Axonn Corporation
FCC Part 15, Certification Application
AX-620 Transmitter

November 17, 2000

MEASUREMENT/TECHNICAL REPORT

COMPANY NAME: **Axonn Corporation**

MODEL: **AX-620 Transmitter**

FCC ID: **L2VAX620**

DATE: **November 17, 2000**

This report concerns (check one): Original grant_X__
Class II change_____

Equipment type: **___Direct Sequence Spread Spectrum (Modular)___**

Deferred grant requested per 47 CFR 0.457(d)(1)(ii)? yes_____ No_X_

If yes, defer until:_____
date

__N.A.__ agrees to notify the Commission by__N.A.____
date
of the intended date of announcement of the product so that the grant can be issued on that date.

Report prepared by:

United States Technologies, Inc.
3505 Francis Circle
Alpharetta, GA 30004

Phone Number: (770) 740-0717
Fax Number: (770) 740-1508

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SECTION 1

GENERAL INFORMATION

GENERAL INFORMATION

1.1 Product Description

The Equipment Under Test (EUT) is the Axonn Corporation's, Model AX-620 Transmitter. The EUT transmits signals of binary switch inputs to a receiver. The EUT utilizes direct sequence spread spectrum technology for communication at 923.58 MHz at approximately 50 mW output power. The EUT will typically derive its power from an internally mounted 3 VDC battery (external to module).

This application is being submitted in order to approve the EUT as a stand-alone module. Please refer to the following letter from Axonn Corporation.

AXONN CORPORATION 101 West Robert E. Lee Boulevard · Suite 202 · New Orleans, Louisiana 70124 · (504) 282-8119 · FAX 282-0999

October 31, 2000

Federal Communications Commission
Equipment Authorization Division
7435 Oakland Mills Road
Columbia, MD 21046

Dear Sir or Madam:

This letter requests that the attached filing (FCC ID L2VAX620) be submitted for modular approval. In reference to FCC Public Notice DA 00-1407, the following is stated:

1. The device incorporates the following harmonic suppression techniques:

   Surface mount and co-planar technology is used throughout the design, minimizing stray RF fields that launch electromagnetic waves.

   Novel filter technology that provides guaranteed suppression of transmitter spurious products by design. Each circuit is statistically modeled using computer aided design techniques for 6-sigma repeatability with the tolerances of the low-cost components used.

   Innovative signal generation techniques which utilize the power of Fourier analysis to suppress even-order harmonics in the generation of the transmitted signal.

   A self-contained, printed-circuit antenna is utilized to guarantee a stable output match to the final amplifier. The printed antenna dispenses with the variability of externally mounted alternatives that could provide indeterminate terminations to the transmitter output. Indeterminate terminations cause reflections to the output circuitry of other transmitters, resulting in increased spurious products.

2. All data inputs are buffered.

3. The device has its own power supply regulation.

4. The device is a complete transmitter module, with its own reference oscillator and printed antenna. All connectors are for power supply data inputs.

5. The device was submitted as a stand-alone unit for testing. The conducted emissions requirements do not apply as this will be a battery-powered unit.

Other points of discussion concerning modular transmitter approvals are covered in other portions of this application.

Best Regards,

David Alley

David Alley
Axonn Corporation

1.2 Related Submittal(s)/Grant(s)

The EUT will be used with part of a system to send/receive data. The transmitter presented in this report will be used with previously approved receivers.

The EUT is subject to the following authorizations:

a) Certification as a transmitter

The information contained in this report is presented for the certification authorization for the EUT.

SECTION 2

TESTS AND MEASUREMENTS

TEST AND MEASUREMENTS

2.1 Configuration of Tested System

The sample was tested per ANSI C63.4, Methods of Measurement from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz (1992). Conducted and radiated emissions data were taken with the test receiver or spectrum analyzer's resolution bandwidth adjusted to 9 kHz and 120 kHz, respectively. All measurements are peak unless stated otherwise. The video filter associated with the spectrum analyzer was off throughout the evaluation process. Interconnecting cables were manipulated as necessary to maximize emissions. Interconnecting cables were manipulated as necessary to maximize emissions. A block diagram of the tested system is shown in Figure 1. Test configuration photographs for spurious and fundamental emissions are shown in Figure 2.

The sample used for testing was received by U.S. Technologies on August 18, 2000 in good condition.

2.2 Test Facility

Testing was performed at US Tech's measurement facility at 3505 Francis Circle, Alpharetta, GA. This site has been fully described and submitted to the FCC, and accepted in their letter marked 31040/SIT. Additionally this site has also been fully described and submitted to Industry Canada (IC), and has been approved under file number IC2982.

2.3 Test Equipment

Table 2 describes test equipment used to evaluate this product.

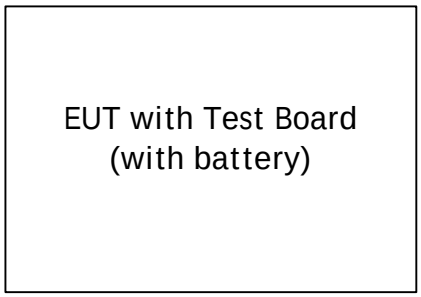
2.4 Modifications

No modifications were made by US Tech, to bring the EUT into compliance with FCC Part 15 limits for the transmitter portion of the EUT.

FIGURE 1

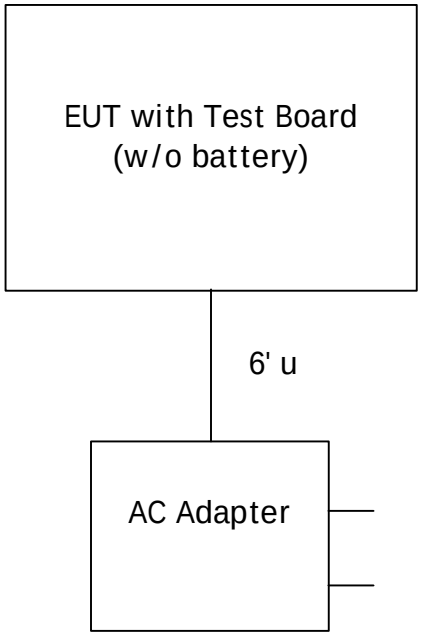
TEST CONFIGURATION

(All tests except for conducted emissions)



Axonn Corporation does not anticipate any applications for use in products other than battery powered applications. Therefore all tests except conducted emissions were performed under battery power as shown above. However, to ensure that the EUT has been tested for all future applications, an additional conducted test was performed by removing the battery from the test board above and attaching an AC adapter as shown below.

