REPORT OF MEASUREMENTS
PART 15C - INTENTIONAL RADIATOR

DEVICE: 1 CHANNEL 2.4 GHZ DIRECT SEQUENCE SPREAD SPECTRUM TRANSCEIVER

MODEL: inFOREmer BASE STATION

MANUFACTURER: INFORETECH GOLF TECHNOLOGY 2000 INC.

ADDRESS: SUITE 214, 5500 – 152ND STREET
SURREY BRITISH COLUMBIA
CANADA V3S 8E7

THE DATA CONTAINED IN THIS REPORT WAS COLLECTED ON 4 JANUARY 2000 AND COMPILED BY:

PAUL G. SLAVENS
CHIEF EMC ENGINEER

WORK ORDER: 30003

1. General

1.1 Purpose

The purpose of this report is to show compliance to the FCC regulations for spread spectrum unlicensed devices operating under section 15.247 of the Code of Federal Regulations title 47.

1.2 Manufacturer

Company Name:	Inforetech Golf Technology 2000 Inc.
Contact:	Jennifer McKinley
Street Address:	Suite 214, 5500 – 152nd Street
City/Province:	Surrey British Columbia
Country/Postal Code:	Canada V3S 8E7
Telephone:	604 576-7442
Fax:	604 576-7460
E-mail:	jenn@inforetech.com

1.3 Test location

Company:	Acme Testing Inc.
Street Address:	2002 Valley Highway
Mailing Address:	PO Box 3
City/State/Zip:	Acme WA 98220-0003
Laboratory:	Test Site 2
Telephone:	888 226-3837
Fax:	360 595-2722
E-mail:	acmetest@acmetesting.com
Web:	www.acmetesting.com
Receipt of EUT:	23 December 1999

1.4 Test Personnel

Paul G. Slavens

2. Test Results Summary

Summary of Test Results
1 Channel 2.4 GHz Spread Spectrum Transceiver, model inFOREmer Base Station

Requirement	CFR Section	Test Result
Radiated Spurs < 15.209	15.205(b)	PASS
Conducted Emissions < 48.0 dBuV	15.207	PASS
6 dB BW > 500 kHz	15.247(a2)	PASS
Max Output Power < 1 W	15.247(a2b)	PASS
Conducted Spurious >-20 dBc	15.247(a2c)	PASS
Power Density < 8dBm in 3 kHz	15.247(a2d)	PASS
Process Gain > 10 dB	15.247(a2e)	PASS

The signed original of this report, supplied to the client, represents the only "official" copy. Retention of any additional copies (electronic or non-electronic media) is at Acme Testing's discretion to meet internal requirements only. The client has made the determination that EUT Condition, Characterization, and Mode of Operation are representative of production units, and meet the requirements of the specifications referenced herein.

Consistent with Industry practice, measurement and test equipment not directly involved in obtaining measurement results but having an impact on measurements (such as cable loss, antenna factors, etc.) is factored into the "Correction Factor" documented in certain test results. Instrumentation employed for testing meets tolerances consistent with known Industry Standards and Regulations.

The measurements contained in this report were made in accordance with the referenced standards and all applicable Public Notices received prior to the date of testing. Acme Testing assumes responsibility only for the accuracy and completeness of this data as it pertains to the sample tested.

Paul G. Slavens
Chief EMC Engineer

Date of Issuance

3. Description of Equipment and Peripherals

3.1 Equipment Under Test (EUT)

Device:	1 Channel 2.4 GHz Direct Sequence Spread Spectrum Transceiver
Model Number:	inFOREmer Base Station
Serial Number:	None
FCC ID:	OXKBSI2000
Power:	120 V/60 Hz
Grounding:	A/C
Antenna Distance:	3 meters

3.2 EUT Peripherals

None, the EUT is a stand alone device.

3.3 Description of Interface Cables

None, the EUT is a stand alone device.

3.4 Mode of Operation During Tests

EUT was constantly transmitting a modulated signal during testing. EUT was tested at only one frequency as it is a one channel device.

3.5 Modifications Required for Compliance

1. None.

4. Antenna requirement

4.1 Regulation

An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this Section. The manufacturer may design the unit so that the user can replace a broken antenna, but the use of a standard antenna jack or electrical connector is prohibited. This requirement does not apply to carrier current devices or to devices operated under the provisions of Sections 15.211, 15.213, 15.217, 15.219, or 15.221. Further, this requirement does not apply to intentional radiators that must be professionally installed, such as perimeter protection systems and some field disturbance sensors, or to other intentional radiators which, in accordance with Section 15.31(d), must be measured at the installation site. However, the installer shall be responsible for ensuring that the proper antenna is employed so that the limits in this Part are not exceeded.

4.2 Result

The intentional radiator uses a standard "N" connector, however the intentional radiator is only installed by professionals.

5. Conducted Emissions Tests

Test Requirement: FCC CFR47, Part 15C

Test Procedure: ANSI C63.4:1992

5.1 Test Equipment

⇒ Spectrum Analyzer: Hewlett-Packard 8566B, Serial Number 2410A-00168, Calibrated: 12 March 1999, Calibration due Date: 12 March 2000

⇒ RF Preselector: Hewlett-Packard 85685, Serial Number 2648A-00519, Calibrated: 12 March 1999, Calibration due Date: 12 March 2000

⇒ Quasi Peak Adapter: Hewlett-Packard 85650A, Serial Number 2043A-00327, Calibrated: 17 March 1999, Calibration due Date: 17 March 2000

⇒ Line Impedance Stabilization Network: Rhode & Schwarz ESH2-Z5, Serial Number ACMERS1, Calibrated: 1 September 1999, Calibration due Date: 01 September 2000

5.2 Purpose

The purpose of this test is to evaluate the level of conducted noise the EUT imposes on the AC mains.

5.3 Test Procedures

For tabletop equipment, the EUT is placed on a 1 meter by 1.5 meters wide and 0.8 meter high nonconductive table that is placed above the groundplane. Floor standing equipment is placed directly on the groundplane. Any supplemental grounding mechanisms are connected, if appropriate. The EUT is connected to its associated peripherals, with any excess I/O cabling bundled to approximately 1 meter. The EUT is connected to a dedicated LISN and all peripherals are connected to a second separate LISN circuit. The LISNs are bonded to the groundplane.

Preview tests are performed to determine the “worst case” mode of operation. With the EUT operating in “worst case” mode, final conducted measurements are taken. Conducted measurements are made on each current carrying conductor with respect to ground.

Conducted Emissions Test Characteristics	
Frequency range	0.45 MHz - 30.0 MHz
Test instrumentation resolution bandwidth	9 kHz
Lines Tested	Line 1/Line 2

5.4 Test Results

LINE 1
PEAK

PEAK #	FREQ. (MHz)	AMPL (dBuV)
1	15.14	37.2
2	13.8	35.4
3	16.26	34.6
4	17.76	34.4
5	15.59	33.7
6	21.63	33.0

LINE 2
PEAK

PEAK #	FREQ. (MHz)	AMPL (dBuV)
1	15.14	33.8
2	21.63	32.5
3	13.41	32.0
4	17.61	31.6
5	17.76	31.1
6	12.38	31.0

6. 6 dB Bandwidth

6.1 Regulation

15.247(a2) For direct sequence systems, the minimum 6 dB bandwidth shall be at least 500 kHz.

