Robertshaw Industrial Products Division
FCC Part 15, Certification Application
Centeron Propane Gauge Monitor

April 23, 2001

MEASUREMENT/TECHNICAL REPORT

COMPANY NAME: **Robertshaw Industrial Products Division**

MODEL: **Centeron Propane Gauge Monitor**

FCC ID: **NU9TX0669-0100**

DATE: **April 23, 2001**

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

Equipment type: **__900 MHz Direct Sequence Spread Spectrum TX___**

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

TABLE OF CONTENTS

LIST OF FIGURES AND TABLES

TABLES

SECTION 1

GENERAL INFORMATION

GENERAL INFORMATION

1.1 Product Description

The Equipment Under Test (EUT) is a Robertshaw Industrial Products Division, Model Centeron Propane Gauge Monitor. The device is a single channel 923.58 MHz Direct Sequence Transmitter which transmits signals that indicate the status level senging and temperature inputs to a receiver. The transmitter derives its power from an internally mounted 3 VDC battery.

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 a previously approved receiver.

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(s) 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 EUT is designed to be mounted on top of a propane tank with the transmitter axis of symmetry positioned in the vertical polarity. Therefore the EUT was positioned in an upright position for all radiated tests performed. The sample used for testing was received by U.S. Technologies on February 8, 2001 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

In order to bring the EUT into compliance with FCC limits for the transmitter portion of the EUT, the following modifications were made:

1) A additional tie point was necessary from the analog ground plane to the RF ground plane near J3 (solder side of board).

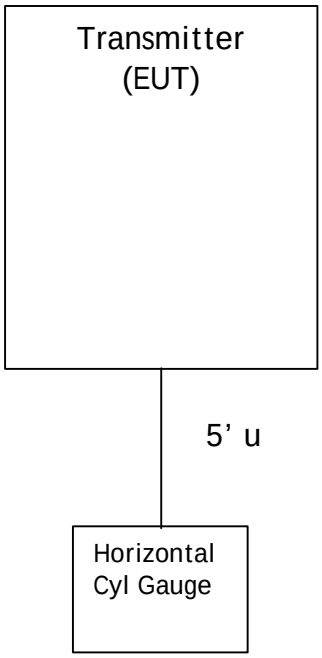
Robertshaw Industrial Products Division/Axonn L.L.C agrees to incorporate the above change in all production models of the equipment.

