NVLAP Lab Code 200087-0

SUBMITTAL APPLICATION REPORT

FOR GRANT OF CERTIFICATION

FOR

MODEL: WBD-500
2412-2472 MHz
Broadband Wireless Data Transmitter

FOR

LIGOWAVE LLC

1440 Dutch Valley Place, Suite 1155
Atlanta, GA 30324

Test Report Number: 080731

Authorized Signatory: Scot D Rogers
Scot D. Rogers

NVLAP Lab Code 200087-0

ROGERS LABS, INC.
4405 West 259th Terrace
Louisburg, KS 66053
Phone / Fax (913) 837-3214

ENGINEERING TEST REPORT
For APPLICATION of
GRANT of CERTIFICATION

FOR

CFR 47, PART 15C - INTENTIONAL RADIATORS
CFR47 Paragraph 15.247
License Exempt Intentional Radiator

For

LIGOWAVE LLC
1440 Dutch Valley Place, Suite 1155
Atlanta, GA 30324

BROADBAND WIRELESS DATA TRANSMITTER
Model: WBD-500
Frequency Range 2412-2472 MHz
FCC ID#: V2V-WBD500
IC: 7607A-WBD500

Test Date: July 31, 2008

Certifying Engineer: Scot D Rogers

Scot D. Rogers
Rogers Labs, Inc.
4405 West 259th Terrace
Louisburg, KS 66053
Phone: (913) 837-3214
Fax: (913) 837-3214

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The following information is submitted for consideration in obtaining a Grant of Certification for a License Exempt Intentional Radiator operating under CFR47 Paragraph 15.247.

Name of Applicant:
LIGOWAVE LLC
1440 Dutch Valley Place, Suite 1155
Atlanta, GA 30324

Model: WBD-500

FCC I.D.: V2V-WBD500 FRN: 0017 41 6041

Frequency Range: 2412-2472MHz.

Operating Power: 540 mW conducted power

Opinion / Interpretation of Results

Tests Performed	Results
Emissions Tests	
Emissions as per CFR47 paragraphs 2 and 15.205	Complies
Emissions as per CFR47 paragraphs 2 and 15.209	Complies
Emissions as per CFR47 paragraphs 2 and 15.247	Complies

Environmental Conditions

Ambient Temperature	22.2° C
Relative Humidity	41%
Atmospheric Pressure	30.00 in Hg

Equipment Tested

Equipment	Model	FCC I.D.#
EUT	WBD-500	V2V-WBD500

2.1033(b) Application for Certification

(1) Manufacturer: LIGOWAVE LLC
1440 Dutch Valley Place, Suite 1155
Atlanta, GA 30324

(2) Identification: Model: WBD-500
FCC I.D.: V2V-WBD500 IC: 7607A-WBD500

(3) Instruction Book:
Refer to Exhibit for Instruction Manual.

(4) Description of Circuit Functions:
Refer to Exhibit of Operational Description.

(5) Block Diagram with Frequencies:
Refer to Exhibit of Operational Description.

(6) Report of Measurements:
Report of measurements follows in this Report.

(7) Photographs: Construction, Component Placement, etc.:
Refer to Exhibit for photographs of equipment.

(8) No Peripheral Equipment was Necessary for operation. A laptop computer was used for testing purposes.

(9) Transition Provisions of 15.37 are not being requested.

(10) Not Applicable. The unit is not a scanning receiver.

(11) Not Applicable. The EUT does not operate in the 59 – 64 GHz frequency band.

Applicable Standards & Test Procedures

In accordance with the Federal Communications Code of Federal Regulations, dated October 1, 2007, Part 2, Subpart J, Paragraphs 2.907, 2.911, 2.913, 2.925, 2.926, 2.1031 through 2.1057, and applicable parts of paragraph 15, Part 15C Paragraph 15.247 the following information is submitted.

Test procedures used are the established Methods of Measurement of Radio-Noise Emissions as described in the ANSI 63.4-2003 Document FCC, documents DA00-1407 and DA00-705 and/or TIA/EIA 603-1. Testing for the line-conducted emissions were performed as defined in sections

8 and 13.1.3, testing of the radiated emissions was performed as defined in sections 8 and 13.1.4 of ANSI C63.4. Testing of the intentional radiated emissions was performed as defined in section 13 of ANSI C63.4.

Equipment Function and Testing Procedures

The EUT is a 2412-2472 MHz radio transmitter module used to transmit data in applications offering broadband wireless connectivity. The unit is marketed for use to incorporate a wireless link to exchange data information from one point to another. For testing purposes the WBD-500 transceiver was placed on a wooden table, interfaced to a Power Over Ethernet (POE) supply allowing power and communications over the network interface between the EUT and supporting computer system. The WBD-500 receives power from the POE adapter and offers no other provision to connect to utility power systems. The WBD-500 design incorporates modulation limiting, power regulation, shielding, and a MMCX antenna connection point. No other interfacing options are provided on the design. For testing purposes WBD-500 was powered from the POE AC power adapter supply and set to transmit in all maximum data modes available. The device is marketed for professionally installed use and the antenna connection complies with the unique antenna connection requirements. Radiated emissions testing for this equipment was performed using the supplied antenna options, Omni directional, panel, and grid.

Equipment and Cable Configurations

AC Line Conducted Emission Test Procedure

The WBD-500 operates from DC power only and must be used with the associated Poe adapter offering DC power and interface capability. The WBD-500 was operated using the manufacturer supplied AC/DC POE power supply. For testing purposes, the manufacturer supplied AC/DC POE power supply was used to power the system. Testing for the AC line-conducted emissions testing was performed as defined in sections 8 and 13.1.3 of ANSI C63.4. The test setup including the EUT was arranged in a typical equipment configuration and placed on a 1 x 1.5-meter wooden bench, 0.8 meters high located in a screen room. The power lines of the system were isolated from the power source using a standard LISN with a 50 µHy choke. EMI was coupled to the spectrum analyzer through a 0.1 µF capacitor internal to the LISN. The LISN was positioned on the floor beneath the wooden bench supporting the EUT. The power lines and cables were draped over the back edge of the table.

Radiated Emission Test Procedure

The EUT was placed on a rotating 1 x 1.5-meter wooden platform, 0.8 meters above the ground plane at a distance of 3 meters from the FSM antenna. Testing for the radiated emissions was performed as defined in sections 8 and 13.1.4 of ANSI C63.4. EMI energy was maximized by equipment placement, raising and lowering the FSM antenna, changing the antenna polarization, and by rotating the turntable. Each emission was maximized before data was taken using a spectrum analyzer. Refer to photographs in the test setup exhibits for EUT placement during testing.

Units of Measurements

Conducted EMI — Data is in dBµV; dB referenced to one microvolt.

Radiated EMI — Data is in dBµV/m; dB/m referenced to one microvolt per meter.

Test Site Locations

Conducted EMI — The AC power line conducted emissions testing performed in a shielded screen room located at Rogers Labs, Inc., 4405 W. 259th Terrace, Louisburg, KS.

Radiated EMI — The radiated emissions tests were performed at the 3 meters, Open Area Test Site (OATS) located at Rogers Labs, Inc., 4405 W. 259th Terrace, Louisburg, KS.

Site Approval — Refer to Annex for FCC Site Registration Letter, # 90910, Industry Canada Site Registration IC3041A-1

List of Test Equipment

A Hewlett Packard 8591EM Spectrum Analyzer was used as the measuring device for the emissions testing of frequencies below 1 GHz. A Hewlett Packard 8562A Spectrum Analyzer was used as the measuring device for testing the emissions at frequencies above 1 GHz. The analyzer settings used are described in the following table. Refer to the appendix for a complete list of test equipment.

HP 8591 EM ANALYZER SETTINGS		
CONDUCTED EMISSIONS		
RBW	AVG. BW	DETECTOR FUNCTION
9 kHz	30 kHz	Peak / Quasi Peak
RADIATED EMISSIONS		
RBW	AVG. BW	DETECTOR FUNCTION
120 kHz	300 kHz	Peak / Quasi Peak
HP 8562A ANALYZER SETTINGS		
RBW	VIDEO BW	DETECTOR FUNCTION
100 kHz	100 kHz	PEAK
1 MHz	1 MHz	Peak / Average

EQUIPMENT	MFG.	MODEL	CAL. DATE	DUE.
LISN	Comp. Design	FCC-LISN-2-MOD.CD	10/07	10/08
LISN	Comp. Design	1762	2/08	2/09
Antenna	ARA	BCD-235-B	10/07	10/08
Antenna	EMCO	3147	10/07	10/08
Antenna	EMCO	3143	5/08	5/09
Analyzer	HP	8591EM	5/08	5/09
Analyzer	HP	8562A	5/08	5/09

Subpart B – Unintentional Radiators

AC Line Conducted EMI

The EUT was arranged in a typical equipment configuration and placed on a 1 x 1.5-meter wooden bench 80 cm above the conducting ground plane, floor of a screen room. The bench was positioned 40 cm away from the wall of the screen room. The LISN was positioned on the floor of the screen room 80-cm from the rear of the EUT. The manufacturer supplied AC power adapter for the EUT was connected to the LISN. A second LISN was positioned on the floor of the screen room 80-cm from the rear of the supporting equipment of the EUT. All power cords except the EUT were then powered from the second LISN. EMI was coupled to the spectrum analyzer through a 0.1 μF capacitor, internal to the LISN. Power line conducted emissions testing were carried out individually for each current carrying conductor of the EUT. The excess length of lead between the system and the LISN receptacle was folded back and forth to form a bundle not exceeding 40 cm in length. The screen room, conducting ground plane, analyzer, and LISN were bonded together to the protective earth ground. Preliminary testing was performed to identify the frequency of each radio frequency emission displaying the highest amplitude. The cables were repositioned to obtain maximum amplitude of measured EMI level. Once the worst-case configuration was identified, plots were made of the EMI from 0.15 MHz to 30 MHz then the data was recorded with maximum conducted emissions levels. Refer to figures one and two for plots of the AC Line conducted emissions.