6.2 Test Equipment

⇒ Spectrum Analyzer: Hewlett-Packard 8566B, Serial Number 2410A-00168, Calibrated: 12 March 1999, Calibration due Date: 12 March 2000

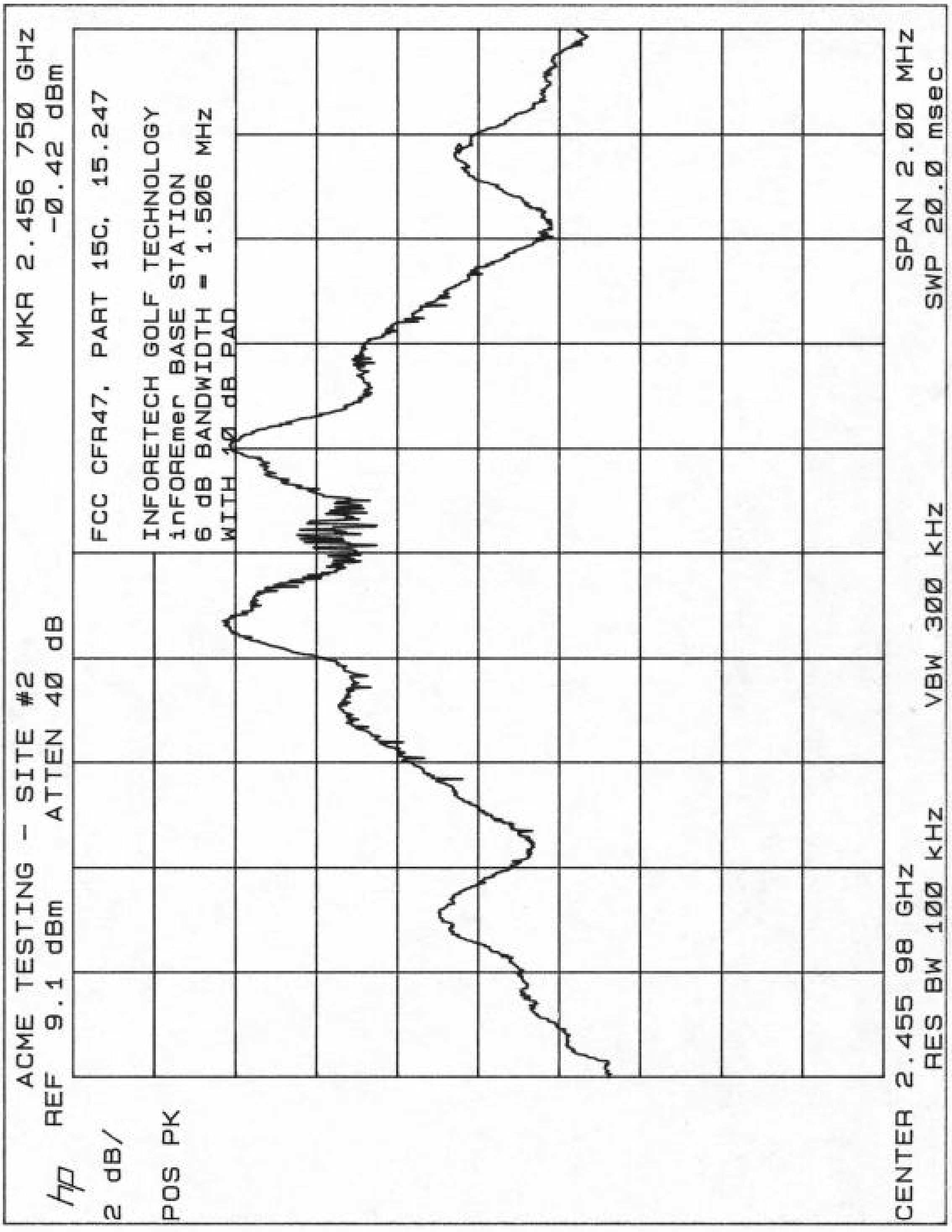
⇒ RF Preselector: Hewlett-Packard 85685, Serial Number 2648A-00519, Calibrated: 12 March 1999, Calibration due Date: 12 March 2000

6.3 Test Procedures

The RF output of the EUT is connected to the RF input port of the RF preselector through a 10 dB pad. The following measurements were made with a RBW = 100 kHz and VBW = 300 KHz.

6.4 Test Results

The 6 dB bandwidth is 1.506 MHz.


ACME TESTING - SITE #2
MKR 2.456 750 GHz
REF 9.1 dBm
ATTEN 40 dB
-0.42 dBm
hp
2 dB/
POS PK
FCC CFR47, PART 15C, 15.247
INFORETECH GOLF TECHNOLOGY
inFOREmer BASE STATION
6 dB BANDWIDTH = 1.506 MHz
WITH 10 dB PAD
CENTER 2.455 98 GHz
SPAN 2.00 MHz
RES BW 100 kHz
VBW 300 kHz
SWP 20.0 msec

7. Power Output

7.1 Regulation

15.247(b1) The maximum peak output power of the intentional radiator shall not exceed the following: For frequency hopping systems operating in the 2400-2483.5 MHz or 5725-5850 MHz band and for all direct sequence systems: 1 watt.

7.2 Test Equipment

⇒ Spectrum Analyzer: Hewlett-Packard 8566B, Serial Number 2410A-00168, Calibrated: 12 March 1999, Calibration due Date: 12 March 2000

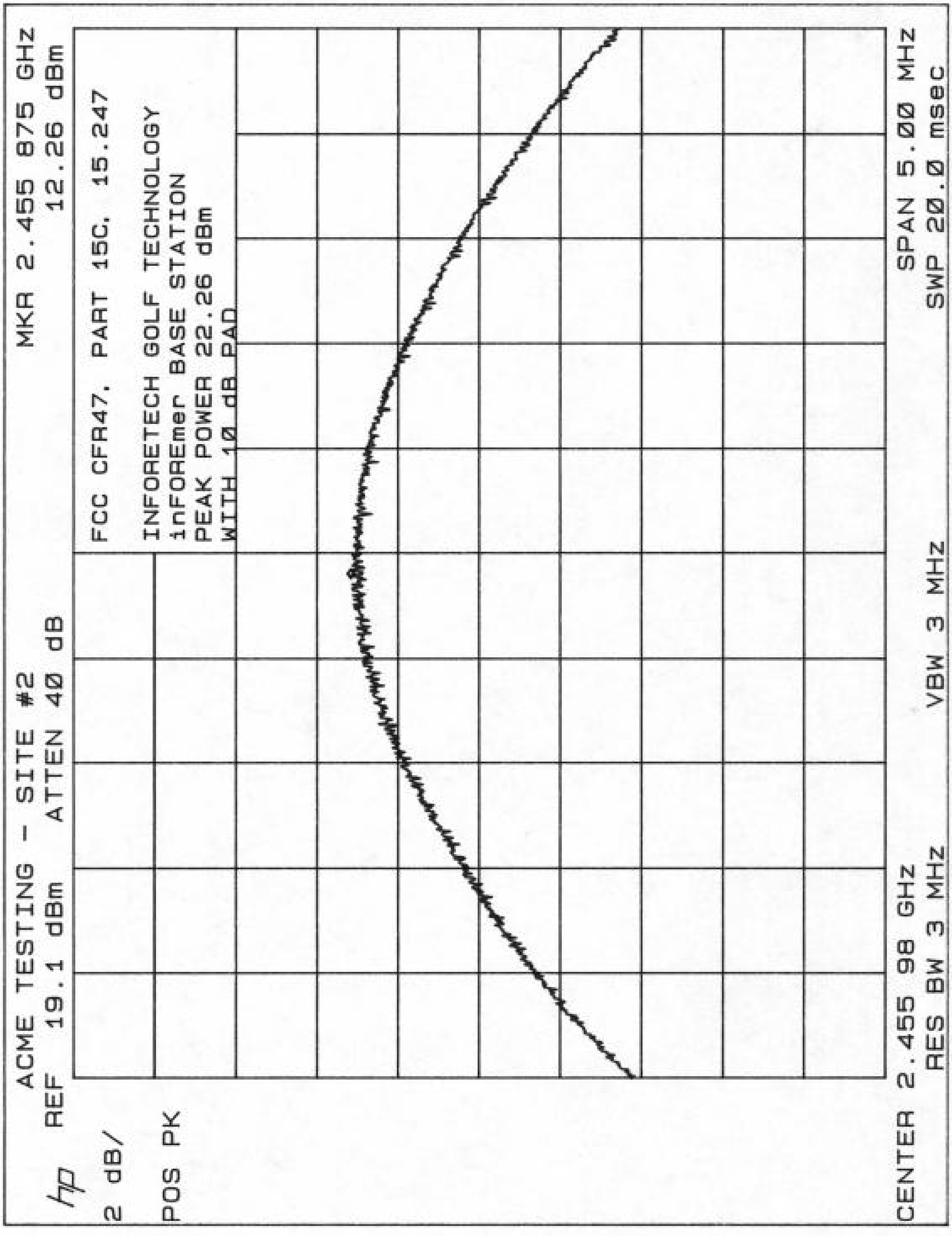
⇒ RF Preselector: Hewlett-Packard 85685, Serial Number 2648A-00519, Calibrated: 12 March 1999, Calibration due Date: 12 March 2000

7.3 Test Procedures

The RF output of the EUT is connected to the RF input port of the RF preselector through a 10 dB pad. The following measurements were made with a RBW = 3 MHz and VBW = 3 MHz.

