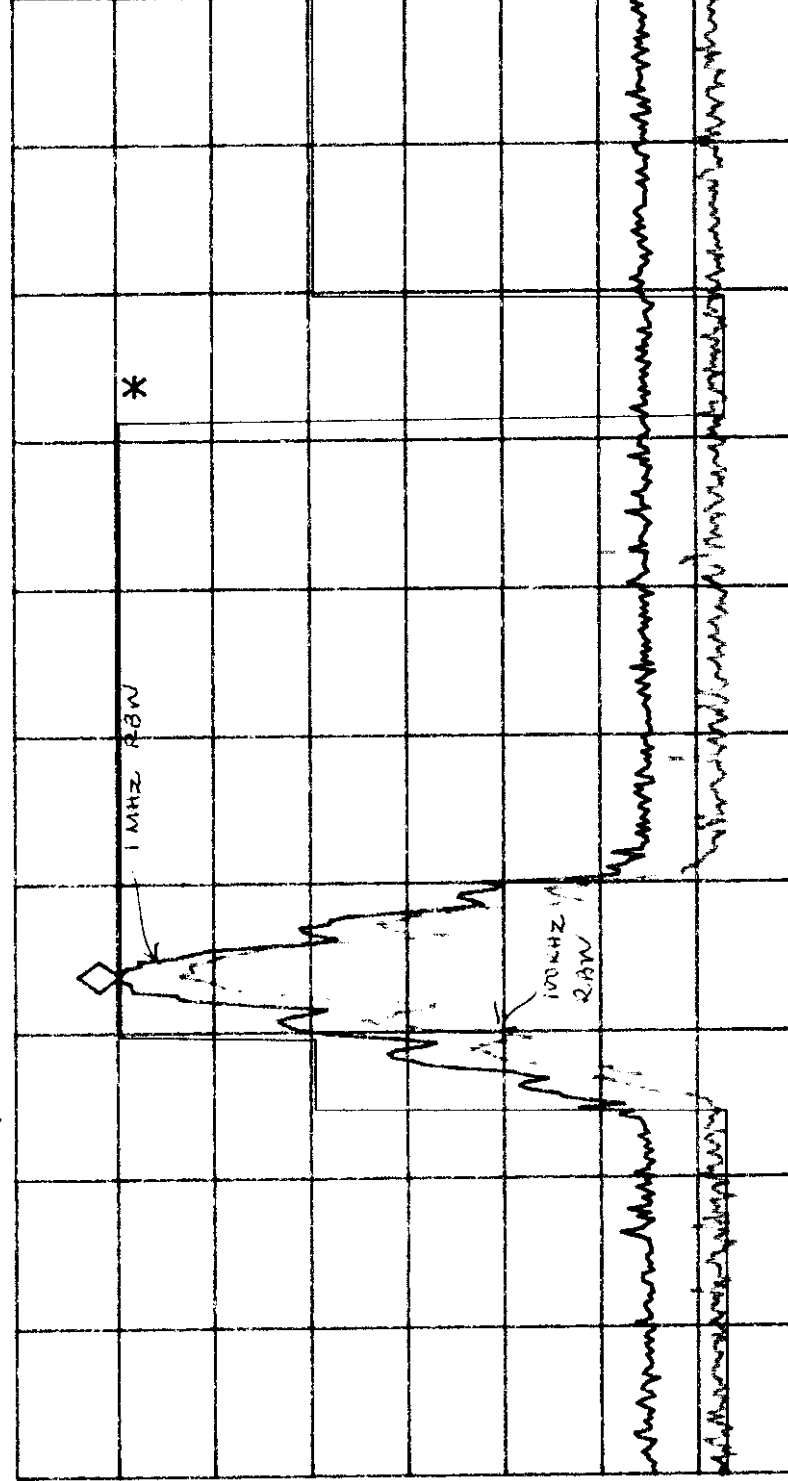
LOG

10

dB/

#ATN

10 dB



VA VB

SC FC

ACORR

CENTER 2.4410 GHz

#IF BW 1.0 MHz

#AVG BW 1 MHz

SPAN 200.0 MHz

SWP 20.0 msec



Date: Mar. 04/98
Tested by: Tri Lum

hp

09:39:31 OCT 24, 1997 10:53:46 OCT 24, 1997

ISP DIRECT, MODEL 2401-01 (INDOOR) & 2401-02 (OUTDOOR)
Channel #: 3, Tx Frequency: 2408.125 MHz, RF Power: 0.19 W
Modulation: DSSS, BW: NARROW (4.5 Mc/s), 11 chips/symbol, 0.818 Mbps DQPSK

Transmitter Radiated
Emissions @ 3m

Antenna Polarization: ~~HORIZONTAL~~

ACTV DET: PEAK
MEAS DET: PEAK QP AVG

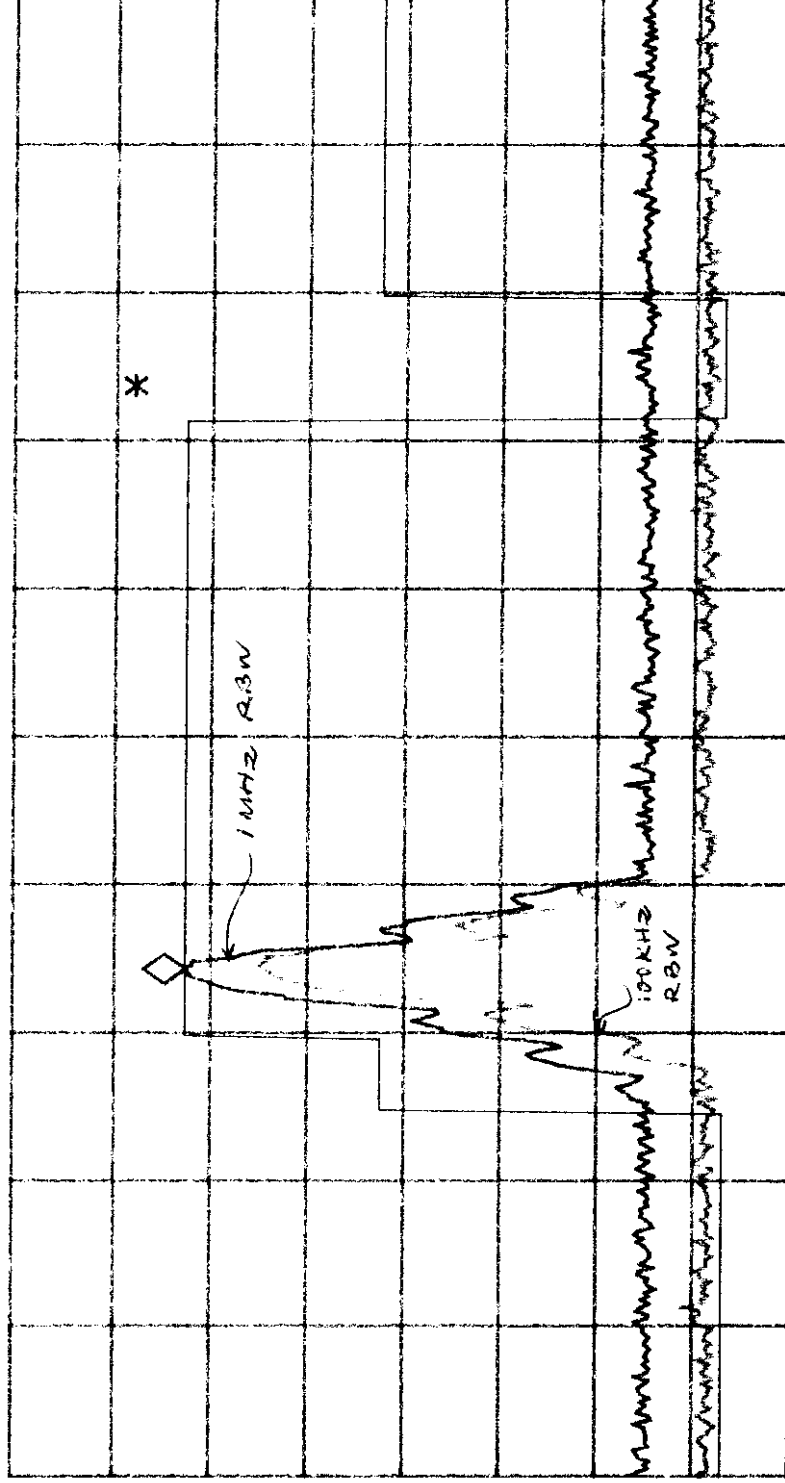
No user

Menu

MKR 2.4095 GHz
109.12 dBμV

REF OFFST 20.0 dB
REF 127.0 dBμV

LOG
10
dB/
#ATN
10 dB



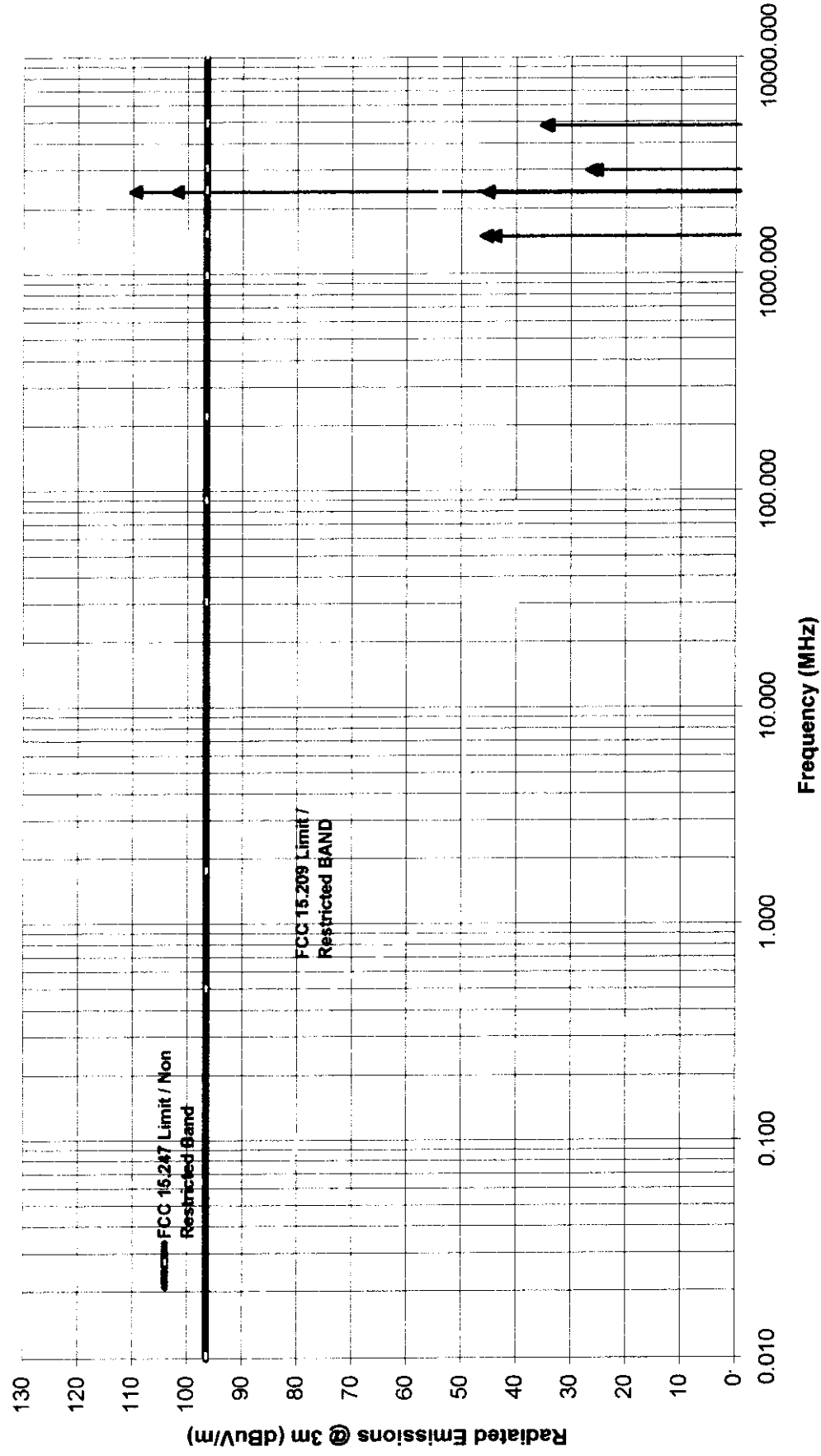
VA VB
SC FC
ACORR

CENTER 2.4410 GHz

SPAN 200.0 MHz
SWP 20.0 msec

#IF BW 1.0 MHz #AVG BW 1 MHz

Transmitter Radiated Emissions Measurements at 3 Meter OFTS
InterAir ISP Direct Indoor (2401-01) and Outdoor (2401-02) Unit
Channel #3, Tx Freq.: 2408.625 MHz, Tx Lo Freq.: 1493.625 MHz





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Engineering Labs Inc.

Date: Mar. 04/98
Tested by: Tri Luu

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Ø9:39:31 OCT 24, 1997 10:53:46 OCT 24, 1997

ISP DIRECT, MODEL 2401-01 (INDOOR) & 2401-02 (OUTDOOR)

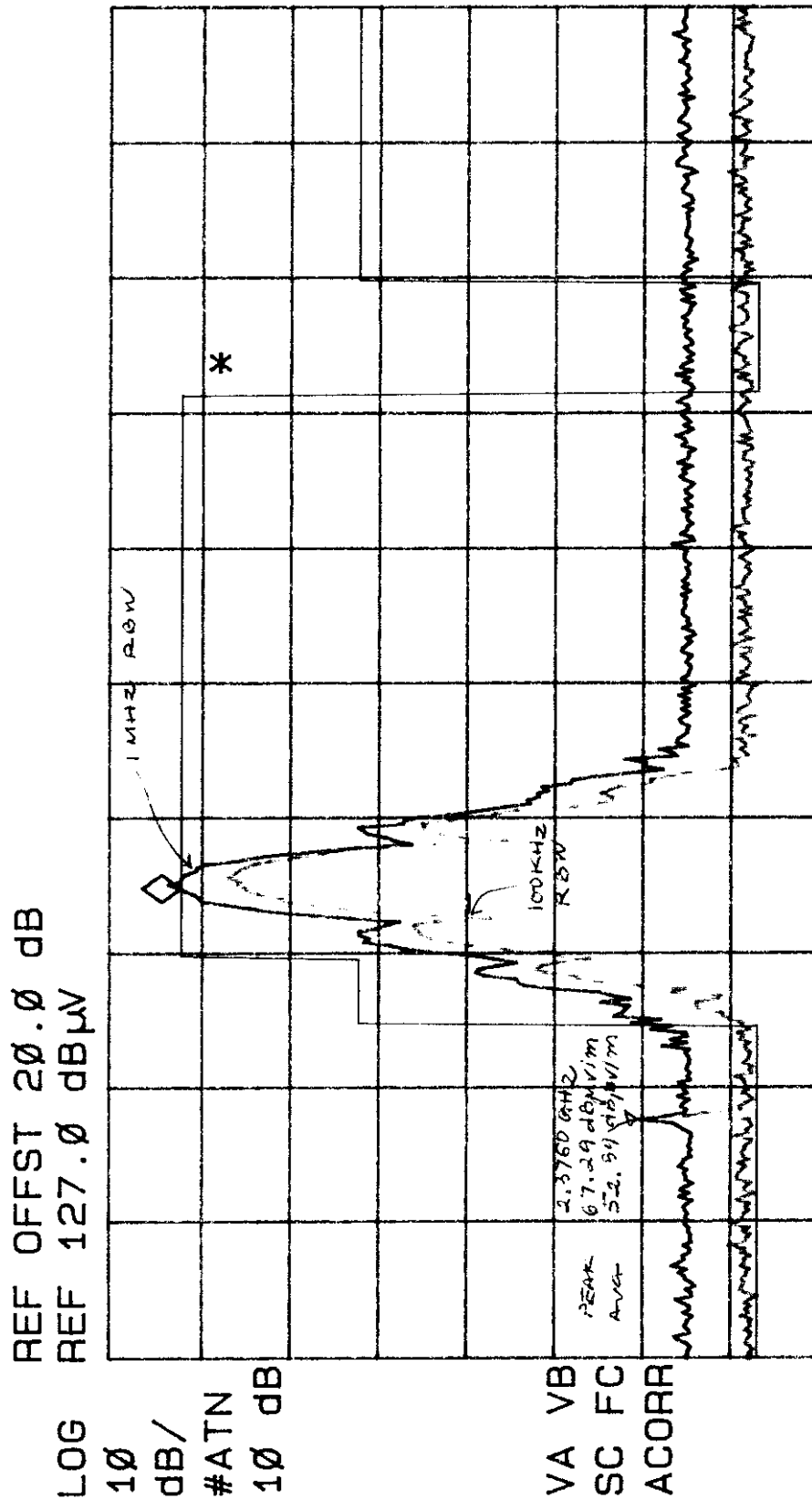
Channel #: 4, Tx Frequency: 2411.4375 MHz, RF Power: 0.19 W
Modulation: DSSS, BW: MEDIUM (5.625 Mc/s), 11 chips/symbol, 1.023 Mbps DQPSK

Transmitter Radiated Emissions @ 3m

Antenna Polarization: $VE\hat{e}_\theta^0 A.L$

No user Menu

MEAS DET: PEAK QP AVG
MKR 2.4105 GHz
118.87 dBmV



CENTER 2.4410 GHZ
#IF BW 1.0 MHZ #AVG BW 1 MHZ
SPAN 200.0 MHZ SWP 20.0 msec



Date: Mar. 04/98
Tested by: Tri Lau

h/p

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ISP DIRECT, MODEL 2401-01 (INDOOR) & 2401-02 (OUTDOOR)
Channel #: 4, Tx Frequency: 2411.4375 MHz, RF Power: 0.19 W
Modulation: DSSS, BW: MEDIUM (5.625 Mc/s), 11 chips/symbol, 1.023 Mbps DQPSK

Transmitter Radiated
Emissions @ 3m

Antenna Polarization: ~~Horizontal~~

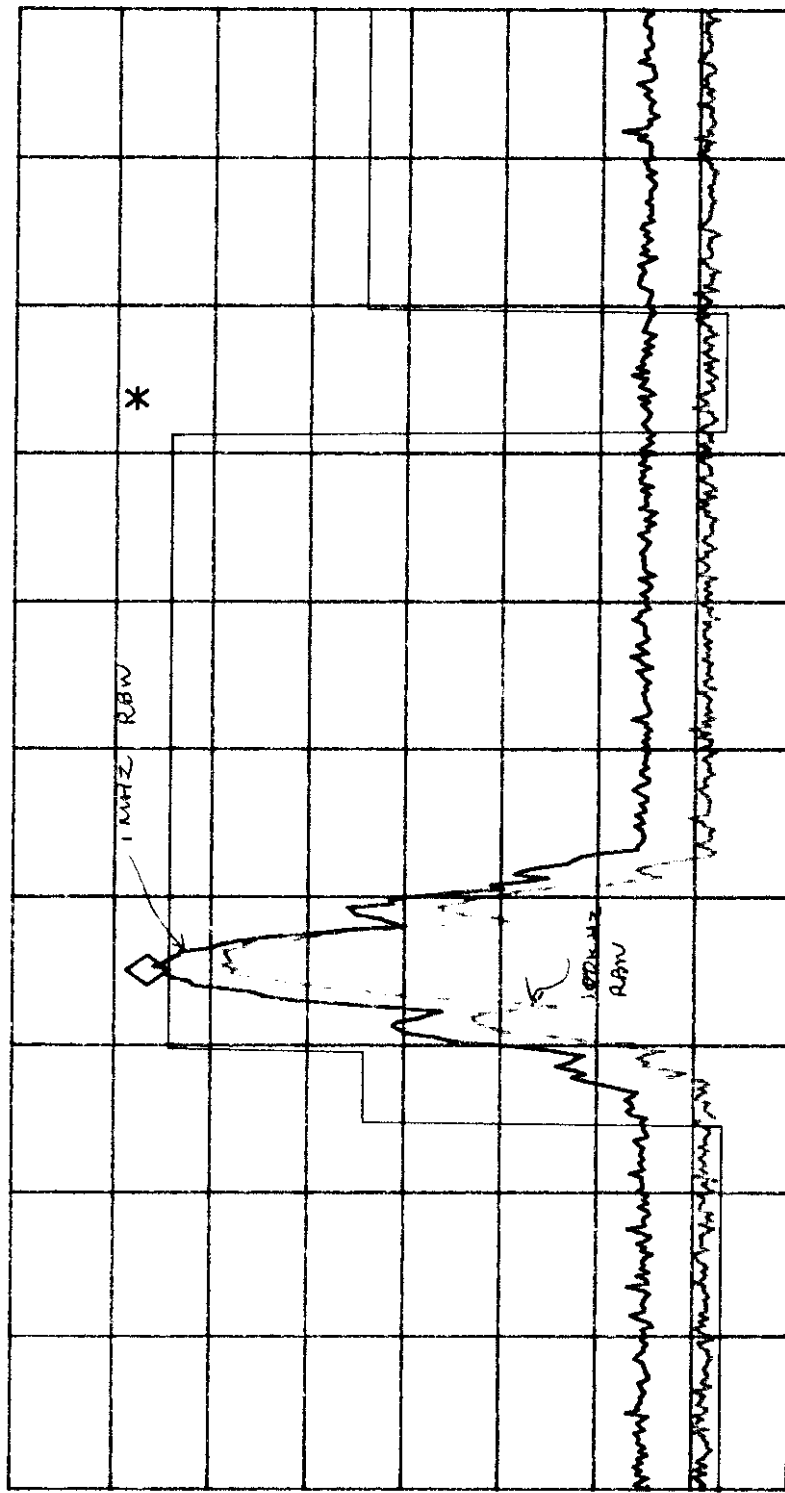
ACTV DET: PEAK
MEAS DET: PEAK QP AVG

No user
Menu

MKR 2.4110 GHz
110.92 dBμV

REF OFFST 20.0 dB
REF 127.0 dBμV

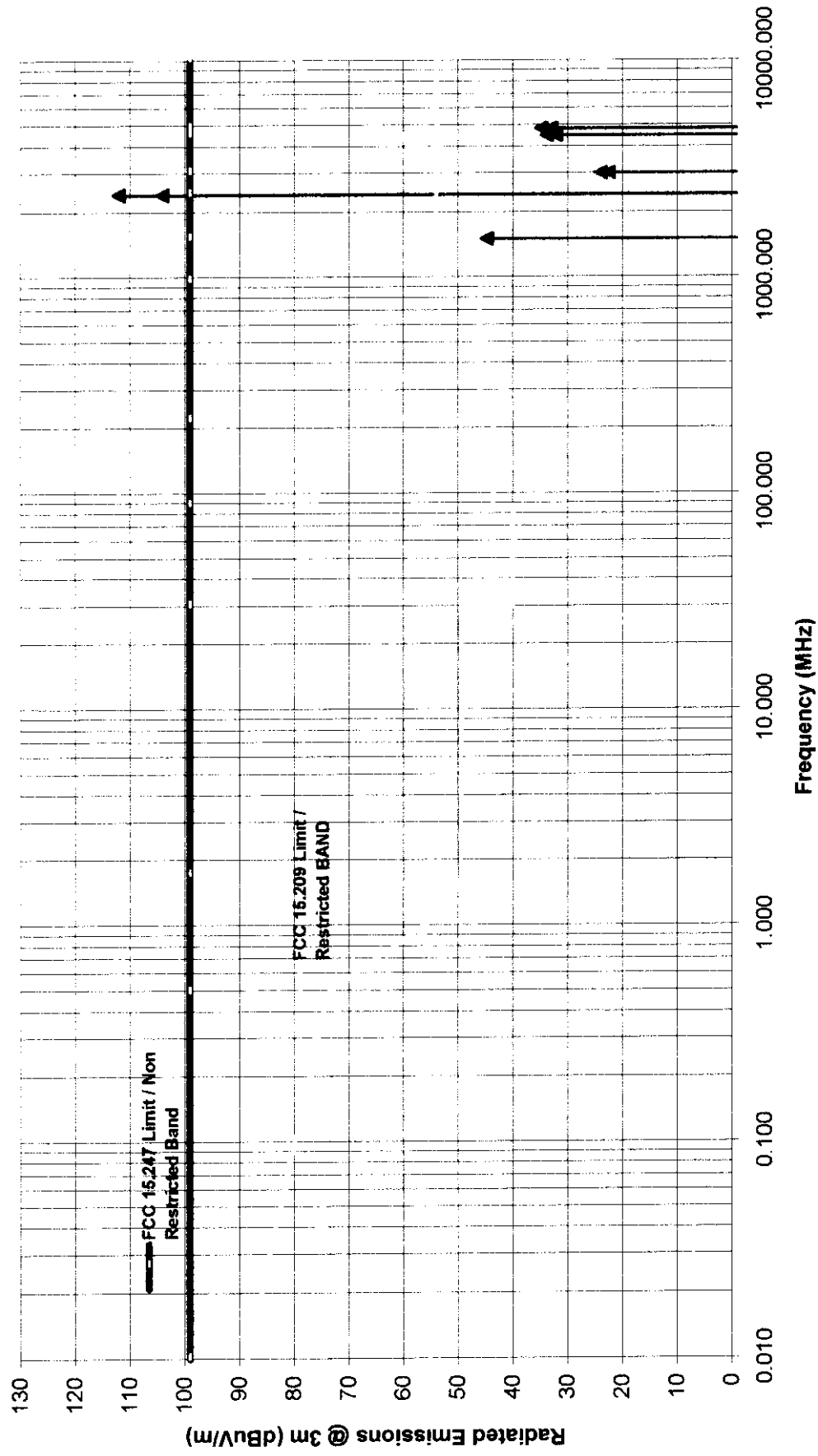
LOG 10
dB/
#ATN
10 dB



VA VB
SC FC
ACORR

CENTER 2.4110 GHz
#IF BW 1.0 MHz #AVG BW 1 MHz SPAN 200.0 MHz
SWP 20.0 msec

Transmitter Radiated Emissions Measurements at 3 Meter OFTS
InterAir ISP Direct Indoor (2401-01) and Outdoor (2401-02) Unit
Channel #4, Tx Freq.: 2411.4375 MHz, Tx Lo Freq.: 1496.4375 MHz