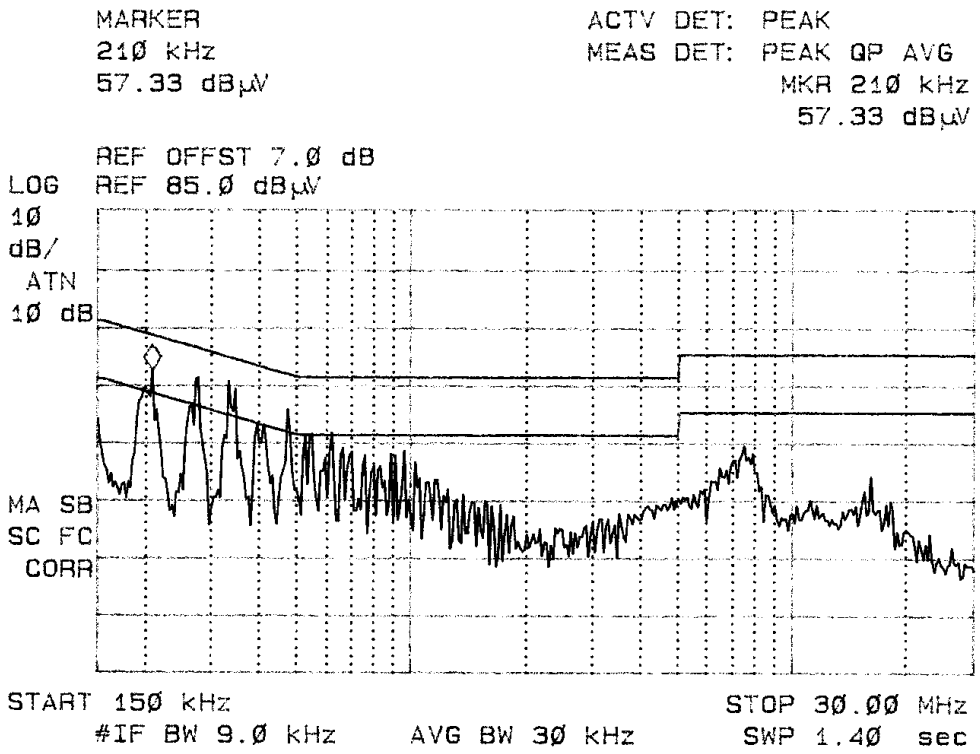

Figure 1 AC Line Conducted Emissions Line 1

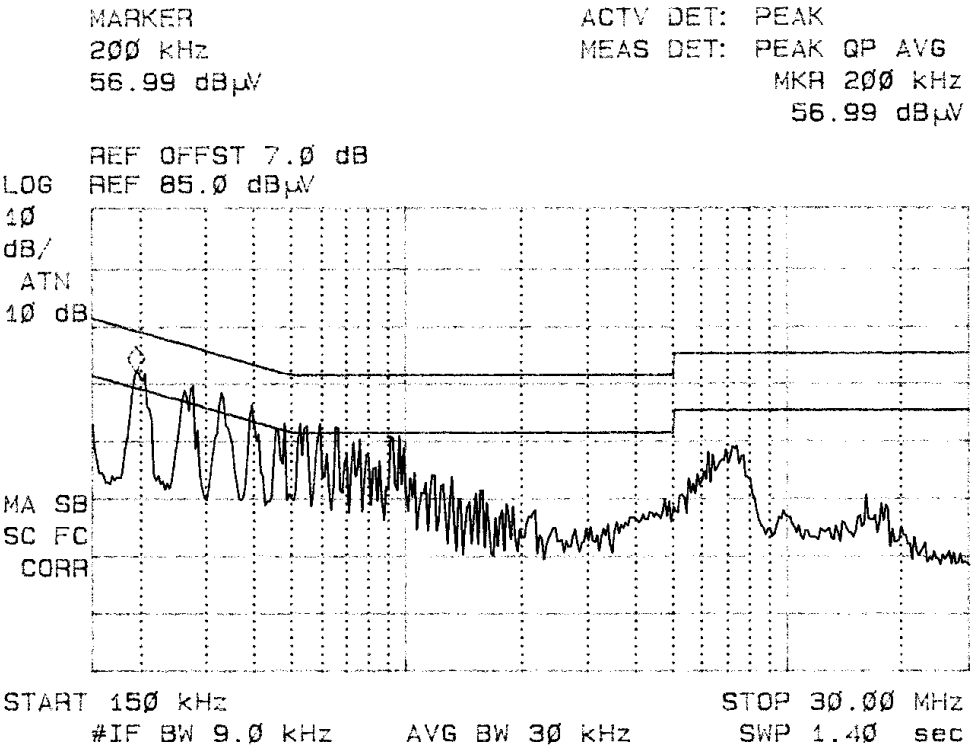

Figure 2 AC Line Conducted Emissions Line 2

Radiated EMI

The EUT was arranged in a typical equipment configuration and operated through all available modes with worst-case data recorded. The antenna port was connected to a 50-ohm load and operated through all available modes for general radiated emissions testing. Preliminary testing was performed in a screen room with the EUT positioned 1 meter from the FSM. Radiated emissions measurements were performed to identify the frequencies, which produced the highest emissions. Plots were made of the radiated frequency spectrum from 30 MHz to 22,000 MHz for the preliminary testing. Refer to figures three through eight for plots of the general radiated emissions spectrum taken in a screen room. The highest radiated emission was then re-maximized at the OATS location before final radiated emissions measurements were performed. Final data was taken with the EUT located at the OATS at a distance of 3 meters between the EUT and the receiving antenna. The frequency spectrum from 30 MHz to 22,000 MHz was searched for general radiated emissions. Measured emission levels were maximized by EUT placement on the table, rotating the turntable through 360 degrees, varying the antenna height between 1 and 4 meters above the ground plane and changing antenna position between horizontal and vertical polarization. Antennas used were Broadband Biconical from 30 to 200 MHz, Biconilog from 30 to 1000 MHz, Log Periodic from 200 MHz to 5 GHz and or, pyramidal horns and mixers from 4 GHz to 40 GHz, notch filters and appropriate amplifiers were utilized.

Sample Calculations:

RFS = Radiated Field Strength
dBµV/m @ 3m = dBµV + A.F. - Amplifier Gain
dBµV/m @ 3m = 48.4 + 7.6 - 30
= 26.0

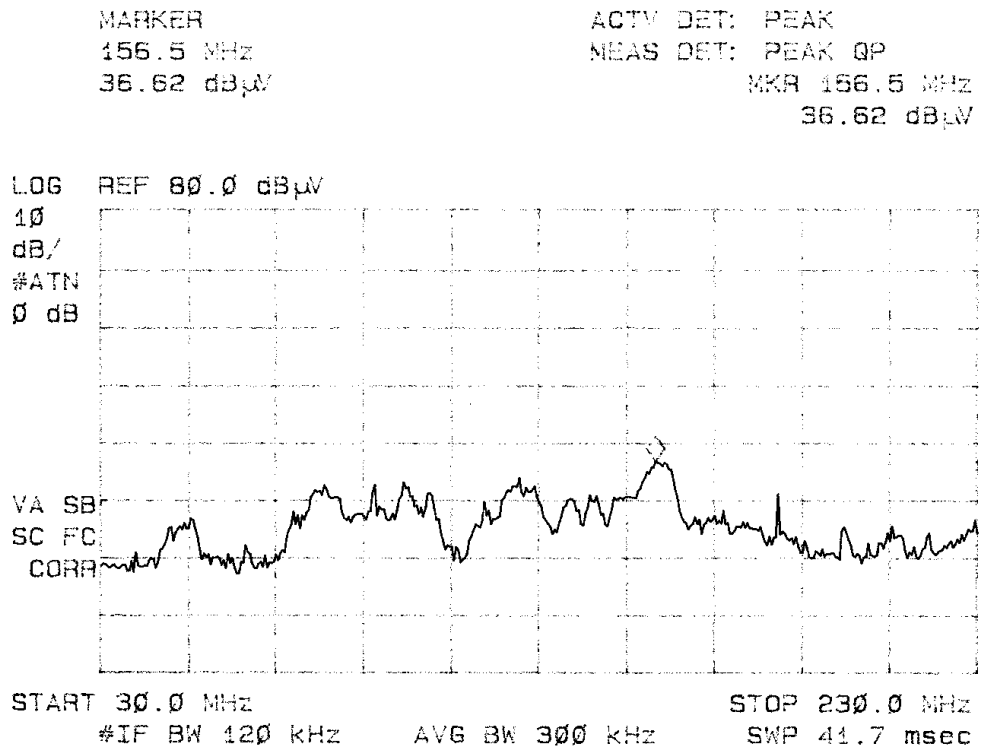

Figure three General Radiated Emissions taken at 1 meter in screen room.

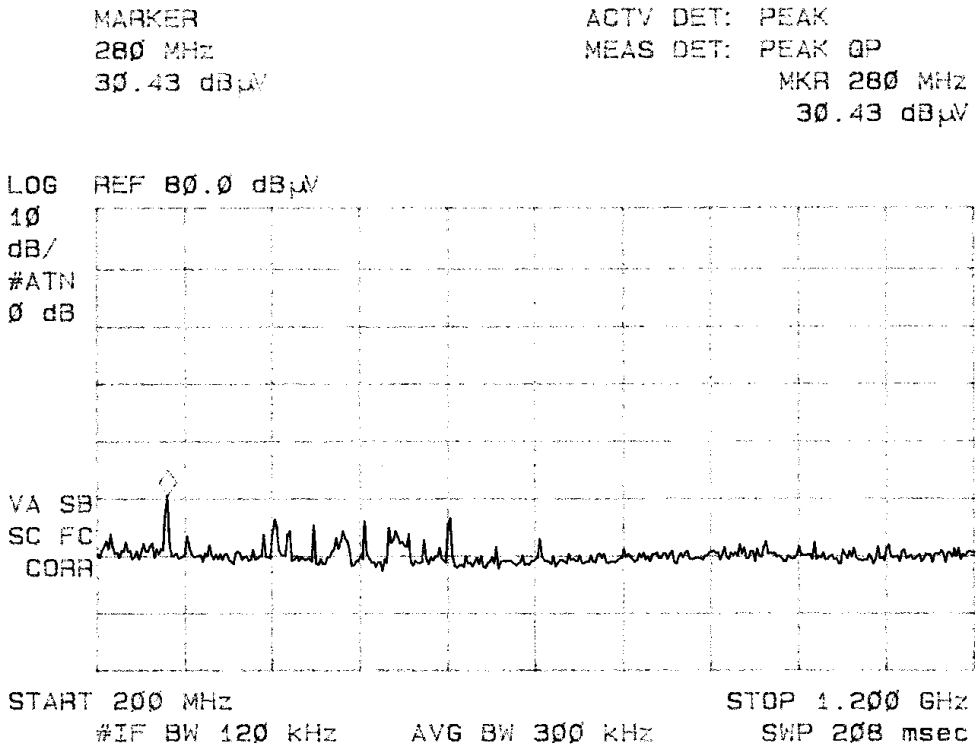

Figure four General Radiated Emissions taken at 1 meter in screen room.

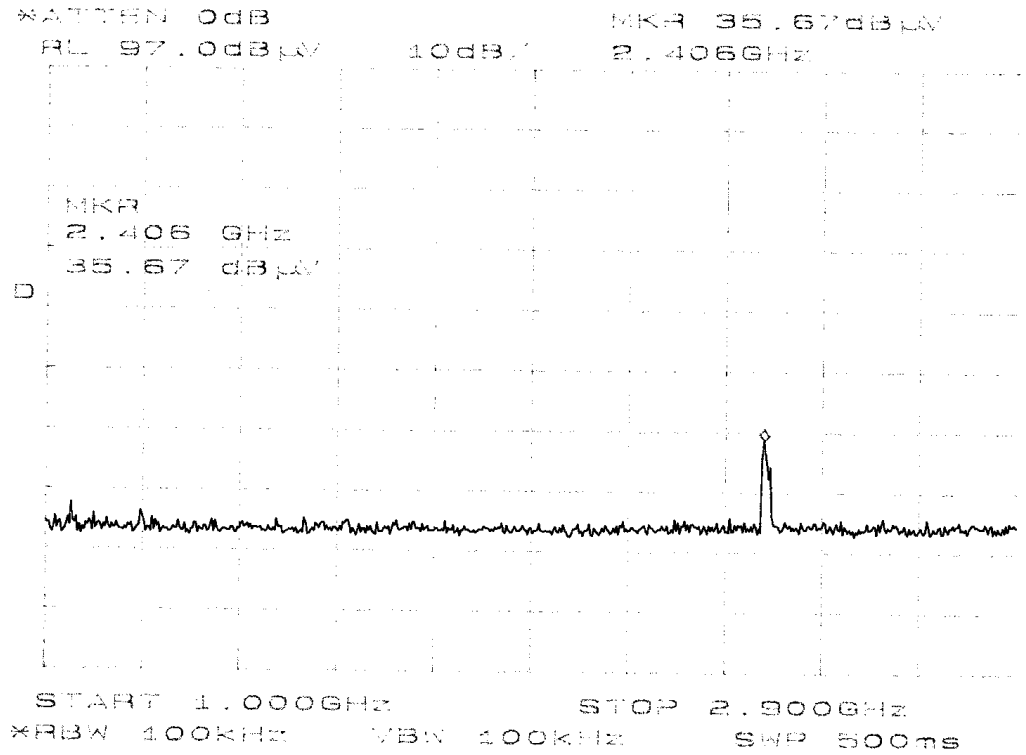

Figure five General Radiated Emissions taken at 1 meter in screen room.