7.4 Test Results

Measured maximum Peak Envelope Power was 22.26 dBm.


hp
ACME TESTING - SITE #2
REF 19.1 dBm ATTEN 40 dB
MKR 2.455 875 GHz
12.26 dBm
2 dB/
POS PK
FCC CFR47, PART 15C, 15.247
INFORETECH GOLF TECHNOLOGY
inFOREmer BASE STATION
PEAK POWER 22.26 dBm
WITH 10 dB PAD
CENTER 2.455 98 GHz
RES BW 3 MHz
VBW 3 MHz
SPAN 5.00 MHz
SWP 20.0 msec

8. Antenna gain requirements

8.1 Regulation

15.247(b3) Except as shown below, if transmitting antennas of directional gain greater than 6 dBi are used the peak output power from the intentional radiator shall be reduced below the above stated values by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

(i) Systems operating in the 2400-2483.5 MHz band that are 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 reduced by 1 dB for every 3 dB that the directional gain of the antenna exceeds 6 dBi.

(ii) Systems operating in the 5725-5850 MHz band that are used exclusively for fixed, point-to-point operations may employ transmitting antennas with directional gain greater than 6 dBi without any corresponding reduction in transmitter peak output power.

(iii) Fixed, point-to-point operation, as used in paragraphs (b)(3)(i) and (b)(3)(ii) of this section, excludes the use of point-to-multipoint systems, omnidirectional applications, and multiple co-located intentional radiators transmitting the same information. The operator of the spread spectrum intentional radiator or, if the equipment is professionally installed, the installer is responsible for ensuring that the system is used exclusively for fixed, point-to-point operations. The instruction manual furnished with the intentional radiator shall contain language in the installation instructions informing the operator and the installer of this responsibility.

8.2 Result

Measured power was 22.26 dBm. The maximum gain antenna for the EUT in fixed point-to-point operation is 13.5 dBi, 13.5 dBi (actual) – 6.0 dBi (allowed) = 7.5 dBi. 7.5 dBi/3 = 2.5 dB reduction in power, 22.26 dBm + 2.5 dB = 24.76 dBm which is less than the 30 dBm allowed.

9. Radio Frequency exposure

9.1 Regulation

15.247(b4) Systems operating under the provisions of this section shall be operated in a manner that ensures that the public is not exposed to radio frequency energy levels in excess of the Commission's guidelines. *See* §1.1307(b)(1) of this Chapter.

9.2 Result

According to par 1.1307b(1), the inFOREmer Base Station does not require an environmental evaluation.

1. This equipment classification is not present within table 1 of part 1.1307 and is not listed in section 1.1307b(2).
2. The inFOREmer Base Station is neither mobile nor portable, and therefore does not fall within the categories covered under part 2.1091 and part 2.1093.

Included are calculations that determine that minimum distance (R) from the transmitter antenna that will ensure an exposure limit at or below the guidelines given in table 1 of part 1.1310 for the general population. The formula for these calculations are taken from OET Bulletin 65, edition 97-01, August 1997; “Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields”.

CALCULATIONS

Per Table 1 of Section 1.1310 the limit for general population exposure at 2.4 GHz is 1.0 mW/cm^2

Per OET Bulletin 65, edition 97-01 the formula for calculating power density is:
$S = P*G/4\pi R^2$
with
Power = 22.26 dBm = 168.3 mW
Gain of Antenna = 13.5 dBi or a numeric gain of 22.38
therefore
Solving for R gives a minimum safe distance of 17.3 cm

CONCLUSION

The transceivers are mounted on top poles on a golf course and the minimum safe distance of 17.3 cm would never be violated.

10. Conducted Spurious Emissions

10.1 Regulation

15.247 (c) In any 100 kHz bandwidth outside the frequency band in which the spread spectrum intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement. Attenuation below the general limits specified in Section 15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in Section 15.205(a), must also comply with the radiated emission limits specified in Section 15.209(a) (see Section 15.205(c)).

10.2 Test Equipment

⇒ Spectrum Analyzer: Hewlett-Packard 8566B, Serial Number 2410A-00168, Calibrated: 12 March 1999, Calibration due Date: 12 March 2000

⇒ RF Preselector: Hewlett-Packard 85685, Serial Number 2648A-00519, Calibrated: 12 March 1999, Calibration due Date: 12 March 2000

⇒ Quasi Peak Adapter: Hewlett-Packard 85650A, Serial Number 2043A-00327, Calibrated: 17 March 1999, Calibration due Date: 17 March 2000