Date: Mar 04/98
Tested by: Tri Luu

ISP DIRECT, MODEL 2401-01 (INDOOR) & 2401-02 (OUTDOOR)
Test Configuration #: 6, Tx Frequency: 2419.875 MHz, RF Power: 0.19 W
Modulation: DSSS, BW: WIDE (11.25 Mc/s), 11 chips/symbol, 2.045 Mbps DQPSK

Transmitter Radiated
Emissions @ 3m

Antenna Polarization: VERTICAL

hp

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AVERAGE BANDWIDTH

1 MHz

ACTV DET: PEAK

No user

MEAS DET: PEAK QP AVG

Menu

MKR 2.4205 GHz

116.36 dBμV

REF OFFST 20.0 dB

REF 127.0 dBμV

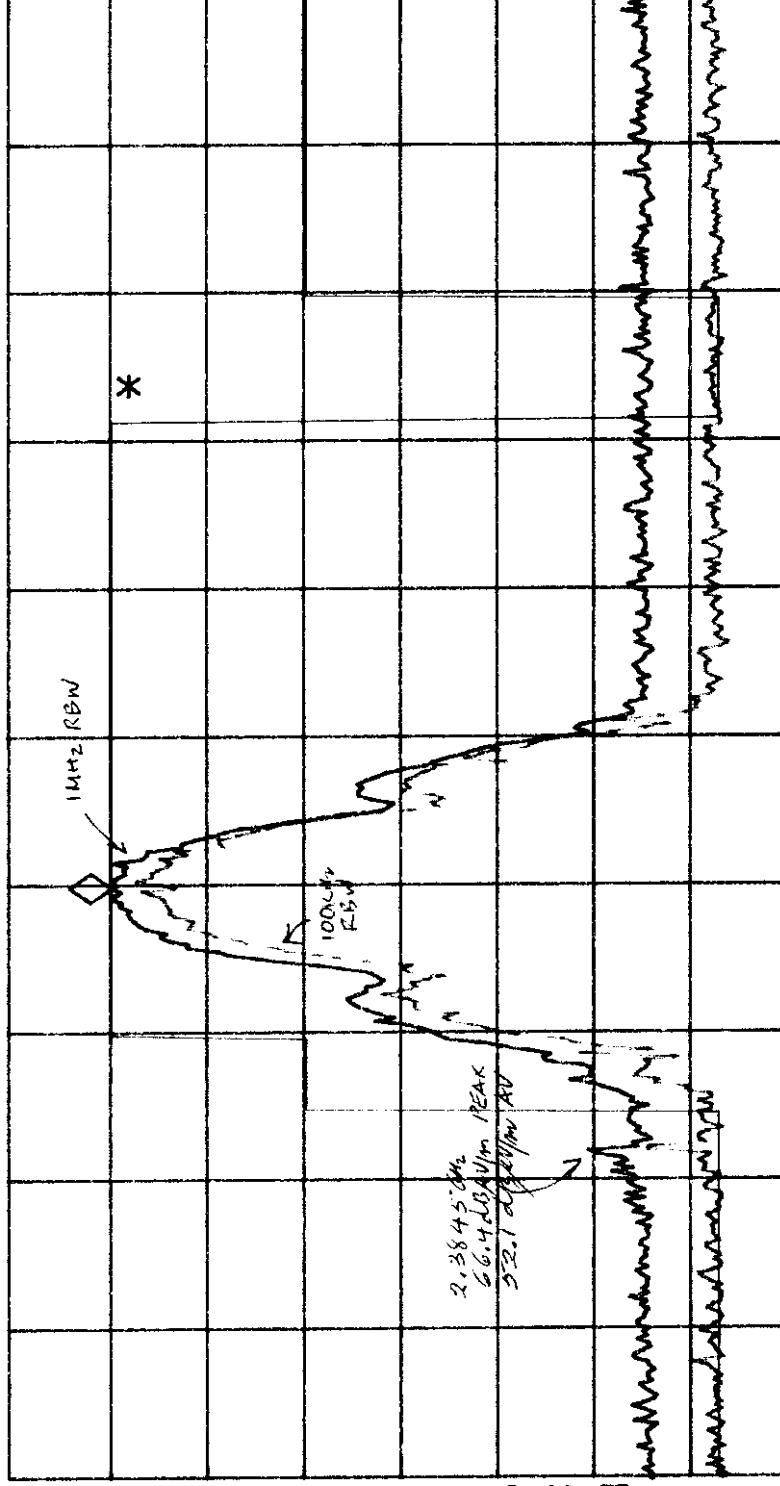
LOG

10

dB/

#ATN

10 dB



VA VB

SC FC

ACORR

CENTER 2.4410 GHz

#IF BW 1.0 MHz

#AVG BW 1 MHz

SPAN 200.0 MHz

SWP 20.0 msec



Date: Mar. 04/98
Tested by: Tri Lam

hp

09:39:31 OCT 24, 1997 10:53:46 OCT 24, 1997

ISP DIRECT, MODEL 2401-01 (INDOOR) & 2401-02 (OUTDOOR)
Test Configuration #: 6, Tx Frequency: 2419.875 MHz, RF Power: 0.19 W
Modulation: DSSS, BW: WIDE (11.25 Mc/s), 11 chips/symbol, 2.045 Mbps DQPSK

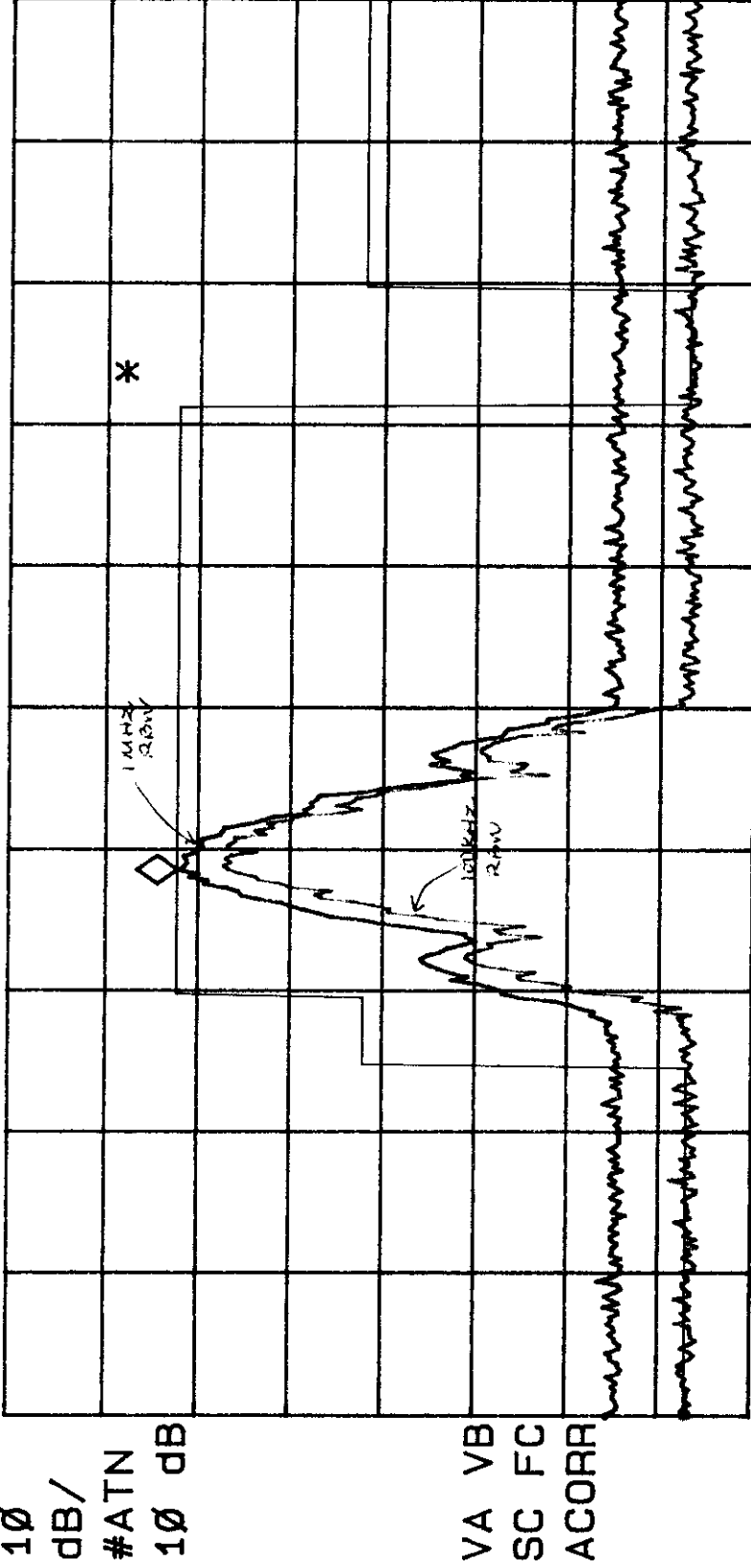
Transmitter Radiated
Emissions @ 3m

Antenna Polarization: *HORIZONTAL*

No user
Menu

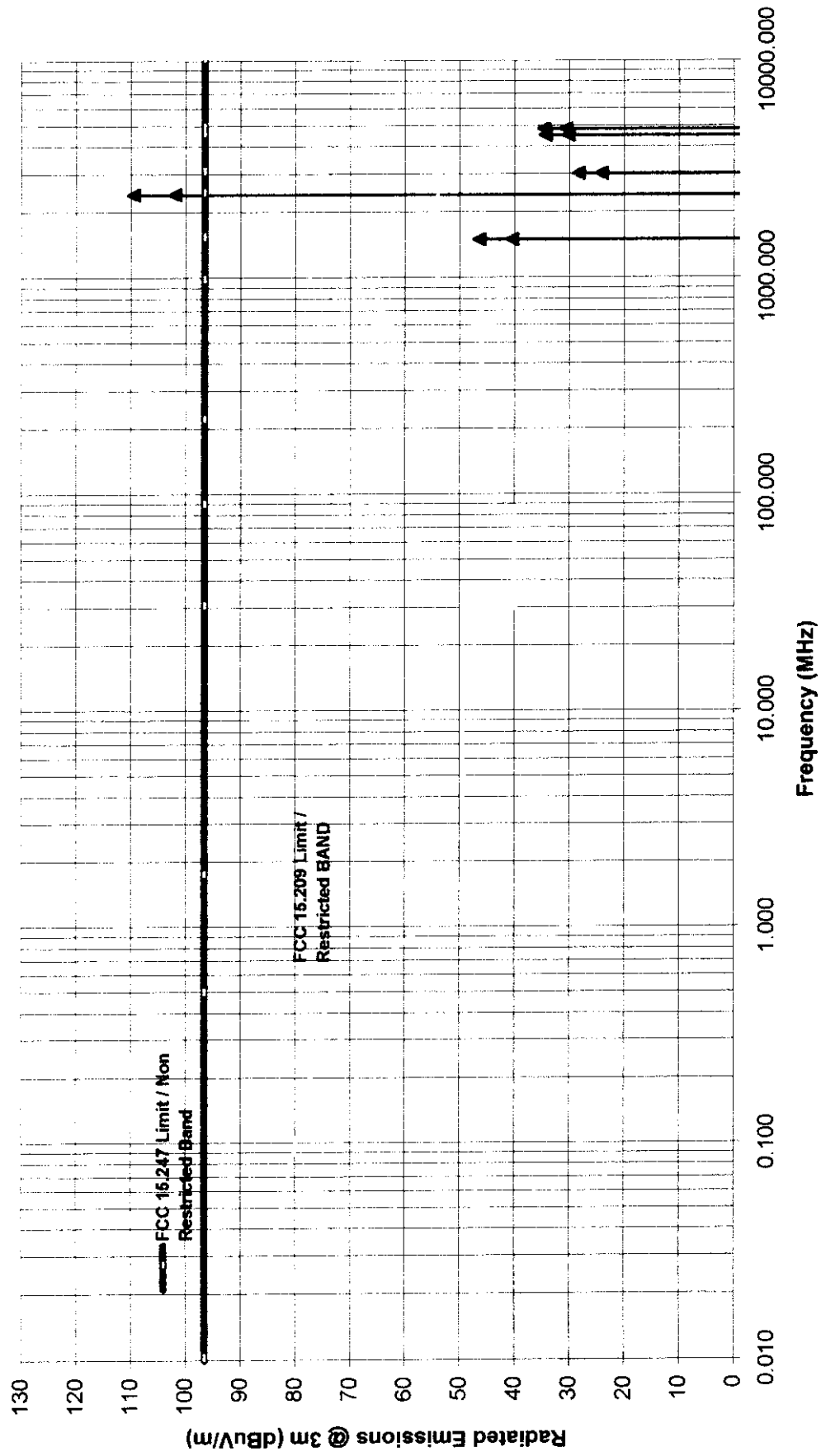
ACTV DET: PEAK
MEAS DET: PEAK QP AVG
MKR 2.4180 GHz
108.75 dBμV

LOG 10 dB / #ATN 10 dB
REF OFFST 20.0 dB
REF 127.0 dBμV



CENTER 2.4410 GHz
#IF BW 1.0 MHz
#AVG BW 1 MHz
SPAN 200.0 MHz
SWP 20.0 msec

Transmitter Radiated Emissions Measurements at 3 Meter OFTS
InterAir ISP Direct Indoor (2401-01) and Outdoor (2401-02) Unit
Channel #6, Tx Freq.: 2419.875 MHz, Tx Lo Freq.: 1504.875 MHz





Date: Mar. 04/98

Tested by: Tri Luu

hp

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ISP DIRECT, MODEL 2401-01 (INDOOR) & 2401-02 (OUTDOOR)
Test Configuration #: 15, Tx Frequency: 2453.625 MHz, RF Power: 0.19 W
Modulation: DSSS, BW: WIDE (11.25 Mc/s), 11 chips/symbol, 2.046 Mbps DQPSK

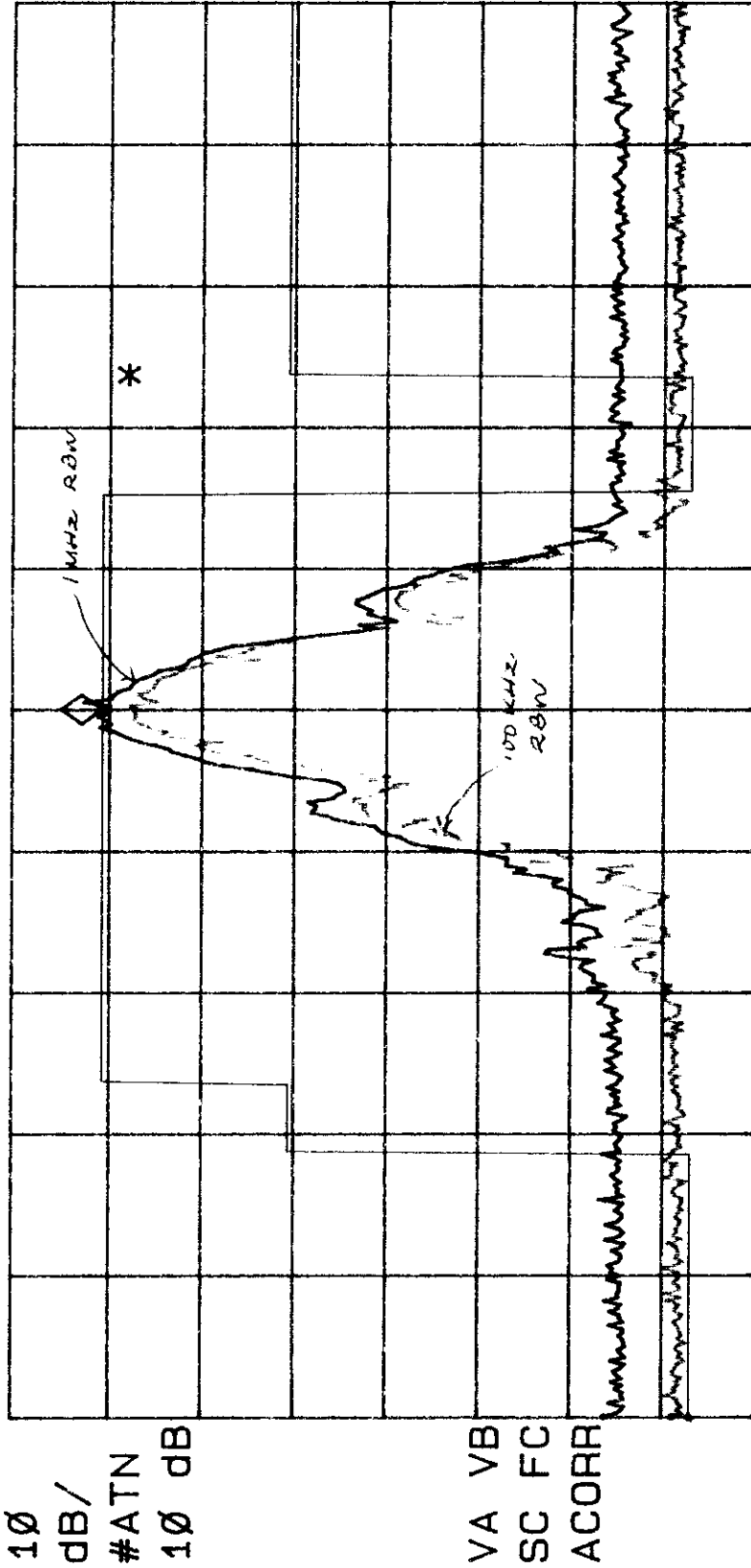
Transmitter Radiated
Emissions @ 3m

Antenna Polarization: *VERTICAL*

No user
Menu

ACTV DET: PEAK
MEAS DET: PEAK QP AVG
MKR 2.4530 GHz
117.32 dBμV

LOG REF OFFST 20.0 dB
10 dB/ REF 127.0 dBμV
#ATN
10 dB



CENTER 2.4530 GHz SPAN 200.0 MHz
#IF BW 1.0 MHz #AVG BW 1 MHz SWP 20.0 msec



Date: Mar. 04/98

Tested by: Tin Lam

ISP DIRECT, MODEL 2401-01 (INDOOR) & 2401-02 (OUTDOOR)
Test Configuration #: 16, Tx Frequency: 2453.625 MHz, RF Power: 0.19 W
Modulation: DSSS, BW: WIDE (11.25 Mc/s), 11 chips/symbol, 2.045 Mbps DQPSK

Transmitter Radiated
Emissions @ 3m

Antenna Polarization: ~~40°~~ 20° 77°

HP

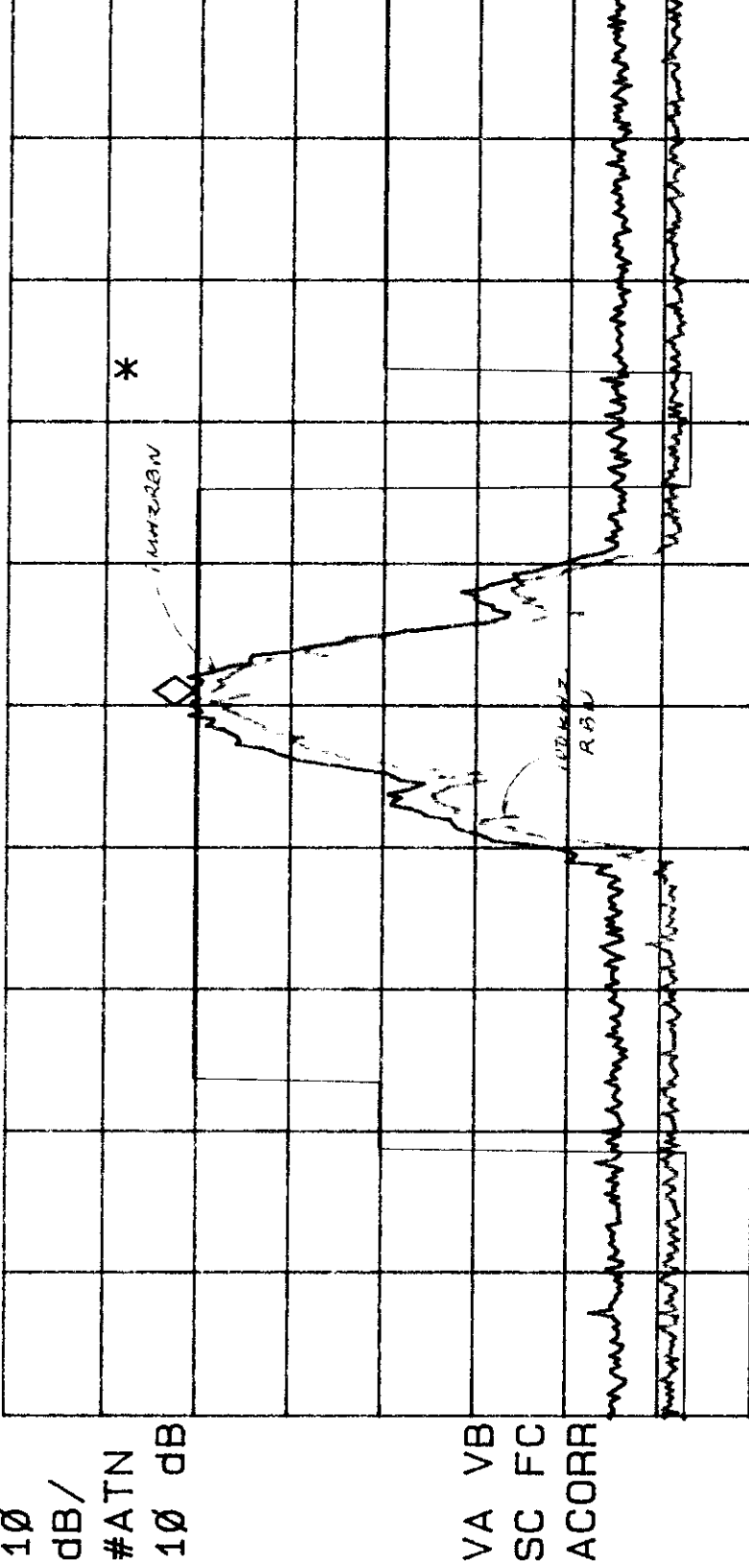
09: 39: 31 OCT 24, 1997 10: 53: 46 OCT 24, 1997