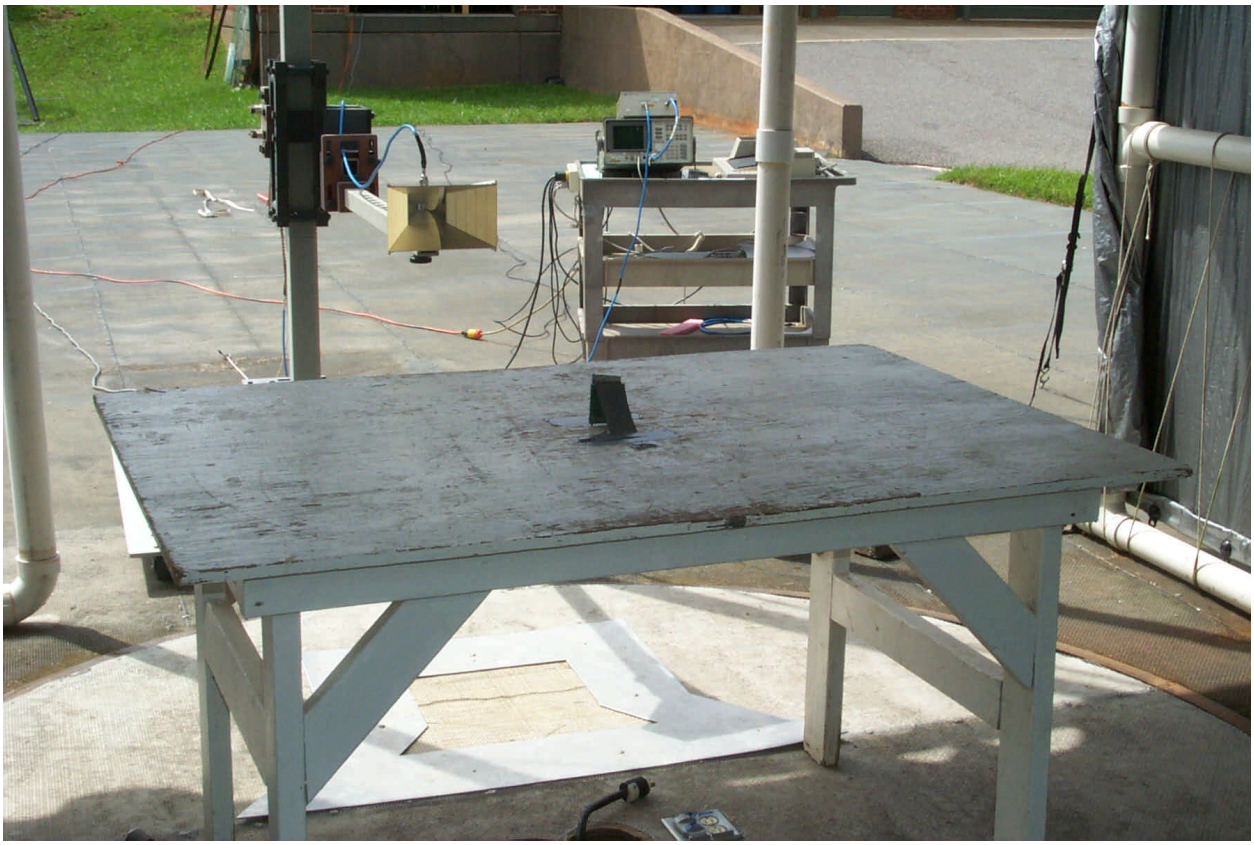
(Conducted emissions only)



Test Date: September 11, 2000
UST Project: 00-0381
Customer: Axonn Corporation
Model: AX-620 Transmitter, 0643-0100

FIGURE 2a

Photograph(s) for Spurious Emissions (Front)



Test Date: September 11, 2000
UST Project: 00-0381
Customer: Axonn Corporation
Model: AX-620 Transmitter, 0643-0100

FIGURE 2b

Photograph(s) for Spurious Emissions (Back)

Test Date: September 11, 2000
UST Project: 00-0381
Customer: Axonn Corporation
Model: AX-620 Transmitter, 0643-0100

FIGURE 2c

Photograph(s) for Digital Device Emissions (Front)

Since the EUT and related circuitry is used to operate a transmitter only, digital device emissions were deemed unnecessary

Test Date: September 11, 2000
UST Project: 00-0381
Customer: Axonn Corporation
Model: AX-620 Transmitter, 0643-0100

FIGURE 2d

Photograph(s) for Digital Device Emissions (Back)

Since the EUT and related circuitry is used to operate a transmitter only, digital device emissions were deemed unnecessary

Test Date: November 15, 2000
UST Project: 00-0381
Customer: Axonn Corporation
Model: AX-620 Transmitter, 0643-0100

FIGURE 2e

Photograph(s) for Conducted Emissions

Performed with power supply attached to battery terminals (battery removed)

TABLE 1

EUT and Peripherals

PERIPHERAL MANUFACTURER	MODEL NUMBER	SERIAL NUMBER	FCC ID:	CABLES P/D
Modular TX Board Axonn Corporation	AX620	None	L2VAX620 (pending)	None
Test Board Axonn Corporation	0643-0300- AWO Rev. A	None	None	None
AC Adapter Radio Shack	273-1661A	None	None	6' u

TABLE 2
TEST INSTRUMENTS

TYPE	MANUFACTURER	MODEL	SN.
SPECTRUM ANALYZER	HEWLETT-PACKARD	8593E	3205A00124
SPECTRUM ANALYZER	HEWLETT-PACKARD	8558B	2332A09900
S A DISPLAY	HEWLETT-PACKARD	853A	2404A02387
COMB GENERATOR	HEWLETT-PACKARD	8406A	1632A01519
RF PREAMP	HEWLETT-PACKARD	8447D	1937A03355
RF PREAMP	HEWLETT-PACKARD	8449B	3008A00480
HORN ANTENNA	EMCO	3115	3723
BICONICAL ANTENNA	EMCO	3110	9307-1431
LOG PERIODIC ANTENNA	EMCO	3146	9110-3600
BILOG	CHASE	CBL6112A	2238
LISN	SOLAR ELE.	8012	865577
LISN	SOLAR ELE.	8028	910494
LISN	SOLAR ELE.	8028	910495
THERMOMETER	FLUKE	52	5215250
MULTIMETER	FLUKE	85	53710469
FUNCTION GENERATOR	TEKTRONIX	CFG250	CFG250TW15059
PLOTTER	HEWLETT-PACKARD	7475A	2325A65394

2.6 Antenna Description (Paragraph 15.203)

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 Axonn Corporation Model AX-620 Transmitter incorporates an internal antenna only.

