UL International EMC Services
333 Pfingsten Road
Northbrook, Illinois 60062-2096
(800) 873-8536
Fax No. (847) 272-8864
http://www.ul.com/emc/

March 23, 2001

Grayhill Inc.
Attn: Mr. Rob Haller
561 Hillgrove Avenue
LaGrange, IL 60525-5997

UL Reference: File MC1099, Project 00NK37578

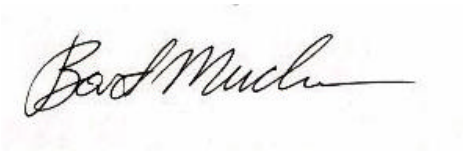
Subject: **Revised** EMC Test and Measurement Report for Model EZCom-IP

Dear Mr.Haller:

We have provided with this letter your revised EMC Test Report for the above referenced model. Section 1.6 has been revised to correct a typographical error in the original test report. The rated high channel was reduced to 2443MHz not 2433MHz as originally stated.

Please review the attached report and direct any questions or comments to me.

Best regards,



Bart Mucha (Ext. 41216)
EMC Engineer
International EMC Services

Reviewed by:

Jack Steiner
Engineering Group Leader
International EMC Services

EMC – TEST REPORT

Issue Date: January 23, 2001

Revised Date: March 23, 2001

Ö **EMISSIONS**

IMMUNITY

Test Report File No.	:	MC1099
Project No.	:	00NK37578
Model / Type	:	EZCom-IP
Kind of Product	:	2.4GHz Direct Sequence Spread Spectrum Transmitter
Applicant	:	Grayhill Inc.
License Holder	:	Grayhill Inc.
Address	:	561 Hillgrove Avenue
	:	LaGrange, IL 60525-5997
Manufacturer	:	Same as Applicant
Test Result	:	**COMPLIANT**

This report without appendices consists of 12 pages. Appendix A contains test photos, Appendix B contains original test data, Appendix C contains sample calculations and Appendix D contains a block diagram of the measurement system.

The data contained in this report reflects only the items tested in the configurations and mode of operations described. An attempt has been made to arrange the EUT, with the equipment provided, into a test configuration which maximizes the observed emissions of the EUT while simulating, as close as practical, a typical end-use installation. The photos and data provided in this report document that configuration.

Underwriters Laboratories Inc. 333 Pfingsten Rd. Northbrook, IL 60062
Fax: (847) 272-8864

REPORT DIRECTORY

SECTION TITLE

GENERAL

EMISSIONS

IMMUNITY

CONCLUSION

APPENDICIES

1.0 GENERAL PRODUCT DESCRIPTION

The EUT is a 2.4GHz, direct sequence spread spectrum transmitter.

1.0.1 Equipment Mobility:

Table-top

1.0.2 Test Voltage and Frequency:

Voltage (V)	Frequency (Hz)
120	60

1.1 MODEL DIFFERENCES

Any other model(s) represented by the models tested in this investigation will be documented by the manufacturer.

1.2 ENVIRONMENTAL CONDITIONS IN TEST LAB

Temperature:	**20-25 ℃**
Relative Humidity:	**30-60% RH**
Atmospheric Pressure:	**860-1060 mbar**

1.3 CALIBRATION OF EQUIPMENT USED FOR MEASUREMENT

All test equipment and test accessories are calibrated on a regular basis. The maximum time between calibrations is one year or what is recommended by the manufacturer, whichever is less.

All test equipment calibrations are traceable to the National Institute of Standards and Technology (NIST), therefore, all test data recorded in this report is traceable to NIST.

1.4 EUT CONFIGURATION(s)

See Appendix A for individual set-up configuration(s). In addition to the EUT, the following peripheral devices and/or cables were connected during the measurement:

Device	Manufacturer	Model	Serial #	FCC ID
EUT	Grayhill	EZCOM-IP	N/A	NMAEZCOMWL24IP
8 dBi **OMNI** Antenna	Maxrad	N/A	N/A	N/A

Cable	Manufacturer	Length	Type
Antenna Cable	Times Microwave	25 feet	LMR-400

1.5 EUT OPERATING MODE(s)

The equipment under test was operated during the measurements under the following conditions:

30-1000MHz - Testing was performed with the radio not transmitting and an Axis 2100 digital camera sending streaming image data to the radio as a traffic generator.

1GHz – 25 GHz - Continuous operation, transmitting 350 mW (25.4dBm) at antenna terminals. The listed antenna's gain is 8dBi resulting in ERP (neglecting coax loss) of 33.4dBm.

1.6 DEVICE MODIFICATIONS

The following modifications were necessary for compliance:

1. Rated output power was reduced from 440mW to 350mW.
2. Rated high channel was reduced to 2443MHz.

These changes will be implemented in firmware in the production radio so users can not go higher in frequency or higher in power.

1.7 REVISION HISTORY

Section 1.6 was revised to correct a typographical error in the original test report. The rated high channel was reduced to 2443MHz not 2433MHz as originally stated.

EMISSIONS TEST REGULATIONS

Emission measurements were performed according to the following regulations:

47 CFR Part 15 Subpart B: 1999

ANSI C63.4 – 1992

Per the manufacturer's request, only spurious measurements were performed per 15.247(c) of Part 15.

The radiated measurements were performed on the highest gain antenna in each antenna family. Since the transmitter operates over a frequency range greater than 10MHz, measurements must be performed on low, mid and high channels per 15.31(m).

Average Value of Measured Emissions

Per clause 15.35 of CFR 47, Part 15 the measured field strength can be determined by averaging the pulse train over a 0.1 second interval. When averaged over a 0.1 second interval, the EUT has a duty cycle of 40%. The average value of measured emissions can be calculated as follows:

$20\log(0.4) =$ **-7.96dB**

At the time of testing the pulse train (duty cycle) was not known. Therefore the limits shown on the plots and data files do not reflect the average value of measured emissions. **The average value can be determined by reducing the measured value by 7.96dB.**

CONDUCTED SPURIOUS EMISSIONS, 1 TO 25 GHz

Test Location

10 Meter Semi-Anechoic Chamber

Test Instruments

Measurement Software

UL-EMC Program, Version V 3.02, validated May 15, 2000

Spectrum Analyzer

Rhode & Schwarz, Model FSEK20, EMC No. 4182
Last Cal. 11-12-99, Next. Cal. 11-12-00

Frequency Range of Measurement

1 to 25 GHz

Test Results

The requirements are:

MET

Remarks

See App. B for complete test results.

RADIATED ELECTRIC FIELD EMISSIONS, 30MHz to 1000MHz

Test Location

10 Meter Semi-Anechoic Chamber

UL Procedure

3014ANBK-LPG-002

Test Instruments

Spectrum Analyzer / Quasi-peak Adapter / Preamplifier / Preselector

Hewlett Packard Model 8566B Spectrum Analyzer
Model 85650A Quasi-peak Adapter
Miteq AM-3A-000110-N Preamp No. FCA4003, EMC4016, EMC4151
Model 85685A RF Preselector No. EMC4015

Antennas

Chase EMC Ltd., Biconical Antenna Model VBA6106A	S/N 1246
Chase EMC Ltd., Log Periodic Antenna Model UPA6109	S/N 1040

Frequency Range of Measurement

30MHz to 1000MHz

Measurement Distance

10 meters

Test Results

The requirements are:
MET

Remarks

See App. B for complete test results.

RADIATED ELECTRIC FIELD EMISSIONS, 1 TO 4 GHz

Test Location

10 Meter Semi-Anechoic Chamber

UL Procedure

3014ANBK-LPG-002A

Test Instruments

Measurement Software

UL-EMC Program, Version V 3.02, validated May 15, 2000

Spectrum Analyzer

Rhode & Schwarz, Model FSEK20, EMC No. 4182
Last Cal. 11-12-99, Next. Cal. 11-12-00

Antennas

EMCO, Model 3115, EMC No. 4033
Last Cal. 4-1-00, Next Cal. 4-1-01

Frequency Range of Measurement

1 to 4 GHz

Measurement Distance

***2 meters**

Test Results

The requirements are:

MET

Remarks

See App. B for complete test results.

*To avoid overload in the transmit mode no preamplifier was used between 1 GHz and 4 GHz. Measurements were made at a 2 meter distance to allow an adequate margin between the measurement systems noise floor and the limit. The 2 meter limit was calculated as follows:

Limit above 960MHz per 15.209 is 500uV/m.
500uV/m * (3 meters / 2meters) = 750uV/m
20 log (750uV/m) = **57.5dBuV/m**

RADIATED ELECTRIC FIELD EMISSIONS, 2 TO 2.5 GHz

Test Location

10 Meter Semi-Anechoic Chamber

UL Procedure

3014ANBK-LPG-002A

Test Instruments

Measurement Software

UL-EMC Program, Version V 3.02, validated May 15, 2000

Spectrum Analyzer

Rhode & Schwarz, Model FSEK20, EMC No. 4182
Last Cal. 11-12-99, Next. Cal. 11-12-00

Antennas

EMCO, Model 3115, EMC No. 4033
Last Cal. 4-1-00, Next Cal. 4-1-01

Frequency Range of Measurement

2 to 2.5 GHz

Measurement Distance

***2 meters**

Test Results

The requirements are:

MET

Remarks

See App. B for complete test results.