ACTV DET: PEAK No user
MEAS DET: PEAK QP AVG Menu

MKR 2.4550 GHZ
106.94 dBμV

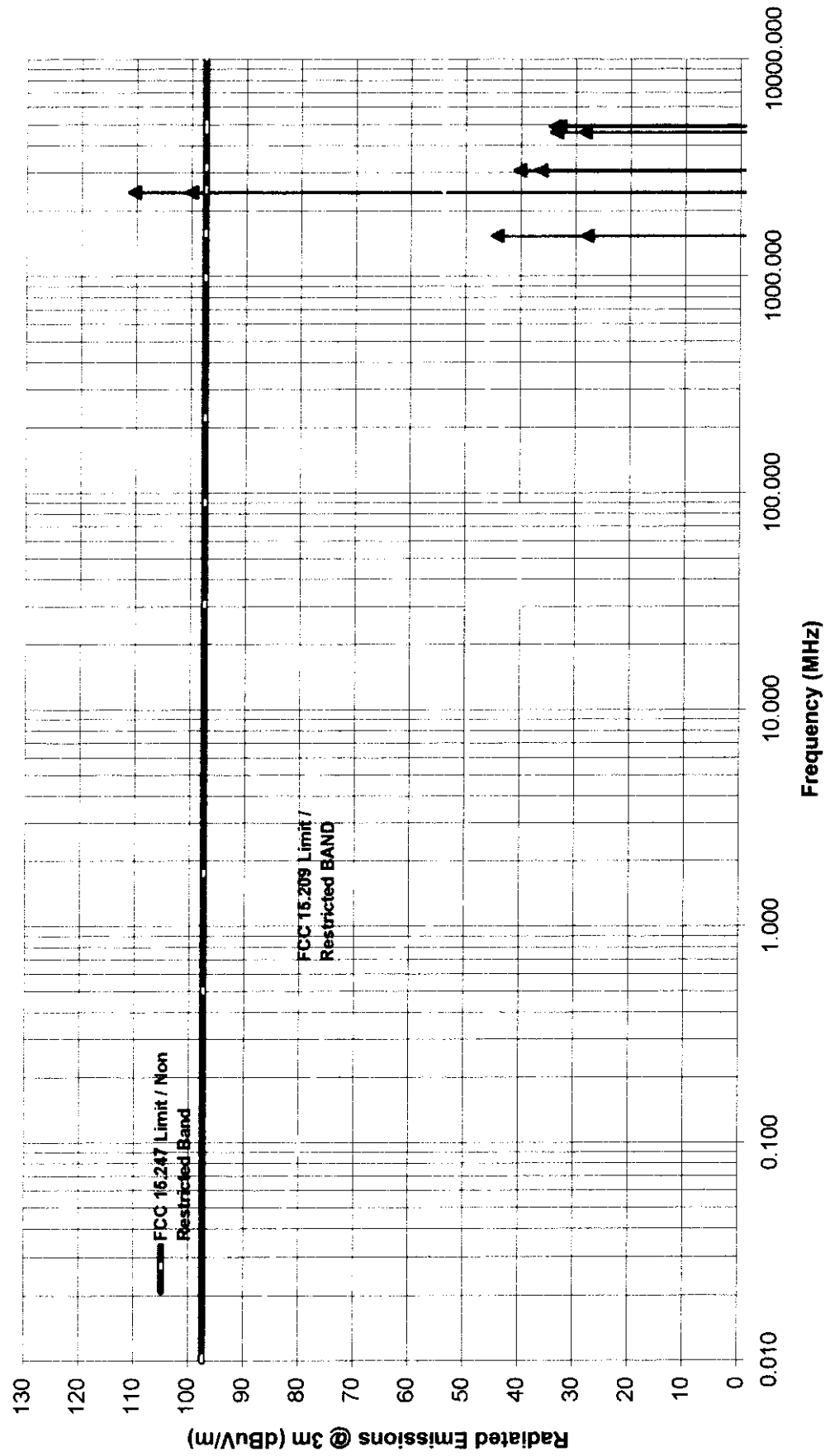
REF OFFST 20.0 dB
REF 127.0 dBμV

LOG
10
dB/
#ATN
10 dB



CENTER 2.4530 GHZ SPAN 200.0 MHz
#IF BW 1.0 MHz #AVG BW 1 MHz SWP 20.0 msec

Transmitter Radiated Emissions Measurements at 3 Meter OFTS
InterAir ISP Direct Indoor (2401-01) and Outdoor (2401-02) Unit
Channel #15, Tx Freq.: 2453.625 MHz, Tx Lo Freq.: 1538.625 MHz





Date: Mar. 04/98
Tested by: Tri Luu

HP

09:39:31 OCT 24, 1997 10:53:46 OCT 24, 1997

ISP DIRECT, MODEL 2401-01 (INDOOR) & 2401-02 (OUTDOOR)
Channel #: 17, Tx Frequency: 2462.025 MHz, RF Power: 0.19 W
Modulation: DSSS, BW: MEDIUM (5.625 Mc/s), 11 chips/symbol, 1.023 Mbps DQPSK

Transmitter Radiated
Emissions @ 3m

Antenna Polarization: VERTICAL

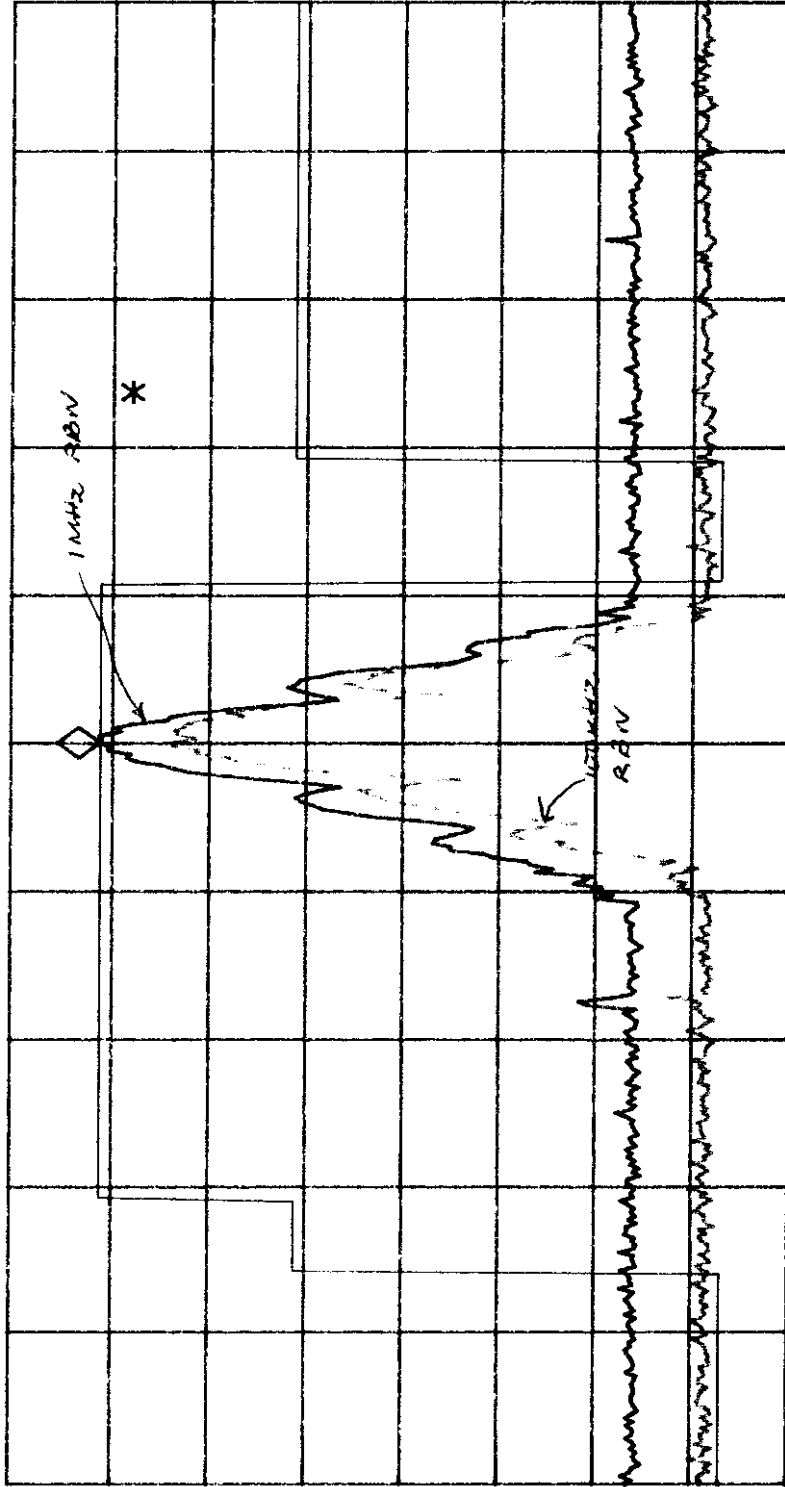
ACTV DET: PEAK
MEAS DET: PEAK QP AVG
MKR 2.4620 GHz
117.79 dBμV

No user

Menu

REF OFFST 20.0 dB
REF 127.0 dBμV

LOG
10
dB/
#ATN
10 dB



VA VB
SC FC
ACORR

CENTER 2.4620 GHz
#IF BW 1.0 MHz
#AVG BW 1 MHz
SPAN 200.0 MHz
SWP 20.0 msec



ISP DIRECT, MODEL 2401-01 (INDOOR) & 2401-02 (OUTDOOR)
Channel #: 17, Tx Frequency: 2462.025 MHz, RF Power: 0.19 W
Modulation: DSSS, BW: MEDIUM (5.625 Mc/s), 11 chips/symbol, 1.023 Mbps DQPSK

Transmitter Radiated Emissions @ 3m

Antenna Polarization: *HORIZONTAL*

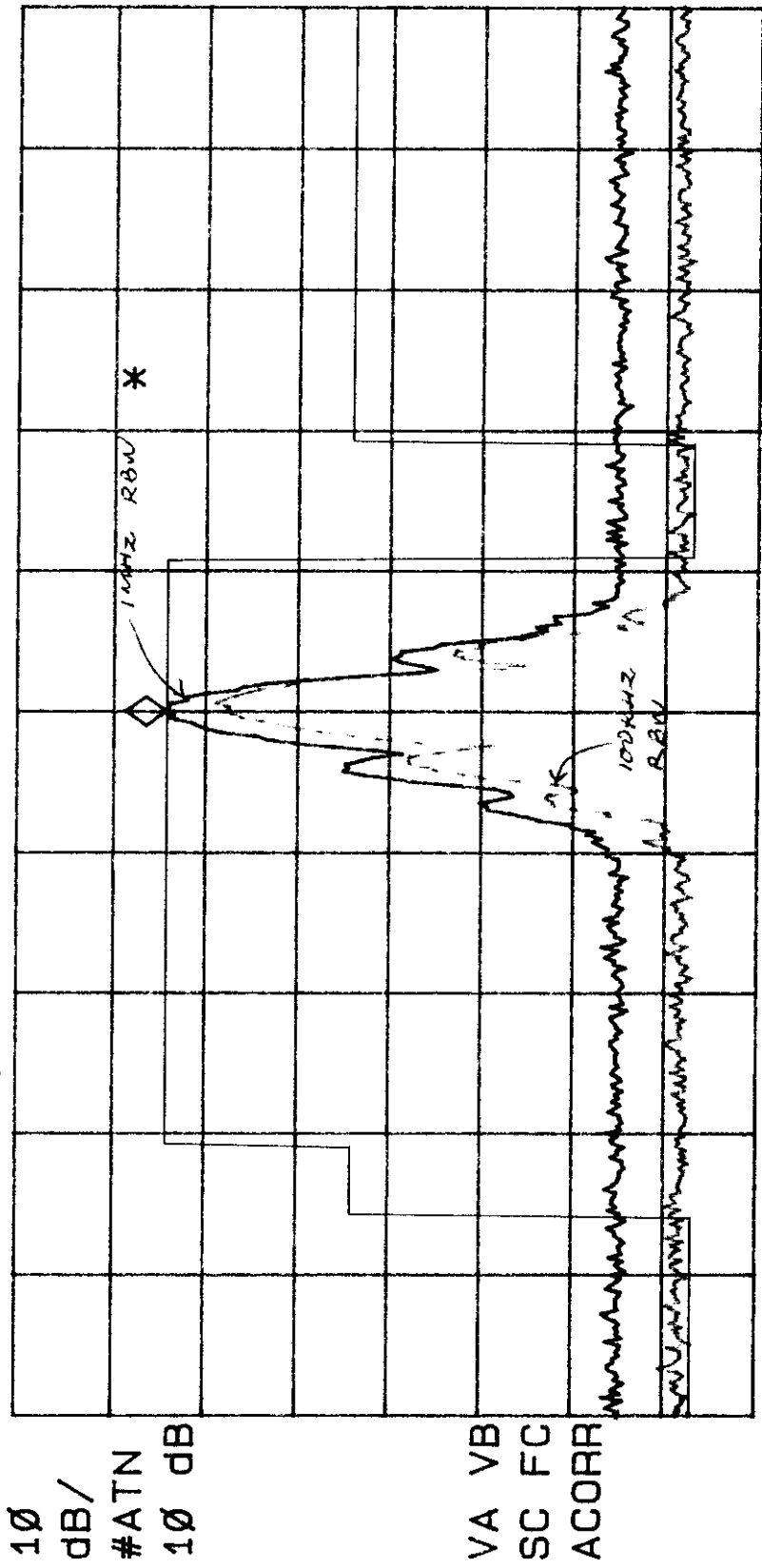
Date: Mar 04/98
Tested by: Tri Lau

hp 09: 39: 31 OCT 24, 1997 10: 53: 46 OCT 24, 1997

ACTV DET: PEAK
MEAS DET: PEAK QP AVG
No user Menu

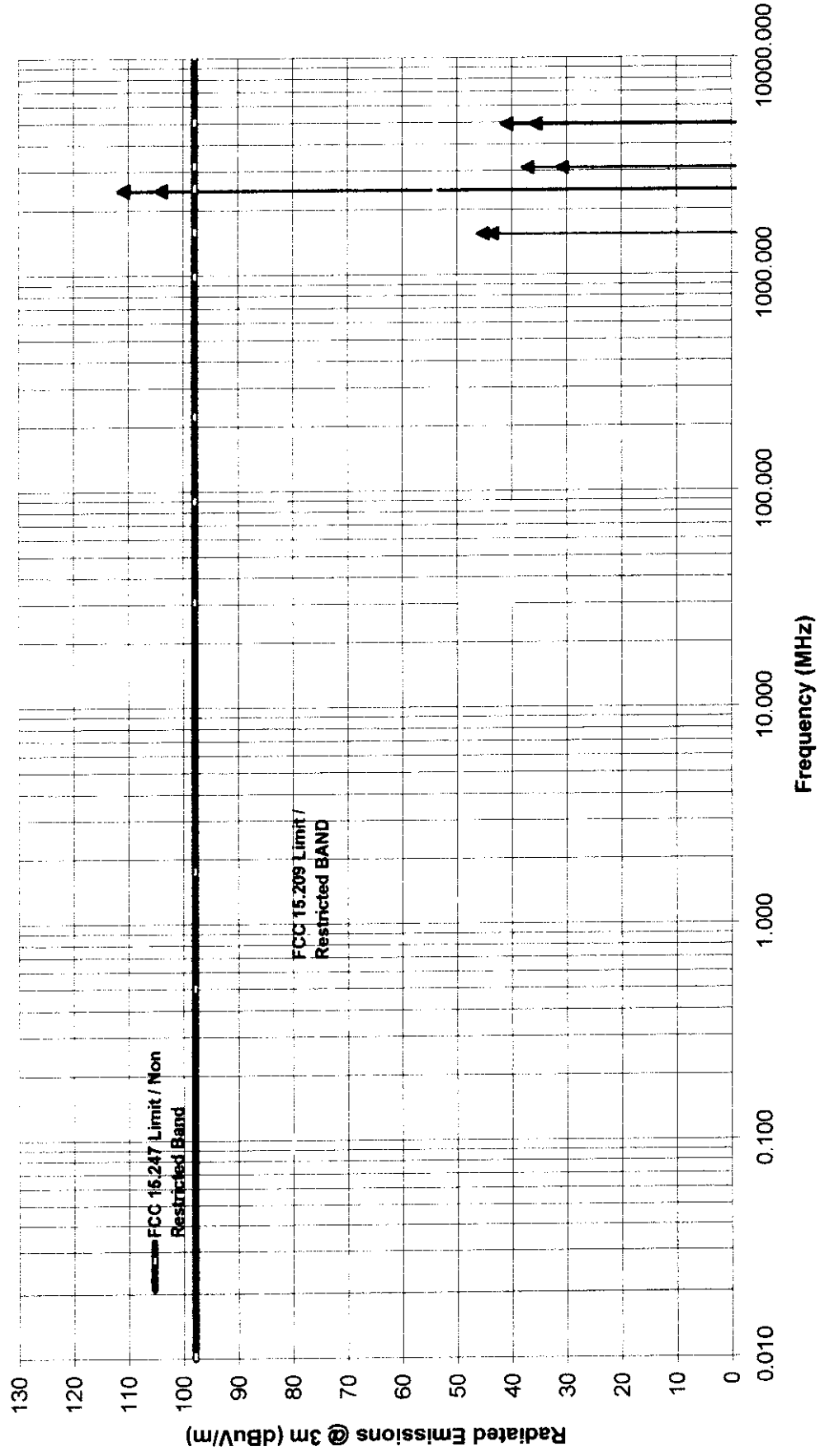
MKR 2.4620 GHz
110.83 dBμV

LOG 10 dB / #ATN 10 dB
REF OFFST 20.0 dB
REF 127.0 dBμV



CENTER 2.4620 GHz
#IF BW 1.0 MHz
#AVG BW 1 MHz
SPAN 200.0 MHz
SWP 20.0 msec

Transmitter Radiated Emissions Measurements at 3 Meter OFTS
InterAir ISP Direct Indoor (2401-01) and Outdoor (2401-02) Unit
Channel #17, Tx Freq.: 2462.0625 MHz, Tx Lo Freq.: 1547.0625 MHz





ISP DIRECT, MODEL 2401-01 (INDOOR) & 2401-02 (OUTDOOR)
Channel #: 18, Tx Frequency: 2464.875 MHz, RF Power: 0.19 W
Modulation: DSSS, BW: NARROW (4.5 Mc/s), 11 chips/symbol, 0.818 Mbps DQPSK

Transmitter Radiated
Emissions @ 3m

Date: Mar. 04/98
Tested by: Tri Liu

Antenna Polarization: VERTICAL

HP

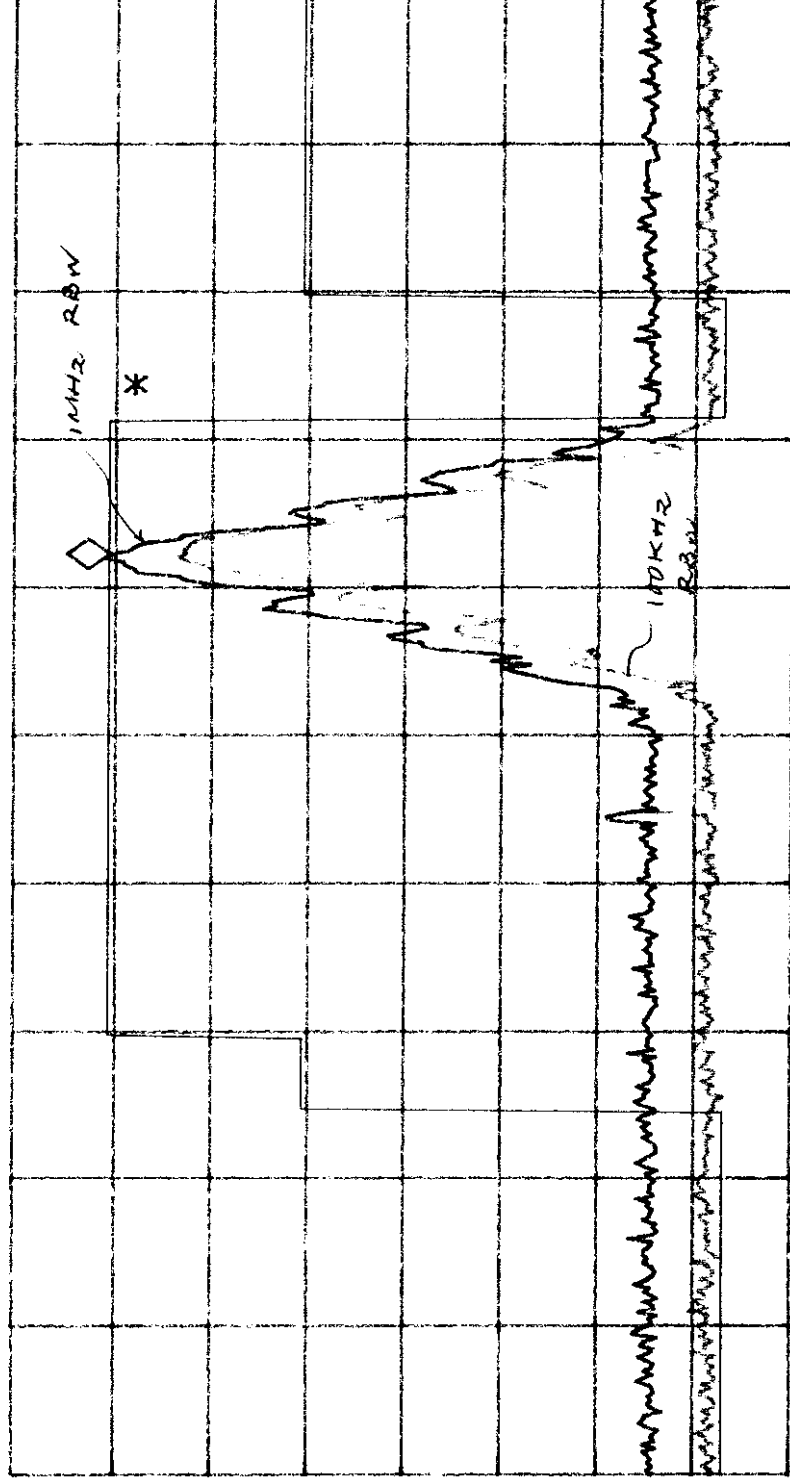
09:39:31 OCT 24, 1997 10:53:46 OCT 24, 1997