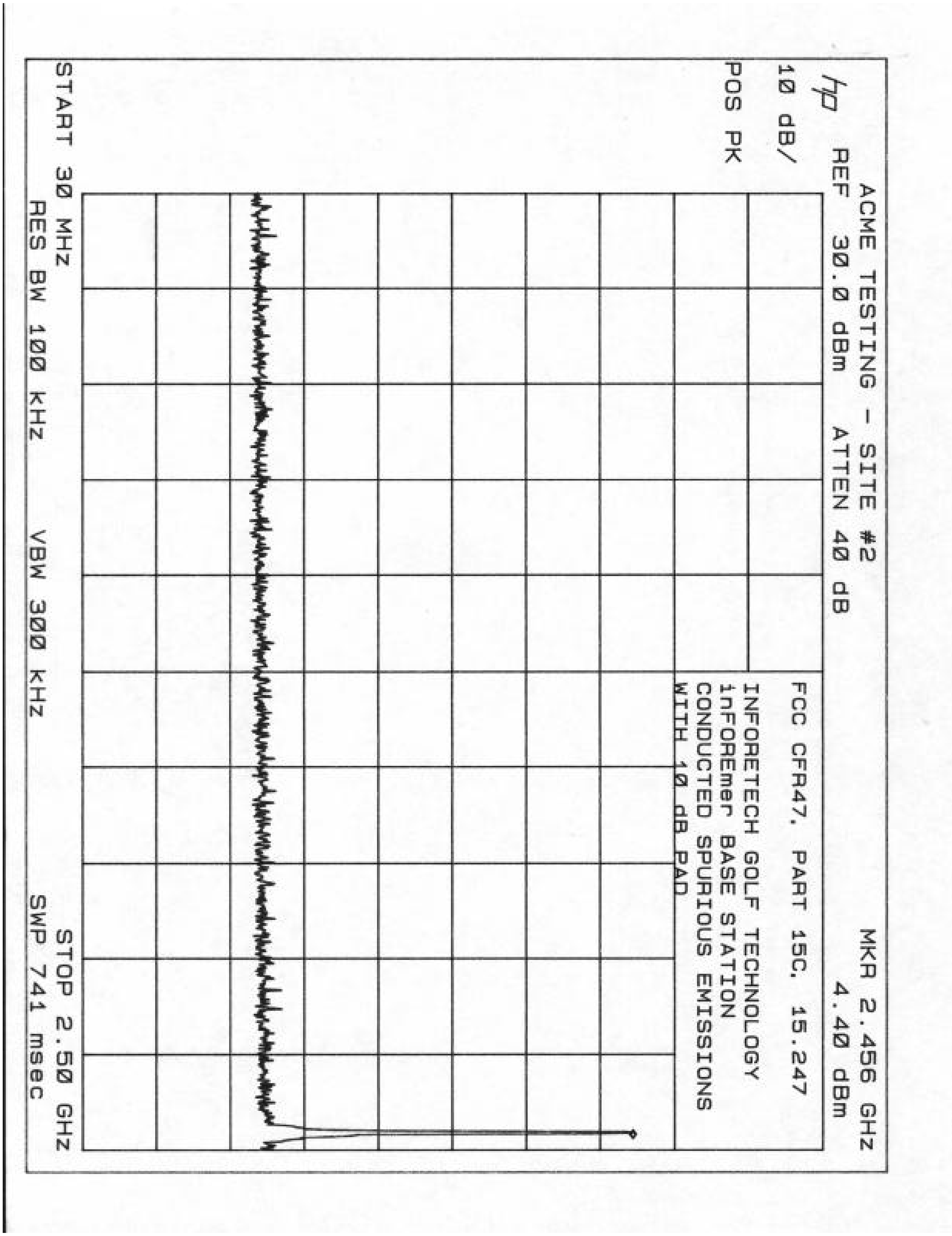
10.3 Test Procedures

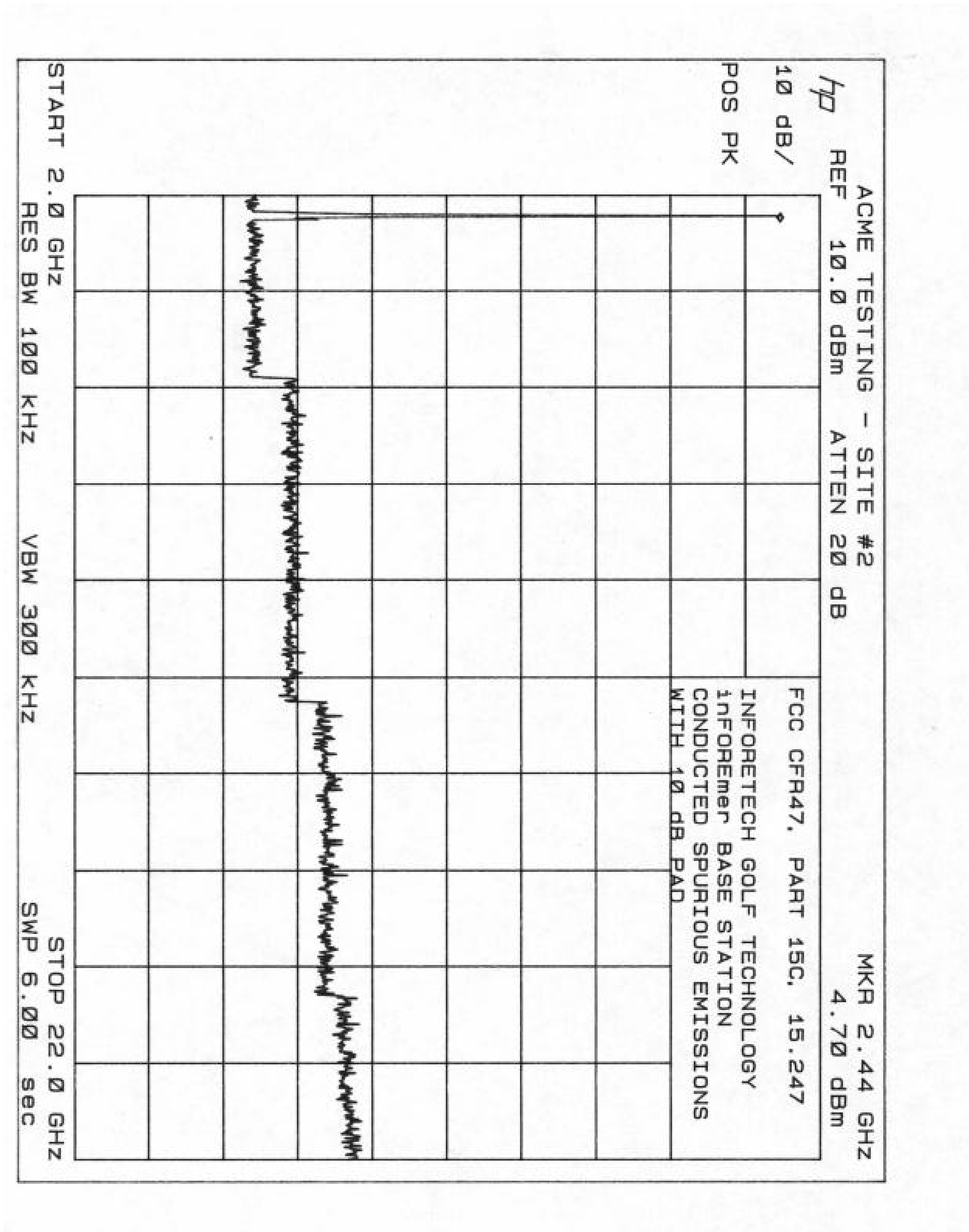
The RF output of the EUT is connected to the RF input port of the RF preselector through a 10 dB pad. The following measurements were made with a RBW = 100 kHz and VBW = 300 kHz.

10.4 Test Results

No out of band conducted emissions detected; see plots.

(Results continued on next page)


hp
ACME TESTING - SITE #2
REF 30.0 dBm ATTEN 40 dB
10 dB/
POS PK
MKR 2.456 GHz
4.40 dBm
FCC CFR47, PART 15C, 15.247
INFORETECH GOLF TECHNOLOGY
inFOREmer BASE STATION
CONDUCTED SPURIOUS EMISSIONS
WITH 10 dB PAD
START 30 MHz
STOP 2.50 GHz
RES BW 100 kHz
VBW 300 kHz
SWP 741 msec


ACME TESTING - SITE #2
hp REF 10.0 dBm ATTEN 20 dB
10 dB/
POS PK
MKR 2.44 GHz
4.70 dBm
FCC CFR47, PART 15C, 15.247
INFORETECH GOLF TECHNOLOGY
inFOREmer BASE STATION
CONDUCTED SPURIOUS EMISSIONS
WITH 10 dB PAD
START 2.0 GHz
STOP 22.0 GHz
RES BW 100 kHz
VBW 300 kHz
SWP 6.00 sec

11. Radiated Spurious Emissions

11.1 Regulation

15.247 (c) In any 100 kHz bandwidth outside the frequency band in which the spread spectrum intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement. Attenuation below the general limits specified in Section 15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in Section 15.205(a), must also comply with the radiated emission limits specified in Section 15.209(a) (see Section 15.205(c)).

11.2 Test Equipment

⇒ Spectrum Analyzer: Hewlett-Packard 8566B, Serial Number 2410A-00168, Calibrated: 12 March 1999, Calibration due Date: 12 March 2000

⇒ RF Preselector: Hewlett-Packard 85685, Serial Number 2648A-00519, Calibrated: 12 March 1999, Calibration due Date: 12 March 2000

⇒ Quasi Peak Adapter: Hewlett-Packard 85650A, Serial Number 2043A-00327, Calibrated: 17 March 1999, Calibration due Date: 17 March 2000

⇒ Line Impedance Stabilization Network: Rhode & Schwarz ESH2-Z5, Serial Number ACMERS1, Calibrated: 1 September 1999, Calibration due Date: 01 September 2000

⇒ Broadband Biconical Antenna (20 MHz to 200 MHz): EMCO 3110, Serial Number 1115, Calibrated: 28 December 1999, Calibration due Date: 28 December 2000

⇒ Broadband Log Periodic Antenna (200 MHz to 1000 MHz): EMCO 3146, Serial Number 2853, Calibrated: 28 December 1999, Calibration due Date: 28 December 2000

⇒ Pyramidal Horn Antenna: EMCO 3160-09, Serial Number 9701-1071, Calibration Not Required.

⇒ EUT Turntable Position Controller: EMCO 1061-3M, Serial Number 9003-1441, No Calibration Required

⇒ Antenna Mast: EMCO 1051, Serial Number 9002-1457, No Calibration Required

⇒ 2 GHz to 10 GHz Low Noise Preamplifier: Milliwave 593-2898, Serial Number 2494, No Calibration Required

⇒ Double Ridge Guide Horn Antenna: EMCO 3115, Serial Number 9807-5534, Calibrated: 30 December 1999, Calibration due Date: 30 December 2000

⇒ 8 GHz to 22 GHz Low Noise Preamplifier: Miteq AFS4-35LN, Serial Number 484280, Calibrated: 28 December 1998, Calibration due Date: 28 December 1999

11.3 Test Procedures

For tabletop equipment, the EUT is placed on a 1 meter by 1.5 meters wide and 0.8 meter high nonconductive table that sits on a flush mounted metal turntable. Floor standing equipment is placed directly on the flush mounted metal turntable. The EUT is connected to its associated peripherals with any excess I/O cabling bundled to approximately 1 meter.

Preview tests are performed to determine the “worst case” mode of operation. With the EUT operating in “worst case” mode, emissions from the unit are maximized by adjusting the polarization and height of the receive antenna and rotating the EUT on the turntable. Manipulating the system cables also maximizes EUT emissions.