*To avoid overload in the transmit mode no preamplifier was used between 1 GHz and 4 GHz. Measurements were made at a 2 meter distance to allow an adequate margin between the measurement systems noise floor and the limit. The 2 meter limit was calculated as follows:

Limit above 960MHz per 15.209 is 500uV/m.
500uV/m * (3 meters / 2meters) = 750uV/m
20 log (750uV/m) = **57.5dBuV/m**

RADIATED ELECTRIC FIELD EMISSIONS, 4 TO 18 GHz

Test Location

10 Meter Semi-Anechoic Chamber

UL Procedure

3014ANBK-LPG-002A

Test Instruments

Measurement Software

UL-EMC Program, Version V 3.02, validated May 15, 2000

Spectrum Analyzer

Rhode & Schwarz, Model FSEK20, EMC No. 4182
Last Cal. 11-12-99, Next. Cal. 11-12-00

Antennas

EMCO, Model 3115, EMC No. 4033
Last Cal. 4-1-00, Next Cal. 4-1-01

Filter/Amplifier Assembly,

Last Char. 10-14-00, Next Char. 10-14-01. Consists of the following:

Hewlett-Packard Step Attenuator, Model HP84904K (used for linearity check)

Cascaded 3.8GHz and 4.8GHz high pass filters, TTE Models H710-3.8G-50-A and H711-4.8G-50-A (attenuates fundamental 90dB)

Preamplifiers, MITEQ, Model ASF5-00501800-5, EMC No. 4194 and EMC No. 4195

Frequency Range of Measurement

4 to 18 GHz

Measurement Distance

3 meters

Test Results

The requirements are: MET

Remarks

See App. B for complete test results. To avoid overload in the transmit mode, two high pass filters were cascaded to attenuate the fundamental (2.4GHz) signal 90dB. These filters were located prior to the preamplifier stage to avoid overload of the preamplifiers. See Appendix D for a block diagram of the measurement system.

RADIATED ELECTRIC FIELD EMISSIONS, 18 TO 26.5 GHz

Test Location

10 Meter Semi-Anechoic Chamber

UL Procedure

3014ANBK-LPG-002A

Test Instruments

Measurement Software

UL-EMC Program, Version V 3.02, validated May 15, 2000

Spectrum Analyzer

Rhode & Schwarz, Model FSEK20, EMC No. 4182
Last Cal. 11-12-99, Next. Cal. 11-12-00

Antennas

ETS, Model 3160-09, EMC No. 4155

Filter/Amplifier Assembly,

Last Char. 10-14-00, Next Char. 10-14-01. Consists of the following:

Hewlett-Packard Step Attenuator, Model HP84904K (used for linearity check)

Preamplifiers, MITEQ, Models AFS44-00102650-40-10P-44 and AFS42-00102650-40-10P-42, EMC No. 4186 and EMC No. 4192

Frequency Range of Measurement

18 to 26.5 GHz

Measurement Distance

3 meters

Test Results

The requirements are:

MET

Remarks

See App. B for complete test results.

The attenuation of fundamental signal (2.4GHz) by the horn antenna is sufficient to avoid overload of the preamplifier stage. See Appendix D for a block diagram of the measurement system.

3.0 IMMUNITY TEST REGULATIONS

Immunity testing was not performed.

4.0 GENERAL REMARKS

Sample Receipt Date : October 3, 2000

Test Dates
Start : October 3, 2000
End : November 6, 2000

4.1 SUMMARY

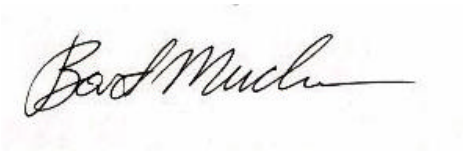
The requirements according to the technical regulations are:

MET

Underwriters Laboratories Inc.
333 Pfingsten Road
Northbrook, IL 60062 USA

FCC Site Number: 31040/SIT 1300F2

Test Engineer:



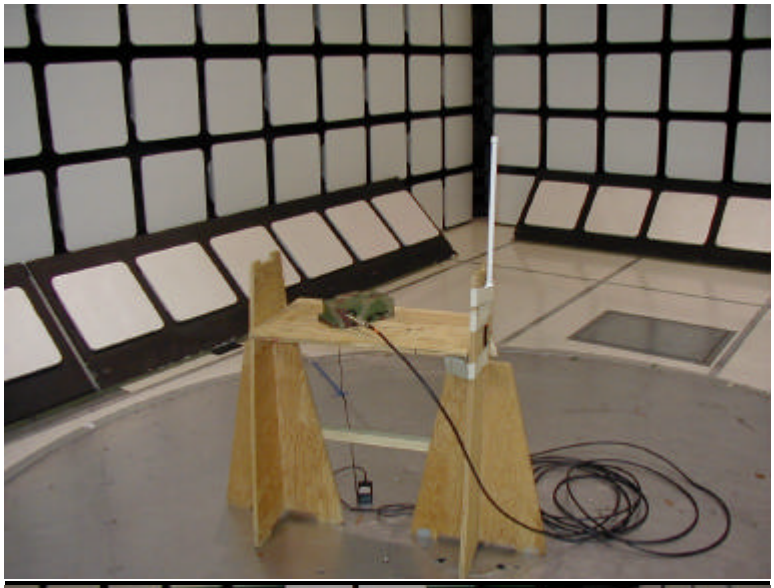
Bart Mucha (Ext 41216)
EMC Engineer
International EMC Services

Reviewed by:

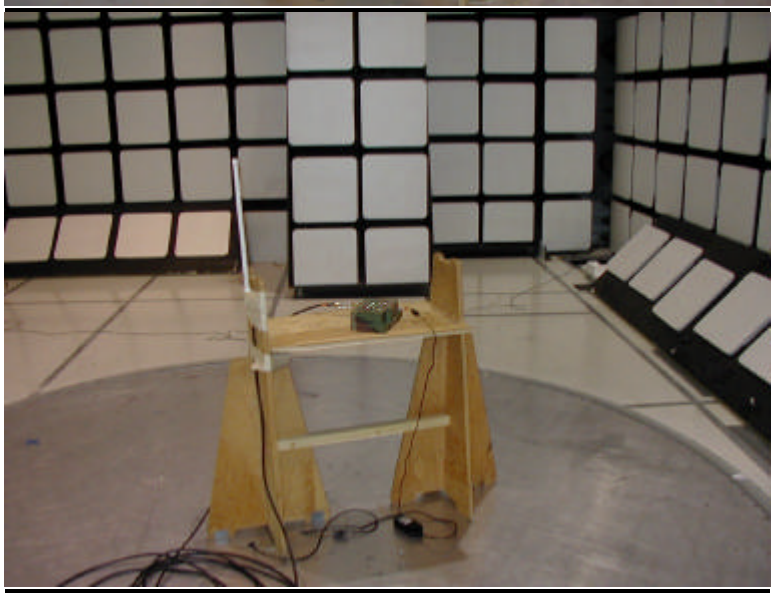
Jack Steiner
Engineering Group Leader
International EMC Services

APPENDIX A

PHOTOS



Radiated Emissions



Radiated Emissions

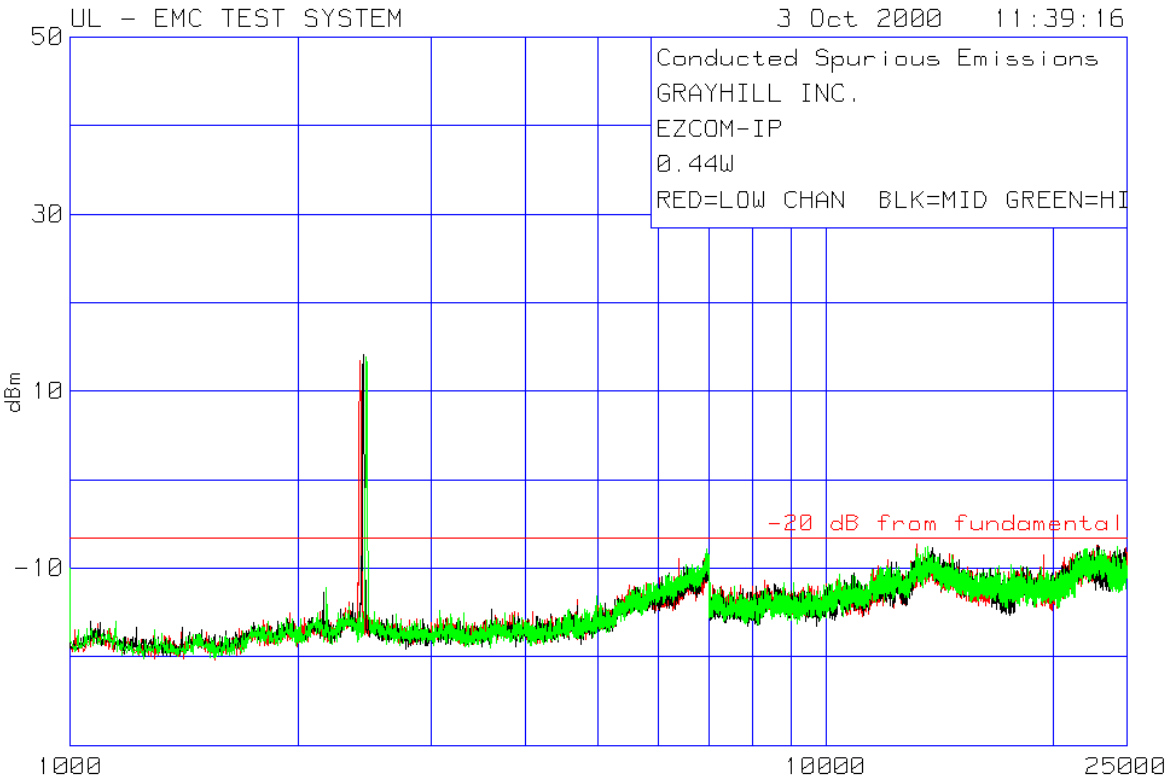
APPENDIX B

TEST DATA

EMISSIONS

Conducted Spurious Emissions, 1 to 25 GHz

RBW = 100 kHz
VBW = 1 MHz



Red = Low Channel (2418 MHz)
Black = Mid Channel (2425 MHz)
Green = High Channel (2462MHz)