ACTV DET: PEAK No user
MEAS DET: PEAK QP AVG Menu

MKR 2.4655 GHz
117.12 dBμV

REF OFFST 20.0 dB
REF 127.0 dBμV

LOG 10
dB/
#ATN
10 dB



VA VB
SC FC
ACORR

CENTER 2.4410 GHz SPAN 200.0 MHz
#IF BW 1.0 MHz #AVG BW 1 MHz SWP 20.0 msec



ISP DIRECT, MODEL 2401-01 (INDOOR) & 2401-02 (OUTDOOR)
Channel #: 18, Tx Frequency: 2464.875 MHz, RF Power: 0.19 W
Modulation: DSSS, BW: NARROW (4.5 Mc/s), 11 chips/symbol, 0.818 Mbps DQPSK

Transmitter Radiated Emissions @ 3m

Antenna Polarization: *40° 20' 20" N 75° W*

Date: Mar. 04/98
Tested by: Tn Lau

hpo 09: 39: 31 OCT 24, 1997 10: 53: 46 OCT 24, 1997

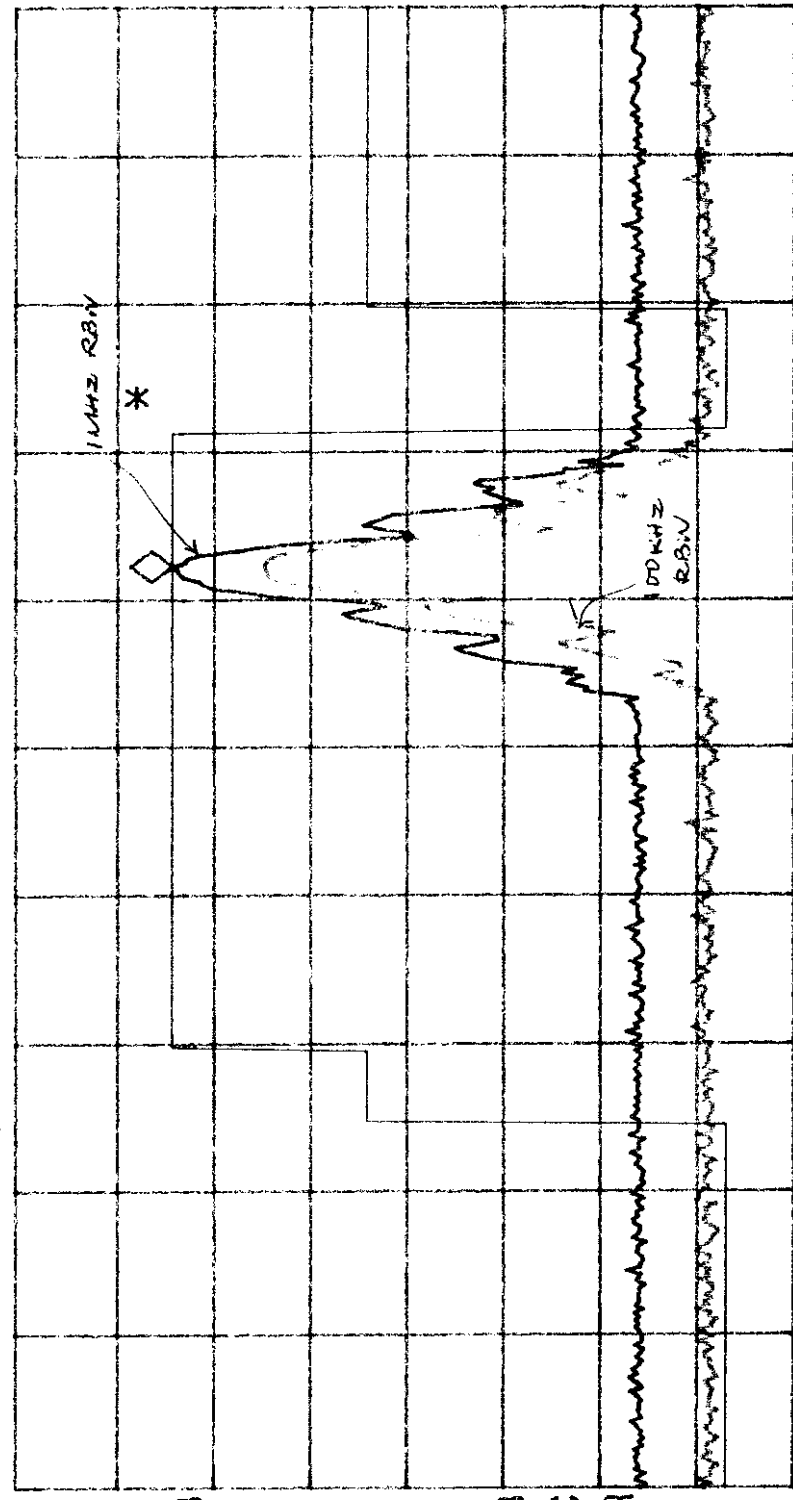
ACTV DET: PEAK
MEAS DET: PEAK QP AVG
LIMIT 1
ON OFF

MKR 2.4655 GHz
110.83 dBμV

MARGIN 1
ON OFF

REF OFFST 20.0 dB
REF 127.0 dBμV

LOG 10
dB/
#ATN
10 dB



VA VB
SC FC
ACORR

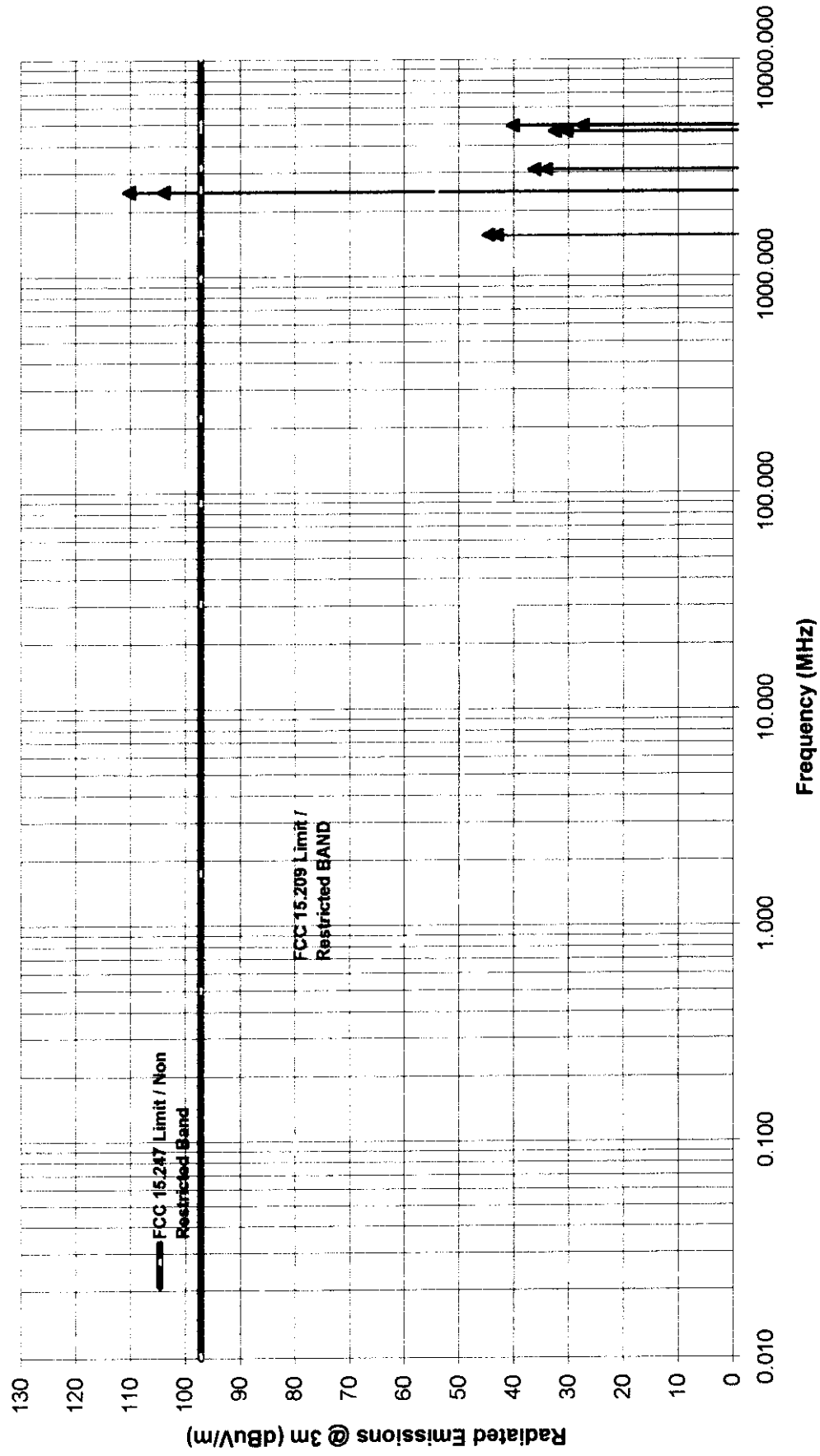
DELETE
LIMIT

EDIT
LIMIT

Previous
Menu

CENTER 2.4410 GHz
SPAN 200.0 MHz
#IF BW 1.0 MHz
#AVG BW 1 MHz
SWP 20.0 msec

Transmitter Radiated Emissions Measurements at 3 Meter OFTS
InterAir ISP Direct Indoor (2401-01) and Outdoor (2401-02) Unit
Channel #18, Tx Freq.: 2464.875 MHz, Tx Lo Freq.: 1549.875 MHz



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

PRODUCT NAME: ISP DIRECT INDOOR & OUTDOOR UNITS, Model No.: 2401-01 (indoor) and 2401-02 (outdoor)

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:

- Ambient temperature: 23 °C
- Relative humidity: 43 %

POWER INPUT:

AC 120 V 60Hz from Elpac external switching power supply, model WRI4232.

TEST EQUIPMENT:

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

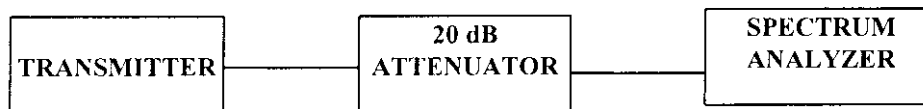
METHOD OF MEASUREMENT:

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 = 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.

- 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**)

TEST ARRANGEMENT**TEST RESULTS:** Conforms.**TEST PERSONNEL:** Mr. Tri M. Luu, P.Eng.**DATE:** Feb. 26 & Mar. 04, 1998**MEASUREMENT DATA:****TEST CONFIGURATION**

- The transmitter was coupled to the Spectrum Analyzer through a 20 dB attenuator.
- The insertion loss between the transmitter output terminal and the spectrum analyzer was measured to be 20 dB
- The channel frequencies were established on the extreme edges (both upper and lower) and middle of the 2408.625 - 2464.875 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 No.	Channel Frequency	Modulation Bandwidth	Data Rate (Mb/s)	Chips per Symbol	Measured Power Density in 3 kHz BW (dBm)	FCC Limit (dBm)
3	2408.625	Narrow	4.5	11	-1.0	8.0
9	2431.125	Wide	11.25	11	1.8	8.0
17	2462.0625	Medium	5.625	11	-3.2	8.0

- 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**)



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ISP DIRECT, MODEL 2401-01 (INDOOR) & 2401-02 (OUTDOOR)

Test Configuration #: 7, Tx Frequency: 2408.625 MHz, RF Power: 0.19 W

Modulation: DSSS, BW: NARROW (4.5 Mc/s), 11 chips/symbol, 0.818 Mbps DQPSK

Date: Feb. 26/98
Tested by: Tri Luu

Channel #3

SWEPTIME

100 sec

ACTV DET: PEAK

No user

MEAS DET: PEAK QP AVG

Menu

MKR 2.40438 GHZ

-1.82 dBm

REF OFFST 20.0 dB

REF 20.0 dBm

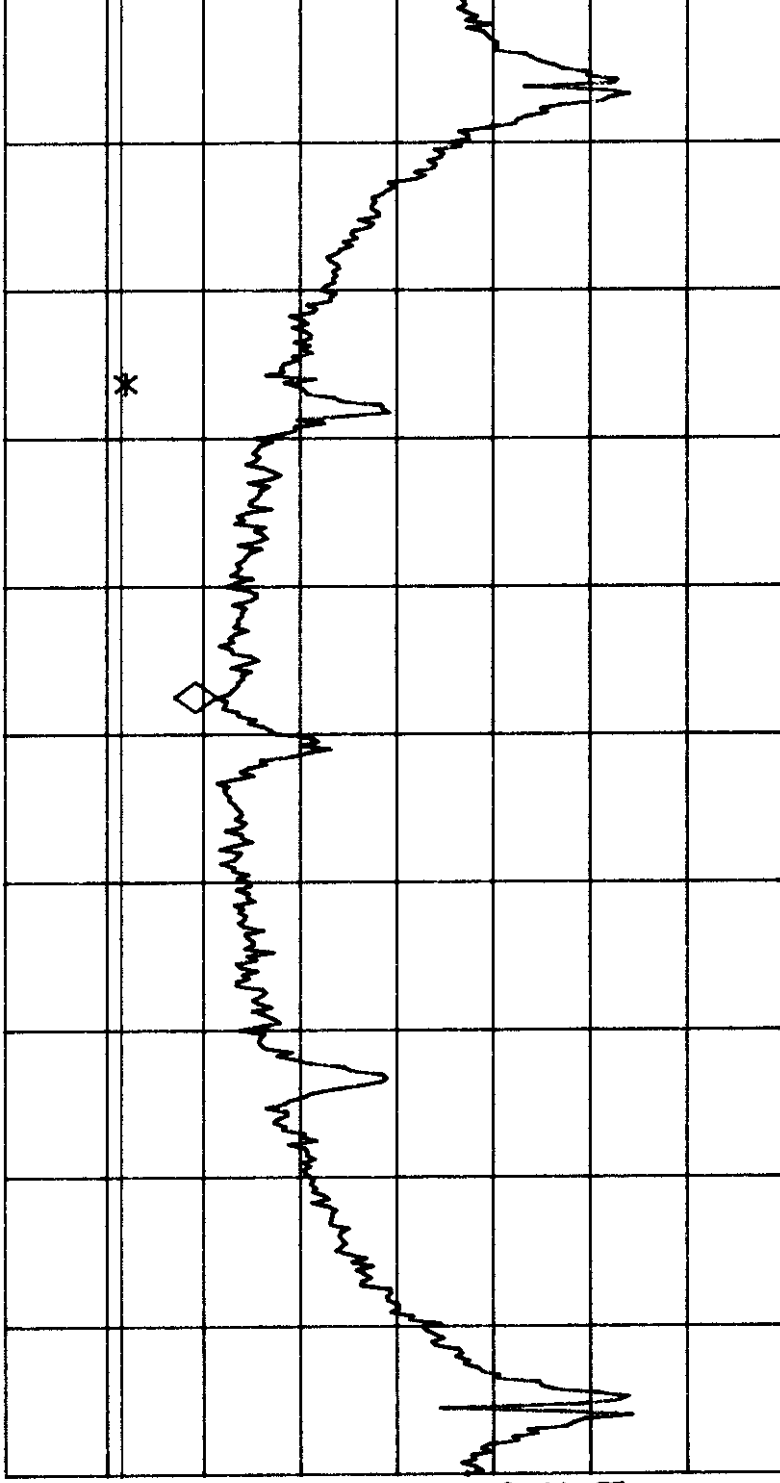
LOG

10

dB/

#ATN

10 dB



VA SB

SC FC

CORR

CENTER 2.40413 GHZ

#IF BW 3.0 KHZ

#AVG BW 300 KHZ

SPAN 10.00 MHZ

#SWP 100 sec



hpf

Date: Feb. 26/98
Tested by: Tri Luna

ISP DIRECT, MODEL 2401-01 (INDOOR) & 2401-02 (OUTDOOR)
Test Configuration #: 7, Tx Frequency: 2408.625 MHz, RF Power: 0.19 W
Modulation: DSSS, BW: NARROW (4.5 Mc/s), 11 chips/symbol, 0.818 Mbps DQPSK

Channel # 3

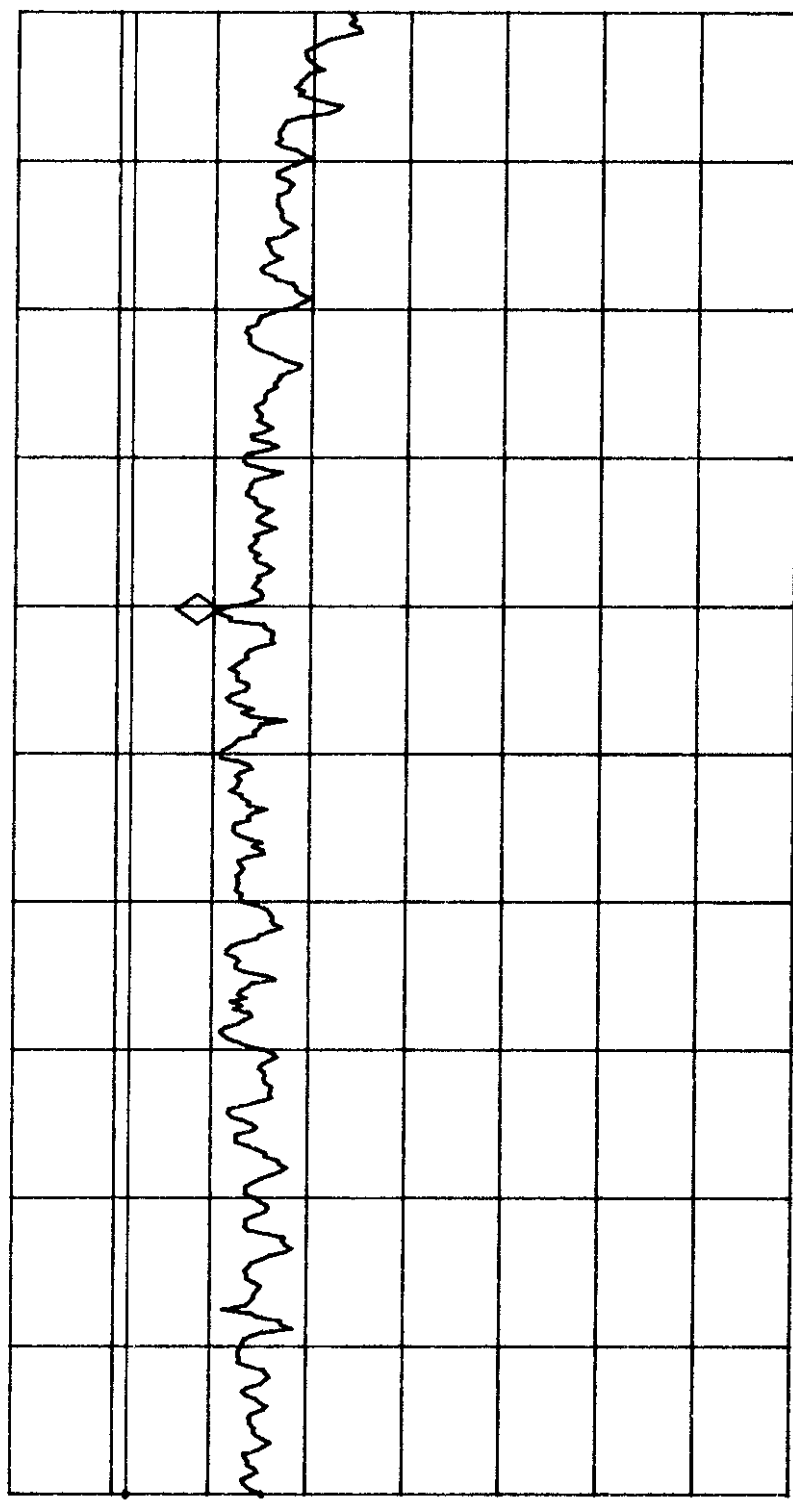
SWEPTIME
100 sec

ACTV DET: PEAK
MEAS DET: PEAK QP AVG
MKR 2.4038738 GHZ
- .95 dBm

No user
Menu

REF OFFST 20.0 dB
REF 20.0 dBm

LOG
10
dB/
#ATN
10 dB



VA SB
SC FC
CORR

CENTER 2.4038250 GHZ
#IF BW 3.0 KHZ
#AVG BW 300 KHZ
SPAN 500.0 KHZ
#SWP 100 sec



hp

ISP DIRECT, MODEL 2401-01 (INDOOR) & 2401-02 (OUTDOOR)
Test Configuration #: 2, Tx Frequency: 2431.13 MHz, RF Power: 0.19 W
Modulation: DSSS, BW: WIDE (11.25 Mc/s), 11 chips/symbol, 2.045 Mbps DQPSK

Date: Feb 26 /98
Tested by: Tri Luu

Channel #4

SPAN
20.00 MHz

ACTV DET: PEAK

No user
Menu

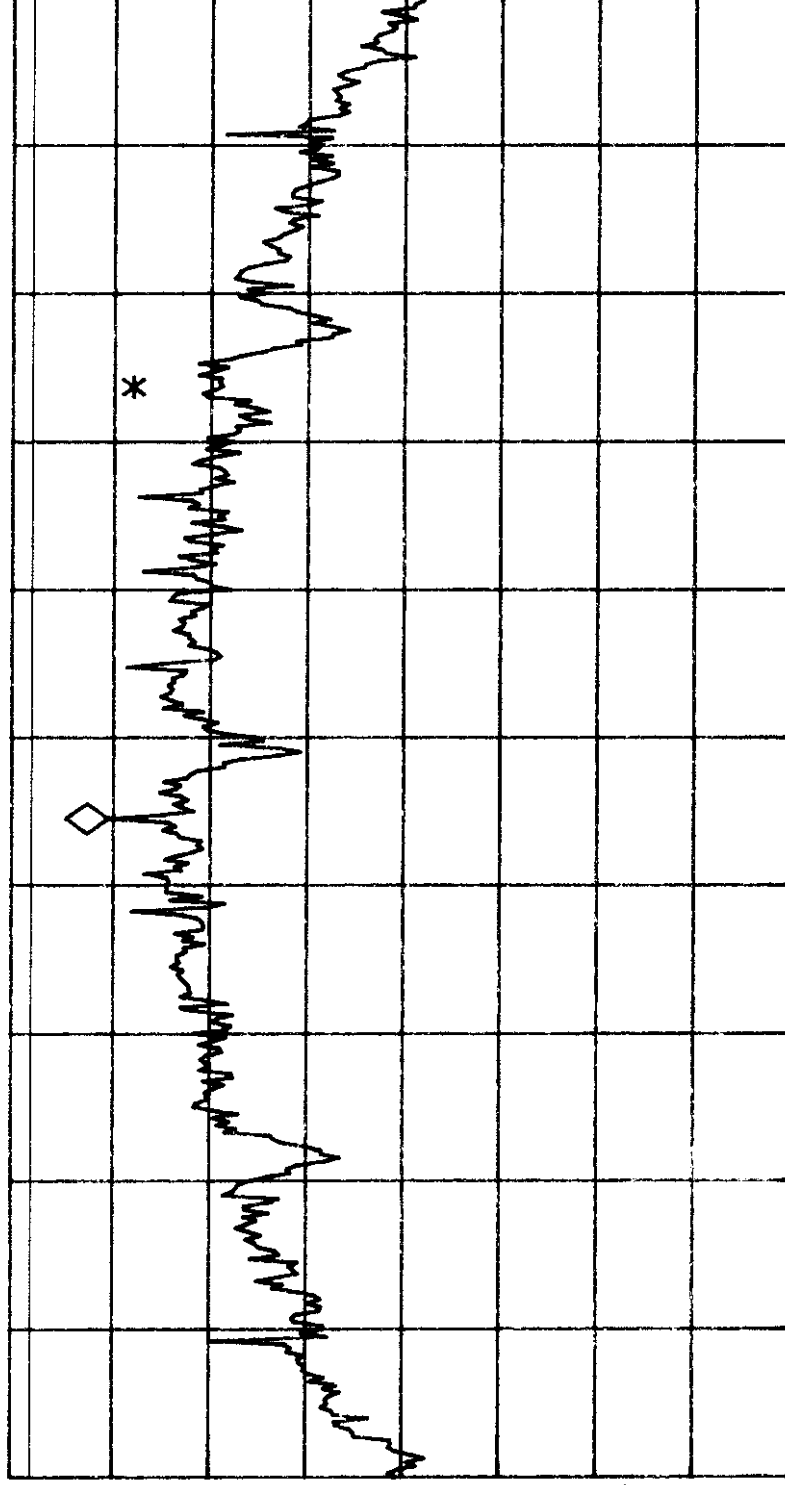
MEAS DET: PEAK QP AVG

MKR 2.43003 GHz
.03 dBm

REF OFFST 20.0 dB

REF 10.0 dBm

LOG
10
dB/
#ATN
10 dB



VA SB
SC FC
CORR

CENTER 2.43113 GHz

#IF BW 3.0 KHZ

#AVG BW 30 KHZ

SPAN 20.00 MHz
#SWP 100 sec



hp

ISP DIRECT, MODEL 2401-01 (INDOOR) & 2401-02 (OUTDOOR)
Test Configuration #: 21, Tx Frequency: 2433.775 MHz, RF Power: 0.19 W
Modulation: DSSS, BW: WIDE (11.25 Mc/s), 11 chips/symbol, 2.045 Mbps DQPSK