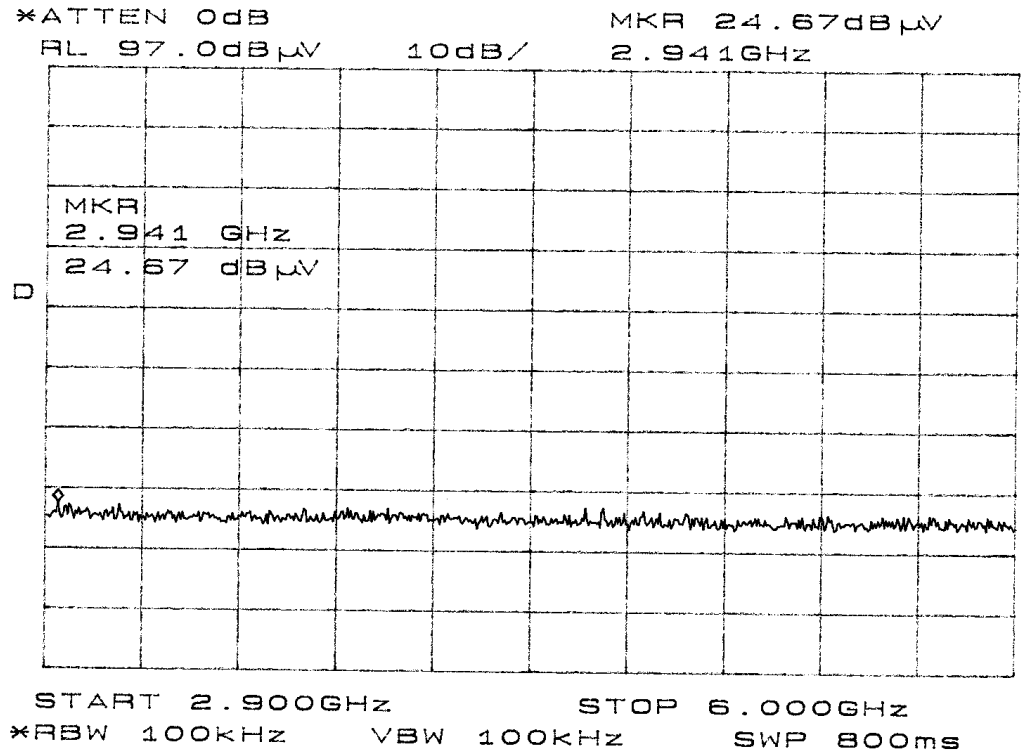

Figure six General Radiated Emissions taken at 1 meter in screen room.

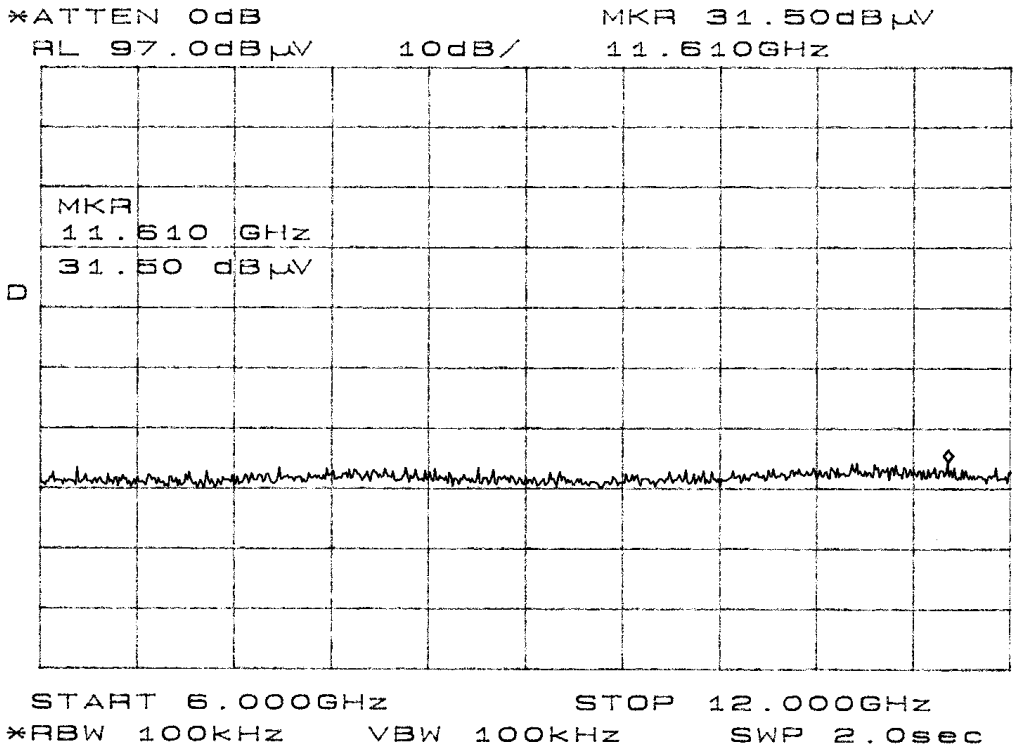

Figure seven General Radiated Emissions taken at 1 meter in screen room.

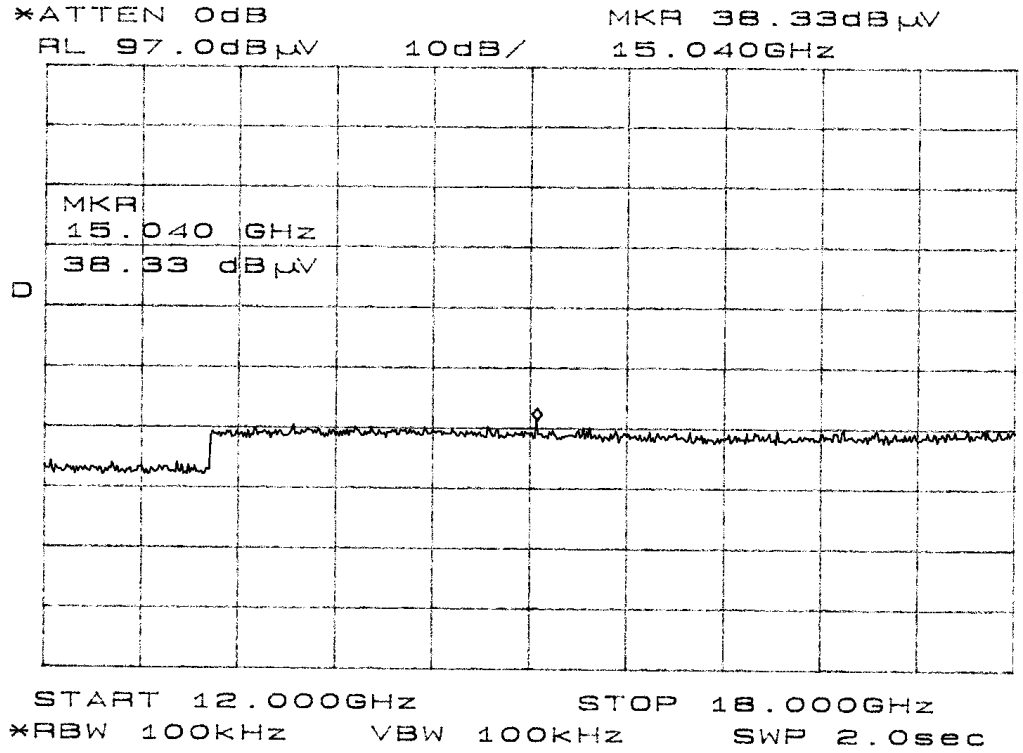

Figure eight General Radiated Emissions taken at 1 meter in screen room.

AC Line Conducted Emissions Data (7 Highest Emissions)

Frequency band (MHz)	L1 Level (dBµV)			L2 Level (dBµV)			CISPR 22 Limit Q.P. Ave(dBµV)
	Peak	Q.P.	AVE	Peak	Q.P.	AVE	
0.15 – 0.5	57.3	54.2	39.2	57.0	53.2	42.5	65 / 55
0.5 – 5	45.7	42.9	38.9	47.4	46.0	41.9	56 / 46
5 – 10	40.4	34.5	23.4	40.6	34.9	22.8	60 / 50
10 – 15	34.1	31.6	29.3	31.6	28.1	25.9	60 / 50
15 – 20	39.4	37.7	35.9	36.4	34.2	32.7	60 / 50
20 – 25	29.6	26.4	22.8	29.3	26.2	23.1	60 / 50
25 – 30	26.3	23.0	18.5	26.3	22.6	18.8	60 / 50

Other emissions present had amplitudes at least 10 dB below the limit.

General Radiated Emissions Data from EUT (Highest Emissions)

Frequency in MHz	FSM Horz. (dBµV)	FSM Vert. (dBµV)	A.F. (dB/m)	Amp. Gain (dB)	RFS Horz. @ 3m (dBµV/m)	RFS Vert. @ 3m (dBµV/m)	FCC Class B Limit @ 3m (dBµV/m)
83.0	48.4	45.4	7.6	30	26.0	23.0	40.0
92.0	57.0	50.0	7.6	30	34.6	27.6	43.5
125.0	50.3	46.8	7.7	30	28.0	24.5	43.5
135.2	47.3	45.1	8.5	30	25.8	23.6	43.5
141.6	45.1	39.8	9.7	30	24.8	19.5	43.5
156.2	44.5	43.9	9.2	30	23.7	23.1	43.5
175.0	52.2	51.3	9.1	30	31.3	30.4	43.5
184.0	53.6	50.2	9.9	30	33.5	30.1	43.5
276.0	60.8	54.4	12.7	30	43.5	37.1	46.0
400.0	50.2	45.9	19.3	30	39.5	35.2	46.0
415.2	52.3	40.6	16.8	30	39.1	27.4	46.0
443.8	47.4	38.7	16.9	30	34.3	25.6	46.0
482.0	39.7	44.7	18.1	30	27.8	32.8	46.0
501.1	48.3	46.4	18.3	30	36.6	34.7	46.0
537.4	46.1	41.6	19.6	30	35.7	31.2	46.0
600.0	43.3	39.9	19.3	30	32.6	29.2	46.0

Other emissions present had amplitudes at least 20 dB below the limit.

Summary of Results for AC Line Conducted Emissions

The conducted emissions for the EUT meet the requirements for CISPR 22 and FCC Part 15B CLASS B Digital Devices. The EUT had a 10.0 dB minimum margin below the Quasi-Peak limit, and a 4.1 dB minimum margin below the CISPR average limit. Measurements were taken using the peak, quasi peak, and average, measurement function for each emissions amplitude and were below the limits stated in the specification. Other emissions were present with recorded data representing worst-case amplitudes.

Summary of Results for General Radiated Emissions

The general radiated emissions for the EUT meet the requirements for CISPR 22 and FCC Part 15B CLASS B Digital Devices. The EUT had a 2.5 dB minimum margin below the quasi-peak limit. Other emissions were present with amplitudes at least 20 dB below the limit.

Statement of Modifications and Deviations

No modifications to the EUT were required for the unit to meet the CISPR 22 or FCC Part 15B CLASS B emissions standards. There were no deviations or exceptions to the specifications.

Subpart C - Intentional Radiators

As per CFR47, Subpart C, paragraph 15.247 the following information is submitted.

15.203 Antenna Requirements

The design utilizes a unique surface mount connector offering a connection for a coaxial cable. The end product is marketed and sold for professional installation only. The antenna connection point complies with the unique antenna connection requirements. The requirements of 15.203 are fulfilled and there are no deviations or exceptions to the specification.

15.205 Restricted Bands of Operation

Spurious emissions falling in the restricted frequency bands of operation were measured at a distance of three meters at the OATS. The EUT utilizes frequency, determining circuitry, which generates harmonics falling in the restricted bands. Emissions were checked at the OATS, using appropriate antennas or pyramidal horns, amplification stages, and a spectrum analyzer. No other significant emission was observed which fell into the restricted bands of operation.

Sample Calculation:

RFS (dBμV/m @ 3m) = FSM(dBμV) + A.F.(dB) - Gain(dB)
= 39.7 + 7.8 - 30
= 17.5

Radiated Emissions in Restricted Bands Data (worst-case)

Frequency in MHz	FSM Horz. (dBμV)	FSM Vert. (dBμV)	A.F. (dB/m)	Amp. Gain (dB)	RFS Horz. @ 3m (dBμV/m)	RFS Vert. @ 3m (dBμV/m)	FCC Class B Limit @ 3m (dBμV/m)
125.0	50.3	46.8	7.7	30	28.0	24.5	43.5
135.2	47.3	45.1	8.5	30	25.8	23.6	43.5
276.0	60.8	54.4	12.7	30	43.5	37.1	46.0
400.0	50.2	45.9	19.3	30	39.5	35.2	46.0
4824.0	21.6	32.0	41.4	30	33.0	43.4	54.0
4884.0	19.8	31.0	41.2	30	31.0	42.2	54.0
4944.0	21.8	28.6	42.1	30	33.9	40.7	54.0
7236.0	21.5	22.6	36.0	30	27.5	28.6	54.0
7326.0	20.3	22.0	36.3	30	26.6	28.3	54.0
7416.0	20.0	20.5	36.6	30	26.6	27.1	54.0
12060.0	22.8	20.8	40.0	30	32.8	30.8	54.0
12210.0	20.0	21.1	40.2	30	30.2	31.3	54.0
12360.0	19.3	21.0	40.4	30	29.7	31.4	54.0

Other emissions present had amplitudes at least 20 dB below the limit.