Conducted Spurious Emissions, 1 to 25 GHz

RBW = 100 kHz
VBW = 1 MHz

GRAYHILL INC.
EZCOM-IP
0.44W
RED=LOW CHAN BLK=MID GREEN=HI

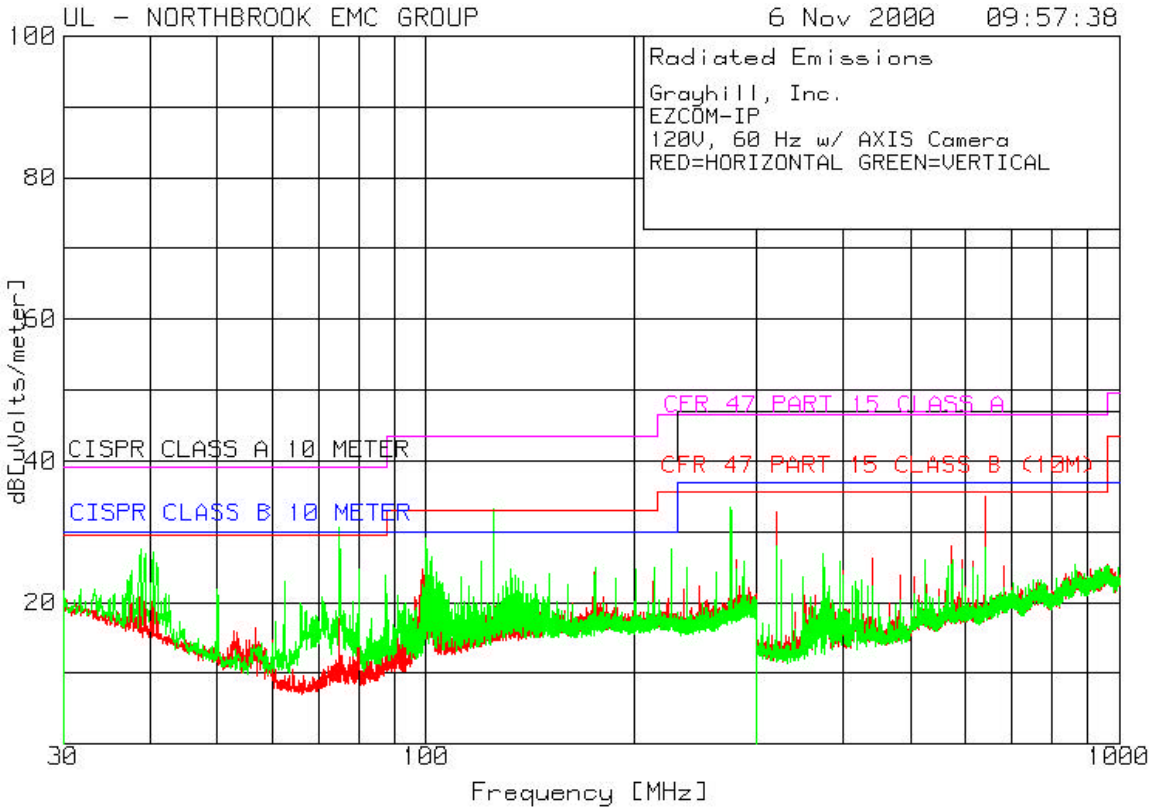
Test Frequency [MHz]	Meter Reading [dB(uV)]	Gain/Loss Factor [dB]	Transducer Factor [dB]	Level dBm	Limit:1	2	3	4
Fundamental								
2416.142	118.43 pk2		-107	13.43	6.57	N/A	N/A	N/A
Azimuth: N/A	Height:100 Horz	Margin [dB]		20		N/A	N/A	N/A
Fundamental								
2440.144	119.11 pk2		-107	14.11	6.57	N/A	N/A	N/A
Azimuth: N/A	Height:100 Horz	Margin [dB]		20.68		N/A	N/A	N/A
Fundamental								
2464.146	118.84 pk2		-107	13.84	6.57	N/A	N/A	N/A
Azimuth: N/A	Height:100 Horz	Margin [dB]		20.41		N/A	N/A	N/A

LIMIT 1: -20dB below fundamental(worst case 13.43dBm – 20dB = -6.57dBm)
LIMIT 2: NONE
LIMIT 3: NONE
LIMIT 4: NONE

pk - Peak detector

All spurious emissions were at least 20dB below the fundamental

Radiated Spurious Emissions, 30-1000MHz
Preliminary Peak Data
Azimuth – 0 to 360 degrees
Antenna Height – 1, 2, 3 and 4 meters



Radiated Spurious Emissions, 30-1000MHz
Preliminary Peak Data
Azimuth – 0 to 360 degrees
Antenna Height – 1, 2, 3 and 4 meters

Grayhill, Inc.
EZCOM-IP
120V, 60 Hz w/ AXIS Camera
RED=HORIZONTAL GREEN=VERTICAL

Test Frequency [MHz]	Meter Reading [dB(uV)]	Gain/Loss Factor [dB]	Transducer Factor [dB]	Level dB[uVolts/meter]	Limit:1	2	3	4
38.7684	43.2 pk	-30.6	14.9	27.5	29.5	30	N/A	N/A
Azimuth: 8	Height:99 Vert	Margin [dB]		-2	-2.5	N/A	N/A	
40.3872	43.3 pk	-30.6	14.3	27	29.5	30	N/A	N/A
Azimuth: 294	Height:99 Vert	Margin [dB]		-2.5	-3	N/A	N/A	
74.9888	54.7 pk	-30.5	6.5	30.7	29.5	30	N/A	N/A
Azimuth: 0	Height:400 Vert	Margin [dB]		1.2	.7	N/A	N/A	
100.0799	48.9 pk	-30.4	10.6	29.1	33.1	30	N/A	N/A
Azimuth: 112	Height:200 Vert	Margin [dB]		-4	-.9	N/A	N/A	
125.1037	49.9 pk	-30.4	13.7	33.2	33.1	30	N/A	N/A
Azimuth: 316	Height:99 Vert	Margin [dB]		.1	3.2	N/A	N/A	
275.2461	45.4 pk	-29.3	17.3	33.4	35.6	37	N/A	N/A
Azimuth: 332	Height:99 Vert	Margin [dB]		-2.2	-3.6	N/A	N/A	
320.1099	50.7 pk	-32.8	14.9	32.8	35.6	37	N/A	N/A
Azimuth: 38	Height:300 Horz	Margin [dB]		-2.8	-4.2	N/A	N/A	
639.7702	46.1 pk	-30.8	19.6	34.9	35.6	37	N/A	N/A
Azimuth: 328	Height:99 Horz	Margin [dB]		-.7	-2.1	N/A	N/A	

LIMIT 1: CFR 47 PART 15 CLASS B (10M)
LIMIT 2: CISPR CLASS B 10 METER
LIMIT 3: CFR 47 PART 15 CLASS A
LIMIT 4: CISPR CLASS A 10 METER

pk - Peak detector

Final Maximized Quasi-Peak Data
Azimuth – 0 to 360 degrees
Antenna Height – 1 to 4 meters