Date: Feb. 26 /98
Tested by: Tri Lau

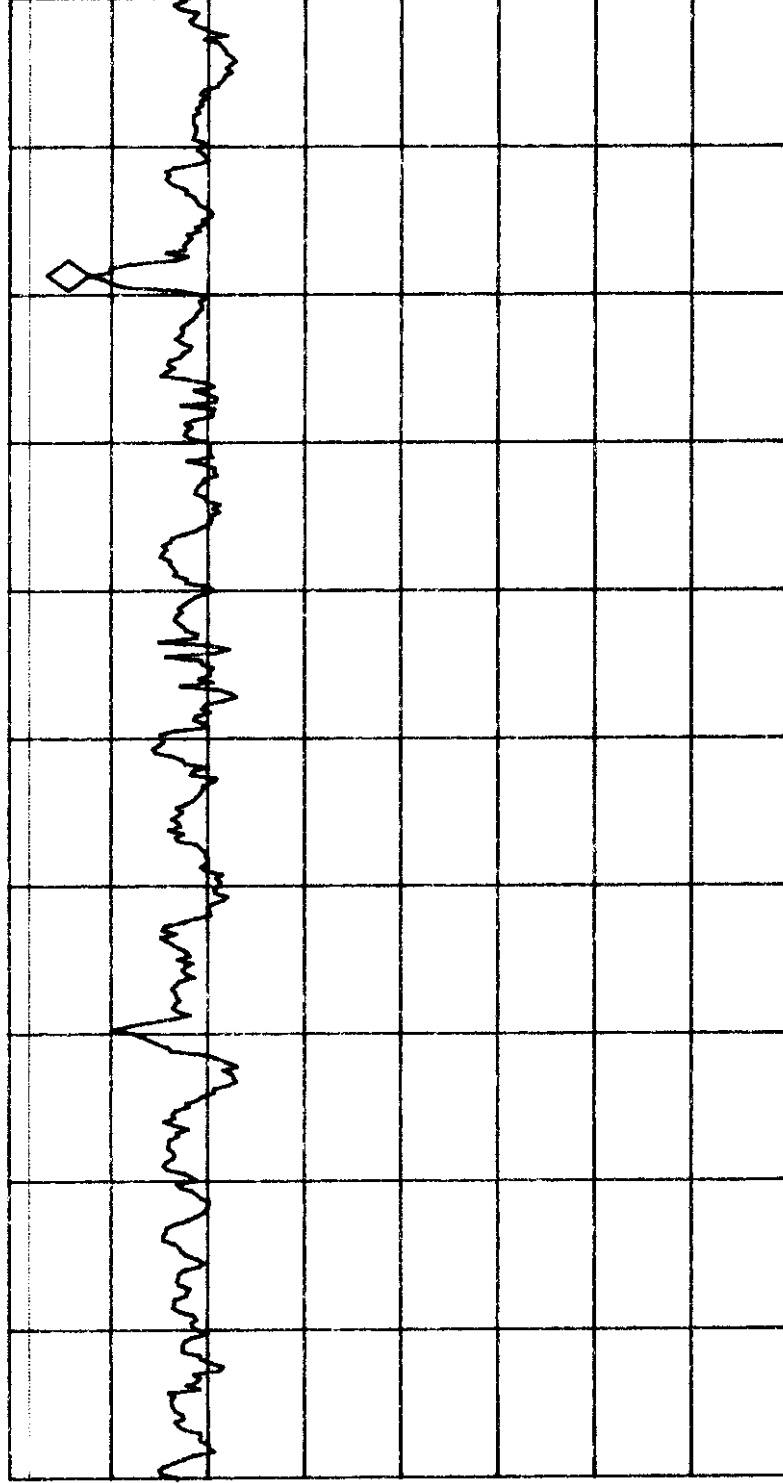
Channel #4

SWEPTIME
100 sec

ACTV DET: PEAK No user
MEAS DET: PEAK QP AVG Menu
MKR 2.4332338 GHz
1.77 dBm

REF OFFST 20.0 dB
REF 10.0 dBm

LOG
10
dB/
#ATN
10 dB



VA SB
SC FC
CORR

CENTER 2.4330775 GHz SPAN 500.0 KHZ
#IF BW 3.0 KHZ #AVG BW 30 KHZ #SWP 100 sec



hp

ISP DIRECT, MODEL 2401-01 (INDOOR) & 2401-02 (OUTDOOR)

Channel #: 17, Tx Frequency: 2464.875 MHz, RF Power: 0.19 W

Modulation: DSSS, BW: MEDIUM (5.625 Mc/s), 11 chips/symbol, 1.023 Mbps DQPSK

Date: Mar. 04/98
Tested by: Tri Lau

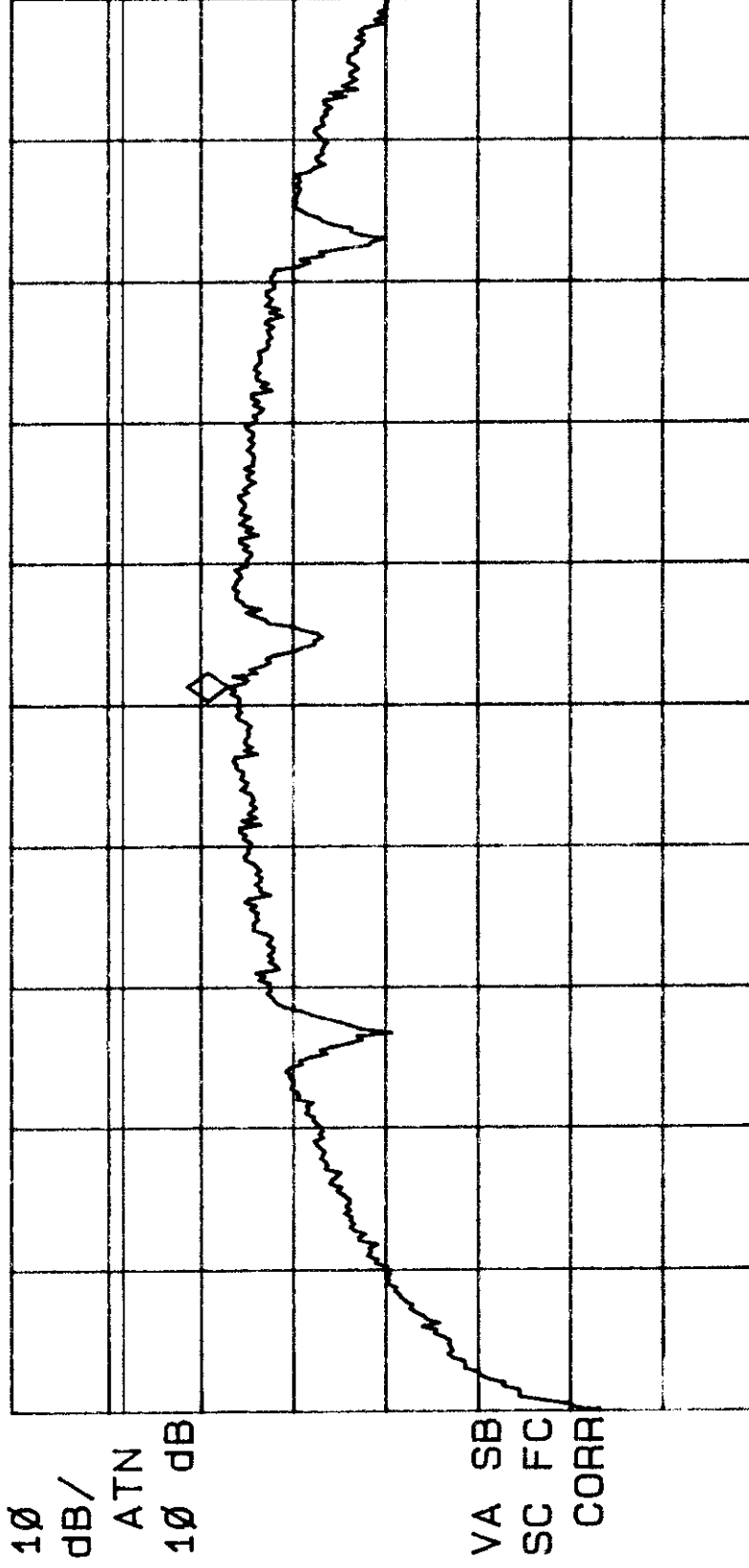
SWEPTIME
100 sec

ACTV DET: PEAK
MEAS DET: PEAK QP AVG

No user
Menu
MKR 2.46168 GHZ
-3.37 dBm

REF OFFST 20.0 dB

LOG REF 20.0 dBm



CENTER 2.46155 GHZ

#IF BW 3.0 KHZ

#AVG BW 300 KHZ

SPAN 10.00 MHZ

#SWP 100 sec



Date: Mar. 04/98
Tested by: Tri Luu

ISP DIRECT, MODEL 2401-01 (INDOOR) & 2401-02 (OUTDOOR)
Channel #: 17, Tx Frequency: 2464.875 MHz, RF Power: 0.19 W
Modulation: DSSS, BW: MEDIUM (5.625 Mc/s), 11 chips/symbol, 1.023 Mbps DQPSK

hp

SWEPTIME
30.0 sec

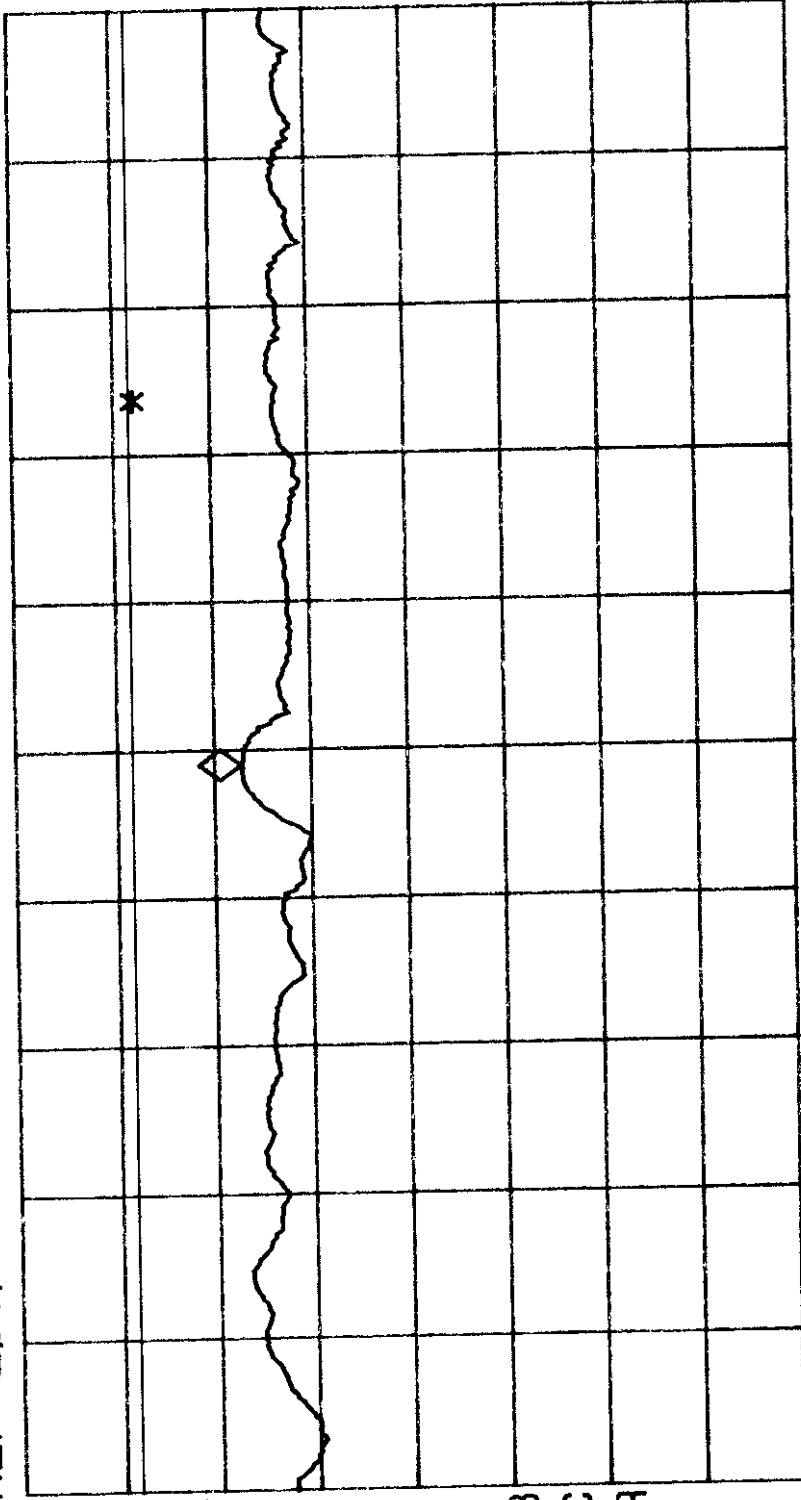
ACTV DET: PEAK
MEAS DET: PEAK QP AVG

No user
Menu

MKR 2.4617503 GHz
-3.18 dBm

REF OFFST 20.0 dB
REF 20.0 dBm

LOG
10
dB/
ATN
10 dB



VA SB
SC FC
CORR

CENTER 2.4617513 GHz
#IF BW 3.0 KHZ

SPAN 100.0 KHZ
#SWP 30.0 sec

#AVG BW 300 KHZ

4.6 Processing Gain of A Direct Sequence Spread Spectrum, FCC CFR 47, Para. 15.247(e)

PRODUCT NAME: ISP DIRECT INDOOR & OUTDOOR UNITS, Model No.: 2401-01 (indoor) and 2401-02 (outdoor)

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:

- Ambient temperature: 23 °C
- Relative humidity: 43 %

POWER INPUT:

AC 120 V 60Hz from Elpac external switching power supply, model WRI4232.

TEST EQUIPMENT:

- Advantest Spectrum Analyzer, Model R3271, S/N: 15050203
- Bird 20 dB Attenuator, 50 Ohm IN/OUT
- IBM PS/1 & IBM 350 ThinkPad Host Computer(s)
- 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.

METHOD OF MEASUREMENT:**METHOD #1:- 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 non-coherent receiver is calculated from:

$$(1) \quad P_e = 1/2e^{(-1/2(S/N)_o)}$$

where: P_e = probability of error (BER)
 $(S/N)_o$ = the required signal to noise ratio at the receiver output for a given received signal quality

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.

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

Where:

- (S/N)_o: 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 2 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 2 dB.

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

The Signal-to-Noise Ratio (S/N) with respect to the probability of bit error for a differentially QPSK (DQPSK) receiver in the presence of additive white Gaussian noise (AWGN) is given by Figure 4.5.1 as attached.

Ref.: Marvin Simon, Spread Spectrum Communication Handbook, page 695.

Since the CW jamming is a tone jamming, the (S/N)_o for a AWGN jamming obtained from Figure 4.5.1 can be converted to the CW jamming or tone jamming using the formula (3.97) of the Marvin Simon Spread Spectrum Communication Handbook as follows:

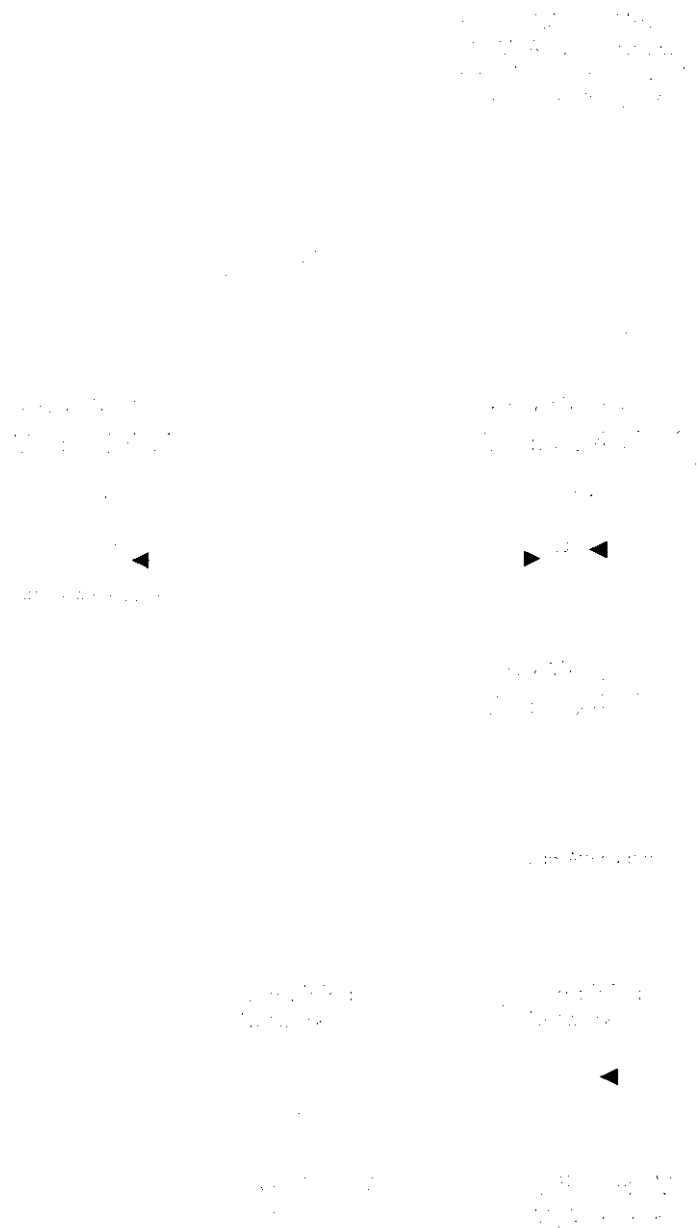
$$(S/N)_o^t \text{ in dB} = (S/N)_o^{AWGN} / 0.8$$

TEST RESULTS: Conforms.

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

DATE: Mar. 31 & Apr. 01, 1998

**Figure 1:- SETUP FOR PROCESSING GAIN MEASUREMENT
 - JAMMING MARGIN METHOD**



MEASUREMENT DATA:

Channel #4, $F_c = 2411.4375$ MHz	Data Rate = 1.023 Mbps (DQPSK), Medium
Chip Rate = 5.625 MHz	PN Code Length = 11 chips/symbol
6 dB BW = 5 MHz	

$(S/N)_o = 12 \text{ dB} / 0.8 = 15 \text{ dB}$ per attached Figure 4.5.1 and formula 3.97

Measured Processing Gain $G_p = (S/N)_o + L_{sys} + M_j = 15 + 2 + M_j = 17 + M_j \text{ (dB)}$

Theoretical Calculated Processing Gain = Chip Rate/Data rate = $\frac{5.625 \text{ MHz}}{(1.023 \text{ Mb/s})/(2 \text{ bits/symbol})} = 11.0 \text{ or } 10.4 \text{ dB}$

Note:

- Total Peak Power from the EUT's Tx measured at the EUT's Rx Input: $P_i = -46.7 \text{ dBm}$
- Jamming signal level at measured at the EUT's receiver input: J
- $M_j = J - P_i$
- The following shaded boxes are discarded worst measurements (17.7% of total measurement points)

SUMMARY OF TEST RESULTS	
Theoretical Process Gain	10.4 dB
Minimum Measured Process Gain with discard of 17.7% of the worst measurements	12.5 dB

Test Point	Jammer Signal Freq. +/- F_c (MHz)	(BER) (DQPSK)	(S/N) _o (dB)	System Loss L_{sys} (dB)	Jammer to Signal Ratio M_j (dB)	Measured Processing Gain (dB)
1	-3.50	0.00001	15.0	2.0	1.7	18.7
2	-3.45	0.00001	15.0	2.0	2.0	19.0
3	-3.40	0.00001	15.0	2.0	1.6	18.6
4	-3.35	0.00001	15.0	2.0	1.7	18.7
5	-3.30	0.00001	15.0	2.0	0.6	17.6
6	-3.25	0.00001	15.0	2.0	-0.4	16.6
7	-3.20	0.00001	15.0	2.0	-0.4	16.6
8	-3.15	0.00001	15.0	2.0	-0.4	16.6
9	-3.10	0.00001	15.0	2.0	0.0	17.0
10	-3.05	0.00001	15.0	2.0	0.8	17.8
11	-3.00	0.00001	15.0	2.0	0.8	17.8
12	-2.95	0.00001	15.0	2.0	1.6	18.6
13	-2.90	0.00001	15.0	2.0	1.6	18.6
14	-2.85	0.00001	15.0	2.0	1.7	18.7
15	-2.80	0.00001	15.0	2.0	1.5	18.5
16	-2.75	0.00001	15.0	2.0	1.1	18.1
17	-2.70	0.00001	15.0	2.0	0.8	17.8
18	-2.65	0.00001	15.0	2.0	0.7	17.7
19	-2.60	0.00001	15.0	2.0	-0.4	16.6
20	-2.55	0.00001	15.0	2.0	-2.4	14.6
21	-2.50	0.00001	15.0	2.0	-2.7	14.3
22	-2.45	0.00001	15.0	2.0	-2.8	14.2

Continued ...