Radiated Emissions Test Characteristics	
Frequency range	30 MHz - 22000 MHz **15.205 RESTRICTED BANDS ONLY**
Test distance	3 m
Test instrumentation resolution bandwidth	120 kHz (30 MHz – 10,000 MHz) 1 MHz (10,000 MHz - 22000 MHz)
Receive antenna scan height	1 m - 4 m
Receive antenna polarization	Vertical/Horizontal

11.4 Test Results

MONOPOLE ANTENNA

ALL DETECTABLE AVERAGE PRODUCT EMISSIONS

No	EMISSION FREQUENCY MHz	SPEC LIMIT dBuV/m	MEASUREMENTS ABS dBuV/m	dLIM dB	MODE	POL	SITE HGT cm	AZM deg	CORR FACTOR dB
1	4912.00	54.0	48.0	-6.0	AVG	V	148	260	14.7
2	7368.00	54.0	44.9	-9.1	AVG	V	100	22.4	17.8

MONOPOLE ANTENNA

ALL DETECTABLE PEAK PRODUCT EMISSIONS

No	EMISSION FREQUENCY MHz	SPEC LIMIT dBuV/m	MEASUREMENTS ABS dBuV/m	dLIM dB	MODE	POL	SITE HGT cm	AZM deg	CORR FACTOR dB
1	4912.00	74.0	52.2	-21.8	PK	V	148	260	14.7
2	7368.00	74.0	49.0	-25.0	PK	V	100	22.4	17.8

YAGI ANTENNA

ALL DETECTABLE PEAK PRODUCT EMISSIONS

No	EMISSION FREQUENCY MHz	SPEC LIMIT dBuV/m	MEASUREMENTS ABS	dLIM dB	MODE	POL	SITE HGT cm	AZM deg	CORR FACTOR dB
1	4911.89	74.0	53.2	-20.8	PK	V	139	354	14.7

YAGI ANTENNA

ALL DETECTABLE AVERAGE PRODUCT EMISSIONS

No	EMISSION FREQUENCY MHz	SPEC LIMIT dBuV/m	MEASUREMENTS ABS	dLIM dB	MODE	POL	SITE HGT cm	AZM deg	CORR FACTOR dB
1	4912.13	54.0	48.5	-5.5	AVG	V	139	354	14.7

12. Peak Power Spectral Density

12.1 Regulation

For direct sequence systems, the peak power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

12.2 Test Equipment

⇒ Spectrum Analyzer: Hewlett-Packard 8566B, Serial Number 2410A-00168, Calibrated: 12 March 1999, Calibration due Date: 12 March 2000

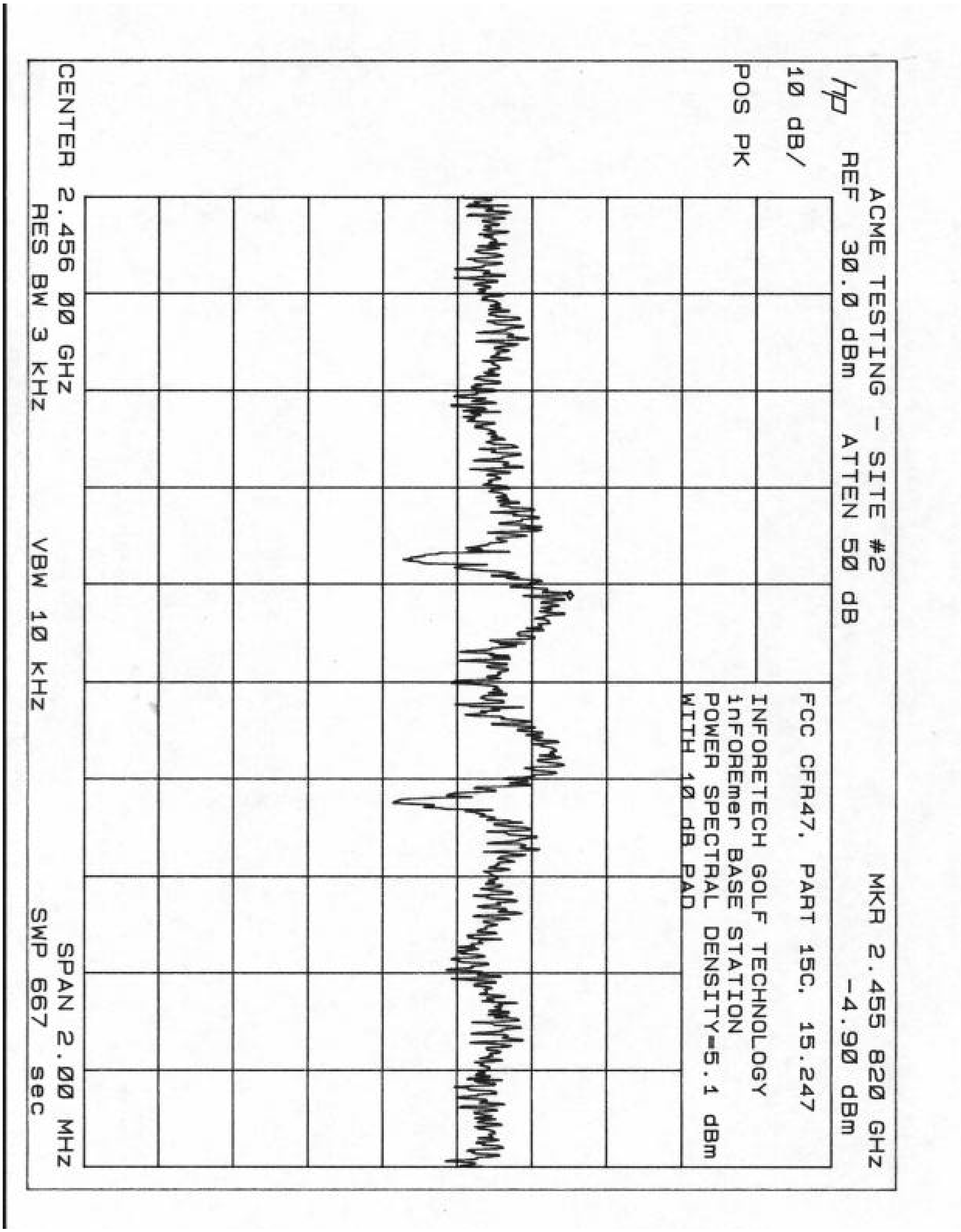
⇒ RF Preselector: Hewlett-Packard 85685, Serial Number 2648A-00519, Calibrated: 12 March 1999, Calibration due Date: 12 March 2000

12.3 Test Procedures

The RF output of the EUT is connected to the RF input port of the RF preselector through a 10 dB pad. The following measurements were made with a RBW = 3 kHz, VBW = 10 kHz and Sweep Time = 666 seconds.

12.4 Test Results

Maximum peak power spectral density is 5.1 dBm


ACME TESTING - SITE #2
MKR 2.455 820 GHz
REF 30.0 dBm ATTEN 50 dB
-4.90 dBm
hp
10 dB/
POS PK
FCC CFR47, PART 15C, 15.247
INFORETECH GOLF TECHNOLOGY
inFOREmer BASE STATION
POWER SPECTRAL DENSITY=5.1 dBm
WITH 10 dB PAD
CENTER 2.456 00 GHz
SPAN 2.00 MHz
RES BW 3 kHz
VBW 10 kHz
SWP 667 sec

13. Process gain requirements

13.1 Regulation

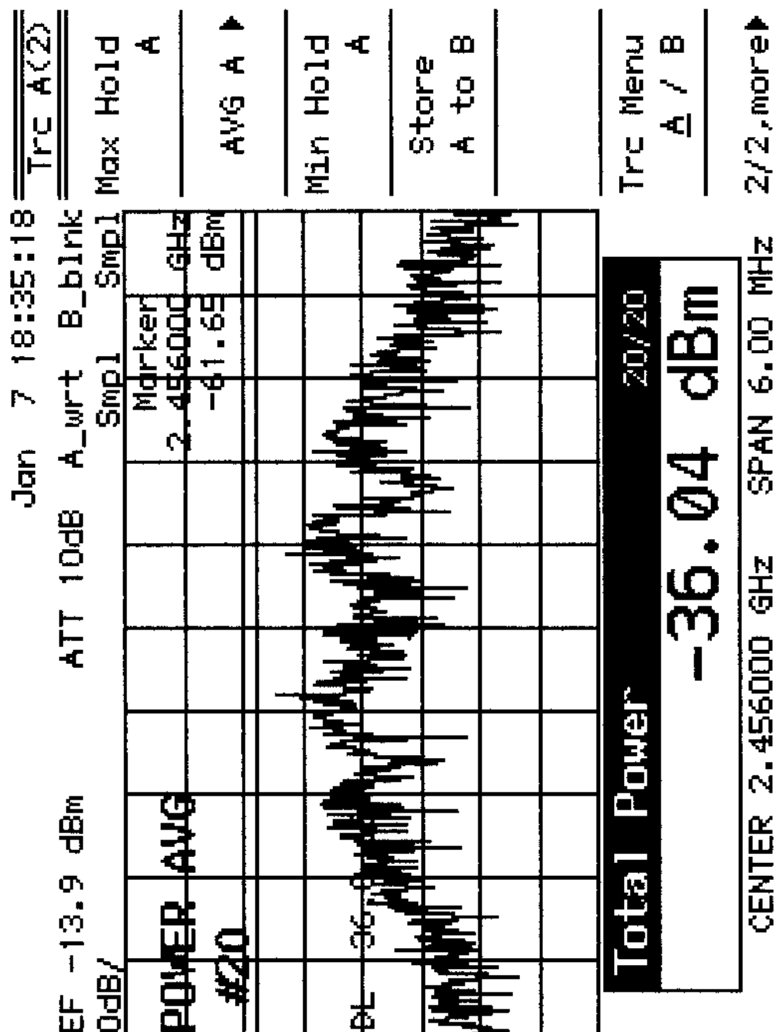
The processing gain of a direct sequence system shall be at least 10 dB. The processing gain represents the improvement to the received signal-to-noise ratio, after filtering to the information bandwidth, from the spreading/despreading function. The processing gain may be determined using one of the following methods:

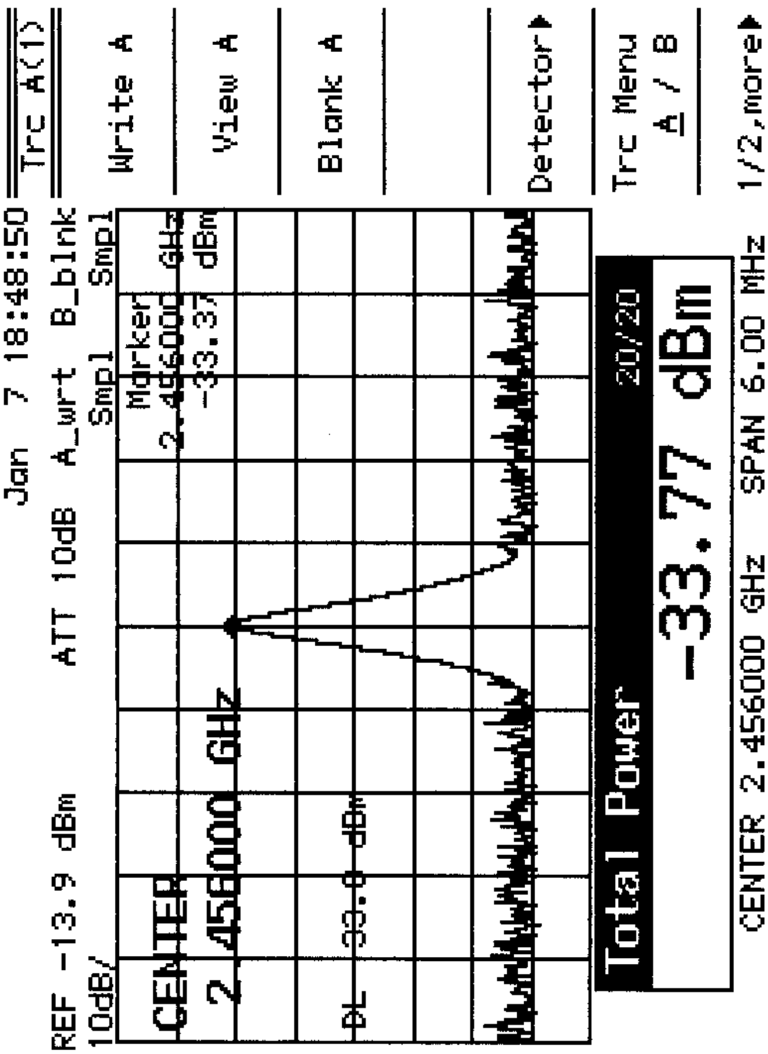
(1) As measured at the demodulated output of the receiver: the ratio in dB of the signal-to-noise ratio with the system spreading code turned off to the signal-to-noise ratio with the system spreading code turned on.

(2) As measured using the CW jamming margin method: a signal generator is stepped in 50 kHz increments across the passband of the system, recording at each point the generator level required to produce the recommended Bit Error Rate (BER). This level is the jammer level. The output power of the intentional radiator is measured at the same point. The jammer to signal ratio (J/S) is then calculated, discarding the worst 20% of the J/S data points. The lowest remaining J/S ratio is used to calculate the processing gain as follows: Gp = (S/N)o + Mj + Lsys, where Gp = processing gain of the system, (S/N)o = signal-to-noise ratio required for the chosen BER, Mj = J/S ratio, and Lsys = system losses. Note that total losses in a system, including intentional radiator and receiver, should be assumed to be no more than 2 dB.

13.2 Result

The original designers of the product performed the process gain measurement. The process gain of the product exceeds 10 dB.


REF -13.9 dBm
10dB/
ATT 10dB
Jan 7 18:35:18
A_wrt B_blnk
Smpl Smpl
Marker
2.456000 GHz
-61.65 dBm
POWER AVG
#20
Total Power 20/20
-36.04 dBm
CENTER 2.456000 GHz SPAN 6.00 MHz
RBW 100 kHz VBW 100 kHz SWP 50 ms
Trc A(2)
Max Hold A
AVG A
Min Hold A
Store A to B
Trc Menu A / B
2/2,more



Jan 7 18:48:50
REF -13.9 dBm
ATT 10dB
A_wrt B_blnk
10dB/
Smpl Smpl
Marker
2.456000 GHz
-33.37 dBm
CENTER
2.456000 GHz
DL -33.0 dBm
Total Power
20/20
-33.77 dBm
CENTER 2.456000 GHz
SPAN 6.00 MHz
RBW 100 kHz
VBW 100 kHz
SWP 50 ms
Trc A(1)
Write A
View A
Blank A
Detector
Trc Menu
A / B
1/2,more

14. Miscellaneous Comments and Notes

1. None.

15. List of Attachments

- Jamming Margin Test & Yagi Series Antenna Spec Sheet.

VALHALLA
SYSTEMS
RF ENGINEERING

Valhalla Systems Inc

399A Mountain Highway
North Vancouver, B.C.
Canada
V7J 2K9

Phone: (604) 904-6515
Fax: (604) 904-6516

Paul Slavens
Chief EMC Engineer
ACME TESTING

Dear Paul,

Please find attached the inFOREmer 2000 product images you requested (product & circuit boards – both sides) in jpeg format, as well as the results of the Jamming margin / processing gain tests.

The processing gain was measured to be 11 dB using the Carrier Peak Power measurement, and 13 dB using the Carrier Avg. Power jamming margin measurement, both exceeding the 10 dB requirement. I've included a copy of the FCC Public Notice 54797 "GUIDANCE ON MEASUREMENTS FOR DIRECT SEQUENCE SPREAD SPECTRUM SYSTEMS", used to do the measurement, as well as the test results, and the jamming margin application notes from the IC supplier (Harris Semiconductor).

PUBLIC NOTICE

Federal Communications Commission
1919 M Street NW
Washington, DC 20554

54797

News media information 202/418-0500

Recorded listing of releases and texts 202/418-2222

July 12, 1995

GUIDANCE ON MEASUREMENTS FOR DIRECT SEQUENCE SPREAD SPECTRUM SYSTEMS

Part 15 of the FCC Rules provides for operation of direct sequence spread spectrum transmitters. Examples of devices that operate under these rules include radio local area networks, cordless telephones, wireless cash registers, and wireless inventory tracking systems.

The Commission frequency receives requests for guidance as to how to perform measurements to demonstrate compliance with the technical standards for such systems. No formal measurement procedure has been established for determining compliance with the technical standards. Such tests are to be performed following the general guidance in Section 15.31 of the FCC Rules using good engineering practice. The following provides information on the measurement techniques the commission has accepted in the past for equipment authorization purposes. Alternative techniques may be acceptable upon the consultation and approval by the Commission staff. The information is organized according to the pertinent FCC rule sections.

Section 15.31(m): This rule specifies the number of operating frequencies to be examined for tunable equipment.
Section 15.207: Power line conducted emissions. If the unit is AC powered, an AC power line conducted test is also required per this rule.

Section 15.247(a)(2): Bandwidth. Make the measurement with the spectrum analyzer's resolution bandwidth (RBW) = 100 kHz. In order to make an accurate measurement, set the span >> RBW.

Section 15.247(b): Power output. This is an RF conducted test. Use a direct connection between the antenna port of the transmitter and the spectrum analyzer, through suitable attenuation. Set the RBW > 6 dB bandwidth of the emission or use a peak power meter.