Grayhill, Inc.
EZCOM-IP
120V, 60 Hz w/ AXIS Camera
RED=HORIZONTAL GREEN=VERTICAL

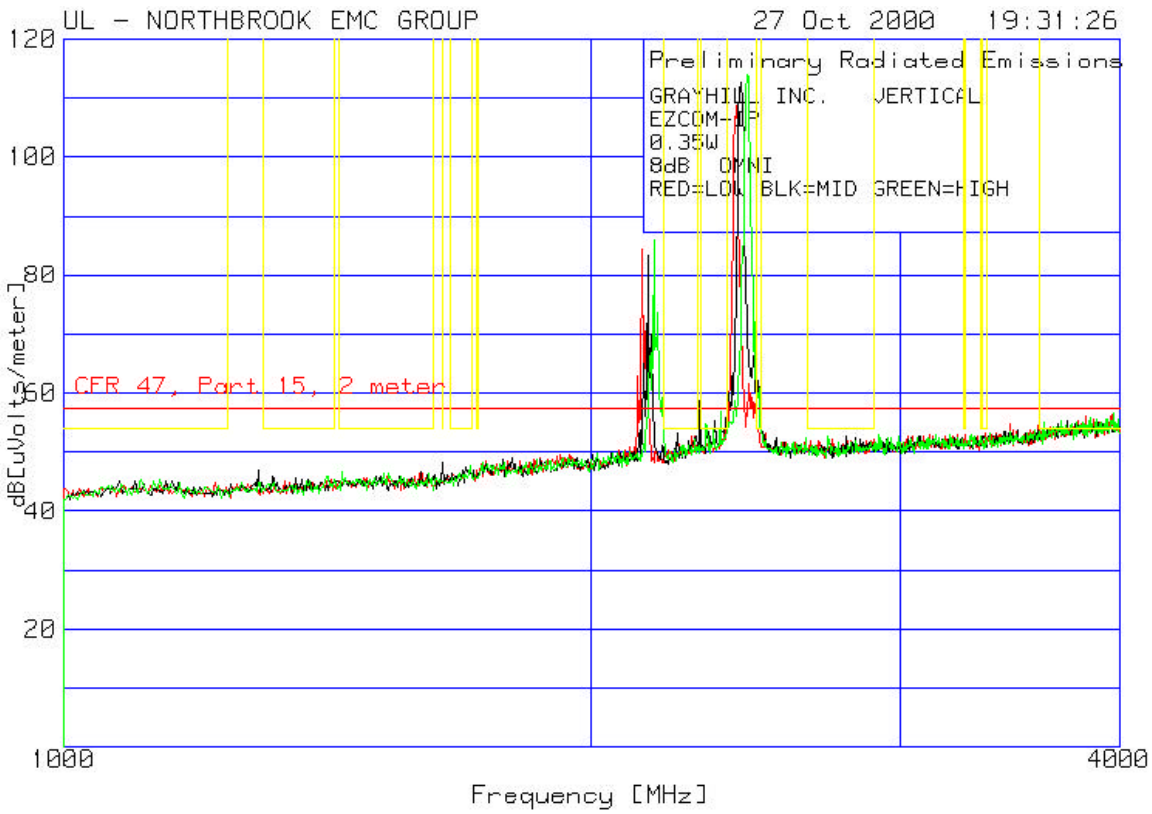
Test Frequency [MHz]	Meter Reading [dB(uV)]	Gain/Loss Factor [dB]	Transducer Factor [dB]	Level dB[uVolts/meter]	Limit:1	2	3	4
38.7649	42.05 qp	-30.6	14.9	26.35	29.5	30	N/A	N/A
Azimuth: 66	Height:100 Vert		Margin [dB]		-3.15	-3.65	N/A	N/A
40.3989	42.95 qp	-30.6	14.3	26.65	29.5	30	N/A	N/A
Azimuth: 168	Height:102 Vert		Margin [dB]		-2.85	-3.35	N/A	N/A
74.9747	53.27 qp	-30.5	6.5	29.27	29.5	30	N/A	N/A
Azimuth: 71	Height:169 Vert		Margin [dB]		-.23	-.73	N/A	N/A
100.0545	48.63 qp	-30.4	10.6	28.83	33.1	30	N/A	N/A
Azimuth: 306	Height:121 Vert		Margin [dB]		-4.27	-1.17	N/A	N/A
124.9498	46.03 qp	-30.4	13.7	29.33	33.1	30	N/A	N/A
Azimuth: 354	Height:104 Vert		Margin [dB]		-3.77	**-.67**	N/A	N/A
275.023	44.73 qp	-29.3	17.3	32.73	35.6	37	N/A	N/A
Azimuth: 330	Height:101 Vert		Margin [dB]		-2.87	-4.27	N/A	N/A
320.0972	51.55 qp	-32.8	14.9	33.65	35.6	37	N/A	N/A
Azimuth: 75	Height:248 Horz		Margin [dB]		-1.95	-3.35	N/A	N/A
640.1438	46.61 qp	-30.8	19.6	35.41	35.6	37	N/A	N/A
Azimuth: 331	Height:143 Horz		Margin [dB]		**-.19**	-1.59	N/A	N/A

LIMIT 1: CFR 47 PART 15 CLASS B (10M)
LIMIT 2: CISPR CLASS B 10 METER
LIMIT 3: CFR 47 PART 15 CLASS A
LIMIT 4: CISPR CLASS A 10 METER

Qp: Quasi-Peak Detection

Radiated Spurious Emissions, 1 to 4GHz
Measurement Antenna - Vertical
Transmit Antenna – 8dBi OMNI
RBW = VBW = 100 kHz

Preliminary Peak Data

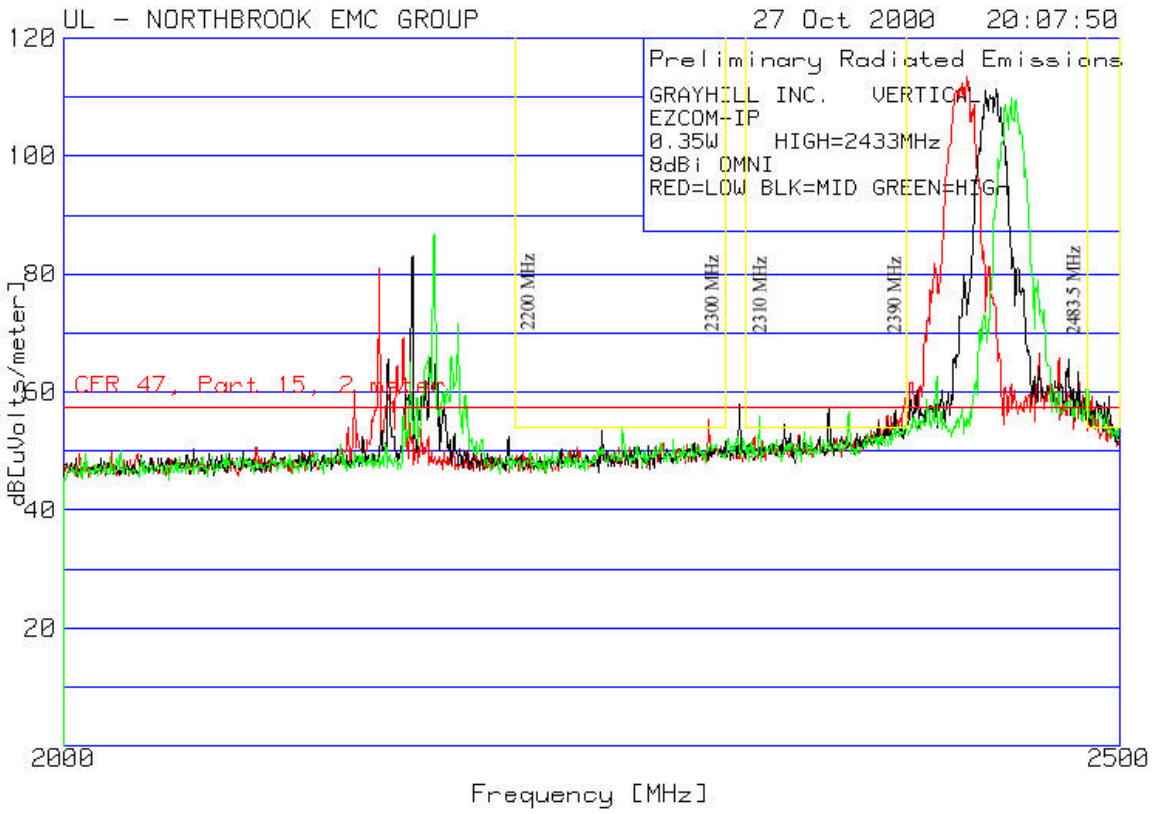


Red = Low Channel (2418 MHz)
Black = Mid Channel (2425 MHz)
Green = High Channel (2433 MHz)

Yellow Limit Line = Restricted Bands per 15.205
Red Limit Line = General Limit at 2 meters per 15.209

Radiated Spurious Emissions, 2 to 2.5GHz
Measurement Antenna - Vertical
Transmit Antenna – 8dBi OMNI
RBW = VBW = 100 kHz

Preliminary Peak Data



Red = Low Channel (2418 MHz)
Black = Mid Channel (2425 MHz)
Green = High Channel (2433 MHz)

Yellow Limit Line = Restricted Bands per 15.205
Red Limit Line = General Limit at 2 meters per 15.209

Preliminary Peak Data

RBW = VBW = 100 kHz

```
 GRAYHILL INC.   VERTICAL
 EZCOM-IP
 0.35W    HIGH=2433MHz
 8dBi OMNI
 RED=LOW BLK=MID GREEN=HIGH

  Test    Meter  Gain/Loss Transducer Level Limit:1   2      3     4
Frequency Reading  Factor    Factor  dB[uVolts/meter]
  [MHz]   [dB(uV)]  [dB]     [dB]
=====================================================================
Mid Channel, Restricted band
2351.351   25.23 pk 2        30.2     57.43  57.5   54      N/A   N/A
Azimuth: N/A  Height:100 Vert  Margin [dB]  -.07   3.43    N/A    N/A

Low Channel, Band-Edge measurement
2392.392   29.37 pk 2        30.3     61.67  57.5   N/A     N/A   N/A
Azimuth: N/A  Height:100 Vert  Margin [dB]  4.17   N/A     N/A    N/A

High Channel, Band-Edge measurement
2483.483   32.41 pk 2        30.6     65.01  57.5   N/A     N/A   N/A
Azimuth: N/A  Height:100 Vert  Margin [dB]  7.51   N/A     N/A    N/A


LIMIT 1: CFR 47, Part 15, 2 meter
LIMIT 2: FCC Restricted Bands 1
LIMIT 3: FCC Restricted Bands 2
LIMIT 4: FCC Restricted Bands 3

pk - Peak detector
```

Per clause 15.35 of CFR 47, Part 15 the measured field strength can be determined by averaging the pulse train over a 0.1 second interval. When averaged over a 0.1 second interval, the EUT has a duty cycle of 40%. The average value of measured emissions cab be calculated as follows:

20log(0.4) = **-7.96dB**

At the time of testing the duty cycle was not known. Therefore the limits shown on the plots and data files do not reflect the average value of measured emissions. **The average value can be determined by reducing the measured value by 7.96dB.**

Final Maximized Average Data
Azimuth – 0 to 360 degrees
Antenna Height – 0.75 to 2.5 meters

RBW = 1 MHz, VBW = 10Hz

```
 GRAYHILL INC.   VERTICAL
 EZCOM-IP
 0.35W    HIGH=2433MHz
 8dBi OMNI
 RED=LOW BLK=MID GREEN=HIGH
```