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Test Point	Jammer Signal Freq. +/- Fc (MHz)	(BER) (DQPSK)	(S/N) _o (dB)	System Loss L _{sys} (dB)	Jammer to Signal Ratio M _j (dB)	Measured Processing Gain (dB)
23	-2.40	0.00001	15.0	2.0	-2.9	14.1
24	-2.35	0.00001	15.0	2.0	-2.9	14.1
25	-2.30	0.00001	15.0	2.0	-2.6	14.4
26	-2.25	0.00001	15.0	2.0	-2.6	14.4
27	-2.20	0.00001	15.0	2.0	-2.5	14.5
28	-2.15	0.00001	15.0	2.0	-2.9	14.1
29	-2.10	0.00001	15.0	2.0	-3.6	13.4
30	-2.05	0.00001	15.0	2.0	-4.4	12.6
31	-2.00	0.00001	15.0	2.0	-4.5	12.5
32	-1.95	0.00001	15.0	2.0	-4.6	12.4
33	-1.90	0.00001	15.0	2.0	-4.5	12.5
34	-1.85	0.00001	15.0	2.0	-4.8	12.2
35	-1.80	0.00001	15.0	2.0	-4.4	12.6
36	-1.75	0.00001	15.0	2.0	-3.8	13.2
37	-1.70	0.00001	15.0	2.0	-3.2	13.8
38	-1.65	0.00001	15.0	2.0	-3.1	13.9
39	-1.60	0.00001	15.0	2.0	-3.3	13.7
40	-1.55	0.00001	15.0	2.0	-4.0	13.0
41	-1.50	0.00001	15.0	2.0	-6.3	10.7
42	-1.45	0.00001	15.0	2.0	-5.4	11.6
43	-1.40	0.00001	15.0	2.0	-5.8	11.2
44	-1.35	0.00001	15.0	2.0	-5.0	12.0
45	-1.30	0.00001	15.0	2.0	-4.8	12.2
46	-1.25	0.00001	15.0	2.0	-4.3	12.7
47	-1.20	0.00001	15.0	2.0	-3.9	13.1
48	-1.15	0.00001	15.0	2.0	-3.8	13.2
49	-1.10	0.00001	15.0	2.0	-3.3	13.7
50	-1.05	0.00001	15.0	2.0	-3.8	13.2
51	-1.00	0.00001	15.0	2.0	-3.8	13.2
52	-0.95	0.00001	15.0	2.0	-4.6	12.4
53	-0.90	0.00001	15.0	2.0	-4.9	12.1
54	-0.85	0.00001	15.0	2.0	-5.1	11.9
55	-0.80	0.00001	15.0	2.0	-5.3	11.7
56	-0.75	0.00001	15.0	2.0	-5.3	11.7
57	-0.70	0.00001	15.0	2.0	-4.8	12.2
58	-0.65	0.00001	15.0	2.0	-4.0	13.0
59	-0.60	0.00001	15.0	2.0	-3.3	13.7
60	-0.55	0.00001	15.0	2.0	-2.7	14.3
61	-0.50	0.00001	15.0	2.0	-3.8	13.2
62	-0.45	0.00001	15.0	2.0	-4.2	12.8
63	-0.40	0.00001	15.0	2.0	-4.1	12.9
64	-0.35	0.00001	15.0	2.0	-4.0	13.0

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ISP DIRECT INDOOR & OUTDOOR UNITS, Model 2401-01 (indoor) and 2401-02 (outdoor)

FCC ID: NUX-ISP2401

65	-0.30	0.00001	15.0	2.0	-4.8	12.2
66	-0.25	0.00001	15.0	2.0	-3.3	13.7
67	-0.20	0.00001	15.0	2.0	-3.8	13.2
68	-0.15	0.00001	15.0	2.0	-3.6	13.4
69	-0.10	0.00001	15.0	2.0	-2.7	14.3
70	-0.05	0.00001	15.0	2.0	-3.0	14.0
71	0.00	0.00001	15.0	2.0	-3.3	13.7
72	0.05	0.00001	15.0	2.0	-5.0	12.0
73	0.10	0.00001	15.0	2.0	-4.6	12.4
74	0.15	0.00001	15.0	2.0	-4.6	12.4
75	0.20	0.00001	15.0	2.0	-4.5	12.5
76	0.25	0.00001	15.0	2.0	-4.7	12.3
77	0.30	0.00001	15.0	2.0	-4.5	12.5
78	0.35	0.00001	15.0	2.0	-5.0	12.0
79	0.40	0.00001	15.0	2.0	-5.0	12.0
80	0.45	0.00001	15.0	2.0	-4.6	12.4
81	0.50	0.00001	15.0	2.0	-4.6	12.4
82	0.55	0.00001	15.0	2.0	-4.2	12.8
83	0.60	0.00001	15.0	2.0	-5.0	12.0
84	0.65	0.00001	15.0	2.0	-4.6	12.4
85	0.70	0.00001	15.0	2.0	-4.2	12.8
86	0.75	0.00001	15.0	2.0	-4.4	12.6
87	0.80	0.00001	15.0	2.0	-4.3	12.7
88	0.85	0.00001	15.0	2.0	-4.2	12.8
89	0.90	0.00001	15.0	2.0	-4.5	12.5
90	0.95	0.00001	15.0	2.0	-4.5	12.5
91	1.00	0.00001	15.0	2.0	-4.1	12.9
92	1.05	0.00001	15.0	2.0	-3.7	13.3
93	1.10	0.00001	15.0	2.0	-3.9	13.1
94	1.15	0.00001	15.0	2.0	-4.0	13.0
95	1.20	0.00001	15.0	2.0	-3.8	13.2
96	1.25	0.00001	15.0	2.0	-4.1	12.9
97	1.30	0.00001	15.0	2.0	-4.4	12.6
98	1.35	0.00001	15.0	2.0	-4.7	12.3
99	1.40	0.00001	15.0	2.0	-4.2	12.8
100	1.45	0.00001	15.0	2.0	-4.7	12.3
101	1.50	0.00001	15.0	2.0	-4.6	12.4
102	1.55	0.00001	15.0	2.0	-2.5	14.5
103	1.60	0.00001	15.0	2.0	-2.2	14.8
104	1.65	0.00001	15.0	2.0	-2.2	14.8
105	1.70	0.00001	15.0	2.0	-3.8	13.2
106	1.75	0.00001	15.0	2.0	-2.6	14.4
107	1.80	0.00001	15.0	2.0	-2.8	14.2
108	1.85	0.00001	15.0	2.0	-2.8	14.2

Continued ...

UltraTech Engineering Labs Inc.

UltraTech's File #: IAW-004FTX

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Test Point	Jammer Signal Freq. +/- Fc (MHz)	(BER) (DQPSK)	(S/N) _o (dB)	System Loss L _{sys} (dB)	Jammer to Signal Ratio M _j (dB)	Measured Processing Gain (dB)
109	1.90	0.00001	15.0	2.0	-2.4	14.6
110	1.95	0.00001	15.0	2.0	-2.4	14.6
111	2.00	0.00001	15.0	2.0	-2.2	14.8
112	2.05	0.00001	15.0	2.0	-1.9	15.1
113	2.10	0.00001	15.0	2.0	-2.7	14.3
114	2.15	0.00001	15.0	2.0	-2.2	14.8
115	2.20	0.00001	15.0	2.0	-2.0	15.0
116	2.25	0.00001	15.0	2.0	-1.8	15.2
117	2.30	0.00001	15.0	2.0	-2.2	14.8
118	2.35	0.00001	15.0	2.0	-2.2	14.8
119	2.40	0.00001	15.0	2.0	-2.4	14.6
120	2.45	0.00001	15.0	2.0	-2.4	14.6
121	2.50	0.00001	15.0	2.0	-2.4	14.6
122	2.55	0.00001	15.0	2.0	-2.3	14.7
123	2.60	0.00001	15.0	2.0	-2.2	14.8
124	2.65	0.00001	15.0	2.0	-1.9	15.1
125	2.70	0.00001	15.0	2.0	0.9	17.9
126	2.75	0.00001	15.0	2.0	1.2	18.2
127	2.80	0.00001	15.0	2.0	1.0	18.0
128	2.85	0.00001	15.0	2.0	1.2	18.2
129	2.90	0.00001	15.0	2.0	1.0	18.0
130	2.95	0.00001	15.0	2.0	1.2	18.2
131	3.00	0.00001	15.0	2.0	0.8	17.8
132	3.05	0.00001	15.0	2.0	0.0	17.0
133	3.10	0.00001	15.0	2.0	-0.7	16.3
134	3.15	0.00001	15.0	2.0	-1.4	15.6
135	3.20	0.00001	15.0	2.0	-1.6	15.4
136	3.25	0.00001	15.0	2.0	-1.6	15.4
137	3.30	0.00001	15.0	2.0	-0.5	16.5
138	3.35	0.00001	15.0	2.0	0.0	17.0
139	3.40	0.00001	15.0	2.0	0.4	17.4
140	3.45	0.00001	15.0	2.0	0.7	17.7
141	3.50	0.00001	15.0	2.0	-0.1	16.9

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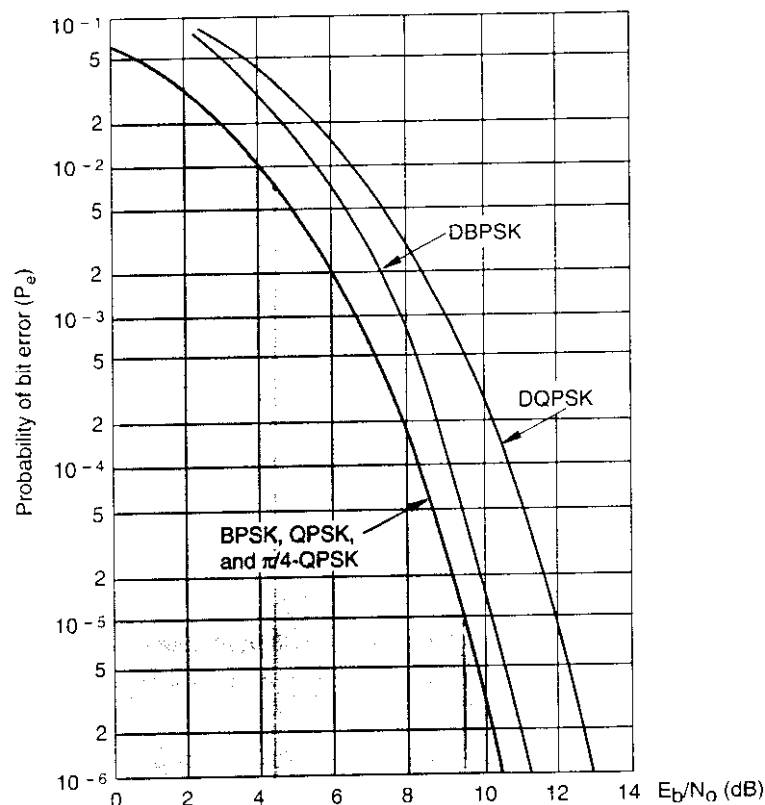


Figure 4.5.1 Theoretical $P_e = f(E_b/N_0)$ performance in a stationary additive white Gaussian noise (AWGN) environment. Ideal, linearly amplified coherent BPSK, QPSK, and differentially demodulated DBPSK systems are illustrated. The performance of non-linearly amplified FQPSK and GMSK is compared to ideal linearly amplified QPSK in Figures 4.3.33 and 4.3.34. (From Proakis, 1989.) See Appendix A.3.

tically equivalent term bit-error rate (BER) is used in applied references and specifications.

Power efficiency of modulated systems is defined as being inversely proportional to the

$$\text{BER} = f(C/N)$$

and/or

$$\text{BER} = f(E_b/N_0)$$

equations and performance curves, where E_b is the average energy of a modulated bit and N_0 is the noise power spectral density (the noise power in a normalized 1-Hz bandwidth) at the demodulator input. The higher the probability of error, the lower the power efficiency, since transmitted power is "wasted" on more bad data.

symbol rate and R_c/R_s represent the *processing gain associated with the spreading*, herein taken to be a larger integer I . It follows from the assumption of a large processing gain that the spread tone jammer possesses a fairly flat power spectral density within the data modulation bandwidth and is now caused to behave like a white noise jammer of spectral density

$$N'_f = J_0/R_c = J_0 T_c. \quad (3.87)$$

Using (3.4) and (3.5), we can rewrite (3.87) as

$$N'_f = J/\rho N R_c. \quad (3.88)$$

Since the hop frequency slots (assumed to be *contiguous*) must now be wide enough to accommodate the PN modulation, in terms of the total hop frequency band W_{ss} and the number of hop slots N in that band, we then have

$$N = W_{ss}/R_c. \quad (3.89)$$

Combining (3.88) and (3.89) gives

$$N'_f = \frac{J/W_{ss}}{\rho} = \frac{N_f}{\rho}, \quad (3.90)$$

which is identical to (3.63) (the case of FH/QPSK in the presence of partial-band noise jamming) *independent of the chip rate R_c* .

The above discussion concerns the spectral characteristics of the spread tone jammer which, as concluded, resembles a white noise jammer with identical spectral density. We shall now discuss the assumptions and the retical adjustments under which the spread tone jammer can also be treated as a *Gaussian* noise interference.

Consider an FH/PN/QPSK demodulator, similar to the one in Figure 3.2, where the despreading process now also includes a PN code correlator following the frequency dehopper. Let p represent the PN code length (in number of chips). Accounting for the effects of the spread jammer only (i.e., neglecting thermal noise), it follows that the decision variable z_I for the in-phase channel (see (3.11)) becomes

$$z_I = a_i \sqrt{\frac{S}{2}} T_s - \sqrt{J_0} \sin \theta_j C_{PN} \quad (3.91)$$

where

$$C_{PN} = \int_{(i-1)T_s}^{iT_s} c(t) dt \quad (3.92)$$

and $c(t)$ is the ± 1 -valued PN waveform. In deriving (3.91), ideal PN code synchronization at the receiver has been assumed. Recalling that the processing gain is the ratio of the PN chip rate to the data symbol rate, or equivalently $T_s/T_c = I$, then it follows that the integral in (3.92) amounts to a partial correlation of the PN code, starting from some random phase,

provided that the number I of integrations is large enough p . Phrased differently, the conclusion is that for in a weaker sense when $1 \ll I$ mod p is well known, the full-period integration of p in which case, no randomness about p is very large, successive code p independent, identically distributed ± 1 -valued random variables. The condition $I \ll p$ would provide a basis for the random variable C_{PN} . The fact that this binomial distribution to behave like a Gaussian. Arguments similar to the above were used in the evaluation of the performance of spread-spectrum systems. A more rigorous Gaussian assumption for C_{PN} has been used for Gold codes, with sufficient evidence to support it, for a wide class of such codes.

Let us now return to (3.91). Conditioned phase θ_j , z_I is, according to the above, whose conditional variance is

$$\text{var}\{z_I|\theta_j\} = T_s$$

Hence, when the jammer is present, the decision variable z_I for the in-phase channel (identically for the Q channel)

$$P_{b_I}^t = \frac{1}{2\pi} \int_0^{2\pi} Q\left(\sqrt{\frac{ST_s}{2T_c J_0}} \frac{1}{|\sin \theta_j|}\right) d\theta_j$$

where (3.18), (3.87), (3.90), and (3.93) have been used. Finally, multiplying (3.94) by ρ gives the bit error probability of FH/PN/QPSK in the presence of partial-band noise jamming, namely,

$$P_{b_I}^t = \frac{2\rho}{\pi} \int_0^{\pi/2} Q\left(\sqrt{\frac{ST_s}{2T_c J_0}} \frac{1}{\sin \theta_j}\right) d\theta_j$$

Although (3.95) can be used in as a basis for evaluating the tone interference effect of a spread tone jammer to an *equivalent* AWGN channel, it is understood in terms of its effect on bit error probability. The one-sided power spectral density of A and the characteristics remain the same after despreading. The error probability in this case is given by

$$P_{b_I}^s = Q\left(\sqrt{\frac{ST_s}{2T_c J_0}}\right)$$

processing gain associated with the PN integer I . It follows from the spread tone jammer possesses the data modulation bandwidth noise jammer of spectral density

$$J_0 T_c. \quad (3.87)$$

) as

$$R_c. \quad (3.88)$$

to be *contiguous*) must now be R_c on, in terms of the total hop slots N in that band, we then

$$c. \quad (3.89)$$

$$\frac{N_j}{\rho}, \quad (3.90)$$

FH/QPSK in the presence of the chip rate R_c .

ral characteristics of the spread tone jammer with discuss the assumptions and theorem one jammer can also be treated

r, similar to the one in Figure includes a PN code correlator present the PN code length (in of the spread jammer only (i.e., the decision variable z_I for the

$$\sin \theta_j C_{PN} \quad (3.91)$$

$$dt \quad (3.92)$$

deriving (3.91), ideal PN code assumed. Recalling that the rate to the data symbol rate, or integral in (3.92) amounts to g from some random phase,

provided that the number I of integrated chips does not equal the code length p . Phrased differently, the conclusions to follow hold when $1 \ll I \ll p$ (or in a weaker sense when $1 \ll I \text{ modulo } p \ll p$). This is because, as is well known, the full-period integration of a PN code equals the constant $1/p$, in which case, no randomness about C_{PN} exists. On the other hand, when p is very large, successive code chips can be considered almost independent, identically distributed ± 1 -valued random variables, in which case the condition $I \ll p$ would provide an approximate binomial distribution for the random variable C_{PN} . The additional constraint $I \gg 1$ then causes this binomial distribution to behave like a Gaussian distribution.

Arguments similar to the above were made in Chapter 1 in connection with the evaluation of the performance of pulse-jammed direct-sequence spread-spectrum systems. A more rigorous treatment of the validity of the Gaussian assumption for C_{PN} has been examined in [6] for a variety of PN and Gold codes, with sufficient evidence that it holds, at least approximately, for a wide class of such codes.

Let us now return to (3.91). Conditioned on the $(0, 2\pi)$ -uniformly distributed phase θ_j , z_I is, according to the above, a Gaussian random variable whose conditional variance is

$$\text{var}\{z_I|\theta_j\} = T_s T_c J_0 \sin^2 \theta_j. \quad (3.93)$$

Hence, when the jammer is present, the average bit error probability for the I channel (identically for the Q channel) is given by

$$P_{b_I}' = \frac{1}{2\pi} \int_0^{2\pi} Q\left(\sqrt{\frac{ST_s}{2T_c J_0}} \frac{1}{|\sin \theta_j|}\right) d\theta_j = \frac{2}{\pi} \int_0^{\pi/2} Q\left(\sqrt{\frac{\rho E_b}{N_j}} \frac{1}{\sin \theta_j}\right) d\theta_j \quad (3.94)$$

where (3.18), (3.87), (3.90), and (3.93) have been used in arriving at this result. Finally, multiplying (3.94) by ρ gives the average bit error probability of FH/PN/QPSK in the presence of partial-band multitone jamming, namely,

$$P_{b_I}' = \frac{2\rho}{\pi} \int_0^{\pi/2} Q\left(\sqrt{\frac{\rho E_b}{N_j}} \frac{1}{\sin \theta_j}\right) d\theta_j. \quad (3.95)$$

Although (3.95) can be used in assessing the effect of a spread tone jammer on system performance, we shall now indicate an even simpler way of evaluating the tone interference effect by means of converting the spread tone jammer to an *equivalent* AWGN interference, where the equivalence is understood in terms of its effect on bit error probability. Let N_{0_j} represent the one-sided power spectral density of AWGN interference whose statistical characteristics remain the same after the PN despreader. Clearly, the bit error probability in this case is given by

$$P_{b_I}'' = Q\left(\sqrt{\frac{2E_b}{N_{0_j}}}\right). \quad (3.96)$$

Equations (3.94) and (3.96) have been plotted in Figure 3.16. The abscissa is the signal-to-jammer power ratio SJR in decibels where, for the spread tone case $(\text{SJR})' = E_b/N_j$ while, for the noise case, $(\text{SJR})'' = E_b/N_{0j}$. A careful examination of Figure 3.16 reveals that, for values of $(\text{SJR})'$ up to approximately 12 dB, the difference $(\text{SJR})'_{(\text{dB})} - (\text{SJR})''_{(\text{dB})}$ between the signal-to-jammer ratios which achieve the same performance is, to a high degree of accuracy, linearly increasing with $(\text{SJR})'_{(\text{dB})}$, the slope of the line being 0.2. It is therefore concluded that, given a spread tone jammer of $(\text{SJR})'_{(\text{dB})}$, an

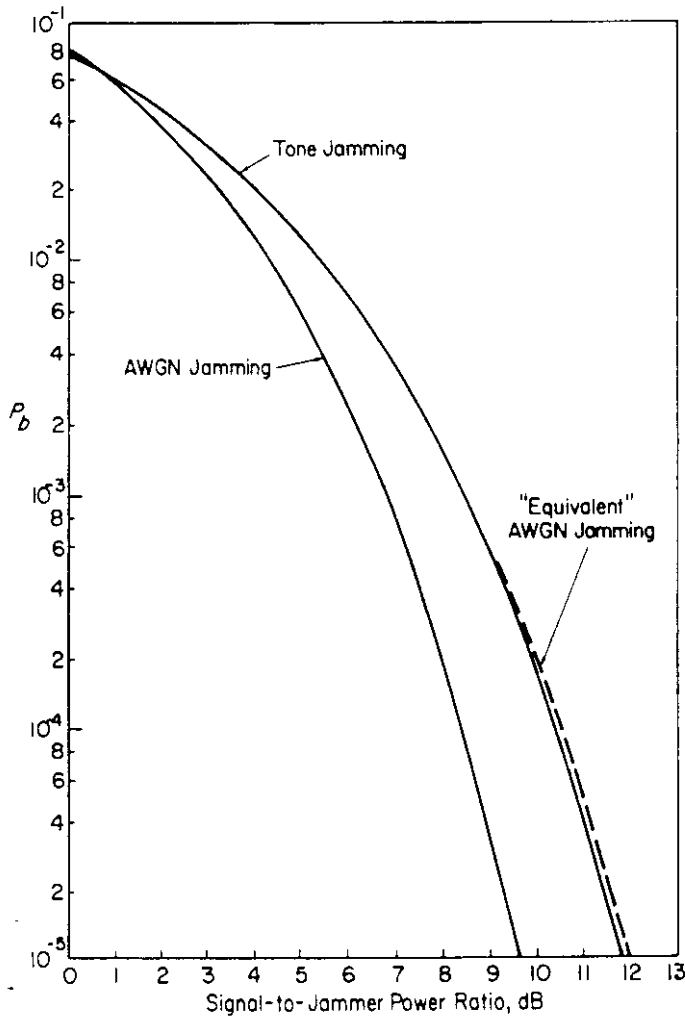


Figure 3.16. QPSK bit error probability versus $\text{SJR}_{(\text{dB})}$ for AWGN and tone jamming and spread tone "equivalent" AWGN jamming.

Performance of FH/PN/QPSK in the I

"equivalent" AWGN jammer can

$$(\text{SJR})''_{\text{equiv}(\text{dB})}$$

If the SJR's are measured in or
(3.97) implies that

$$(\text{SJR})''_{\text{equ}}$$

From (3.96) and (3.98), it then fol
conveniently thought of as an "
sponding bit error probability

$$P'_{bj} = Q$$

Equation (3.99) has been plotted
the high degree of agreement w
witnessed. The range of applicabi
more than adequate since, in th
present, the system is forced to op
especially true when the jamme
optimized). From (3.99), it follow
ability (accounting for partial-ban

$$P'_b = \rho Q$$

The worst case jammer can be l

$$\rho_{wc} = \begin{cases} \frac{0.9220}{E_b/N_j} \\ 1; \end{cases}$$

with corresponding

$$P'_{b_{\max}} = \begin{cases} \frac{0.0789}{E_b/N_j}; \\ Q\left(\sqrt{2\left(\frac{E_b}{N_j}\right)}\right) \end{cases}$$

A comparison of (3.102) with (3.73
FH/PN/QPSK is slightly less ef
FH/QPSK.

otted in Figure 3.16. The abscissa is decibels where, for the spread tone case, $(SJR)^n = E_b/N_{0j}$. A careful at, for values of $(SJR)'$ up to ap- $(SJR)'_{(dB)} - (SJR)^n_{(dB)}$ between the signal- performance is, to a high degree of $(SJR)'_{(dB)}$, the slope of the line being 0.2. spread tone jammer of $(SJR)'_{(dB)}$, an

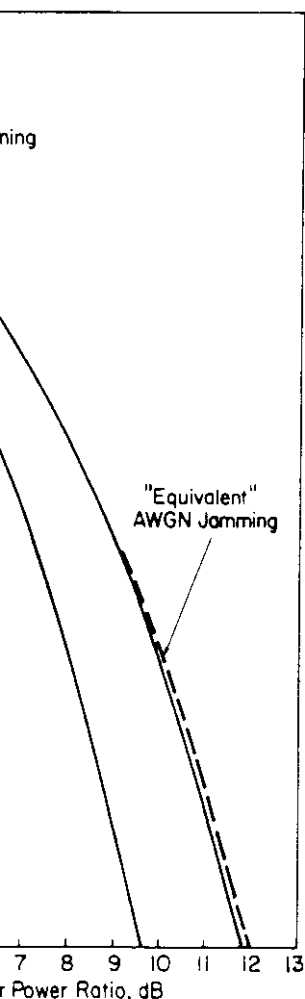


Figure 3.16. Comparison of P_b^t versus $SJR_{(dB)}$ for AWGN and tone jamming.