Summary of Results for Radiated Emissions in Restricted Bands

The radiated emissions for the EUT meet the requirements for FCC Part 15C Intentional Radiators. The EUT had a 2.5 dB minimum margin below the limits. Peak, Quasi-peak, and average amplitudes were checked for compliance with the regulations. No other emissions where found in the restricted frequency bands. Other emissions were present with amplitudes at least 20 dB below the FCC Limits.

Statement of Modifications and Deviations

No modifications to the EUT were required for the unit to meet the FCC Part 15C paragraph 15.205 emissions requirements. There were no deviations or exceptions to the specifications.

15.209 Radiated Emissions Limits; General Requirements

The EUT was arranged in a typical equipment configuration and operated through all of its various modes. Preliminary testing was performed in a screen room with the EUT positioned 1 meter from the FSM. Radiated emissions measurements were performed to identify the frequencies, which produced the highest emissions. Radiated emissions were observed in the screen room from 30 to 18,000 MHz and plots were made of the radiated emissions frequency spectrum from 30 MHz to 18,000 MHz for the preliminary testing. The highest radiated emission was then re-maximized at the OATS location before final radiated emissions measurements were performed. Final data was taken with the EUT located at the open area test site at a distance of 3 meters between the EUT and the receiving antenna. The frequency spectrum from 30 MHz to 25,000 MHz was searched for radiated emissions. Measured emission levels were maximized by EUT placement on the table, rotating the turntable through 360 degrees, varying the antenna height between 1 and 4 meters above the ground plane and changing antenna polarization between horizontal and vertical. Antennas used were Broadband Biconical from 30 MHz to 200 MHz, Biconilog from 30 MHz to 1000 MHz, Log Periodic from 200 MHz to 5 GHz, and/or Pyramidal Horns from 4 GHz to 40 GHz.

Sample Calculations:

RFS = Radiated Field Strength

dBµV/m @ 3m = dBµV + A.F. - Amplifier Gain

dBµV/m @ 3m = 48.4 + 7.6 - 30

= 26.0

General Radiated Emissions from EUT Data (Highest Emissions)

Frequency in MHz	FSM Horz. (dBµV)	FSM Vert. (dBµV)	A.F. (dB/m)	Amp. Gain (dB)	RFS Horz. @ 3m (dBµV/m)	RFS Vert. @ 3m (dBµV/m)	FCC Class B Limit @ 3m (dBµV/m)
83.0	48.4	45.4	7.6	30	26.0	23.0	40.0
92.0	57.0	50.0	7.6	30	34.6	27.6	43.5
125.0	50.3	46.8	7.7	30	28.0	24.5	43.5
135.2	47.3	45.1	8.5	30	25.8	23.6	43.5
141.6	45.1	39.8	9.7	30	24.8	19.5	43.5
156.2	44.5	43.9	9.2	30	23.7	23.1	43.5
175.0	52.2	51.3	9.1	30	31.3	30.4	43.5
184.0	53.6	50.2	9.9	30	33.5	30.1	43.5
276.0	60.8	54.4	12.7	30	43.5	37.1	46.0
400.0	50.2	45.9	19.3	30	39.5	35.2	46.0
415.2	52.3	40.6	16.8	30	39.1	27.4	46.0
443.8	47.4	38.7	16.9	30	34.3	25.6	46.0
482.0	39.7	44.7	18.1	30	27.8	32.8	46.0
501.1	48.3	46.4	18.3	30	36.6	34.7	46.0
537.4	46.1	41.6	19.6	30	35.7	31.2	46.0
600.0	43.3	39.9	19.3	30	32.6	29.2	46.0

Other emissions present had amplitudes at least 20 dB below the limit.

Summary of Results for General Radiated Emissions

The radiated emissions for the EUT meet the requirements for FCC Part 15C paragraph 15.209 Intentional Radiators. The EUT had a 2.5 dB minimum margin below the limits. Other emissions were present with amplitudes at least 20 dB below the FCC Limits.

15.247 Operation in the Band 2412-2472 MHz

The power output was measured both at the antenna connection and at the open area test site at a three-meter distance. Three antenna configurations were offered and tested for certification. The panel offers gain of 19 dBi, the Grid offers gain of 24 dBi, and the Omni offers gain of 12 dBi. Data was taken per Paragraph 2.1046(a) and 15.247. Figures nine and ten demonstrate compliance with frequencies of operation and maximum output power requirements of 15.247(a)(2) across the band. Figures eleven through sixteen demonstrate compliance with the minimum 6 db bandwidth requirements of 15.247(A)(2). Figures seventeen through nineteen demonstrate compliance to power spectral density per 15.247(d). Figures nineteen through twenty-four demonstrate antenna conducted emissions and compliance with the requirements of 15.247(c) for emission limitations. Compliance to band edge requirements per 15.209 and 15.247 are demonstrated in radiated emissions tables for each antenna configuration. Antenna option configurations tested for compliance ranged in gain from 12 dBi to 24 dBi with worst case emissions presented in this document.