Test Frequency [MHz]	Meter Reading [dB(uV)]	Gain/Loss Factor [dB]	Transducer Factor [dB]	Level dB[uVolts/meter]	Limit:1	2	3	4
Low Channel, **Restricted band**								
2350.9599	23.6 av	2	30.2	55.8	57.5	54	N/A	N/A
Azimuth: 55	Height:102 Vert			Margin [dB]	**-1.7**	1.8	N/A	N/A

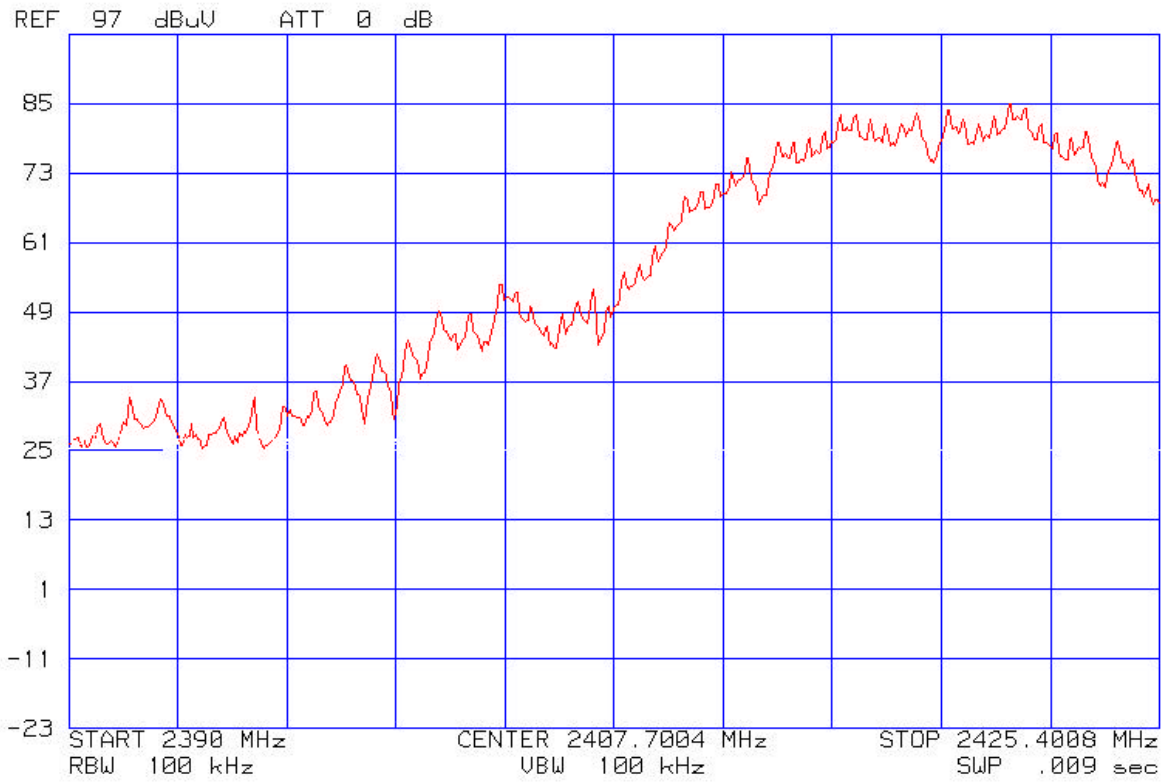
```
LIMIT 1: CFR 47, Part 15, 2 meter
LIMIT 2: FCC Restricted Bands 1
LIMIT 3: FCC Restricted Bands 2
LIMIT 4: FCC Restricted Bands 3

av - Average detector
```

Per clause 15.35 of CFR 47, Part 15 the measured field strength can be determined by averaging the pulse train over a 0.1 second interval. When averaged over a 0.1 second interval, the EUT has a duty cycle of 40%. The average value of measured emissions cab be calculated as follows:

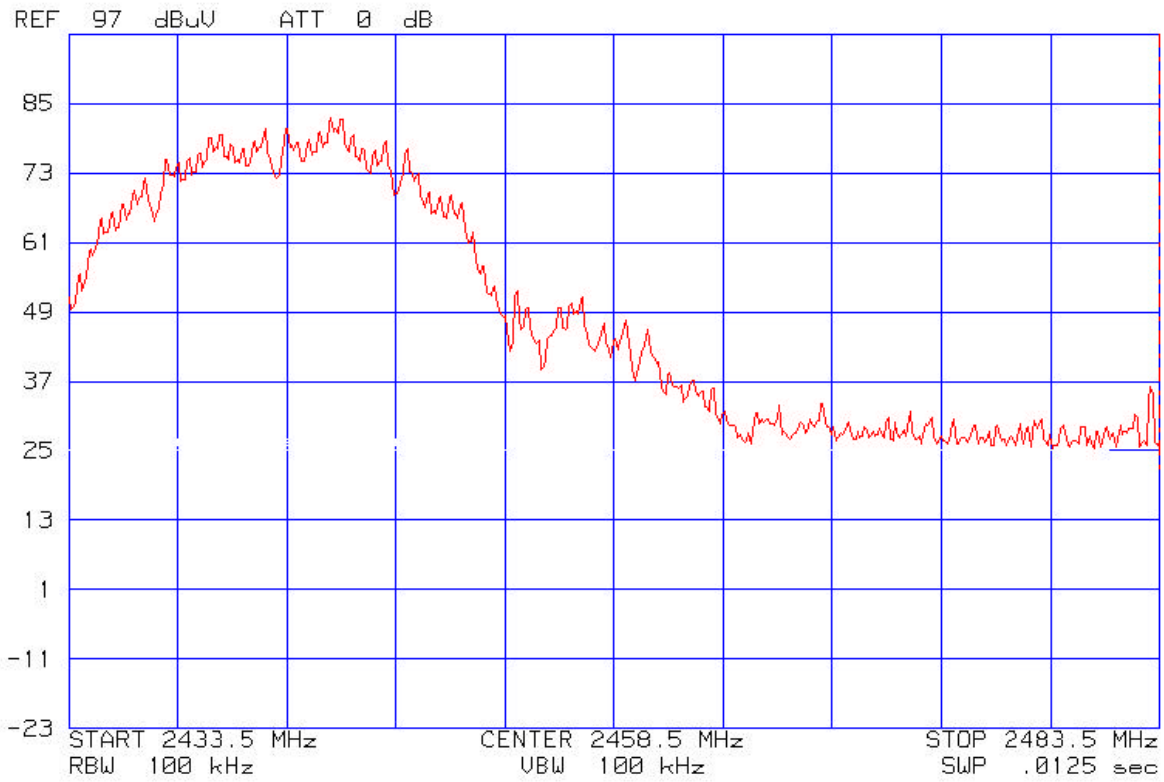
20log(0.4) = **-7.96dB**

At the time of testing the duty cycle was not known. Therefore the limits shown on the plots and data files do not reflect the average value of measured emissions. **The average value can be determined by reducing the measured value by 7.96dB.**

2390MHz Band-Edge Measurement

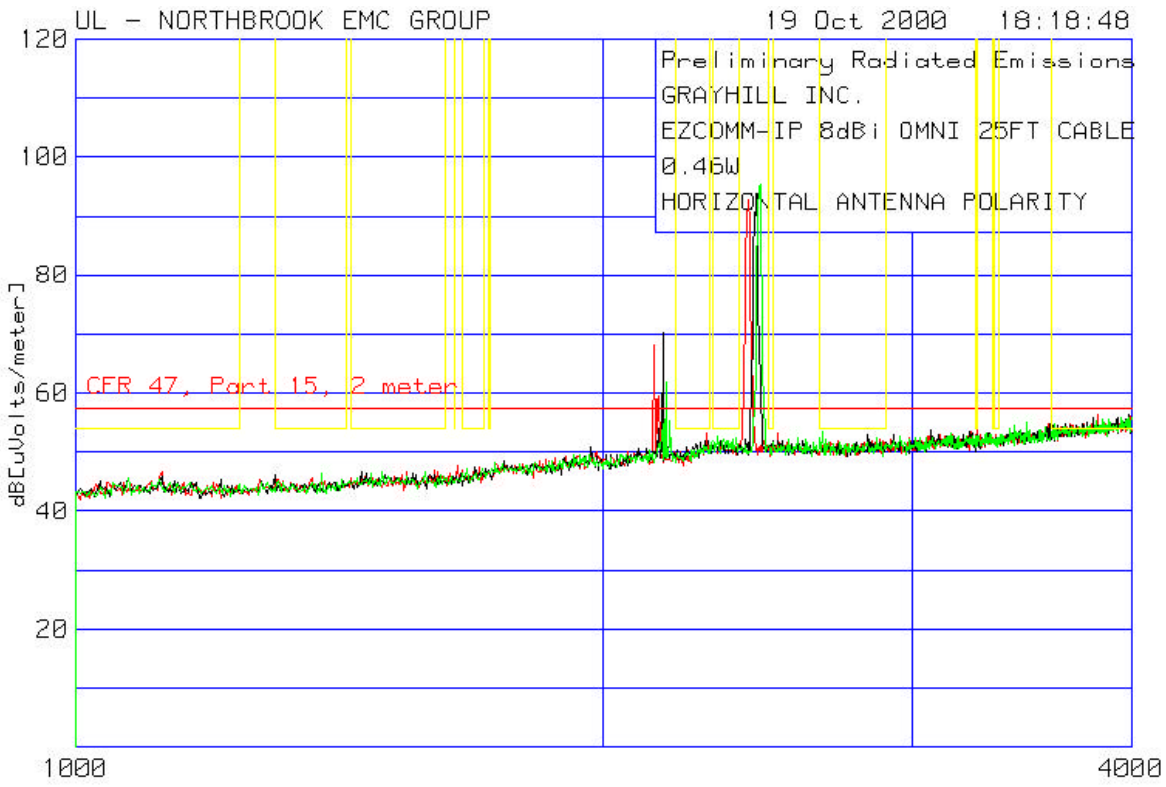


2483.5MHz Band-Edge Measurement



Radiated Spurious Emissions, 1 to 4GHz
Measurement Antenna - Horizontal
Transmit Antenna – 8dBi OMNI
RBW = VBW = 100 kHz