“equivalent” AWGN jammer can be devised for which

$$(SJR)_{equiv(dB)}^n = (0.8) \times (SJR)'_{(dB)}. \quad (3.97)$$

If the SJR's are measured in ordinary numbers rather than decibels, then (3.97) implies that

$$(SJR)_{equiv}^n = ((SJR)')^{0.8}. \quad (3.98)$$

From (3.96) and (3.98), it then follows that the spread tone jammer can be conveniently thought of as an “equivalent” AWGN jammer with corresponding bit error probability

$$P_{b_j}^t = Q \left(\sqrt{2 \left(\frac{\rho E_b}{N_j} \right)^{0.8}} \right). \quad (3.99)$$

Equation (3.99) has been plotted in Figure 3.16 (dashed lines), from which the high degree of agreement with the exact expression for $P_{b_j}^t$ can be witnessed. The range of applicability of (3.99) is, for the current purposes, more than adequate since, in the frequency bands where the jammer is present, the system is forced to operate at high bit error probabilities (this is especially true when the jammer strategy, i.e., choice of ρ , has been optimized). From (3.99), it follows that the overall average bit error probability (accounting for partial-band jamming) is given by

$$P_b^t = \rho Q \left(\sqrt{2 \left(\frac{\rho E_b}{N_j} \right)^{0.8}} \right). \quad (3.100)$$

The worst case jammer can be found from (3.100), with the result

$$\rho_{wc} = \begin{cases} \frac{0.9220}{E_b/N_j}; & E_b/N_j \geq 0.9220 \\ 1; & E_b/N_j < 0.9220 \end{cases} \quad (3.101)$$

with corresponding

$$P_{b_{max}}^t = \begin{cases} \frac{0.0789}{E_b/N_j}; & E_b/N_j \geq 0.9220 \\ Q \left(\sqrt{2 \left(\frac{E_b}{N_j} \right)^{0.8}} \right); & E_b/N_j < 0.9220. \end{cases} \quad (3.102)$$

A comparison of (3.102) with (3.73) indicates that the worst tone jammer for FH/PN/QPSK is slightly less effective than the worst noise jammer for FH/QPSK.

Channel #6, Fc = 2419.8750 MHz	Data Rate = 2.045 Mbps (DQPSK), Wide
Chip Rate = 11.25 MHz	PN Code Length = 11 chips/symbol
6 dB BW = 8.4 MHz	

$(S/N)_o = 12 \text{ dB} / 0.8 = 15 \text{ dB}$ per attached Figure 4.5.1 and formula 3.97

Measured Processing Gain $G_p = (S/N)_o + L_{sys} + M_j = 15 + 2 + M_j = 17 + M_j \text{ (dB)}$

Theoretical Calculated Processing Gain = Chip Rate/Data rate = $\frac{11.25 \text{ MHz}}{(2.045 \text{ Mb/s})/(2 \text{ bits/symbol})} = 11.0 \text{ or } 10.4 \text{ dB}$

Note:

- Total Peak Power from the EUT's Tx measured at the EUT's Rx Input: $P_i = -46.7 \text{ dBm}$
- Jamming signal level at measured at the EUT's receiver input: J
- $M_j = J - P_i$
- The following shaded boxes are discarded worst measurements (19.9% of total measurement points)

SUMMARY OF TEST RESULTS	
Theoretical Process Gain	10.4 dB
Minimum Measured Process Gain with discard of 19.9% of the worst measurements	11.1 dB

Test Point	Jammer Signal Freq. +/- Fc (MHz)	(BER) (DQPSK)	(S/N) _o (dB)	System Loss L _{sys} (dB)	Jammer to Signal Ratio M _j (dB)	Measured Processing Gain (dB)
1	-5.00	0.00001	15.0	2.0	-3.7	13.3
2	-4.95	0.00001	15.0	2.0	-4.2	12.8
3	-4.90	0.00001	15.0	2.0	-4.2	12.8
4	-4.85	0.00001	15.0	2.0	-4.6	12.4
5	-4.80	0.00001	15.0	2.0	-4.6	12.4
6	-4.75	0.00001	15.0	2.0	-4.1	12.9
7	-4.70	0.00001	15.0	2.0	-3.6	13.4
8	-4.65	0.00001	15.0	2.0	-3.6	13.4
9	-4.60	0.00001	15.0	2.0	-3.6	13.4
10	-4.55	0.00001	15.0	2.0	-3.5	13.5
11	-4.50	0.00001	15.0	2.0	-3.5	13.5
12	-4.45	0.00001	15.0	2.0	-3.4	13.6
13	-4.40	0.00001	15.0	2.0	-3.5	13.5
14	-4.35	0.00001	15.0	2.0	-3.6	13.4
15	-4.30	0.00001	15.0	2.0	-4.3	12.7
16	-4.25	0.00001	15.0	2.0	-4.9	12.1
17	-4.20	0.00001	15.0	2.0	-5.6	11.4
18	-4.15	0.00001	15.0	2.0	-5.7	11.3
19	-4.10	0.00001	15.0	2.0	-5.8	11.2
20	-4.05	0.00001	15.0	2.0	-5.8	11.2

Continued ...

Test Point	Jammer Signal Freq. +/- Fc (MHz)	(BER) (DQPSK)	(S/N) _o (dB)	System Loss L _{sys} (dB)	Jammer to Signal Ratio M _j (dB)	Measured Processing Gain (dB)
21	-4.00	0.00001	15.0	2.0	-6.2	10.8
22	-3.95	0.00001	15.0	2.0	-6.2	10.8
23	-3.90	0.00001	15.0	2.0	-6.2	10.8
24	-3.85	0.00001	15.0	2.0	-6.0	11.0
25	-3.80	0.00001	15.0	2.0	-6.0	11.0
26	-3.75	0.00001	15.0	2.0	-6.0	11.0
27	-3.70	0.00001	15.0	2.0	-6.0	11.0
28	-3.65	0.00001	15.0	2.0	-6.0	11.0
29	-3.60	0.00001	15.0	2.0	-6.0	11.0
30	-3.55	0.00001	15.0	2.0	-5.0	12.0
31	-3.50	0.00001	15.0	2.0	-5.2	11.8
32	-3.45	0.00001	15.0	2.0	-5.0	12.0
33	-3.40	0.00001	15.0	2.0	-4.8	12.2
34	-3.35	0.00001	15.0	2.0	-5.0	12.0
35	-3.30	0.00001	15.0	2.0	-5.4	11.6
36	-3.25	0.00001	15.0	2.0	-7.2	9.8
37	-3.20	0.00001	15.0	2.0	-8.0	9.0
38	-3.15	0.00001	15.0	2.0	-8.0	9.0
39	-3.10	0.00001	15.0	2.0	-8.0	9.0
40	-3.05	0.00001	15.0	2.0	-8.0	9.0
41	-3.00	0.00001	15.0	2.0	-7.9	9.1
42	-2.95	0.00001	15.0	2.0	-7.2	9.8
43	-2.90	0.00001	15.0	2.0	-7.2	9.8
44	-2.85	0.00001	15.0	2.0	-6.7	10.3
45	-2.80	0.00001	15.0	2.0	-6.2	10.8
46	-2.75	0.00001	15.0	2.0	-6.0	11.0
47	-2.70	0.00001	15.0	2.0	-6.0	11.0
48	-2.65	0.00001	15.0	2.0	-5.8	11.2
49	-2.60	0.00001	15.0	2.0	-5.8	11.2
50	-2.55	0.00001	15.0	2.0	-5.8	11.2
51	-2.50	0.00001	15.0	2.0	-5.4	11.6
52	-2.45	0.00001	15.0	2.0	-5.0	12.0
53	-2.40	0.00001	15.0	2.0	-5.0	12.0
54	-2.35	0.00001	15.0	2.0	-5.0	12.0
55	-2.30	0.00001	15.0	2.0	-4.6	12.4
56	-2.25	0.00001	15.0	2.0	-4.8	12.2
57	-2.20	0.00001	15.0	2.0	-5.1	11.9
58	-2.15	0.00001	15.0	2.0	-5.2	11.8
59	-2.10	0.00001	15.0	2.0	-5.4	11.6
60	-2.05	0.00001	15.0	2.0	-5.8	11.2

Continued...

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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**)

Test Point	Jammer Signal Freq. +/- Fc (MHz)	(BER) (DQPSK)	(S/N) _o (dB)	System Loss L _{sys} (dB)	Jammer to Signal Ratio Mj (dB)	Measured Processing Gain (dB)
61	-2.00	0.00001	15.0	2.0	-5.8	11.2
62	-1.95	0.00001	15.0	2.0	-6.4	10.6
63	-1.90	0.00001	15.0	2.0	-6.1	10.9
64	-1.85	0.00001	15.0	2.0	-5.4	11.6
65	-1.80	0.00001	15.0	2.0	-5.3	11.7
66	-1.75	0.00001	15.0	2.0	-5.5	11.5
67	-1.70	0.00001	15.0	2.0	-5.6	11.4
68	-1.65	0.00001	15.0	2.0	-5.5	11.5
69	-1.60	0.00001	15.0	2.0	-5.4	11.6
70	-1.55	0.00001	15.0	2.0	-4.5	12.5
71	-1.50	0.00001	15.0	2.0	-5.8	11.2
72	-1.45	0.00001	15.0	2.0	-4.4	12.6
73	-1.40	0.00001	15.0	2.0	-4.9	12.1
74	-1.35	0.00001	15.0	2.0	-4.9	12.1
75	-1.30	0.00001	15.0	2.0	-5.1	11.9
76	-1.25	0.00001	15.0	2.0	-5.2	11.8
77	-1.20	0.00001	15.0	2.0	-5.1	11.9
78	-1.15	0.00001	15.0	2.0	-5.4	11.6
79	-1.10	0.00001	15.0	2.0	-5.6	11.4
80	-1.05	0.00001	15.0	2.0	-5.6	11.4
81	-1.00	0.00001	15.0	2.0	-5.6	11.4
82	-0.95	0.00001	15.0	2.0	-5.9	11.1
83	-0.90	0.00001	15.0	2.0	-6.5	10.5
84	-0.85	0.00001	15.0	2.0	-6.8	10.2
85	-0.80	0.00001	15.0	2.0	-6.9	10.1
86	-0.75	0.00001	15.0	2.0	-6.6	10.4
87	-0.70	0.00001	15.0	2.0	-6.9	10.1
88	-0.65	0.00001	15.0	2.0	-6.9	10.1
89	-0.60	0.00001	15.0	2.0	-6.9	10.1
90	-0.55	0.00001	15.0	2.0	-6.7	10.3
91	-0.50	0.00001	15.0	2.0	-6.7	10.3
92	-0.45	0.00001	15.0	2.0	-5.8	11.2
93	-0.40	0.00001	15.0	2.0	-5.1	11.9
94	-0.35	0.00001	15.0	2.0	-5.1	11.9
95	-0.30	0.00001	15.0	2.0	-5.1	11.9
96	-0.25	0.00001	15.0	2.0	-5.1	11.9
97	-0.20	0.00001	15.0	2.0	-5.1	11.9
98	-0.15	0.00001	15.0	2.0	-5.5	11.5

Continued ...

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

Test Point	Jammer Signal Freq. +/- Fc (MHz)	(BER) (DQPSK)	(S/N) _o (dB)	System Loss L _{sys} (dB)	Jammer to Signal Ratio M _j (dB)	Measured Processing Gain (dB)
99	-0.10	0.00001	15.0	2.0	-6.3	10.7
100	-0.05	0.00001	15.0	2.0	-6.7	10.3
101	0.00	0.00001	15.0	2.0	-6.5	10.5
102	0.05	0.00001	15.0	2.0	-6.6	10.4
103	0.10	0.00001	15.0	2.0	-6.5	10.5
104	0.15	0.00001	15.0	2.0	-5.7	11.3
105	0.20	0.00001	15.0	2.0	-5.2	11.8
106	0.25	0.00001	15.0	2.0	-5.0	12.0
107	0.30	0.00001	15.0	2.0	-5.1	11.9
108	0.35	0.00001	15.0	2.0	-5.3	11.7
109	0.40	0.00001	15.0	2.0	-5.5	11.5
110	0.45	0.00001	15.0	2.0	-5.5	11.5
111	0.50	0.00001	15.0	2.0	-5.7	11.3
112	0.55	0.00001	15.0	2.0	-5.7	11.3
113	0.60	0.00001	15.0	2.0	-5.7	11.3
114	0.65	0.00001	15.0	2.0	-5.7	11.3
115	0.70	0.00001	15.0	2.0	-5.6	11.4
116	0.75	0.00001	15.0	2.0	-6.1	10.9
117	0.80	0.00001	15.0	2.0	-6.1	10.9
118	0.85	0.00001	15.0	2.0	-6.1	10.9
119	0.90	0.00001	15.0	2.0	-6.1	10.9
120	0.95	0.00001	15.0	2.0	-5.5	11.5
121	1.00	0.00001	15.0	2.0	-5.5	11.5
122	1.05	0.00001	15.0	2.0	-5.3	11.7
123	1.10	0.00001	15.0	2.0	-5.3	11.7
124	1.15	0.00001	15.0	2.0	-4.8	12.2
125	1.20	0.00001	15.0	2.0	-5.3	11.7
126	1.25	0.00001	15.0	2.0	-5.3	11.7
127	1.30	0.00001	15.0	2.0	-4.8	12.2
128	1.35	0.00001	15.0	2.0	-4.7	12.3
129	1.40	0.00001	15.0	2.0	-4.6	12.4
130	1.45	0.00001	15.0	2.0	-4.9	12.1
131	1.50	0.00001	15.0	2.0	-4.9	12.1
132	1.55	0.00001	15.0	2.0	-5.5	11.5
133	1.60	0.00001	15.0	2.0	-6.0	11.0
134	1.65	0.00001	15.0	2.0	-5.8	11.2
135	1.70	0.00001	15.0	2.0	-5.5	11.5
136	1.75	0.00001	15.0	2.0	-5.4	11.6
137	1.80	0.00001	15.0	2.0	-5.7	11.3
138	1.85	0.00001	15.0	2.0	-5.7	11.3

Continued ...

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Test Point	Jammer Signal Freq. +/- Fc (MHz)	(BER) (DQPSK)	(S/N) _o (dB)	System Loss L _{sys} (dB)	Jammer to Signal Ratio M _j (dB)	Measured Processing Gain (dB)
139	1.90	0.00001	15.0	2.0	-5.5	11.5
140	1.95	0.00001	15.0	2.0	-5.7	11.3
141	2.00	0.00001	15.0	2.0	-5.2	11.8
142	2.05	0.00001	15.0	2.0	-4.7	12.3
143	2.10	0.00001	15.0	2.0	-4.3	12.7
144	2.15	0.00001	15.0	2.0	-4.2	12.8
145	2.20	0.00001	15.0	2.0	-4.4	12.6
146	2.25	0.00001	15.0	2.0	-4.9	12.1
147	2.30	0.00001	15.0	2.0	-5.1	11.9
148	2.35	0.00001	15.0	2.0	-5.1	11.9
149	2.40	0.00001	15.0	2.0	-5.1	11.9
150	2.45	0.00001	15.0	2.0	-5.1	11.9
151	2.50	0.00001	15.0	2.0	-5.2	11.8
152	2.55	0.00001	15.0	2.0	-5.3	11.7
153	2.60	0.00001	15.0	2.0	-5.3	11.7
154	2.65	0.00001	15.0	2.0	-5.4	11.6
155	2.70	0.00001	15.0	2.0	-5.3	11.7
156	2.75	0.00001	15.0	2.0	-5.4	11.6
157	2.80	0.00001	15.0	2.0	-5.4	11.6
158	2.85	0.00001	15.0	2.0	-5.5	11.5
159	2.90	0.00001	15.0	2.0	-5.8	11.2
160	2.95	0.00001	15.0	2.0	-5.9	11.1
161	3.00	0.00001	15.0	2.0	-5.9	11.1
162	3.05	0.00001	15.0	2.0	-5.9	11.1
163	3.10	0.00001	15.0	2.0	-5.5	11.5
164	3.15	0.00001	15.0	2.0	-5.5	11.5
165	3.20	0.00001	15.0	2.0	-5.5	11.5
166	3.25	0.00001	15.0	2.0	-5.7	11.3
167	3.30	0.00001	15.0	2.0	-5.7	11.3
168	3.35	0.00001	15.0	2.0	-5.7	11.3
169	3.40	0.00001	15.0	2.0	-5.6	11.4
170	3.45	0.00001	15.0	2.0	-5.9	11.1
171	3.50	0.00001	15.0	2.0	-5.9	11.1
172	3.55	0.00001	15.0	2.0	-5.5	11.5
173	3.60	0.00001	15.0	2.0	-5.5	11.5
174	3.65	0.00001	15.0	2.0	-5.5	11.5
175	3.70	0.00001	15.0	2.0	-5.5	11.5
176	3.75	0.00001	15.0	2.0	-5.5	11.5
177	3.80	0.00001	15.0	2.0	-4.8	12.2
178	3.85	0.00001	15.0	2.0	-4.9	12.1

Continued ...

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Test Point	Jammer Signal Freq. +/- Fc (MHz)	(BER) (DQPSK)	(S/N) _o (dB)	System Loss L _{sys} (dB)	Jammer to Signal Ratio M _j (dB)	Measured Processing Gain (dB)
179	3.90	0.00001	15.0	2.0	-4.9	12.1
180	3.95	0.00001	15.0	2.0	-4.9	12.1
181	4.00	0.00001	15.0	2.0	-4.9	12.1
182	4.05	0.00001	15.0	2.0	-4.9	12.1
183	4.10	0.00001	15.0	2.0	-4.5	12.5
184	4.15	0.00001	15.0	2.0	-4.5	12.5
185	4.20	0.00001	15.0	2.0	-4.1	12.9
186	4.25	0.00001	15.0	2.0	-4.1	12.9
187	4.30	0.00001	15.0	2.0	-3.9	13.1
188	4.35	0.00001	15.0	2.0	-3.9	13.1
189	4.40	0.00001	15.0	2.0	-3.9	13.1
190	4.45	0.00001	15.0	2.0	-3.9	13.1
191	4.50	0.00001	15.0	2.0	-3.7	13.3
192	4.55	0.00001	15.0	2.0	-3.7	13.3
193	4.60	0.00001	15.0	2.0	-3.7	13.3
194	4.65	0.00001	15.0	2.0	-3.7	13.3
195	4.70	0.00001	15.0	2.0	-3.7	13.3
196	4.75	0.00001	15.0	2.0	-3.7	13.3
197	4.80	0.00001	15.0	2.0	-3.7	13.3
198	4.85	0.00001	15.0	2.0	-3.7	13.3
199	4.90	0.00001	15.0	2.0	-3.7	13.3
200	4.95	0.00001	15.0	2.0	-3.7	13.3
201	5.00	0.00001	15.0	2.0	-3.3	13.7

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Channel #18, Fc = 2464.8750 MHz	Data Rate = 0.818 Mbps (DQPSK), Narrow
Chip Rate = 4.5 MHz	PN Code Length = 11 chips/symbol
6 dB BW = 4 MHz	

$(S/N)_o = 12 \text{ dB} / 0.8 = 15 \text{ dB}$ per attached Figure 4.5.1 and formula 3.97

Measured Processing Gain $G_p = (S/N)_o + L_{sys} + M_j = 15 + 2 + M_j = 17 + M_j \text{ (dB)}$

Theoretical Calculated Processing Gain = Chip Rate/Data rate = $\frac{4.5 \text{ MHz}}{(0.818 \text{ Mb/s})/(2 \text{ bits/symbol})} = 11 \text{ or } 10.4 \text{ dB}$

Note:

- Total Peak Power from the EUT's Tx measured at the EUT's Rx Input: $P_t = -49.9 \text{ dBm}$
- Jamming signal level at measured at the EUT's receiver input: J
- $M_j = J - P_t$
- The following shaded boxes are discarded worst measurements (18.8% of total measurement points)

SUMMARY OF TEST RESULTS	
Theoretical Process Gain	10.4 dB
Minimum Measured Process Gain with discard of 18.8% of the worst measurements	11.2 dB

Test Point	Jammer Signal Freq. +/- Fc (MHz)	(BER) (DQPSK)	(S/N) _o (dB)	System Loss L _{sys} (dB)	Jammer to Signal Ratio M _j (dB)	Measured Processing Gain (dB)
1	-2.50	0.00001	15.0	2.0	-1.0	16.0
2	-2.45	0.00001	15.0	2.0	-1.1	15.9
3	-2.40	0.00001	15.0	2.0	-0.1	16.9
4	-2.35	0.00001	15.0	2.0	0.0	17.0
5	-2.30	0.00001	15.0	2.0	0.8	17.8
6	-2.25	0.00001	15.0	2.0	1.3	18.3
7	-2.20	0.00001	15.0	2.0	2.1	19.1
8	-2.15	0.00001	15.0	2.0	1.6	18.6
9	-2.10	0.00001	15.0	2.0	1.0	18.0
10	-2.05	0.00001	15.0	2.0	0.2	17.2
11	-2.00	0.00001	15.0	2.0	-0.4	16.6
12	-1.95	0.00001	15.0	2.0	-1.7	15.3
13	-1.90	0.00001	15.0	2.0	-1.6	15.4
14	-1.85	0.00001	15.0	2.0	-1.3	15.7
15	-1.80	0.00001	15.0	2.0	0.4	17.4
16	-1.75	0.00001	15.0	2.0	0.6	17.6
17	-1.70	0.00001	15.0	2.0	0.6	17.6
18	-1.65	0.00001	15.0	2.0	0.1	17.1
19	-1.60	0.00001	15.0	2.0	0.1	17.1
20	-1.55	0.00001	15.0	2.0	0.5	17.5
21	-1.50	0.00001	15.0	2.0	0.6	17.6
22	-1.45	0.00001	15.0	2.0	0.6	17.6

Continued ...