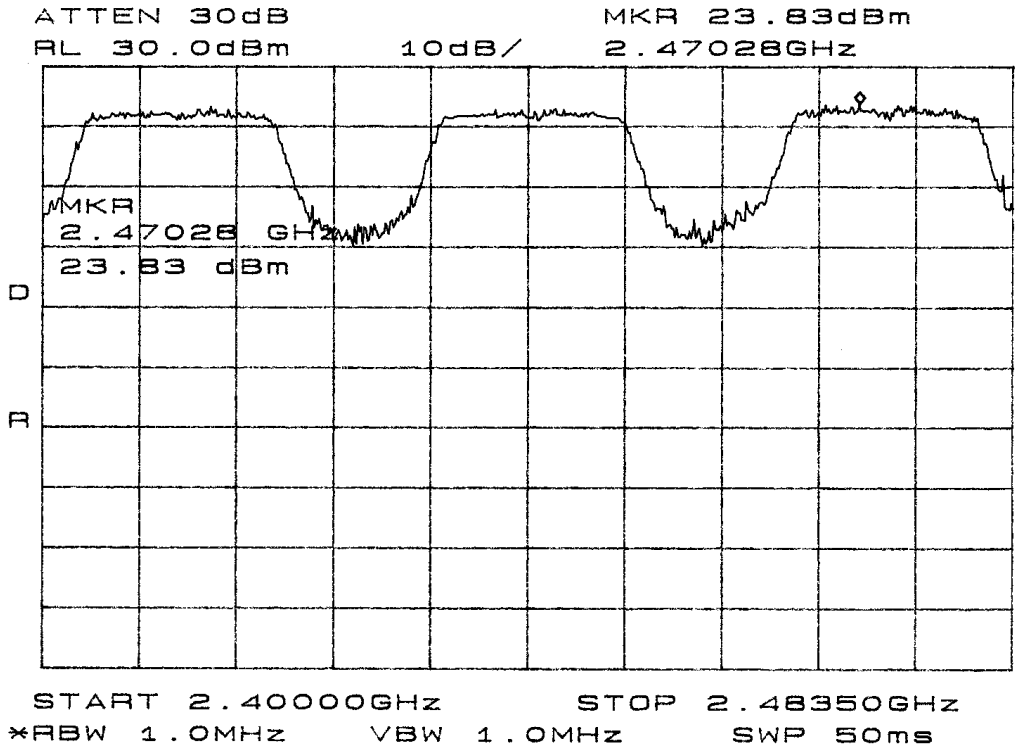

Figure 9 Operations at three frequencies in band

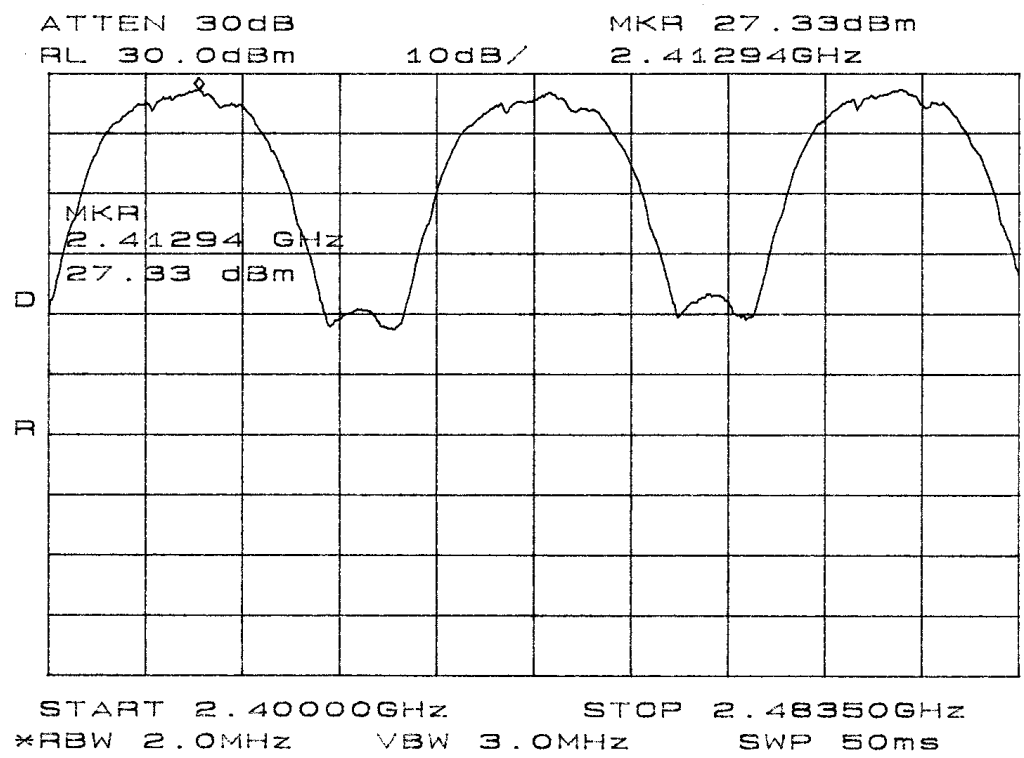

Figure 10 Maximum output power at three frequencies in band

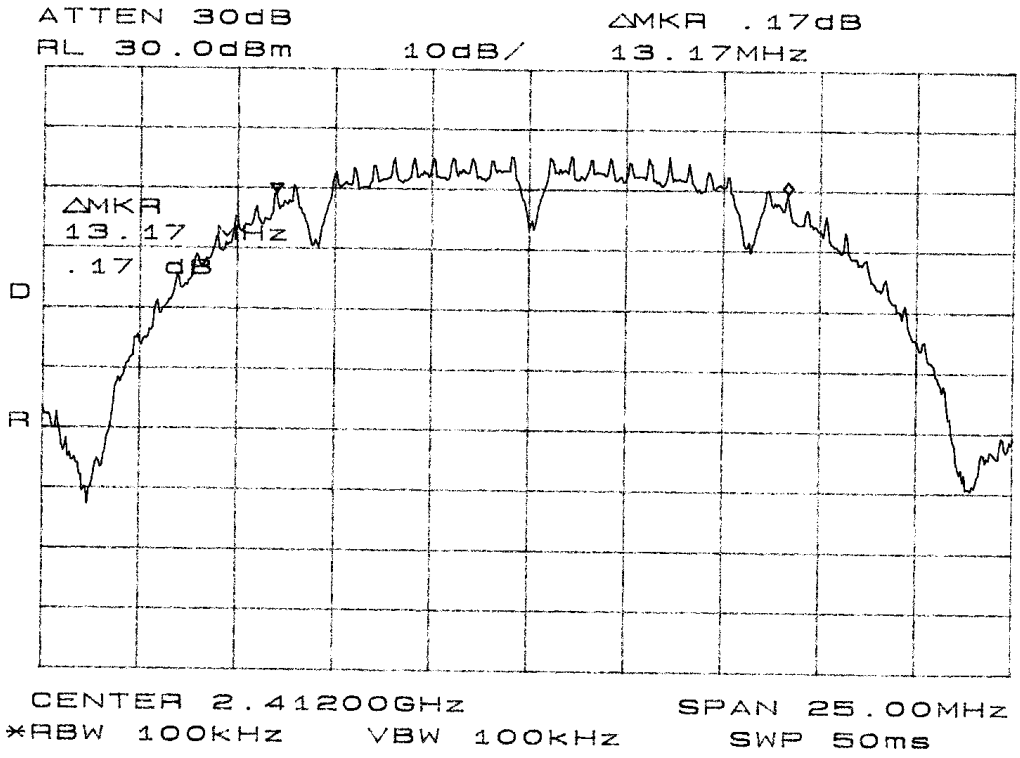

Figure 11 6dB Band width Requirement plot taken in screen room

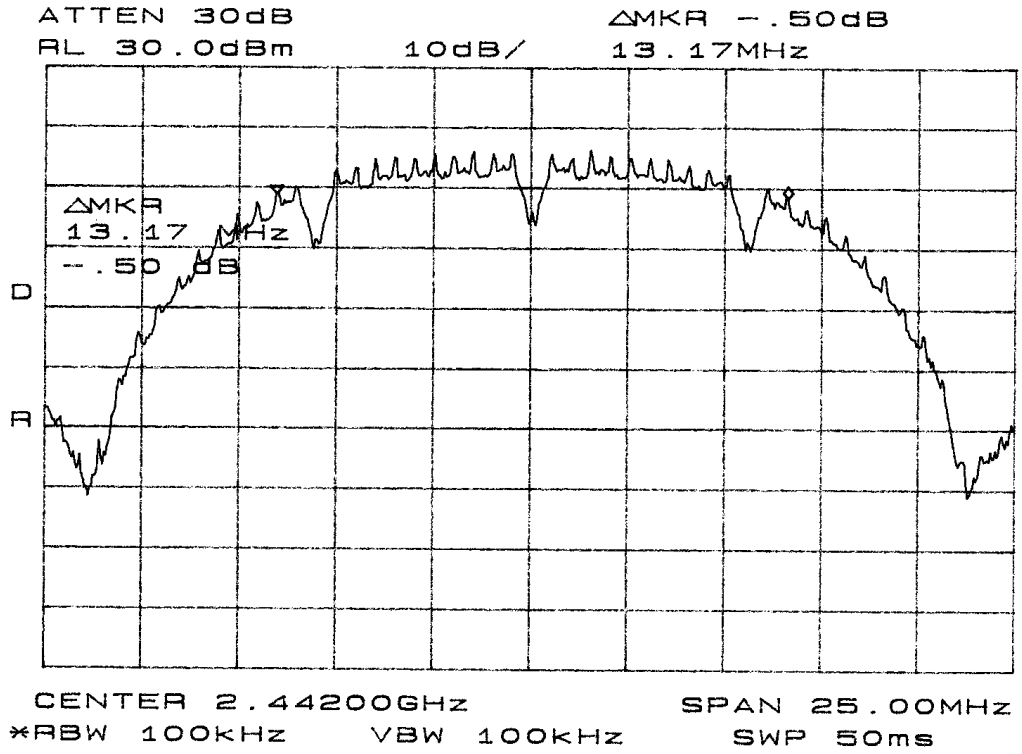

Figure 12 6dB Band width Requirement plot taken in screen room

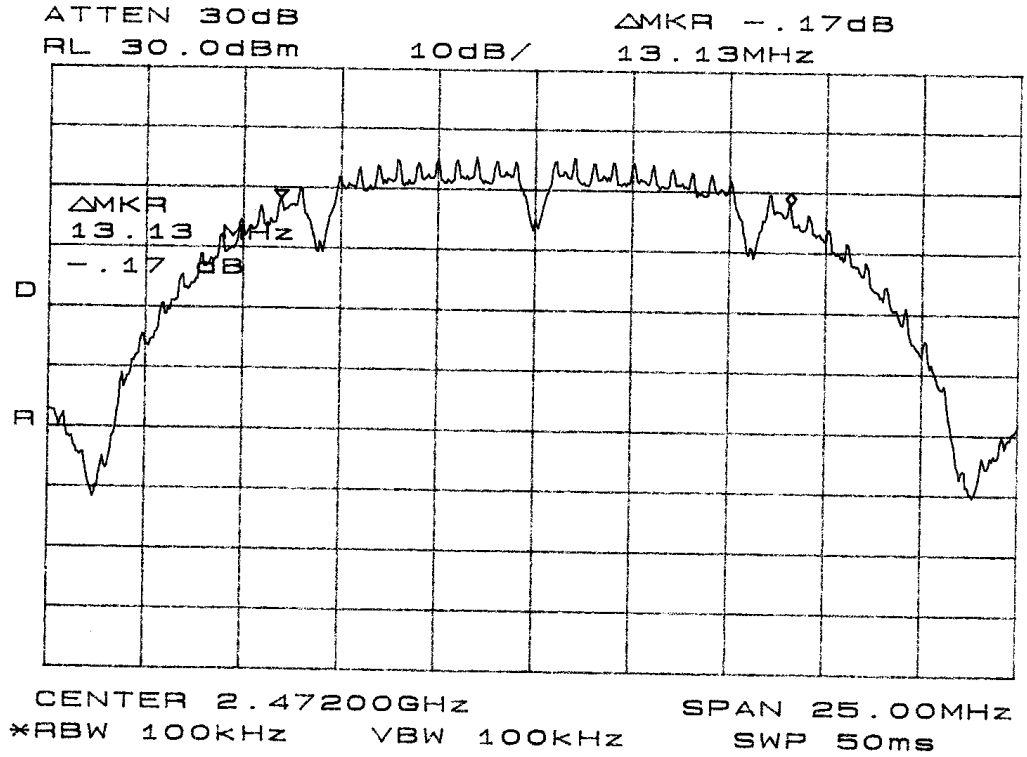

Figure 13 6dB Band width Requirement plot taken in screen room

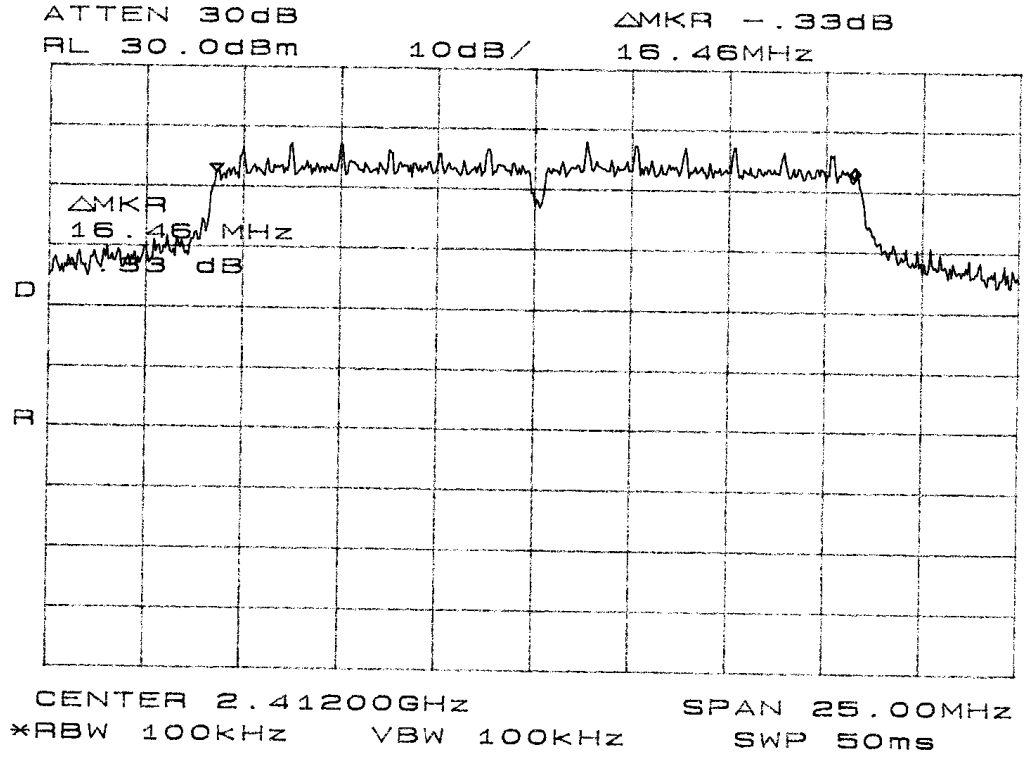

Figure 14 6dB Band width Requirement plot taken in screen room

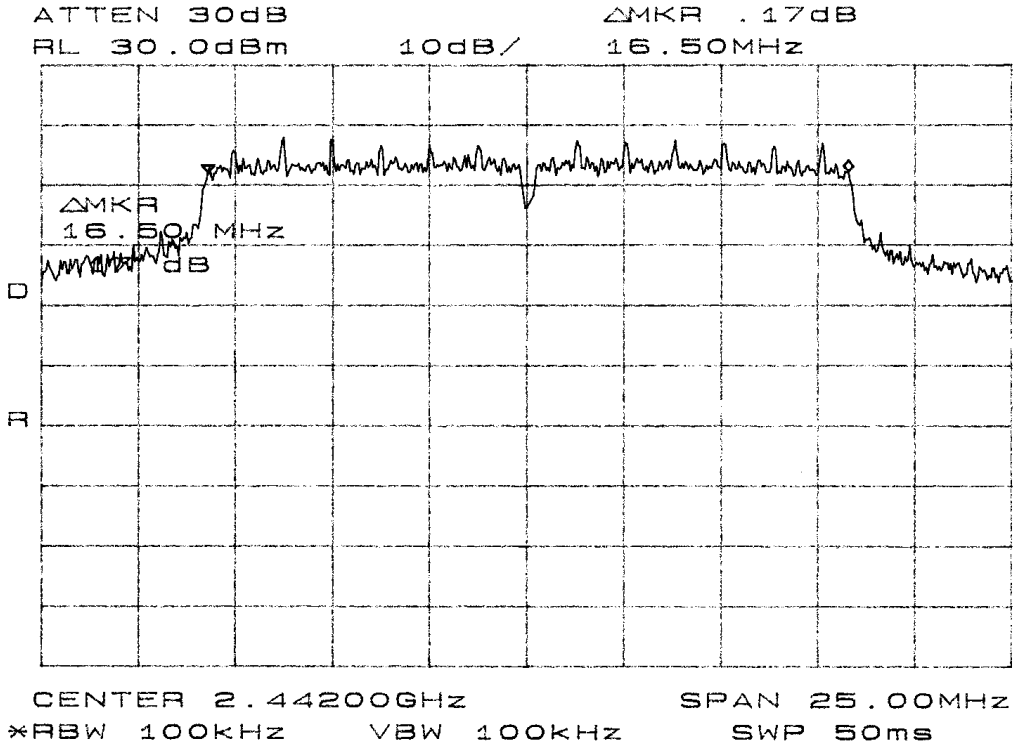

Figure 15 6dB Band width Requirement plot taken in screen room

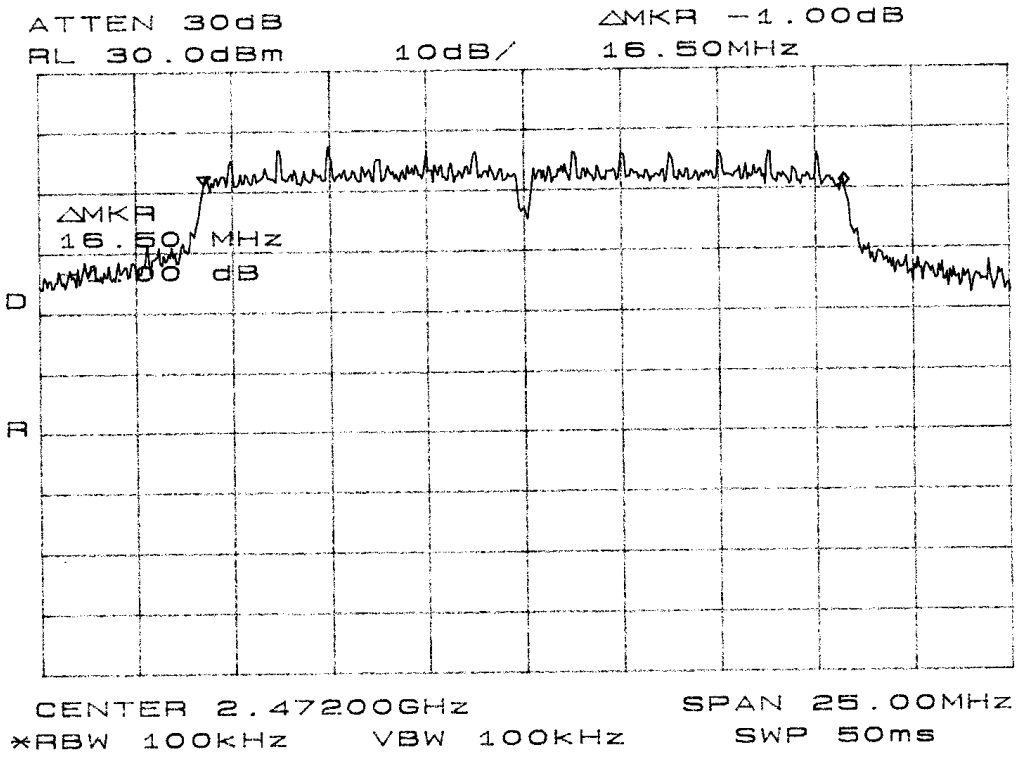

Figure 16 6dB Band width Requirement plot taken in screen room

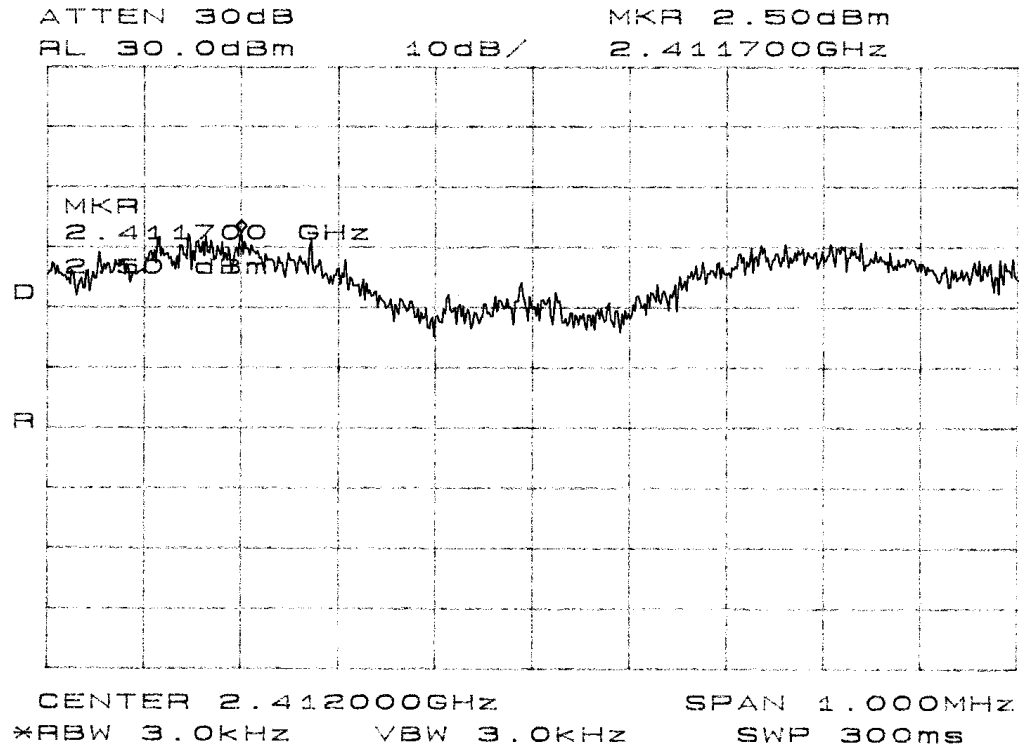

Figure 17 Power Spectral Density plot taken in screen room

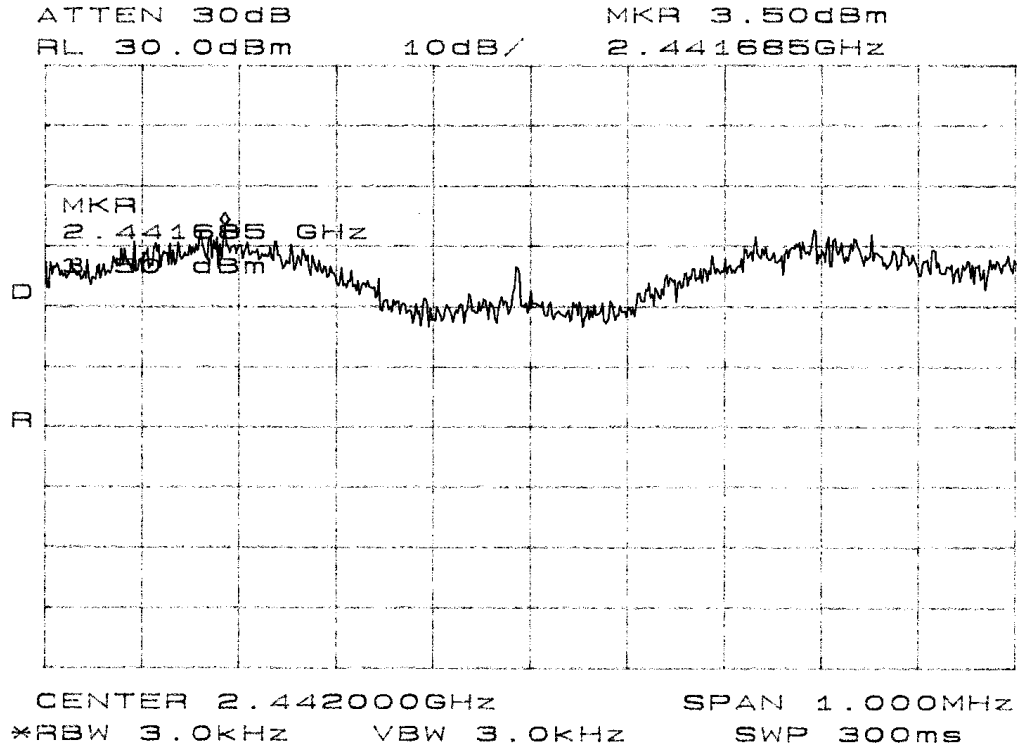

Figure 18 Power Spectral Density plot taken in screen room