Preliminary Peak Data

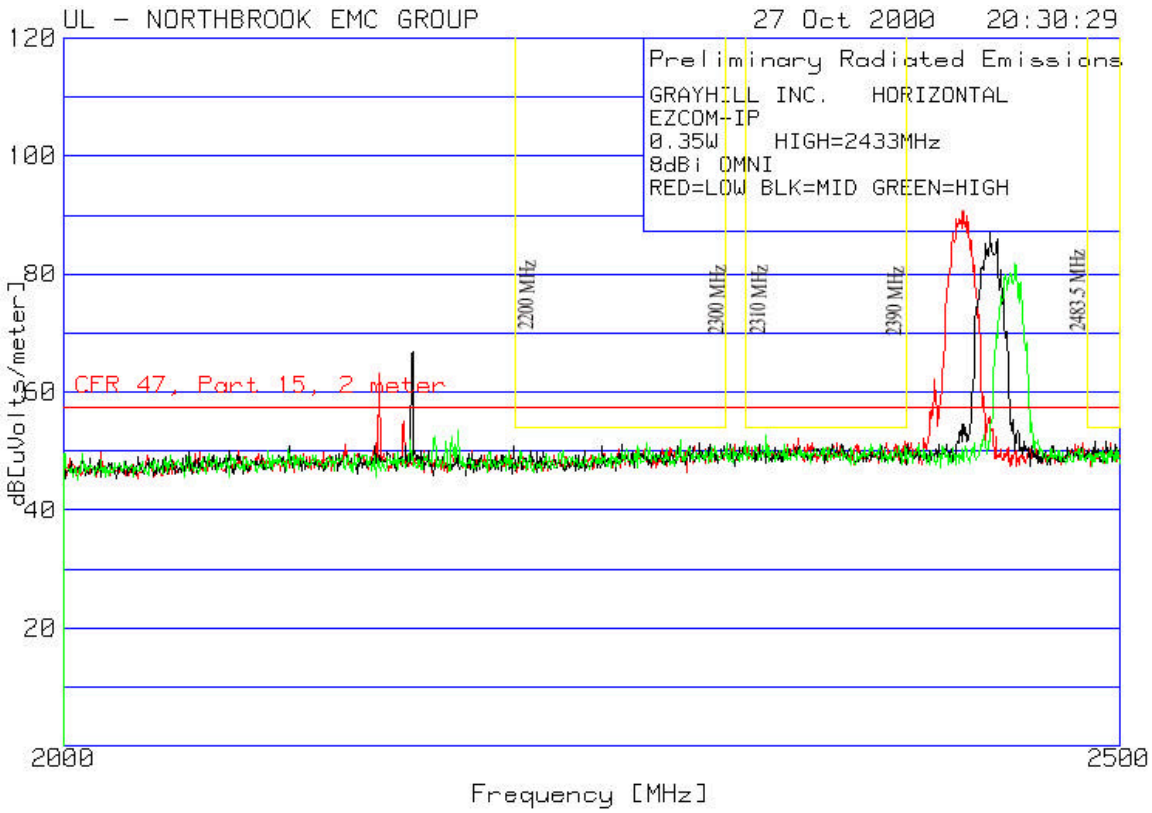


Red = Low Channel (2418 MHz)
Black = Mid Channel (2425 MHz)
Green = High Channel (2433 MHz)

Yellow Limit Line = Restricted Bands per 15.205
Red Limit Line = General Limit at 2 meters per 15.209

Radiated Spurious Emissions, 2 to 2.5GHz
Measurement Antenna - Horizontal
Transmit Antenna – 8dBi OMNI
RBW = VBW = 100 kHz

Preliminary Peak Data



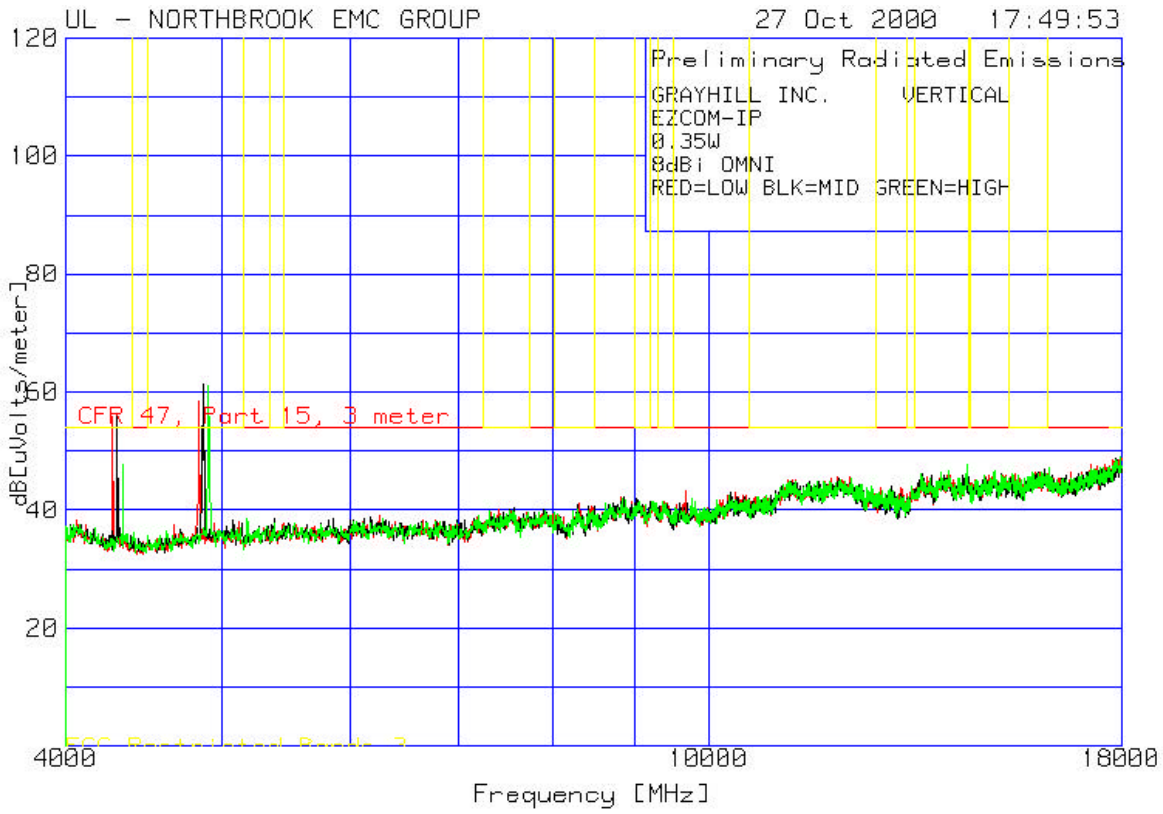
Red = Low Channel (2418 MHz)
Black = Mid Channel (2425 MHz)
Green = High Channel (2433 MHz)

Yellow Limit Line = Restricted Bands per 15.205
Red Limit Line = General Limit at 2 meters per 15.209

Average measurements were not considered necessary in the horizontal antenna polarity based on preliminary data. Measurements in vertical polarity were considered to cover horizontal polarity data (vertical more severe).

Radiated Spurious Emissions, 4 to 18GHz
Measurement Antenna - Vertical
Transmit Antenna – 8dBi OMNI
RBW = VBW = 100 kHz

Preliminary Peak Data



Red = Low Channel (2418 MHz)
Black = Mid Channel (2425 MHz)
Green = High Channel (2433 MHz)

Yellow Limit Line = Restricted Bands per 15.205
Red Limit Line = General Limit at 3 meters per 15.209

Preliminary Peak Data

RBW = VBW = 100 kHz

GRAYHILL INC. VERTICAL
EZCOM-IP
0.35W
8dBi OMNI
RED=LOW BLK=MID GREEN=HIGH

Test Frequency [MHz]	Meter Reading [dB(uV)]	Gain/Loss Factor [dB]	Transducer Factor [dB]	Level dB[uVolts/meter]	Limit:1	2	3	4
Low Channel, **Restricted band**								
4275.425	72.68 pk	-51	34.2	55.88	54	54	N/A	N/A
Azimuth: N/A	Height:101 Vert		Margin [dB]	**1.88**	1.88	N/A	N/A	
Mid Channel, **Restricted band**								
4303.434	72.62 pk	-51	34.1	55.72	54	54	N/A	N/A
Azimuth: N/A	Height:101 Vert		Margin [dB]	1.72	1.72	N/A	N/A	
High Channel, **Restricted band**								
4340.78	64.77 pk	-51.1	34.1	47.77	54	54	N/A	N/A
Azimuth: N/A	Height:101 Vert		Margin [dB]	-6.23	-6.23	N/A	N/A	
Low Channel, **Restricted band**								
4835.612	73.58 pk	-50.1	35	58.48	54	54	N/A	N/A
Azimuth: N/A	Height:101 Vert		Margin [dB]	4.48	4.48	N/A	N/A	
Mid Channel, **Restricted band**								
4863.621	76.12 pk	-50	35.1	61.22	54	54	N/A	N/A
Azimuth: N/A	Height:101 Vert		Margin [dB]	**7.22**	7.22	N/A	N/A	
High Channel, **Restricted band**								
4900.967	75.61 pk	-49.9	35.3	61.01	54	54	N/A	N/A
Azimuth: N/A	Height:101 Vert		Margin [dB]	7.01	7.01	N/A	N/A	