AXONN L.L.C.
Title:: SENIOR PROJECT ENGR. Date: 19 APRIL 2001

Signature: Lee Ivy Williams

FIGURE 1

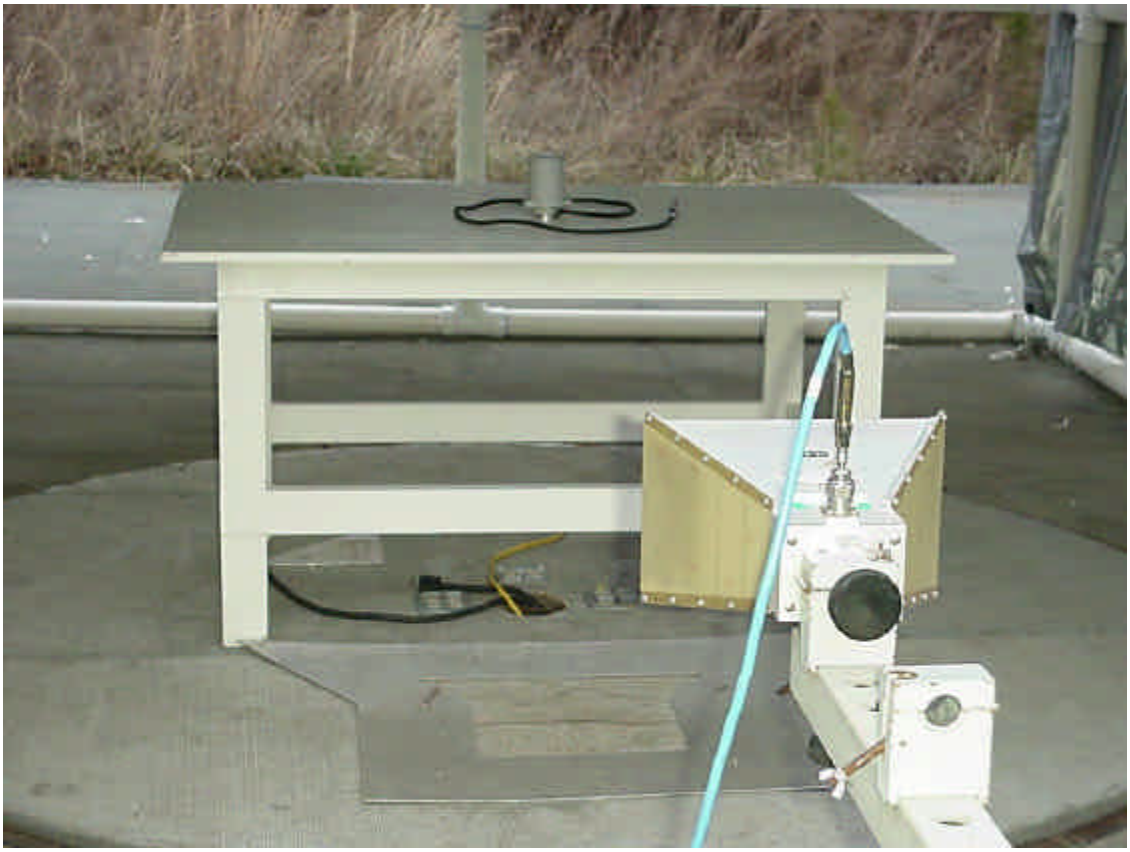
TEST CONFIGURATION



Test Date: February 27, 2001
UST Project: 01-0121
Customer: Robertshaw Industrial Products Division
Model: Centeron Propane Gauge Monitor

FIGURE 2a

Photograph(s) for Spurious Emissions (Front)



Test Date: February 27, 2001
UST Project: 01-0121
Customer: Robertshaw Industrial Products Division
Model: Centeron Propane Gauge Monitor

FIGURE 2b

Photograph(s) for Spurious Emissions (Back)

Test Date: March 10, 2001
UST Project: 01-0121
Customer: Robertshaw Industrial Products Division
Model: Centeron Propane Gauge Monitor

FIGURE 2c

Photograph(s) for Digital Device Emissions (Front)

Since the EUT's digital devices circuitry is used only to enable operation of the transmitter and does not control additional functions or capability, testing of the digital device emissions was deemed not necessary.

Test Date: March 10, 2001
UST Project: 01-0121
Customer: Robertshaw Industrial Products Division
Model: Centeron Propane Gauge Monitor

FIGURE 2d

Photograph(s) for Digital Device Emissions (Back)

Since the EUT's digital devices circuitry is used only to enable operation of the transmitter and does not control additional functions or capability, testing of the digital device emissions was deemed not necessary.

Test Date: **March 10, 2001**
UST Project: **01-0121**
Customer: **Robertshaw Industrial Products Division**
Model: **Centeron Propane Gauge Monitor**

FIGURE 2e

Photograph(s) for Digital Device Conducted Emissions

Conducted Emissions were considered not applicable since the EUT is battery powered.

TABLE 1

EUT and Peripherals

PERIPHERAL MANUFACTURER	MODEL NUMBER	SERIAL NUMBER	FCC ID:	CABLES P/D
Transmitter (EUT) Axonn	Centeron Propane Gauge Monitor	4	NU9TX0669-0100 (Pending)	
Gauge Rochester Gauges Inc.	None	5848S02669 4300	N/A	5’ 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
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 Robertshaw Industrial Products Division, Centeron Propane Gauge Monitor incorporates an internal antenna only.