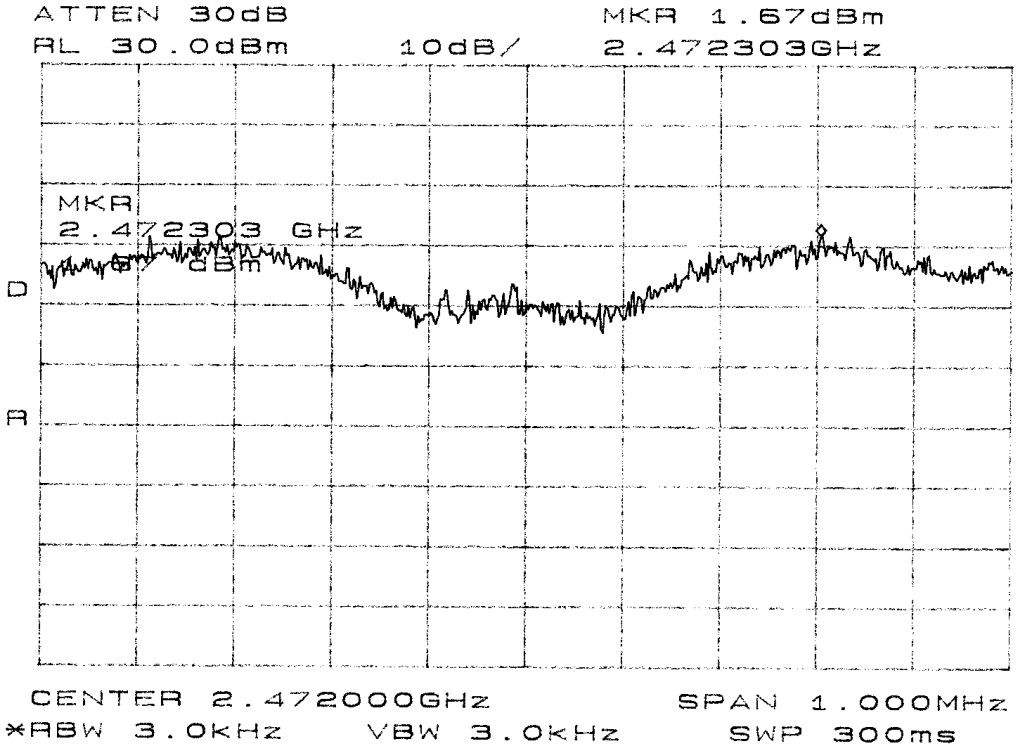

Figure 19 Power Spectral Density plot taken in screen room

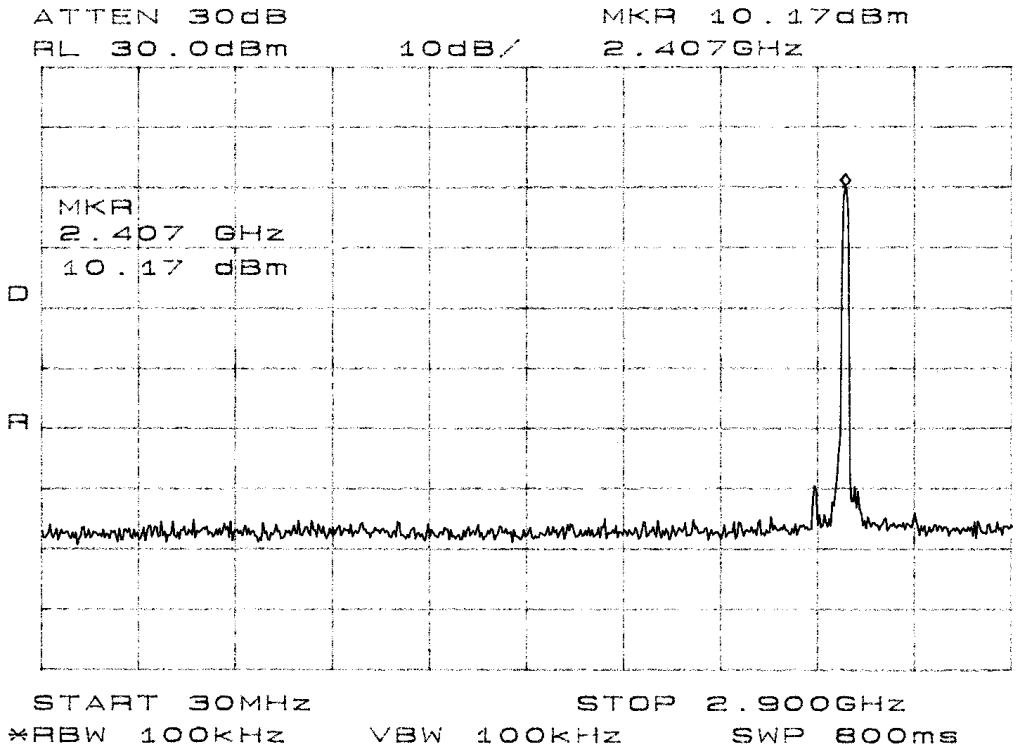

Figure 20 Antenna Conducted Emission plot taken in screen room

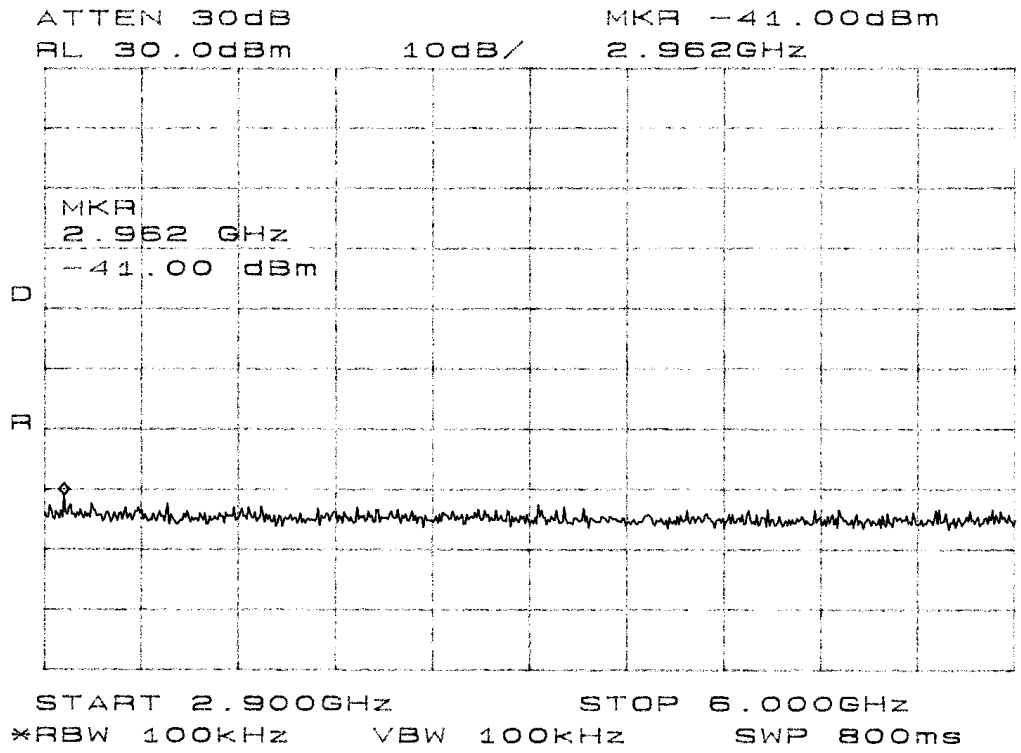

Figure 21 Antenna Conducted Emission plot taken in screen room

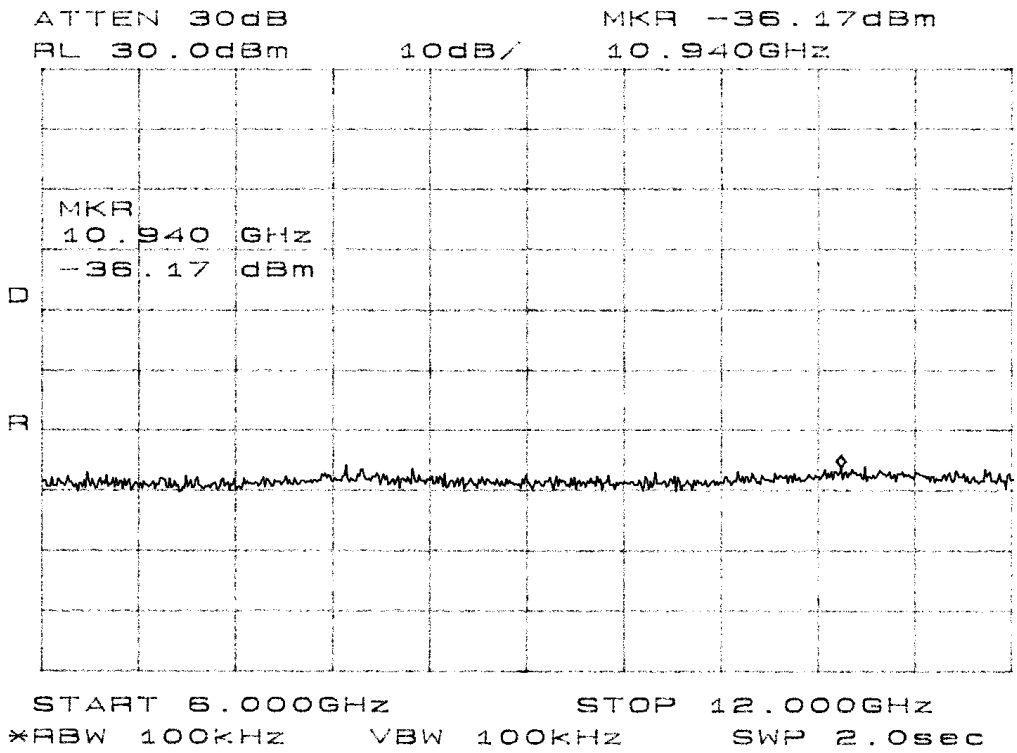

Figure 22 Antenna Conducted Emission plot taken in screen room

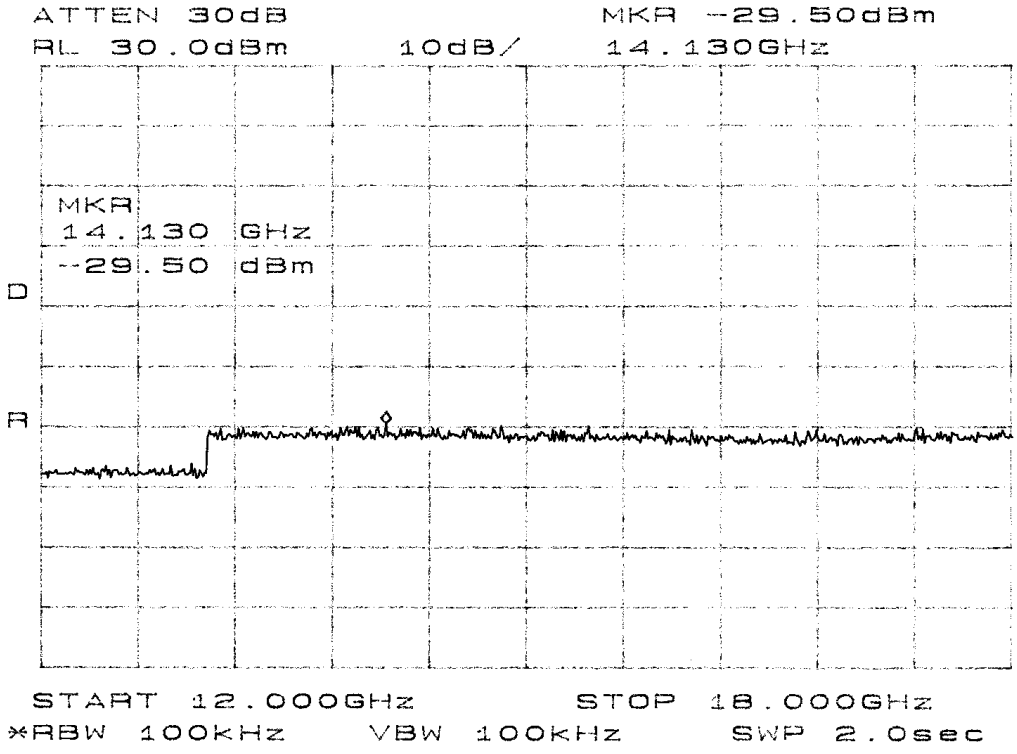

Figure 23 Antenna Conducted Emission plot taken in screen room

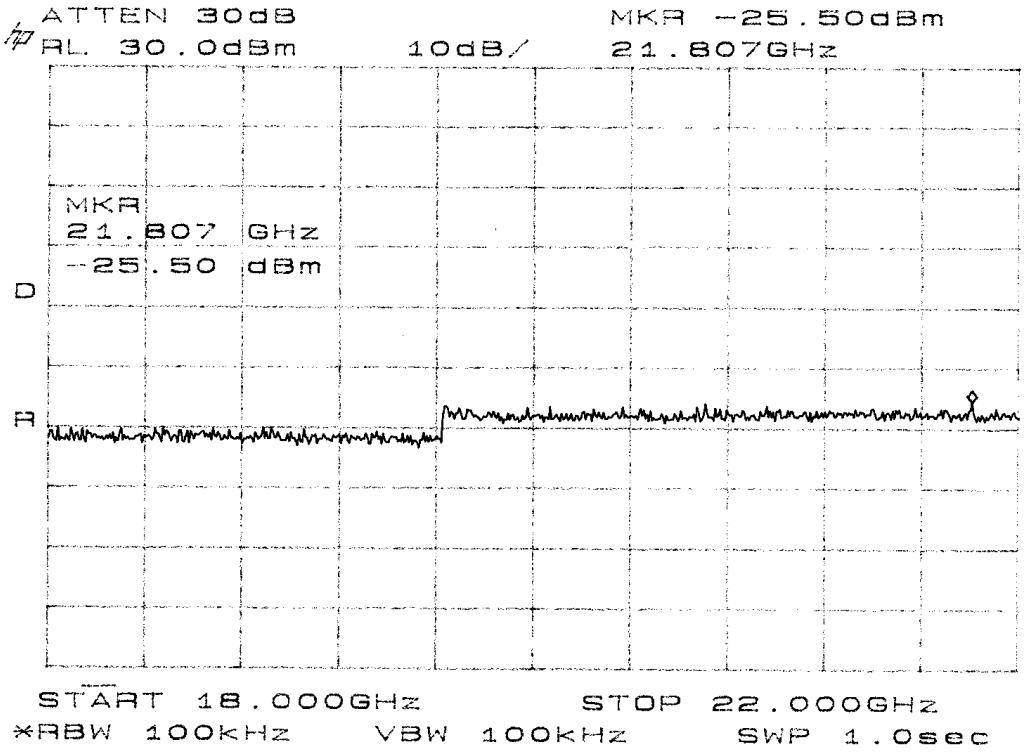

Figure 24 Antenna Conducted Emission plot taken in screen room

Transmitter Information and Data

The antenna conducted output power, power spectral density, and 20-dB bandwidth were measured at three frequencies in the band of operation. The data reported below represents the worst-case operational conditions.

Frequency MHz	Antenna Conducted Output Power dBm (mW)	Occupied Bandwidth MHz	Power Spectral Density dBm
2412	27.33 (540.75 mW)	16.46	2.50