LIMIT 1: CFR 47, Part 15, 3 meter
LIMIT 2: FCC Restricted Bands 2
LIMIT 3: FCC Restricted Bands 3
LIMIT 4: NONE

pk - Peak detector

Final Maximized Average Data
Azimuth – 0 to 360 degrees
Antenna Height – 0.75 to 2.5 meters

RBW = 1 MHz, VBW = 10Hz

```
 GRAYHILL INC.     VERTICAL
 EZCOM-IP
 0.35W
 8dBi OMNI
 RED=LOW BLK=MID GREEN=HIGH
```

Test Frequency [MHz]	Meter Reading [dB(uV)]	Gain/Loss Factor [dB]	Transducer Factor [dB]	Level dB[uVolts/meter]	Limit:1	2	3	4
*Low Channel, **Restricted band**								
4275.9699	74.7 av	-51	34.2	57.9	54	54	N/A	N/A
Azimuth: 195	Height:122 Vert		Margin [dB]	3.9		**3.9**	N/A	N/A
*Mid Channel, **Restricted band**								
4865.9709	74.78 av	-50	35.1	59.88	54	54	N/A	N/A
Azimuth: 341	Height:179 Vert		Margin [dB]	5.88		**5.88**	N/A	N/A

```
LIMIT 1: CFR 47, Part 15, 3 meter
LIMIT 2: FCC Restricted Bands 2
LIMIT 3: FCC Restricted Bands 3
LIMIT 4: NONE

av - Average detector


*Based on preliminary measurements, these average measurements were
considered representative of the low, mid and high channels.
```

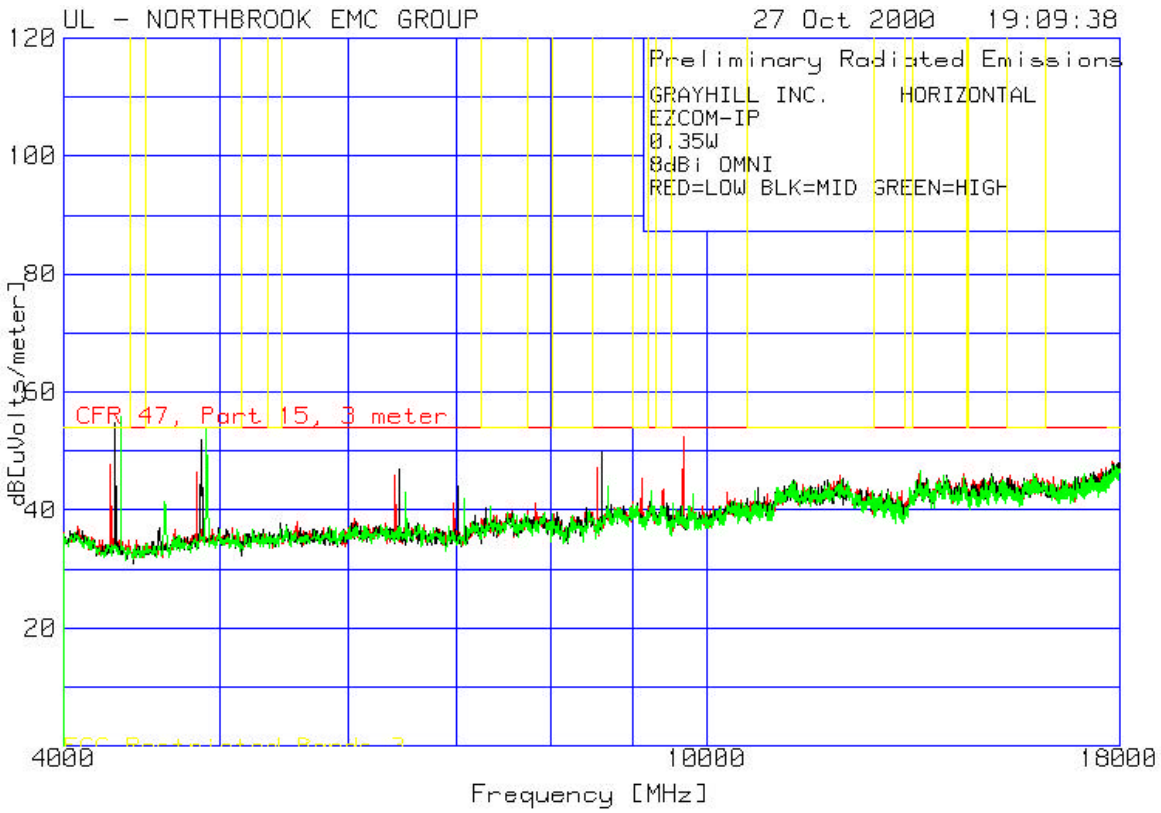
Per clause 15.35 of CFR 47, Part 15 the measured field strength can be determined by averaging the pulse train over a 0.1 second interval. When averaged over a 0.1 second interval, the EUT has a duty cycle of 40%. The average value of measured emissions cab be calculated as follows:

20log(0.4) = **-7.96dB**

At the time of testing the duty cycle was not known. Therefore the limits shown on the plots and data files do not reflect the average value of measured emissions. **The average value can be determined by reducing the measured value by 7.96dB.**

Radiated Spurious Emissions, 4 to 18GHz
Measurement Antenna - Horizontal
Transmit Antenna – 8dBi OMNI
RBW = VBW = 100 kHz

Preliminary Peak Data



Red = Low Channel (2418 MHz)
Black = Mid Channel (2425 MHz)
Green = High Channel (2433 MHz)

Yellow Limit Line = Restricted Bands per 15.205
Red Limit Line = General Limit at 3 meters per 15.209

Preliminary Peak Data

RBW = VBW = 100 kHz

GRAYHILL INC. HORIZONTAL
EZCOM-IP
0.35W
8dBi OMNI
RED=LOW BLK=MID GREEN=HIGH

Test Frequency [MHz]	Meter Reading [dB(uV)]	Gain/Loss Factor [dB]	Transducer Factor [dB]	Level dB[uVolts/meter]	Limit:1	2	3	4
High Channel, Restricted band								
4340.78	72.96 pk	-51.1	34.1	55.96	54	54	N/A	N/A
Azimuth: N/A	Height:113 Horz	Margin [dB]		1.96	1.96	N/A	N/A	
High Channel, Restricted band								
4900.967	68.26 pk	-49.9	35.3	53.66	54	54	N/A	N/A
Azimuth: N/A	Height:113 Horz	Margin [dB]		-.34	-.34	N/A	N/A	
Mid Channel, Restricted band								
6455.485	58.02 pk	-47.8	36.8	47.02	54	999	N/A	N/A
Azimuth: N/A	Height:100 Horz	Margin [dB]		-6.98	-951.98	N/A	N/A	
Mid Channel, Restricted band								
8612.204	60.8 pk	-49.5	38.5	49.8	54	999	N/A	N/A
Azimuth: N/A	Height:100 Horz	Margin [dB]		-4.2	-949.2	N/A	N/A	
Low Channel, Restricted band								
9671.891	64.14 pk	-50	38.4	52.54	54	999	N/A	N/A
Azimuth: N/A	Height:100 Horz	Margin [dB]		-1.46	-946.46	N/A	N/A	

LIMIT 1: CFR 47, Part 15, 3 meter
LIMIT 2: FCC Restricted Bands 2
LIMIT 3: FCC Restricted Bands 3
LIMIT 4: NONE

pk - Peak detector

Final Maximized Average Data
Azimuth – 0 to 360 degrees
Antenna Height – 0.75 to 2.5 meters

RBW = 1 MHz, VBW = 10Hz

```
 GRAYHILL INC.     HORIZONTAL
 EZCOM-IP
 0.35W
 8dBi OMNI
 RED=LOW BLK=MID GREEN=HIGH
```

Test Frequency [MHz]	Meter Reading [dB(uV)]	Gain/Loss Factor [dB]	Transducer Factor [dB]	Level dB[uVolts/meter]	Limit:1	2	3	4
*High Channel, **Restricted band**								
4343.989	75.35 av	-51.1	34.1	58.35	54	54	N/A	N/A
Azimuth: 210	Height:110 Horz		Margin [dB]	4.35		**4.35**	N/A	N/A
*High Channel, **Restricted band**								
4904.007	71.12 av	-49.9	35.3	56.52	54	54	N/A	N/A
Azimuth: 202	Height:111 Horz		Margin [dB]	2.52		**2.52**	N/A	N/A

```
LIMIT 1: CFR 47, Part 15, 3 meter
LIMIT 2: FCC Restricted Bands 2
LIMIT 3: FCC Restricted Bands 3
LIMIT 4: NONE

av - Average detector

*Based on preliminary measurements, these average measurements were
considered representative of the low, mid and high channels.
```