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Test Point	Jammer Signal Freq. +/- Fc (MHz)	(BER) (DQPSK)	(S/N) _o (dB)	System Loss L _{sys} (dB)	Jammer to Signal Ratio M _j (dB)	Measured Processing Gain (dB)
23	-1.40	0.00001	15.0	2.0	2.0	19.0
24	-1.35	0.00001	15.0	2.0	1.9	18.9
25	-1.30	0.00001	15.0	2.0	2.1	19.1
26	-1.25	0.00001	15.0	2.0	2.0	19.0
27	-1.20	0.00001	15.0	2.0	2.4	19.4
28	-1.15	0.00001	15.0	2.0	2.4	19.4
29	-1.10	0.00001	15.0	2.0	2.4	19.4
30	-1.05	0.00001	15.0	2.0	3.0	20.0
31	-1.00	0.00001	15.0	2.0	-4.1	12.9
32	-0.95	0.00001	15.0	2.0	-5.7	11.3
33	-0.90	0.00001	15.0	2.0	-5.6	11.4
34	-0.85	0.00001	15.0	2.0	-5.2	11.8
35	-0.80	0.00001	15.0	2.0	-5.6	11.4
36	-0.75	0.00001	15.0	2.0	-5.5	11.5
37	-0.70	0.00001	15.0	2.0	-6.4	10.6
38	-0.65	0.00001	15.0	2.0	-5.9	11.1
39	-0.60	0.00001	15.0	2.0	-5.2	11.8
40	-0.55	0.00001	15.0	2.0	-4.5	12.5
41	-0.50	0.00001	15.0	2.0	-5.0	12.0
42	-0.45	0.00001	15.0	2.0	-5.8	11.2
43	-0.40	0.00001	15.0	2.0	-6.3	10.7
44	-0.35	0.00001	15.0	2.0	-5.6	11.4
45	-0.30	0.00001	15.0	2.0	-6.1	10.9
46	-0.25	0.00001	15.0	2.0	-6.8	10.2
47	-0.20	0.00001	15.0	2.0	-5.5	11.5
48	-0.15	0.00001	15.0	2.0	-4.9	12.1
49	-0.10	0.00001	15.0	2.0	-4.7	12.3
50	-0.05	0.00001	15.0	2.0	-4.4	12.6
51	0.00	0.00001	15.0	2.0	-6.6	10.4
52	0.05	0.00001	15.0	2.0	-4.8	12.2
53	0.10	0.00001	15.0	2.0	-4.5	12.5
54	0.15	0.00001	15.0	2.0	-3.9	13.1
55	0.20	0.00001	15.0	2.0	-4.4	12.6
56	0.25	0.00001	15.0	2.0	-5.1	11.9
57	0.30	0.00001	15.0	2.0	-6.5	10.5
58	0.35	0.00001	15.0	2.0	-4.9	12.1
59	0.40	0.00001	15.0	2.0	-4.5	12.5
60	0.45	0.00001	15.0	2.0	-5.3	11.7
61	0.50	0.00001	15.0	2.0	-4.5	12.5
62	0.55	0.00001	15.0	2.0	-6.3	10.7
63	0.60	0.00001	15.0	2.0	-6.5	10.5

Continued ..

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Test Point	Jammer Signal Freq. +/- Fc (MHz)	(BER) (DQPSK)	(S/N) _o (dB)	System Loss L _{sys} (dB)	Jammer to Signal Ratio M _j (dB)	Measured Processing Gain (dB)
64	0.65	0.00001	15.0	2.0	-5.7	11.3
65	0.70	0.00001	15.0	2.0	-5.6	11.4
66	0.75	0.00001	15.0	2.0	-6.1	10.9
67	0.80	0.00001	15.0	2.0	-5.2	11.8
68	0.85	0.00001	15.0	2.0	-5.2	11.8
69	0.90	0.00001	15.0	2.0	-5.2	11.8
70	0.95	0.00001	15.0	2.0	-4.6	12.4
71	1.00	0.00001	15.0	2.0	-4.6	12.4
72	1.05	0.00001	15.0	2.0	-6.5	10.5
73	1.10	0.00001	15.0	2.0	-6.7	10.3
74	1.15	0.00001	15.0	2.0	-5.8	11.2
75	1.20	0.00001	15.0	2.0	-6.6	10.4
76	1.25	0.00001	15.0	2.0	-7.0	10.0
77	1.30	0.00001	15.0	2.0	-6.3	10.7
78	1.35	0.00001	15.0	2.0	-5.9	11.1
79	1.40	0.00001	15.0	2.0	-5.9	11.1
80	1.45	0.00001	15.0	2.0	-5.9	11.1
81	1.50	0.00001	15.0	2.0	-5.8	11.2
82	1.55	0.00001	15.0	2.0	-5.9	11.1
83	1.60	0.00001	15.0	2.0	-5.8	11.2
84	1.65	0.00001	15.0	2.0	-5.7	11.3
85	1.70	0.00001	15.0	2.0	-4.8	12.2
86	1.75	0.00001	15.0	2.0	-4.4	12.6
87	1.80	0.00001	15.0	2.0	-4.4	12.6
88	1.85	0.00001	15.0	2.0	-4.4	12.6
89	1.90	0.00001	15.0	2.0	-4.4	12.6
90	1.95	0.00001	15.0	2.0	-4.3	12.7
91	2.00	0.00001	15.0	2.0	-5.2	11.8
92	2.05	0.00001	15.0	2.0	-3.3	13.7
93	2.10	0.00001	15.0	2.0	-0.8	16.2
94	2.15	0.00001	15.0	2.0	0.7	17.7
95	2.20	0.00001	15.0	2.0	0.9	17.9
96	2.25	0.00001	15.0	2.0	0.9	17.9
97	2.30	0.00001	15.0	2.0	1.2	18.2
98	2.35	0.00001	15.0	2.0	1.0	18.0
99	2.40	0.00001	15.0	2.0	0.6	17.6
100	2.45	0.00001	15.0	2.0	1.0	18.0
101	2.50	0.00001	15.0	2.0	1.0	18.0

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

PRODUCT NAME: ISP DIRECT INDOOR & OUTDOOR UNITS, Model No.: 2401-01 (indoor) and 2401-02 (outdoor)

NAME OF TEST: AC Powerline Conducted Emissions.

FCC LIMIT:

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

CLIMATE CONDITION:

Standard Temperature and Humidity:

- Ambient temperature: 23 °C
- Relative humidity: 43 %

POWER INPUT:

AC 120 V 60Hz from Elpac external switching power supply, model WRI4232.

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.
- 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: Mr. Tri M. Luu, P.Eng.

DATE: Mar. 04, 1998

MEASUREMENT DATA**AC POWER-LINE CONDUCTED EMISSIONS****REMARKS**

- 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.

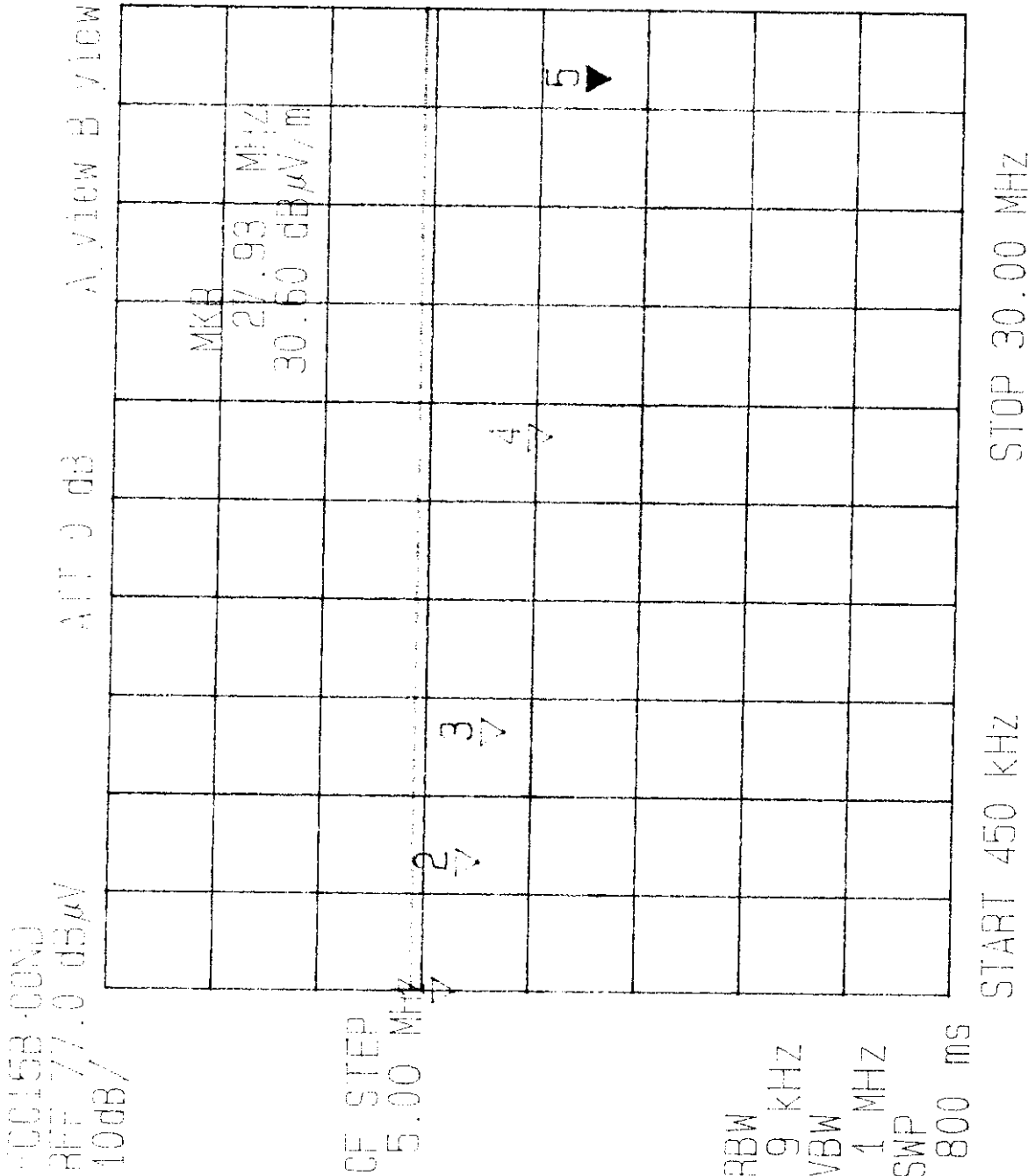
FREQUENCY (MHz)	RF LEVEL (dBuV)	RECEIVER DETECTOR (P/QP/AVG)	QP/NB LIMIT (dBuV)	QP/BB LIMIT (dBuV)	MARGIN (dB)	PASS/ FAIL	LINE TESTED (L1/L2)
0.450	43.9	Peak	48.0	61.0	-4.1	PASS	L1
4.380	42.0	Peak	48.0	61.0	-6.0	PASS	L1
8.300	39.7	Peak	48.0	61.0	-8.3	PASS	L1
17.170	35.7	Peak	48.0	61.0	-25.3	PASS	L1
27.930	30.6	Peak	48.0	61.0	-17.4	PASS	L1
0.790	37.1	Peak	48.0	61.0	-23.9	PASS	L2
4.420	39.8	Peak	48.0	61.0	-8.2	PASS	L2
8.600	37.7	Peak	48.0	61.0	-23.3	PASS	L2
16.580	33.6	Peak	48.0	61.0	-14.4	PASS	L2
27.890	29.7	Peak	48.0	61.0	-31.3	PASS	L2

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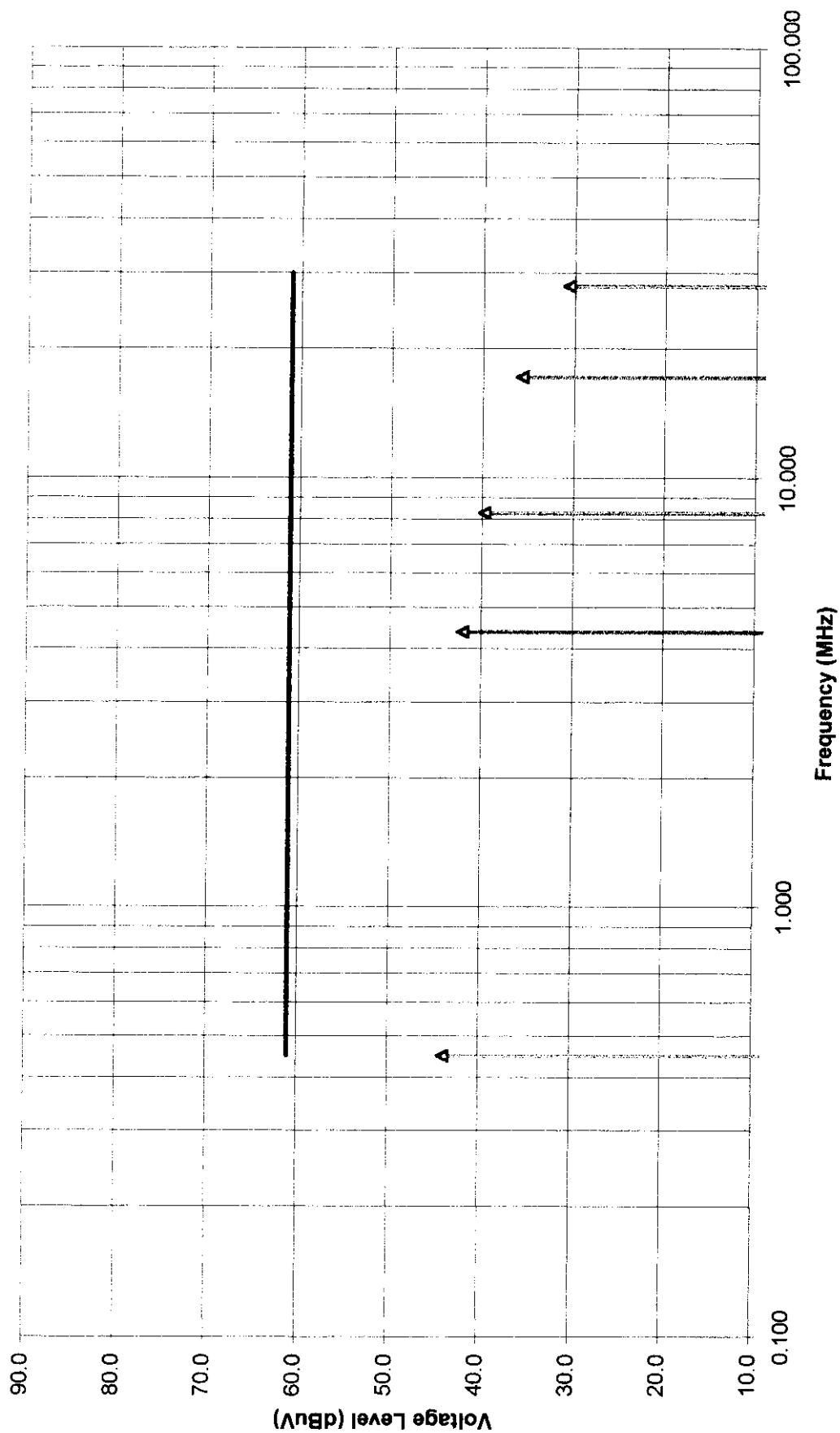
APPLICANT:
PRODUCT:
MODEL:

INTERAIR WIRELESS
SPREAD SPECTRUM DEVICE

EMI Detector: [☒ Peak [] Quasi Peak [] Average Temp.: 22 °C, Humidity: 82%
Line Tested: 1, Input Voltage: 120, Tested by: HUNTER Test Date: 04 MAR 08
Comments: FCC 15.103



AC Conducted Emissions - Line #1 (Hot)
InterAir ISP Direct Indoor (2401-01) & Outdoor (2401-02) Units
Operating Modes: Transmit & receive



APPLICANT:
PRODUCT:
MODEL:

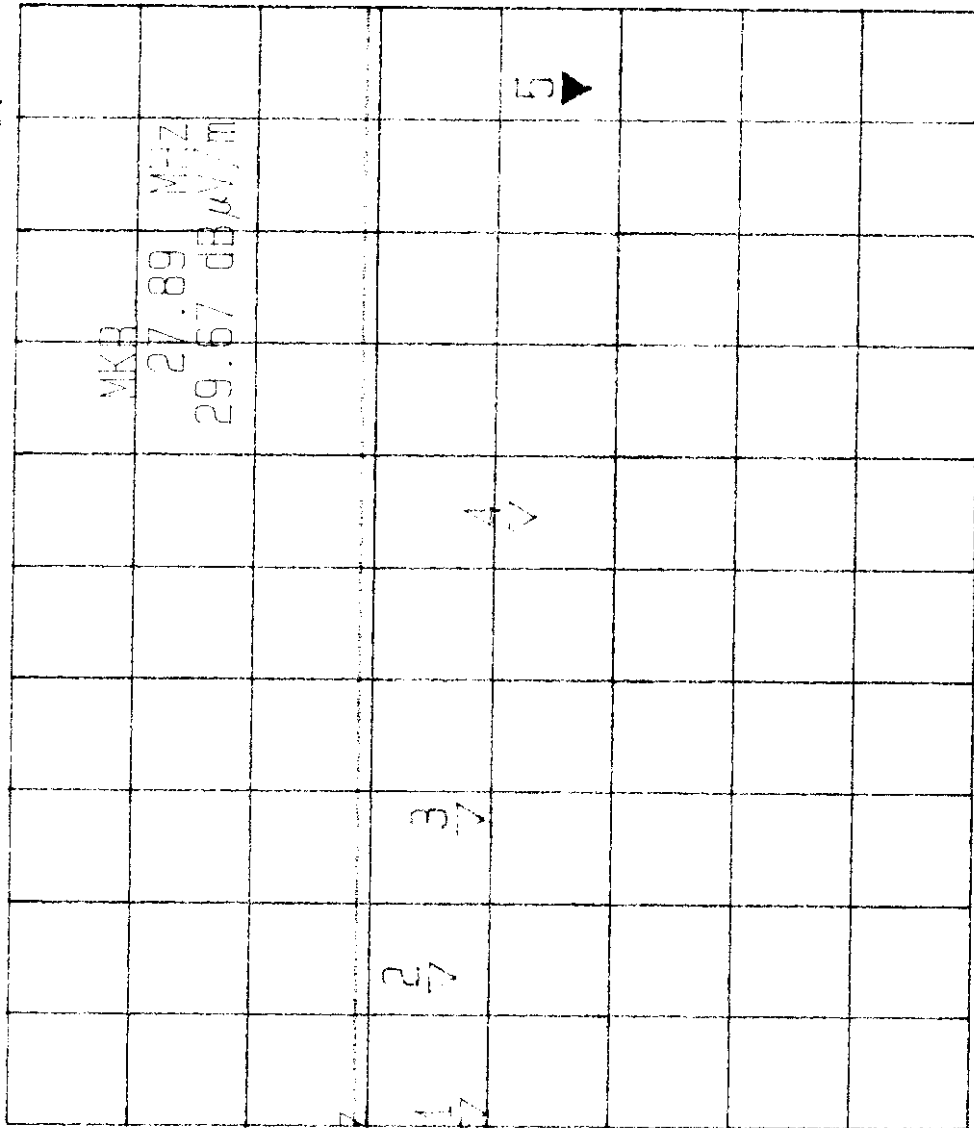
INTERAIR WIRELESS
BROAD SPECTRUM DEVICE

EMI Detector: [Y] Peak [] Quasi Peak [] Average
Line Tested: 2, Input Voltage: 120, Temp.: 23 °C, Humidity: 27 %
Comments: FCC 15B, Tested by: HUNGT Test Date: 02/11/2013

FCC15B-COND
REF 77.0 dBμV
10dB/

ATT 0 dB A view B view

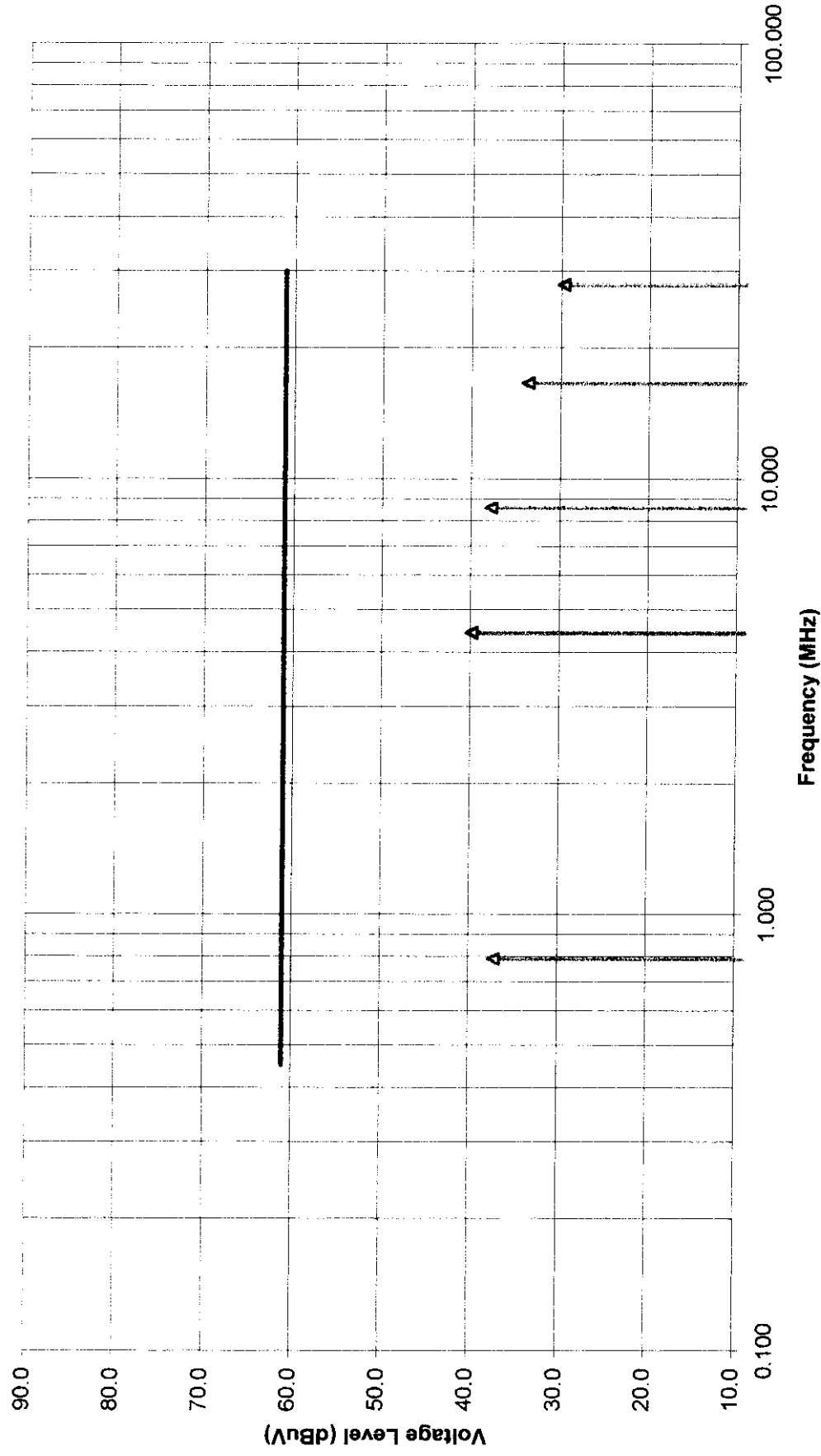
CF STEP
5.00 MHz



RBW 9 kHz
VBW 1 MHz
SWP 800 ms

START 450 KHZ STOP 30.00 MHz

AC Conducted Emissions - Line #2 (Neutral)
InterAir ISP Direct Indoor (2401-01) & Outdoor (2401-02) Units
Operating Modes: Transmit & receive



5. EXHIBIT 5 - GENERAL TEST PROCEDURES

5.1 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.

5.2 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 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
 - 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:

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- 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**)

- 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.

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 dBμV 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:

$$\text{Field Level in dB}\mu\text{V/m} = 60 + 7.0 + 1.0 - 30 = 38.0 \text{ dB}\mu\text{V/m.}$$

$$\text{Field Level in } \mu\text{V/m} = 10^{(38/20)} = 79.43 \mu\text{V/m.}$$

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.

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6. EXHIBIT 6 - INFORMATION RELATED TO EQUIPMENT UNDER TESTS**6.1 FCC ID Labeling and Sketch of FCC Label Location**

Refer to the attached sheets

6.2 Photographs of Equipment under Test

Refer to the attached photographs

6.3 System Block Diagram(s)

Refer to the attached sheets

6.4 Schematic Diagrams

Refer to the attached sheets

6.5 User's Manual with "FCC Information to User Statements"

Refer to the attached Users' manual

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