Section 15.247(c): Spurious emissions. The following tests are required:

1. RF antenna conducted test: Set RBW = 100 kHz, Video bandwidth (VBW) > RBW, scan up through 10th harmonic. All harmonics/spurs must be at least 20 dB down from the highest emission level within the authorized band *as measured with a 100 kHz RBW*.
2. Radiated emission test: Applies to harmonics/spurs 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 possibly a high-pass filter) is necessary for this measurement. For measurements above 1 GHz, set RBW = 1 MHz, VBW = 10 Hz, Sweep: Auto. If the emission is pulsed, modify the unit for continuous operation, use the settings shown above, 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).

Section 15.247(d): Power spectral density. Locate and zoom in on emission peak(s) within the passband. Set RBW = 3 kHz, VBW > RBW, sweep = (Span / 3 kHz) e.g., for a span of 1.5 MHz, the sweep should be 1.5 x 10^6 / 3 x 10^3 = 500 seconds. The peak level measured must be no greater than +8 dBm. If external attenuation is used, don't forget to add this value to the reading. Use the following guidelines for modifying the power spectral density measurement procedure when necessary.

- 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 a 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 analyzers will directly measure the noise power density normalized to a 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 the HP 89440A Vector Signal Analyzer for final measurement unless a clear showing can be made for a further alternate.

Section 15.247(e): Processing Gain. 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 the jammer level. The output power of the transmitting unit is measured at the same point. The Jammer to Signal (J/S) ratio is then calculated. Discard the worst 20% of the J/S data points. The lowest remaining J/S ratio is used when calculating the Processing Gain. In a practical system, there are always implementation losses which degrade the performance below that of an optimal theoretical system of the same type. Losses occur due to non-optimal filtering, lack of equalization, LO phase noise, "corner cutting in digital processing," etc. Total losses in a system, including transmitter and receiver, should be assumed to be no more that 2 dB.
The signal to noise for and ideal non-coherent receiver is calculated from:

(1) $Pe = 1/2e^{(-1/2(S/N)o)}$

Where: ***Pe*** **= probability of error (BER)**
(S/N)o **= the required signal to noise ratio at the receiver output for a given received signal quality**

This is an example. You should use the equation (or curve) dictated by your demodulation scheme. Ref.: Viterbi, A. J. Principles of Coherent Communications, Pg. 207 (New York: McGraw-Hill, 1966).
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 Processing Gain of the system.

$Gp = (S/N)o)+Mj+Lsys$

Where: ***(S/N)o*** **= Signal to noise ratio**
Mj **= J/S ration** ***Lsys*** **= System losses.**

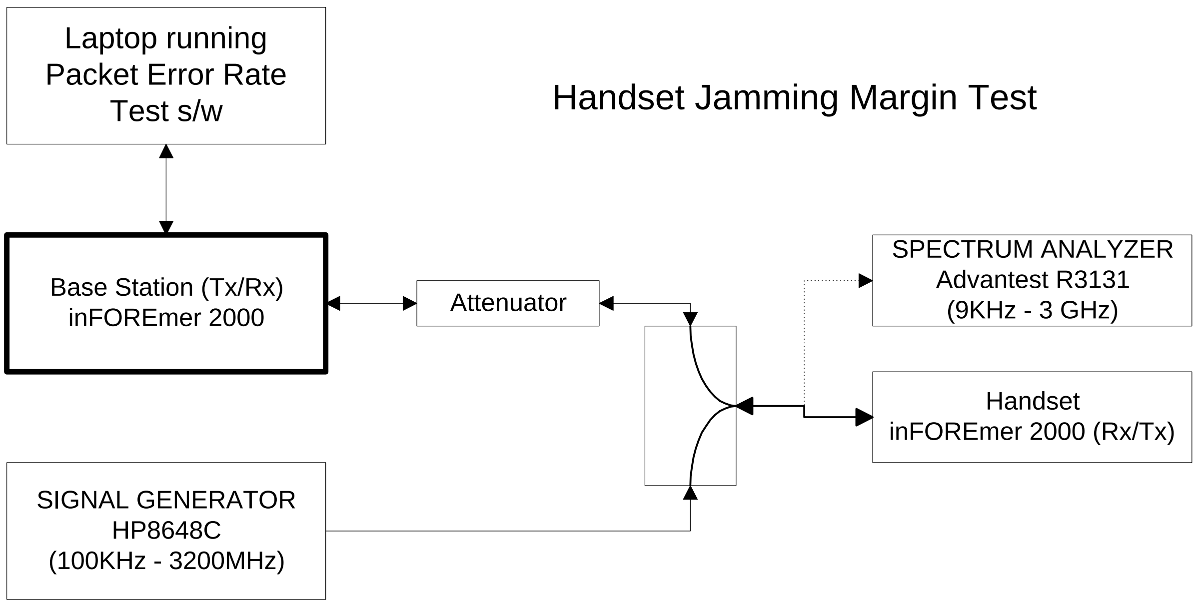
Ref.: Dixon, R. Spread Spectrum Systems, Chapter 1 (New York: Wiley, 1984)

Jamming Margin Test

InFOREmer 2000 Base Station & Handset

Background: The tests were made at Valhalla Systems by John Turner (P.Eng) & Dean Schebel.

The test setup is as shown in Fig 1.



Description:

A laptop running packet data throughput s/w was used to send a 1000 bit packet to the Handset from the Base Station. Successful packet transmission was monitored and the interfering signal's power (sig. gen.) was raised until the packets started showing errors. The last good level was used as the maximum interferer. Note that to complete the loop, the packet received by the handset was re-transmitted back to the Base Station, but in the reverse direction the interferer was significantly less than the main carrier in power.

The same test was done for the units reversed, i.e. to measure the Base Station's jamming margin. As can be seen from the tests, the results were almost identical, which makes sense, as the radios in both units are identical. In both cases the change of 1 dB resulted in a sharp BER performance, allowing for accurate jamming margin measurements

Note: The SNR for the coherent BPSK was taken from theoretical curves. The Harris Semiconductor engineers recommended adding a D-BPSK factor of 0.7 dB to the 9.6 dB to get an SNR = 10.3 dB. We left that out, as the test results measured did not seem to require this adjustment factor. Also, the jamming margin was arrived at using the "peak" envelope total power and not the avg. total power. If the avg. total power was to be used, it would result in a jamming margin 2 dB better than the peak determination.

Testing Results

	BS	HS
Actual Signal Power (Peak)	-34.0	-34.0 dBm
Actual Signal Power (Avg)	-36.0	-36.0 dBm
Lowest Interferer after 20% of worst case measurements removed		-35.0 dBm
SN o (Theretical Coherent DBPSK required Signal to Noise Ratio)		9.6 dB
Li (Implementation efficiency of the Denodulator) (2 dB max as per FCC guidelines)	2.0	2.0 dB
Pg (Theoretical Processing Gain 16 bit spreading code)	12.0	12.0 dB
Predicted Jamming Margin =Pg -SN o - Li	0.4	0.4 dB

Thus a signal greater than 0.4 dB above the desired signal will jam the receiver.

Actual Results

	BS	HS
Actual Signal Power	-34.0	-34.0 dBm
Actual Interferer Power	-35.0	-35.0 dBm
Measured Jamming Margin:	1.0	1.0 dBm
Therefore Measured Processing Gain:	12.6	12.6 dB

Freq. Range:

Freq MHz	BS to HS	HS to BS
2453.00	-24	-25
2453.05	-24	-25
2453.10	-24	-25
2453.15	-24.5	-25
2453.20	-24.5	-25
2453.25	-25	-26
2453.30	-25	-26
2453.35	-25.5	-27
2453.40	-26.5	-27
2453.45	-27	-28
2453.50	-28	-28
2453.55	-28.5	-29
2453.60	-29.5	-30
2453.65	-29.5	-31
2453.70	-30.5	-32
2453.75	-32	-32.5
2453.80	-32	-33
2453.85	-32	-33
2453.90	-33	-33
2453.95	-33	-33
2454.00	-33	-33
2454.05	-35	-33
2454.10	-33.5	-33