2.7 Peak Power Within the Band 902 - 928 MHz per FCC Section 15.247(b)

Peak power within the band 902 - 928 MHz has been measured with a spectrum analyzer by connecting the spectrum analyzer directly via a short cable to the antenna output terminals or across the antenna leads on the PCB as specified by the manufacturer. Since the antenna output has particular filtering components in the antenna path and normally only has an antenna trace on the board, a special modified sample (to be used only for power measurements) was provided by Axonn Corporation which allowed the EUT to be directly attached to a spectrum analyzer. The spectrum analyzer was set for a 50 Ω impedance with the VBW ≥ RBW 6 dB bandwidth. The results of the measurements are given in Table 3 and Figure 3.

The EUT did not incorporate any antennas of directional gain greater than 6 dBi, therefore the output power has not been reduced as required by 15.247(b)(3).

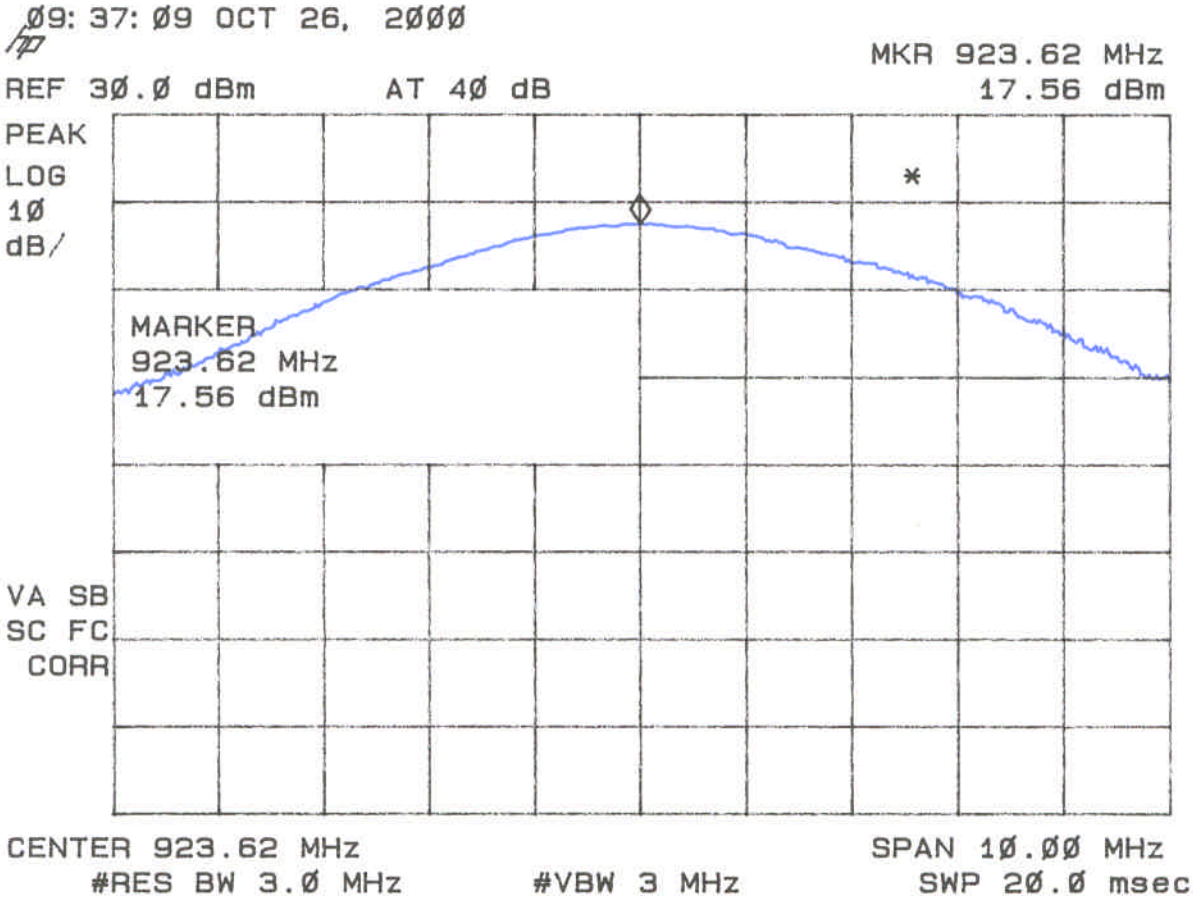
TABLE 3
PEAK POWER OUTPUT

Test Date: **October 26, 2000**
UST Project: **00-0381**
Customer: **Axonn Corporation**
Model: **AX-620 Transmitter, 0643-0100**

Frequency of Fundamental (MHz)	Measurement (dBm)	Measurement (Watt)*	FCC Limit (Watt)
923.62	17.56	0.057	1.0

Tester
Signature: _____ **Name:** **Tim R. Johnson**

Figure 3
Peak Power per FCC Section 15.247(b)



2.8 Antenna Conducted Spurious Emission in the Frequency Range 30 - 10000 MHz (FCC Section 15.247(c))

Since the EUT has an integrated antenna only, Antenna Conducted Spurious Emissions have been deemed not necessary.

2.9 Peak Radiated Spurious Emission in the Frequency Range 30 -10000 MHz (FCC Section 15.247(c))

A preliminary scan was performed on the EUT to determine frequencies that were caused by the transmitter portion of the product. Significant emissions that fell within restricted bands were then measured on an OAT's site. Radiated measurements below 1 GHz were tested with a RBW = 120 kHz. Radiated measurements above 1 GHz were measured using a RBW = VBW = 1 MHz. The results of peak radiated spurious emissions falling within restricted bands are given in Table 4 and Figure 5a-5e.

Figure 5a
Peak Radiated Spurious Emission 15.247(c)