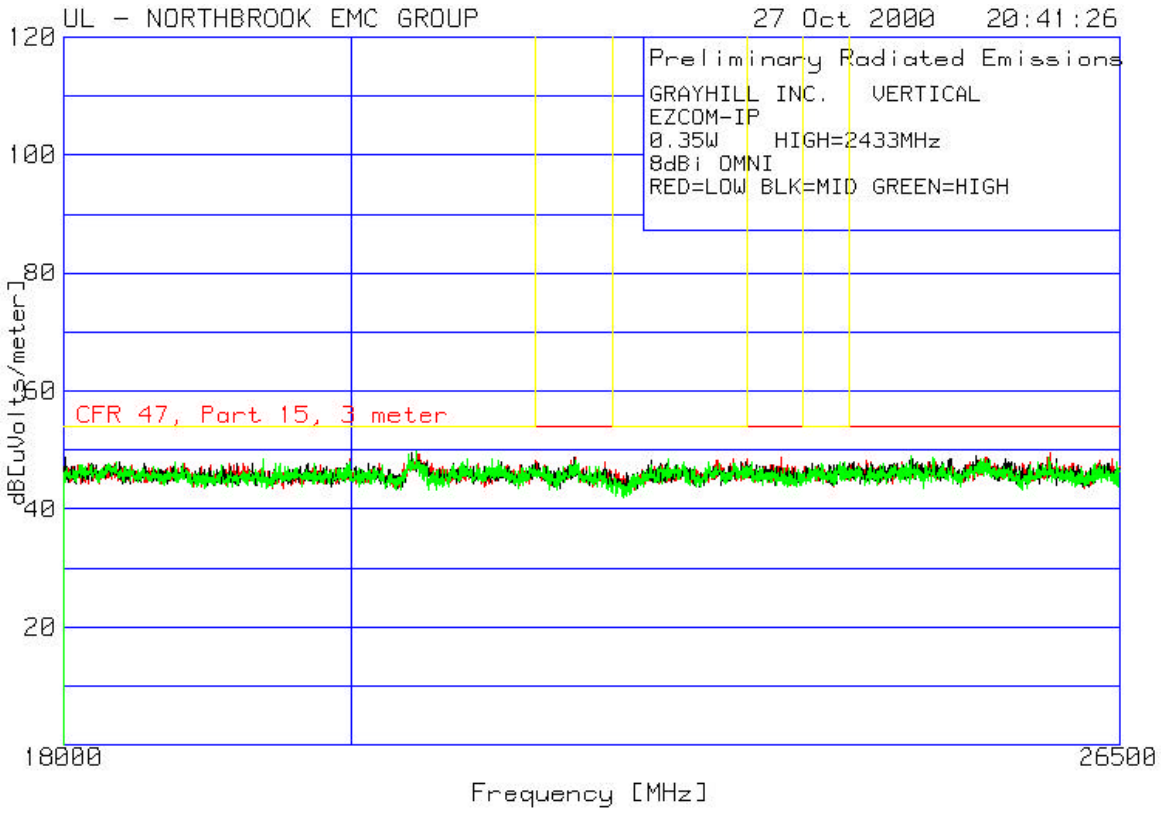
Per clause 15.35 of CFR 47, Part 15 the measured field strength can be determined by averaging the pulse train over a 0.1 second interval. When averaged over a 0.1 second interval, the EUT has a duty cycle of 40%. The average value of measured emissions cab be calculated as follows:

20log(0.4) = **-7.96dB**

At the time of testing the duty cycle was not known. Therefore the limits shown on the plots and data files do not reflect the average value of measured emissions. **The average value can be determined by reducing the measured value by 7.96dB.**

Radiated Spurious Emissions, 18 to 26.5GHz
Measurement Antenna - Vertical
Transmit Antenna – 8dBi OMNI
RBW = VBW = 50 kHz

Preliminary Peak Data

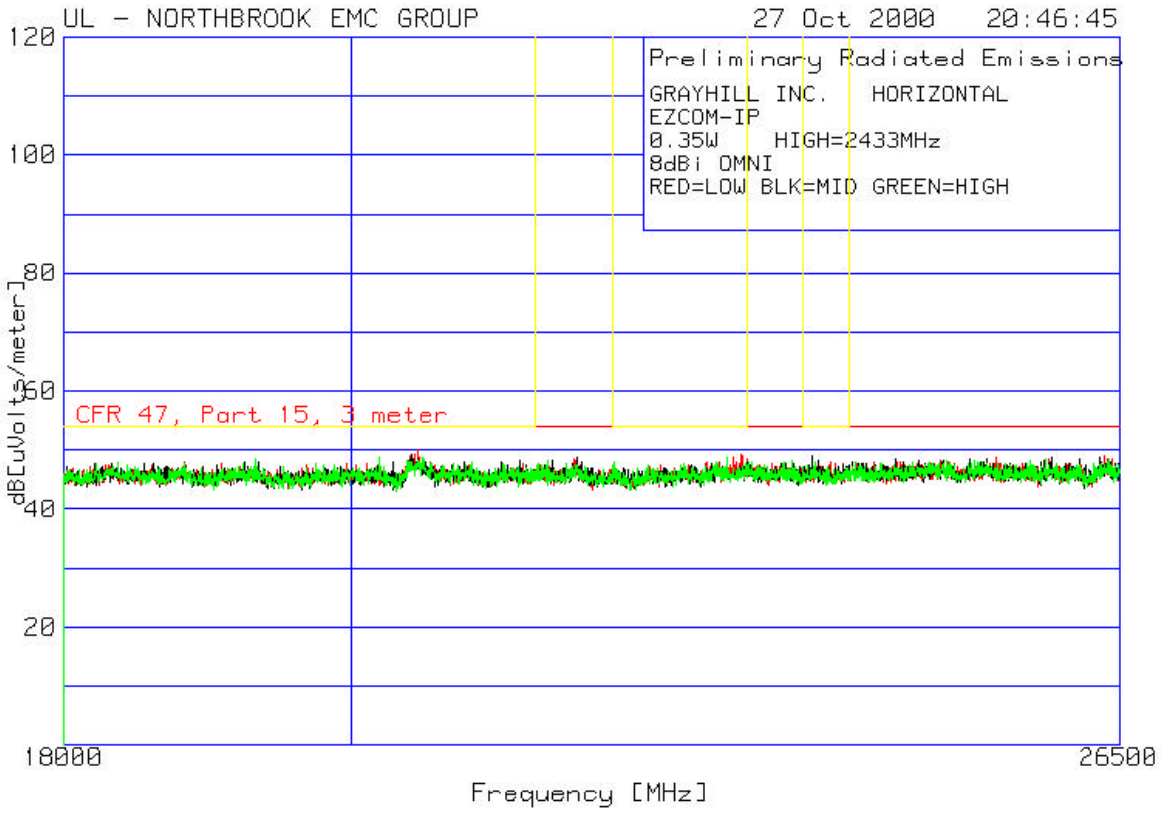


Red = Low Channel (2418 MHz)
Black = Mid Channel (2425 MHz)
Green = High Channel (2433 MHz)

Yellow Limit Line = Restricted Bands per 15.205
Red Limit Line = General Limit at 3 meters per 15.209

Radiated Spurious Emissions, 18 to 26.5GHz
Measurement Antenna - Horizontal
Transmit Antenna – 8dBi OMNI
RBW = VBW = 50 kHz

Preliminary Peak Data



Red = Low Channel (2418 MHz)
Black = Mid Channel (2425 MHz)
Green = High Channel (2433 MHz)

Yellow Limit Line = Restricted Bands per 15.205
Red Limit Line = General Limit at 3 meters per 15.209

APPENDIX C

Sample Calculations of Field Strengths

Basic Equation:

The field strength is calculated by adding the Meter Reading, Cable Set Gain/Loss and Transducer (Antenna or LISN) Factor. The basic equation is as follows:

FS = MR + GL + TF

Where:

FS = Calculated Field Strength in dB(uV)/meter

MR = Meter Reading of receiver amplitude in dB(uV)

GL = Gain/Loss factor of cable set in dB
A negative Gain/Loss indicates signal amplification (gain)
A positive Gain/Loss indicates signal attenuation (loss)

TF = Transducer Factor of antenna or LISN in dB

Sample Calculation:

The measured receiver amplitude is 52.7 dB(uV).

The gain/loss factor is –30.2 dB (indicating a preamplifier is included in the cable set).

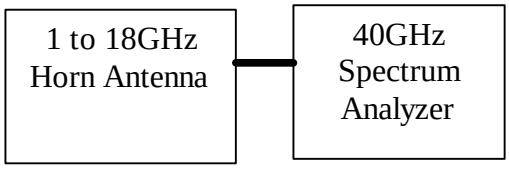
The transducer factor (antenna factor) is 6.6 dB.

These factors are added (52.7 + (-30.2) + 6.6) resulting in a calculated field strength of 29.1 dB(uV)/meter.

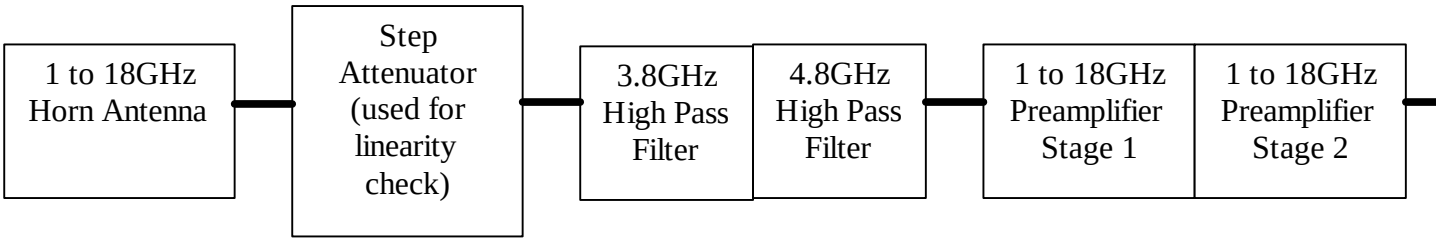
APPENDIX D

Block Diagram of Measurement System

1 to 4GHz Measurement System



4 to 18GHz Measurement System



18 to 26.5GHz Measurement System