2454.15	-34	-33
2454.20	-34.5	-34
2454.25	-34.5	-33
2454.30	-34.5	-34
2454.35	-34.5	-33
2454.40	-35	-33
2454.45	-35	-33
2454.50	-35	-34
2454.55	-35	-34
2454.60	-35	-34
2454.65	-35	-34
2454.70	-34.5	-34
2454.75	-34.5	-34
2454.80	-34.5	-34
2454.85	-34.5	-34
2454.90	-34.5	-34
2454.95	-34.5	-34
2455.00	-34.5	-34
2455.05	-34.5	-34
2455.10	-34.5	-34
2455.15	-34.5	-34
2455.20	-34.5	-34
2455.25	-34.5	-34
2455.30	-34.5	-34
2455.35	-34.5	-34
2455.40	-34.5	-35
2455.45	-34.5	-35
2455.50	-34.5	-35
2455.55	-34.5	-35
2455.60	-34.5	-35
2455.65	-34	-35
2455.70	-33.5	-35
2455.75	-33.5	-35
2455.80	-34	-35
2455.85	-35	-35
2455.90	-34	-35
2455.95	-34	-35.5 *
2456.00	-34.5	-35 *
2456.05	-34.5	-35.5 *
2456.10	-34.5	-35.5 *
2456.15	-35.5 *	-35.5 *
2456.20	-35	-35.5 *
2456.25	-35	-35 *
2456.30	-35 *	-35 *
2456.35	-35 *	-35 *
2456.40	-35 *	-35 *
2456.45	-35.5 *	-35 *
2456.50	-35.5 *	-35 *
2456.55	-35.5 *	-35 *
2456.60	-35.5 *	-35 *
2456.65	-35.5 *	-35 *
2456.70	-35.5 *	-35 *
2456.75	-35.5 *	-35 *
2456.80	-35.5 *	-35 *
2456.85	-35.5 *	-35 *
2456.90	-35.5 *	-35 *
2456.95	-35.5 *	-35 *
2457.00	-35.5 *	-35 *

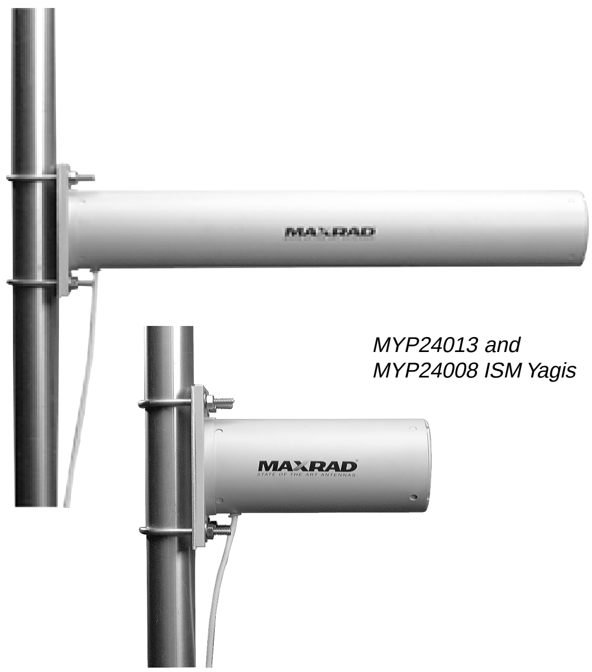
2457.05	-35.5 *	-34
2457.10	-35.5 *	-34.5
2457.15	-35.5 *	-34.5
2457.20	-35.5 *	-34.5
2457.25	-35 *	-35 *
2457.30	-35 *	-35 *
2457.35	-35 *	-34.5
2457.40	-35 *	-34.5
2457.45	-35	-34.5
2457.50	-34.5	-34.5
2457.55	-34.5	-34.5
2457.60	-34.5	-34.5
2457.65	-34	-34.5
2457.70	-34	-34.5
2457.75	-33.5	-34.5
2457.80	-33	-34
2457.85	-32.5	-33.5
2457.90	-32.5	-33
2457.95	-33	-33.5
2458.00	-32	-33.5
2458.05	-31.5	-33
2458.10	-32	-33
2458.15	-31	-32
2458.20	-30.5	-32
2458.25	-31	-32
2458.30	-29.5	-31.5
2458.35	-29	-30
2458.40	-29	-30
2458.45	-28.5	-29
2458.50	-28	-28.5
2458.55	-27.5	-28.5
2458.60	-27	-28
2458.65	-26.5	-27.5
2458.70	-26	-27
2458.75	-25.5	-26
2458.80	-25.5	-26
2458.85	-25.5	-26
2458.90	-25.5	-26
2458.95	-25	-26
2459.00	-25	-26

* indicates 20% rejected measurement as per FCC test outline

2.4 GHz ISM - MYP Yagi Antenna Series

The MAXRAD MYP24008 is a totally enclosed 6 element Yagi antenna for the 2400 to 2483.5 MHz frequency band. The MAXRAD MYP24013 is a totally enclosed 16 element Yagi antenna for the 2400 to 2483.5 MHz frequency band. Both models can be used as bridge antennas between two networks or for point-to-point communications. Each antenna has a nominal VSWR of 1.5:1 and is less than 2:1 over the entire frequency band. The MYP24008 gain is 8.8 dBi and the half-power beamwidth is 55 degrees. The MYP24013 gain is 13.5 dBi and the half-power beamwidth is 30 degrees. Each antenna is typically mast mounted and vertically polarized.

General Specifications:
2.4 GHz ISM - MYP Yagi Antenna Series
Termination:
N, female
Wind Survival:
120 mph
Maximum Mount Pipe Diameter:
1 5/8 inches
Mounting Hardware:
MYK24 standard yagi mounting kit (included) clamps to a vertical mast of up to 1-5/8" O.D.
MYK26 adjustable yagi mounting kit (optional) clamps to a vertical mast of up to 1-1/2" O.D.
Lightning Protection:
DC grounded
Nominal Impedance:
50 Ohms



MYP24013 and MYP24008 ISM Yagis

Electrical Specifications
2.4 GHz ISM - MYP Yagi Antenna Series

Model #	Frequency Range	VSWR	Front-to-Back Ratio	Gain	Vertical Beamwidth @ 1/2 Power	Horizontal Beamwidth @ 1/2 Power
MYP24008	2400-2483.5 MHz	< 2:1, 1.5:1 nominal	>13.5 dB	8.8 dBi (6.6 dBd) nominal	55°	47°
MYP24013	2400-2483.5 MHz	< 2:1, 1.5:1 nominal	> 20 dB	13.5 dBi (11.3 dBd) nominal	30°	28°

Mechanical Specifications
2.4 GHz ISM - MYP Yagi Antenna Series

Model #	Equivalent Flat Plate Area	Lateral Thrust at Rated Wind	Bending Moment at Base at Rated Wind	Cable Length	Cable Type	Connector	Length	Weight	List Price
MYP24008	0.146 ft^2	12.2 lbs.	3.6 lb-ft	18 inches	High performance LMR195	Type N, female	7-1/4 inches	.48 lbs	$228.99
MYP24013	0.375 ft^2	31.4 lbs.	23.6 lb-ft	18 inches	High performance LMR195	Type N, female	18 inches	.76 lbs	$259.73

Mounting Hardware and Accessories
2.4 GHz ISM - MYP Yagi Antenna Series

Model #	Description	List Price
MYK24	Standard Yagi mounting kit	$41.80
MYK26	Adjustable Yagi mounting kit	$105.08


MYK24


MYK26

Note: Other cable and connector options are available. Please consult the factory for details.

2.4 GHz ISM - MYP Yagi Antenna Series
Feature / Benefit List

Feature:	Versatile mounting hardware allows easy installation
Benefit:	*Two mounting kits clamp to masts of 1-5/8" and 1-1/2" O.D.*
Feature:	Optional, articulating mount
Benefit:	*Allows precise adjustment of the antenna both vertically and horizontally*
Feature:	Very few mechanical parts
Benefit:	*More robust and reliable antenna*
Feature:	One-piece unit construction design
Benefit:	*Minimizes potential intermodulation problems that can occur with multiple joint designs*
Feature:	Antenna elements made from high grade aluminum
Benefit:	*Provide maximum mechanical strength, stability, and reliability*
Feature:	Attractive weather-proof radome constructed of UV stabilized material
Benefit:	*Provides robust and trouble free use in harsh outdoor environments*

2.4 GHz ISM - MYP Yagi Antenna Series
Frequently Asked Questions

Question:	What gain versions are available?
Answer:	***The Yagi is available in 8.8 dBi gain (Model MYP24008) and 13.5 dBi gain (Model MYP24013)***
Question:	What frequencies do the Yagi antennas cover?
Answer:	***2400-2483.5 MHz (2.4-2.4835 GHz)***