2442	27.30 (537.03 mW)	16.50	3.50
2472	27.20 (524.81 mW)	16.50	1.67

Radiated Emissions from EUT Data (12 dBi Omni)

Frequency in MHz	FSM Horz. (dBµV)	FSM Vert. (dBµV)	A.F. (dB/m)	Amp. Gain (dB)	RFS Horz. @ 3m (dBµV/m)	RFS Vert. @ 3m (dBµV/m)	Limit @ 3m (dBµV/m)
2412.0	73.0	84.8	32.8	0	105.8	117.6	--
4824.0	18.5	20.0	41.4	30	29.9	31.4	54.0
7236.0	18.0	19.5	36.0	30	24.0	25.5	54.0
9648.0	20.0	21.6	38.1	30	28.1	29.7	54.0
12060.0	19.5	19.5	40.0	30	29.5	29.5	54.0
2442.0	71.0	83.3	33.2	0	104.2	116.5	--
4884.0	19.0	19.5	41.2	30	30.2	30.7	54.0
7326.0	17.5	20.5	36.3	30	23.8	26.8	54.0
9768.0	18.6	18.8	38.2	30	26.8	27.0	54.0
12210.0	18.3	18.5	40.2	30	28.5	28.7	54.0
2472.0	70.5	82.4	33.4	0	103.9	115.8	--
4944.0	18.2	18.5	42.1	30	30.3	30.6	54.0
7416.0	18.0	17.0	36.0	30	24.0	23.0	54.0
9888.0	18.8	18.8	38.1	30	26.9	26.9	54.0
12360.0	18.0	18.2	40.0	30	28.0	28.2	54.0
Band Edge Compliance							
2400.0	46.0	50.0	32.9	30	48.9	52.9	54.0
2483.5	43.0	48.0	33.3	30	46.3	51.3	54.0

Other emissions present had amplitudes at least 20 dB below the limit.