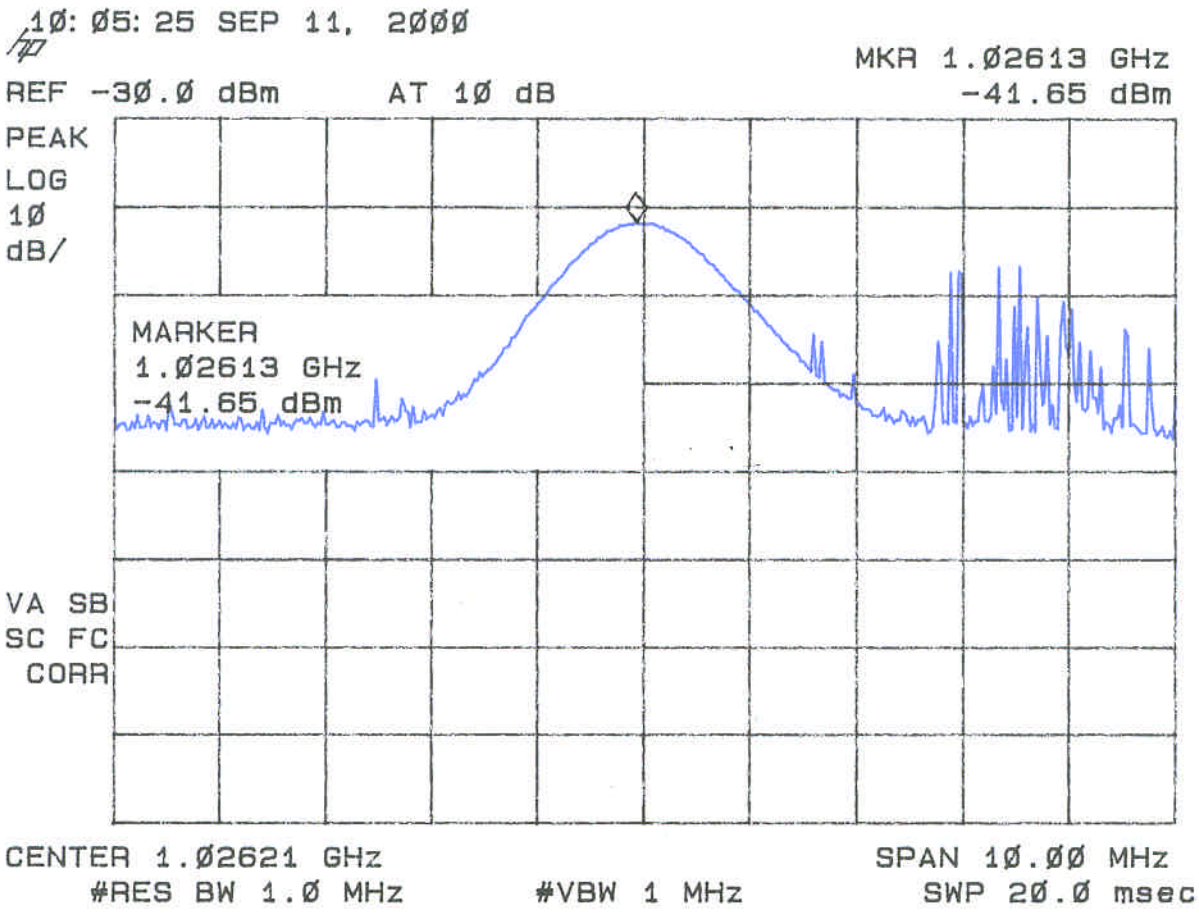


Figure 5b
Peak Radiated Spurious Emission 15.247(c)

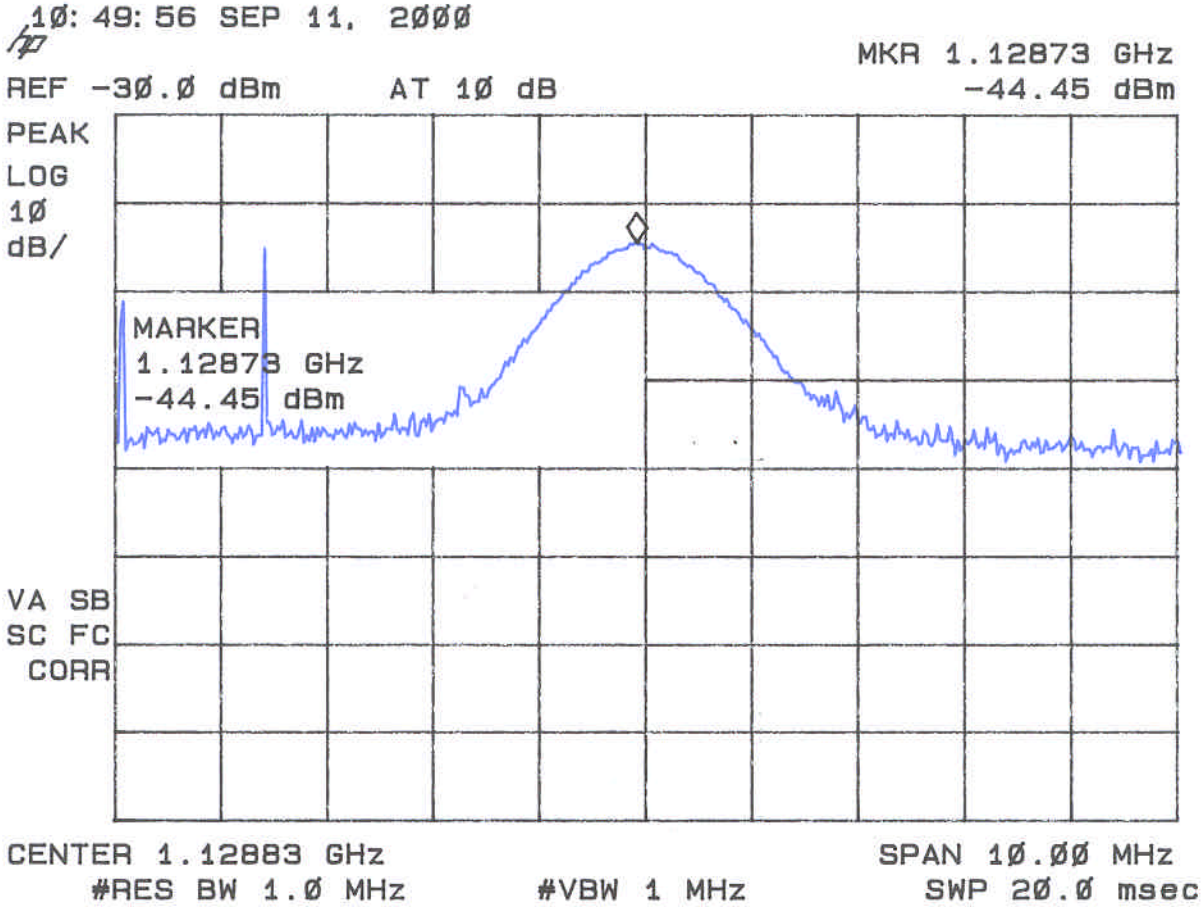


Figure 5c
Peak Radiated Spurious Emission 15.247(c)