Type:	Printed PWB
Model Number:	N/A
Gain:	-1.0 dBi
Connector:	N/A

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. 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

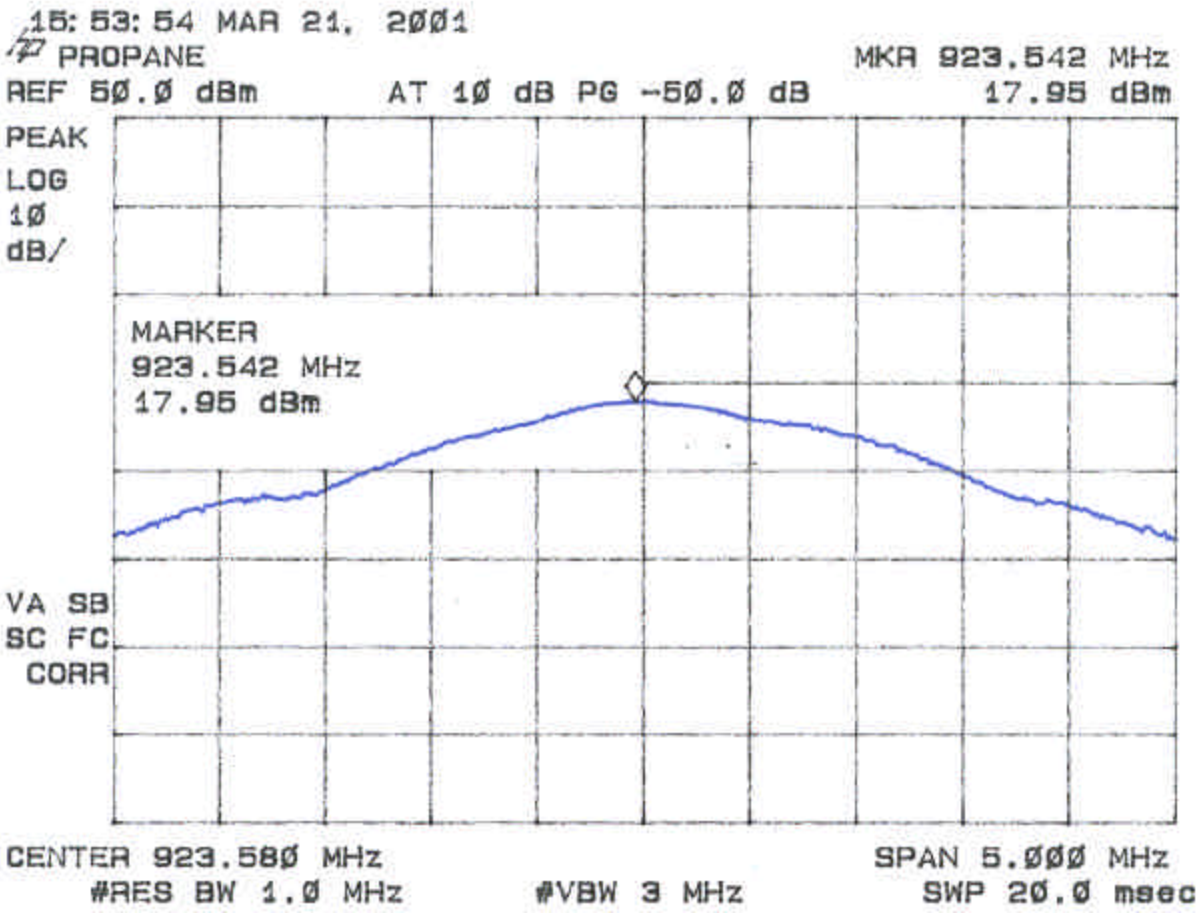
Test Date: **March 21, 2001**
UST Project: **01-0121**
Customer: **Robertshaw Industrial Products Division**
Model: **Centeron Propane Gauge Monitor**

Frequency of Fundamental (MHz)	Measurement (dBm)*	Measurement (Watt)*	FCC Limit (Watt)
923.58	18.0	0.063	1.0

*** Measurement cable was not considered significant**

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))

Antenna conducted spurious emissions in the frequency range 30 – 10000 MHz have 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. The spectrum analyzer was set for a 50 Ω impedance with the RBW = 100 kHz & VBW > RBW. All spurious emissions were measured to be greater than 20 dB down from the fundamental. The results of conducted spurious emissions are given in Figure 4a through Figure 4d.