Radiated Emissions from EUT Data (19 dBi Panel)

Frequency in MHz	FSM Horz. (dBµV)	FSM Vert. (dBµV)	A.F. (dB/m)	Amp. Gain (dB)	RFS Horz. @ 3m (dBµV/m)	RFS Vert. @ 3m (dBµV/m)	Limit @ 3m (dBµV/m)
2412.0	89.0	94.1	32.8	0	121.8	126.9	--
4824.0	20.6	22.0	41.4	30	32.0	33.4	54.0
7236.0	17.6	19.8	36.0	30	23.6	25.8	54.0
9648.0	19.0	19.5	38.1	30	27.1	27.6	54.0
12060.0	17.5	20.6	40.0	30	27.5	30.6	54.0
2442.0	88.1	92.8	33.2	0	121.3	126.0	--
4884.0	20.0	22.6	41.2	30	31.2	33.8	54.0
7326.0	18.8	20.5	36.3	30	25.1	26.8	54.0
9768.0	17.1	20.8	38.2	30	25.3	29.0	54.0
12210.0	18.5	18.9	40.2	30	28.7	29.1	54.0
2472.0	88.1	92.3	33.4	0	121.5	125.7	--
4944.0	21.3	22.3	42.1	30	33.4	34.4	54.0
7416.0	19.0	21.1	36.6	30	25.6	27.7	54.0
9888.0	19.1	19.7	38.3	30	27.4	28.0	54.0
12360.0	19.3	20.5	40.4	30	29.7	30.9	54.0
Band Edge Compliance							
2400.0	41.7	48.5	32.9	30	44.6	51.4	54.0
2483.5	41.1	49.0	33.3	30	44.4	52.3	54.0

Other emissions present had amplitudes at least 20 dB below the limit.

Radiated Emissions from EUT Data (24 dBi Grid)

Frequency in MHz	FSM Horz. (dBµV)	FSM Vert. (dBµV)	A.F. (dB/m)	Amp. Gain (dB)	RFS Horz. @ 3m (dBµV/m)	RFS Vert. @ 3m (dBµV/m)	Limit @ 3m (dBµV/m)
2412.0	85.1	95.8	32.8	0	117.9	128.6	--
4824.0	21.6	32.0	41.4	30	33.0	43.4	54.0
7236.0	21.5	22.6	36.0	30	27.5	28.6	54.0
9648.0	21.5	19.8	38.1	30	29.6	27.9	54.0
12060.0	22.8	20.8	40.0	30	32.8	30.8	54.0
2442.0	84.5	94.5	33.2	0	117.7	127.7	--
4884.0	19.8	31.0	41.2	30	31.0	42.2	54.0
7326.0	20.3	22.0	36.3	30	26.6	28.3	54.0
9768.0	19.2	21.0	38.2	30	27.4	29.2	54.0
12210.0	20.0	21.1	40.2	30	30.2	31.3	54.0
2472.0	83.6	94.6	33.4	0	117.0	128.0	--
4944.0	21.8	28.6	42.1	30	33.9	40.7	54.0
7416.0	20.0	20.5	36.6	30	26.6	27.1	54.0
9888.0	21.0	21.0	38.3	30	29.3	29.3	54.0
12360.0	19.3	21.0	40.4	30	29.7	31.4	54.0
Band Edge Compliance							
2400.0	46.2	50.0	32.9	30	49.1	52.9	54.0
2483.5	47.0	48.0	33.3	30	50.3	51.3	54.0

Other emissions present had amplitudes at least 20 dB below the limit.

Summary of Results for Radiated Emissions of Intentional Radiator

The EUT had the highest radiated emission of 128.6 dBµV/m at 3 meters at the fundamental frequency of operation utilizing the dish antenna. The EUT had a worst-case of 10.6 dB margin below the limit for the harmonic emissions. The EUT had a worst-case of 1.1 dB margin below the limit at band edges. The radiated emissions for the EUT meet the requirements for FCC Part 15.247 Intentional Radiators. There are no measurable emissions in the restricted bands other than those recorded in this report. Other emissions were present with amplitudes at least 20 dB below the FCC Limits. The specifications of 15.247 were met; there are no deviations or exceptions to the requirements.

Statement of Modifications and Deviations

No modifications to the EUT were required for the unit to meet the FCC Part 15C emissions standards. There were no deviations to the specifications.

Annex

- Annex A Measurement Uncertainty Calculations
- Annex B Test Equipment List.
- Annex C Rogers Qualifications.
- Annex D FCC Site Registration Letter.

Annex A Measurement Uncertainty Calculations

Radiated Emissions Measurement Uncertainty Calculation

Measurement of vertically polarized radiated field strength over the frequency range 30 MHz to 1 GHz on an open area test site at 3m and 10m includes following uncertainty:

Contribution	Probability Distribution	Uncertainty (dB)
Antenna factor calibration	normal (k = 2)	±0.58
Cable loss calibration	normal (k = 2)	±0.2
Receiver specification	rectangular	±1.0
Antenna directivity	rectangular	±0.1
Antenna factor variation with height	rectangular	±2.0
Antenna factor frequency interpolation	rectangular	±0.1
Measurement distance variation	rectangular	±0.2
Site Imperfections	rectangular	±1.5

Combined standard uncertainty $u_c(y)$ is

$$U_c(y) = \pm \sqrt{\left[\frac{1.0}{2}\right]^2 + \left[\frac{0.2}{2}\right]^2 + \left[\frac{1.0^2 + 0.1^2 + 2.0^2 + 0.1^2 + 0.2^2 + 1.5^2}{3}\right]}$$

$U_c(y) = \pm 1.6$ dB

It is probable that $u_c(y) / s(q_k) > 3$, where $s(q_k)$ is estimated standard deviation from a sample of n readings unless the repeatability of the EUT is particularly poor, and a coverage factor of k = 2 will ensure that the level of confidence will be approximately 95%, therefore:

$$s(q_k) = \sqrt{\frac{1}{(n-1)} \sum_{k-1}^{n} (q_k - \bar{q})^2}$$

$$U = 2\, U_c(y) = 2 \times \pm 1.6 \text{ dB} = \pm 3.2 \text{ dB}$$

Notes:

1.1 Uncertainties for the antenna and cable were estimated, based on a normal probability distribution with k = 2.

1.2 The receiver uncertainty was obtained from the manufacturer's specification for which a rectangular distribution was assumed.

1.3 The antenna factor uncertainty does not take account of antenna directivity.

1.4 The antenna factor varies with height and since the height was not always the same in use as when the antenna was calibrated an additional uncertainty is added.

1.5 The uncertainty in the measurement distance is relatively small but has some effect on the received signal strength. The increase in measurement distance as the antenna height is increased is an inevitable consequence of the test method and is therefore not considered a contribution to uncertainty.

1.6 Site imperfections are difficult to quantify but may include the following contributions:
-Unwanted reflections from adjacent objects.
-Ground plane imperfections: reflection coefficient, flatness, and edge effects.
-Losses or reflections from "transparent" cabins for the EUT or site coverings.
-Earth currents in antenna cable (mainly effect biconical antennas).

The specified limits for the difference between measured site attenuation and the theoretical value (± 4 dB) were not included in total since the measurement of site attenuation includes uncertainty contributions already allowed for in this budget, such as antenna factor.

Conducted Measurements Uncertainty Calculation

Measurement of conducted emissions over the frequency range 9 kHz to 30 MHz includes following uncertainty:

Contribution	Probability Distribution	Uncertainty (dB)
Receiver specification	rectangular	±1.5
LISN coupling specification	rectangular	±1.5
Cable and input attenuator calibration	normal (k=2)	±0.5

Combined standard uncertainty $u_c(y)$ is

$$U_c(y) = \pm \sqrt{\left[\frac{0.5}{2}\right]^2 + \frac{1.5^2 + 1.5^2}{3}}$$

$$U_c(y) = \pm 1.2 \text{ dB}$$

As with radiated field strength uncertainty, it is probable that $u_c(y) / s(q_k) > 3$ and a coverage factor of k = 2 will suffice, therefore:

$$U = 2\, U_c(y) = 2 \times \pm 1.2 \text{ dB} = \pm 2.4 \text{ dB}$$

Annex B Test Equipment List For Rogers Labs, Inc.

The test equipment used is maintained in calibration and good operating condition. Use of this calibrated equipment ensures measurements are traceable to national standards.

List of Test Equipment	Calibration Date
Oscilloscope Scope: Tektronix 2230	2/08
Wattmeter: Bird 43 with Load Bird 8085	2/08
Power Supplies: Sorensen SRL 20-25, SRL 40-25, DCR 150, DCR 140	2/08
H/V Power Supply: Fluke Model: 408B (SN: 573)	2/08
R.F. Generator: HP 606A	2/08
R.F. Generator: HP 8614A	2/08
R.F. Generator: HP 8640B	2/08
Spectrum Analyzer: HP 8562A, Mixers: 11517A, 11970A, 11970K, 11970U, 11970V, 11970W HP Adapters: 11518, 11519, 11520	5/08
Spectrum Analyzer: HP 8591EM	5/08
Frequency Counter: Leader LDC825	2/08
Antenna: EMCO Biconilog Model: 3143	5/08
Antenna: EMCO Log Periodic Model: 3147	10/07
Antenna: Antenna Research Biconical Model: BCD 235	10/07
Antenna: EMCO Dipole Set 3121C	2/08
Antenna: C.D. B-101	2/08
Antenna: Solar 9229-1 & 9230-1	2/08
Antenna: EMCO 6509	2/08
Audio Oscillator: H.P. 201CD	2/08
R.F. Power Amp 65W Model: 470-A-1010	2/08
R.F. Power Amp 50W M185- 10-501	2/08
R.F. PreAmp CPPA-102	2/08
LISN 50 µHy/50 ohm/0.1 µf	10/07
LISN Compliance Eng. 240/20	2/08
LISN Fischer Custom Communications FCC-LISN-50-16-2-08	2/08
Peavey Power Amp Model: IPS 801	2/08
Power Amp A.R. Model: 10W 1010M7	2/08
Power Amp EIN Model: A301	2/08
ELGAR Model: 1751	2/08
ELGAR Model: TG 704A-3D	2/08
ESD Test Set 2010i	2/08
Fast Transient Burst Generator Model: EFT/B-101	2/08
Current Probe: Singer CP-105	2/08
Current Probe: Solar 9108-1N	2/08
Field Intensity Meter: EFM-018	2/08
KEYTEK Ecat Surge Generator	2/08
Shielded Room 5 M x 3 M x 3.0 M	

Annex C Qualifications

SCOT D. ROGERS, ENGINEER

ROGERS LABS, INC.

Mr. Rogers has approximately 17 years experience in the field of electronics. Six years working in the automated controls industry and 6 years working with the design, development and testing of radio communications and electronic equipment.

POSITIONS HELD:

Systems Engineer: A/C Controls Mfg. Co., Inc. 6 Years

Electrical Engineer: Rogers Consulting Labs, Inc. 5 Years

Electrical Engineer: Rogers Labs, Inc. Current

EDUCATIONAL BACKGROUND:

1) Bachelor of Science Degree in Electrical Engineering from Kansas State University.

2) Bachelor of Science Degree in Business Administration Kansas State University.

3) Several Specialized Training courses and seminars pertaining to Microprocessors and Software programming.

Scot D Rogers

Scot D. Rogers

NVLAP Lab Code 200087-0

Annex D FCC Site Registration Letter

FEDERAL COMMUNICATIONS COMMISSION

Laboratory Division
7435 Oakland Mills Road
Columbia, MD 21046

June 18, 2008

Registration Number: 90910

Rogers Labs, Inc.
4405 West 259th Terrace,
Louisburg, KS 66053

Attention: Scot Rogers

Re: Measurement facility located at Louisburg
3 & 10 meter site
Date of Renewal: June 18, 2008

Dear Sir or Madam:

Your request for renewal of the registration of the subject measurement facility has been received. The information submitted has been placed in your file and the registration has been renewed. The name of your organization will remain on the list of facilities whose measurement data will be accepted in conjunction with applications for Certification under Parts 15 or 18 of the Commission's Rules. Please note that the file must be updated for any changes made to the facility and the registration must be renewed at least every three years.

Measurement facilities that have indicated that they are available to the public to perform measurement services on a fee basis may be found on the FCC website www.fcc.gov under E-Filing, OET Equipment Authorization Electronic Filing, Test Firms.

Sincerely,

Phyllis Parrish
Industry Analyst