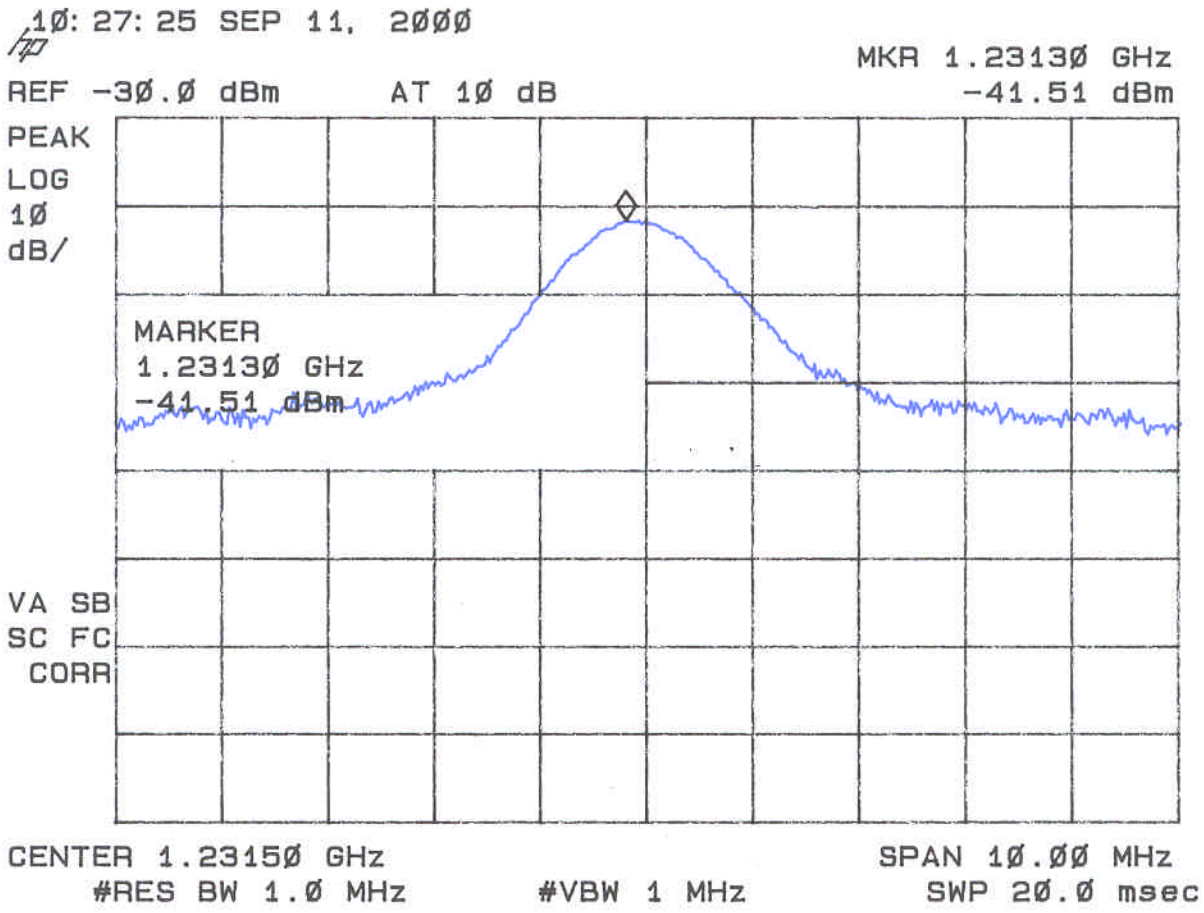


Figure 5d
Peak Radiated Spurious Emission 15.247(c)

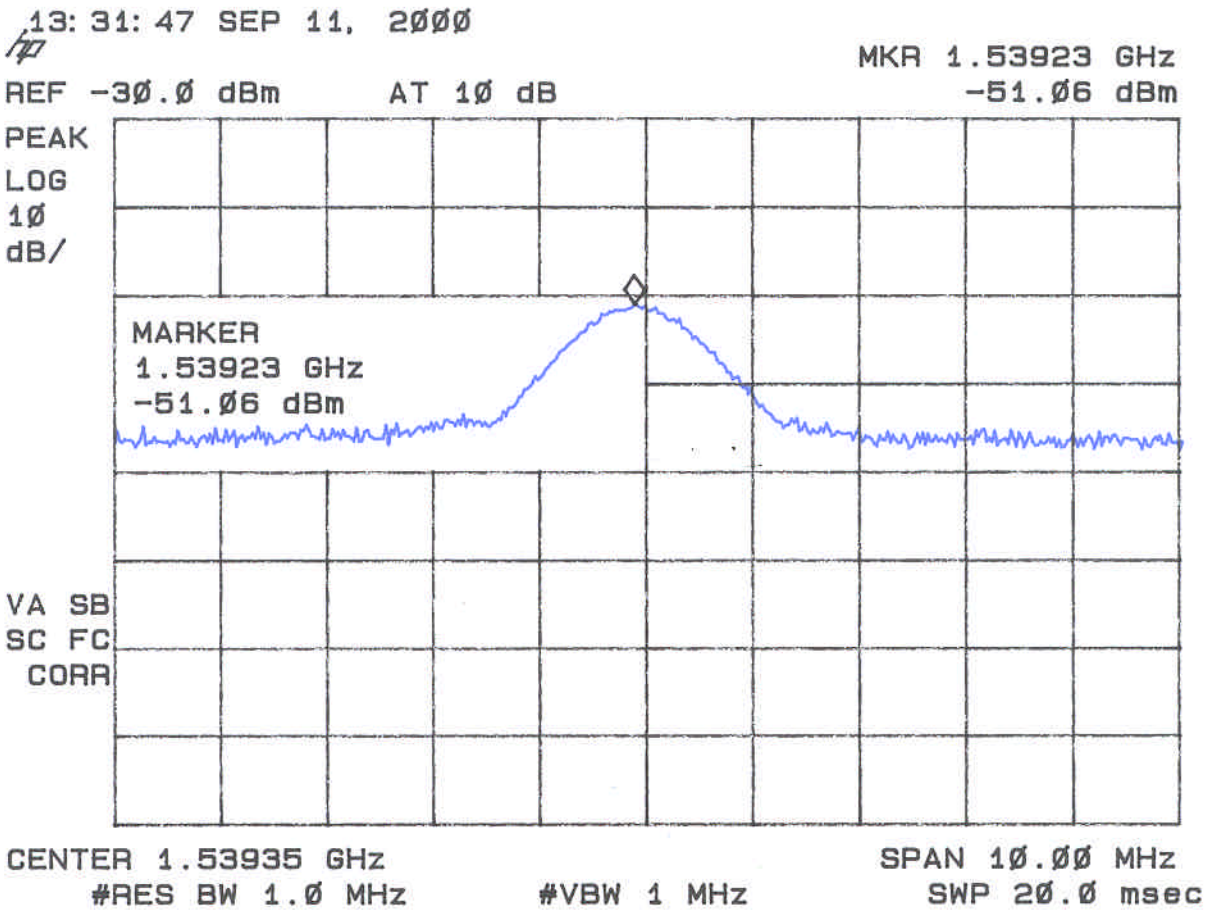


Figure 5e
Peak Radiated Spurious Emission 15.247(c)