Figure 4a
Antenna Conducted Spurious Emissions 15.247(c)

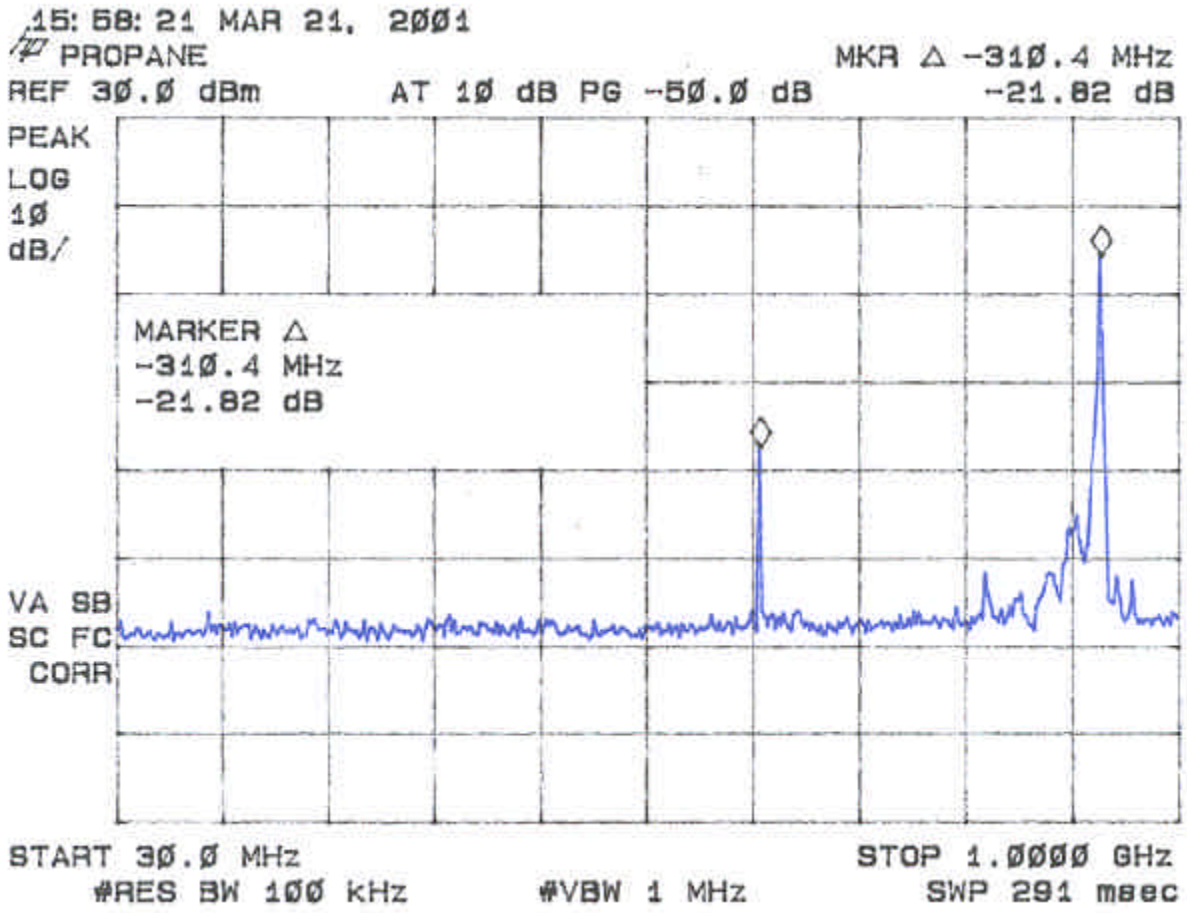


Figure 4b
Antenna Conducted Spurious Emissions 5.247(c)