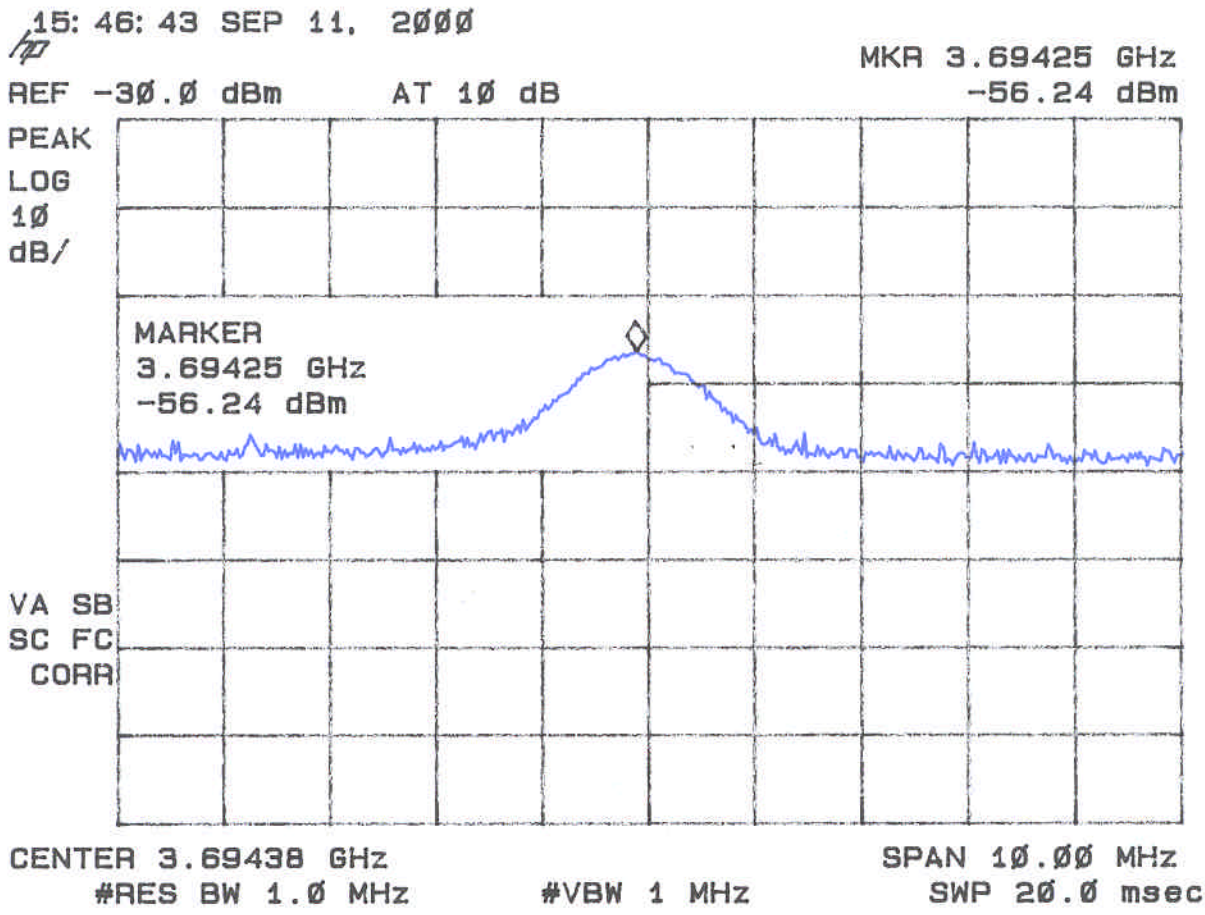


TABLE 4 PEAK RADIATED SPURIOUS EMISSIONS

Freq. (GHz)	Test Data* (dBm) @3m	Amp. Gain (dB)	Antenna Factor (dB)	Cable Loss (dB)	Results (uV/m) @3m	FCC Limits (uV/m) @3m
1.03	-41.7	35.9	25.6	2.3	732.8	5000
1.13	-44.5	35.8	25.9	2.5	568.9	5000
1.23	-41.5	35.6	26.1	2.6	851.1	5000
1.54	-51.1	35.3	27.1	3.0	342.8	5000
3.69	-55.2	34.6	33.5	5.3	630.9	5000

*** = Data above 2 GHz adjusted by + 1 dB for high pass filter**

SAMPLE CALCULATION:
RESULTS (uV/m @ 3m) = Antilog ((-41.7 – 35.9 + 25.6 + 2.3 + 107)/20) = 732.8
CONVERSION FROM dBm TO dBuV = 107 dB

Tester
Signature: _____ Name: Tim R. Johnson

2.10 Average Spurious Emission in the Frequency Range 30 - 10000 MHz (FCC Section 15.247(c))

The results of average radiated spurious emissions falling within restricted bands are given in Table 5 and Figure 6.

Duty Cycle Correction During 100 msec:

The EUT has an RF active transmit time interval for each transmission that is less than or equal to 10.52 msec. The transmission consists of two intervals, a 4.74 msec interval during which the RF is continuously broadcast. Immediately following this interval (and with no interruption in RF output) the device transmits digital data for a period of 5.78 msec. This transmission, under normal operating modes, occurs at a minimum of every 4 seconds (programmable up to 17 minutes). This yields a duty cycle during 100 msec of the following:

Duty Cycle Correction = 20 log (0.1052) = -19.6 dB

Figure 6
Average Radiated Spurious Emission 15.247(c)

Since the average limits were met by applying a duty cycle correction to the peak measurements, average measurements were deemed not necessary.

TABLE 5 AVERAGE RADIATED SPURIOUS EMISSIONS

Freq. (GHz)	Test Data* (dBm) @3m	Amp. Gain (dB)	Antenna Factor (dB)	Cable Loss (dB)	Results (uV/m) @3m	FCC Limits (uV/m) @3m
1.03	-61.3	35.9	25.6	2.3	76.7	500
1.13	-64.1	35.8	25.9	2.5	59.6	500
1.23	-61.1	35.6	26.1	2.6	89.1	500
1.54	-70.7	35.3	27.1	3.0	35.9	500
3.69	-74.8	34.6	33.5	5.3	66.1	500

*** = Data above 2 GHz adjusted by + 1 dB for high pass filter and – 19.6 dB for duty cycle.**

SAMPLE CALCULATION:

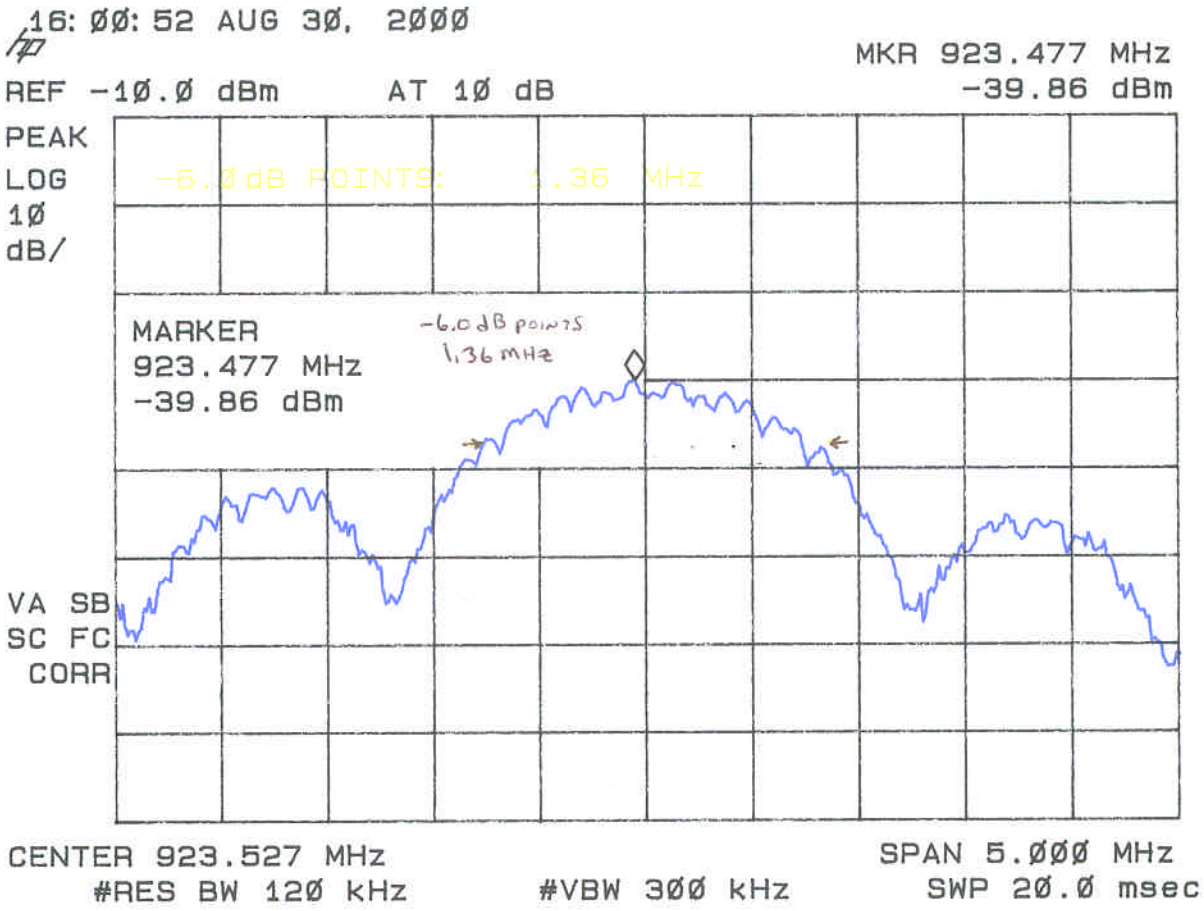
RESULTS (uV/m @ 3m) =
Antilog ((-61.3 - 35.9 + 25.6 + 2.3 + 107)/20) = 76.7
CONVERSION FROM dBm TO dBuV = 107 dB

Tester
Signature: _____ Name: Tim R. Johnson

2.11 Minimum 6 dB Bandwidth per FCC Section 15.247(a)(2)

The minimum requirement is given in Figure 7. If the EUT incorporates different spreading codes or data rates these were each investigated and the one which produced the smallest 6 dB bandwidth was selected for test.

Figure 7
6 dB Bandwidth per FCC Section 15.247(a)(2)



2.12 Power Spectral Density FCC Section 15.247(d)

The transmitter power spectral density averaged over any 1 second interval is given in Table 7 and Figure 8. If the EUT incorporates different spreading codes or data rates these were each investigated and the one which produced the smallest 6 dB bandwidth was selected for test.

Since the EUT incorporated an integrated antenna, this measurement was made on a OAT's by tuning a spectrum analyzer to the highest point of the maximized fundamental emission and zooming in on this portion of the emission utilizing the following spectrum analyzer settings: RBW = 3 kHz, VBW > RBW, span = 300 kHz, sweep = 100 seconds. The maximized point obtained by this method was then used to calculate the power spectral density as shown in Table 6.

TABLE 6
POWER SPECTRAL DENSITY

Test Date: August 30, 2000
UST Project: 00-0381
Customer: Axonn Corporation
Model: AX-620 Transmitter

Frequency (MHz)	Receiver Reading (dBm) @3m	Correction Factor (dB)	Corrected Reading (V/m) @3m	Measured Power (Watt)	FCC Limit (Watt)
923.44	-49.4	31.2	0.027542	<0.0010	0.0063

NOTE: Limit = Antilog(+8dBm/10) * 10^{-3} = 0.0063 Watts

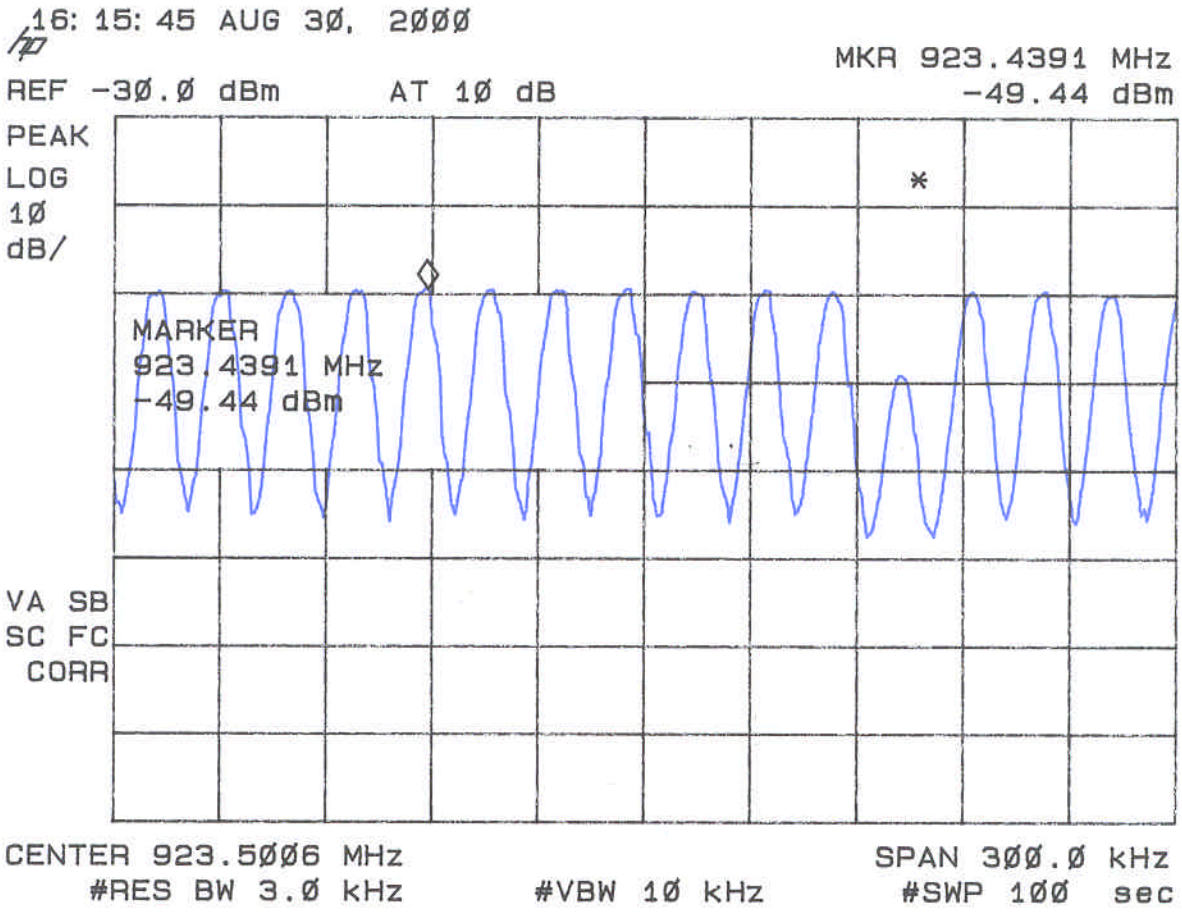
Transmitters peak power calculated using:

$$P\ (W) = \frac{(E*d)^2}{30*G}$$

where d = 3 meters, E = corrected measured field strength in V/m, and G = numeric gain of transmitting antenna (0.79 for –1.0 dBi).

Tester Signature: _____ **Name:** Tim R. Johnson

Figure 8
Power Spectral Density 15.247(d)



2.13 Processing Gain

The processing gain is realized in the receiver, which is a separate unit from the EUT presented in this application. Data regarding processing gain for the receiver has been provided on the following page from Axonn Corporation.

AXONN CORPORATION 101 West Robert E. Lee Boulevard · Suite 202 · New Orleans, Louisiana 70124 · (504) 282-8119 · FAX 282-0999

September 7, 2000

Scott Proffitt
U. S. Technologies
3505 Francis Circle
Alpharetta, GA 30004
(770) 740-0717

RE: System Processing Gain

Dear Scott,
I am sending you the Processing Gain Report for FCC ID L2V0536ASR2, which is the Spread Spectrum Receiver that can be used to receive the AX-620 and AX-630 Transmitters.

The System Processing Gain testing was performed using a transmitter whose key parameters (chipping rate, chipping modulation type, chipping code length, chipping code sequence, data rate, data modulation type, pseudo-random code, signal filtering, and oscillator phase noise) are equivalent to this transmitter currently under application for certification. Consequently, we feel that that the System Processing Gain data submitted with this application is representative of the test results that would have been yielded if the process gain test was conducted using the AX-620 and AX-630 Transmitters currently under test.

The theoretical process gain of the system defined by the spread occupied bandwidth (2*chipping frequency) divided by the narrowest filter in the receiver is:

10 log (2.44MHz / 110kHz) = 13.46 dB

Implementation losses are appended to the receiver report and show theoretical process gain plus implementation losses exceeds the FCC's 10 dB process gain requirement.

Best regards,

David Alley
Axonn Corporation

2.14 Power Line Conducted Emissions for Transmitter FCC Section 15.207

Axonn Corporation does not anticipate any applications for use in products other than battery powered applications. Therefore all tests except conducted emissions were performed under battery power. However, to ensure that the EUT has been tested for all future applications, an additional conducted test was performed by removing the battery from the test board above and attaching an AC adapter.

The conducted voltage measurements have been carried out in accordance with FCC Section 15.207, with a spectrum analyzer connected to a LISN and the EUT placed into a continuous mode of transmit. The results are given in Table 7.

TABLE 7. CONDUCTED EMISSIONS DATA
CLASS B

Test Date: November 15, 2000
UST Project: 00-0381
Customer: Axonn Corporation
Product: AX-620 Transmitter

Frequency (MHz)	Test Data (dBm)		Results (uV)		FCC Limits (uV)
	Phase	Neutral	Phase	Neutral	
1.5	-89.0	-91.0	7.9	6.3	250
4.9	-90.0	-92.0	7.1	5.6	250
13.8	-92.0	-91.0	5.6	6.3	250
14.7	-91.0	-91.0	6.3	6.3	250
15.2	-88.0	-89.0	8.9	7.9	250
17.7	-86.0	-87.0	11.2	10.0	250

SAMPLE CALCULATIONS:

RESULTS uV = ANTILOG ((-89.0 + 107)/20) = 7.9
CONVERSION FROM dBm TO dBuV = 107 dB

Tester
Signature: _____ **Name:** Tim R. Johnson

2.15 Radiated Emissions (47 CFR 15.109a)

Radiated emissions were evaluated from 30 to 5000 MHz. Measurements were made with the analyzer's bandwidth set to 120 kHz measurements made less than 1 GHz and 1 MHz are shown in Table 8.

TABLE 8. RADIATED EMISSIONS DATA

CLASS B

Test Date: September 11-November 15, 2000
UST Project: 00-0381
Customer: Axonn Corporation
Product: AX-620 Transmitter

Frequency (MHz)	Receiver Reading (dBm) @3m	Correction Factor (dB)	Corrected Reading (uV/m)	FCC Limit (uV/m) @3m
Since the EUT was tested in a modular fashion and the digital devices circuitry was used only to enable operation of the transmitter and did not control additional functions or capability, testing of the digital device emissions was deemed not necessary				

Tester Signature: _____ **Name:** Tim R. Johnson

2.16 Power Line Conducted Emissions for Digital Device FCC Section 15.107

The conducted voltage measurements have been carried out in accordance with FCC Section 15.107, with a spectrum analyzer connected to a LISN and the EUT placed into a continuous mode of transmit. The results are given in Table 9.

TABLE 9. CONDUCTED EMISSIONS DATA – DIGITAL DEVICE

Test Date: September 11 - November 15, 2000
UST Project: 00-0381
Customer: Axonn Corporation
Product: AX-620 Transmitter

Frequency (MHz)	Test Data (dBm) Phase Neutral	RESULTS (uV) Phase Neutral	FCC Limits (uV)
Since the EUT was tested in a modular fashion and the digital devices circuitry was used only to enable operation of the transmitter and did not control additional functions or capability, testing of the digital device emissions was deemed not necessary			

Test Results Reviewed By
Signature: _____ **Name:** Tim R. Johnson