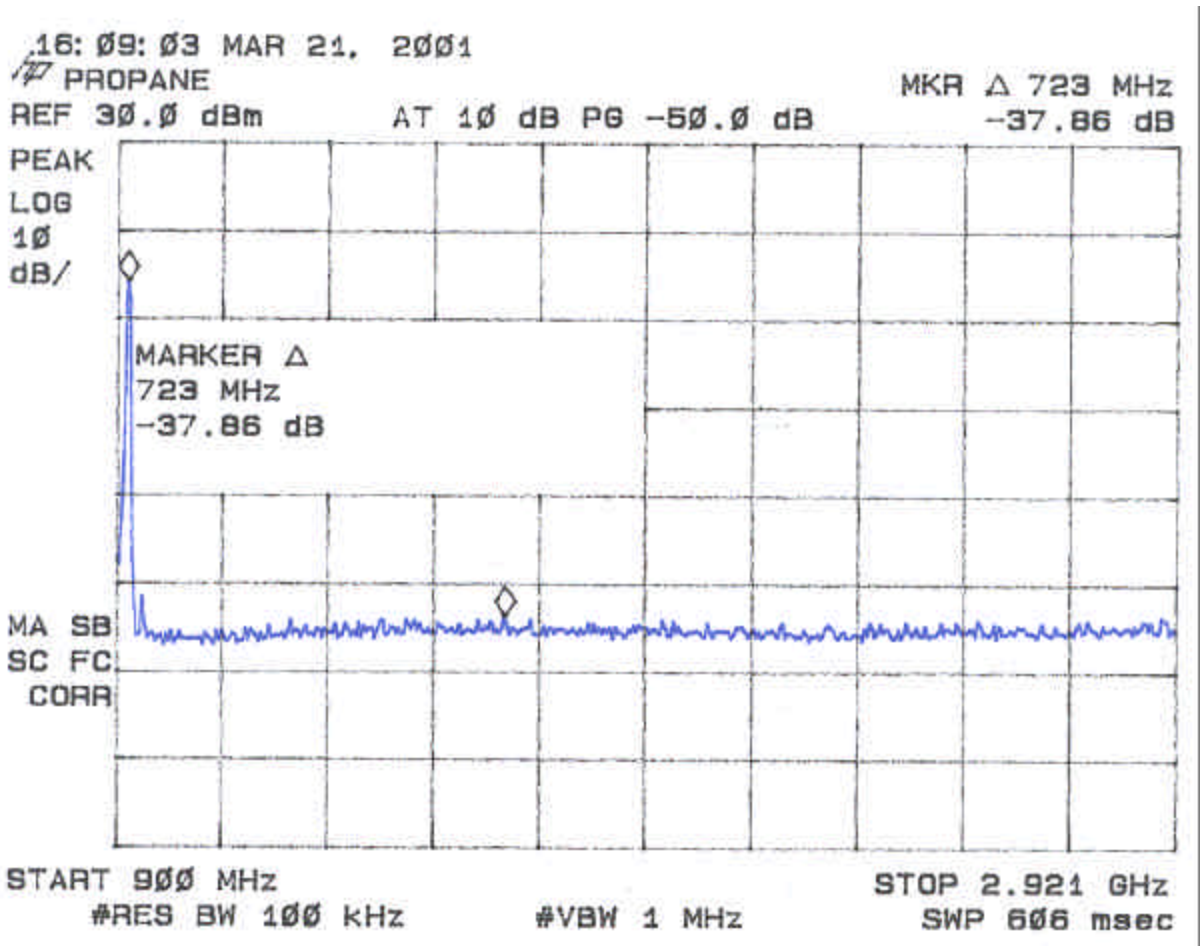


Figure 4c
Antenna Conducted Spurious Emissions 15.247(c)

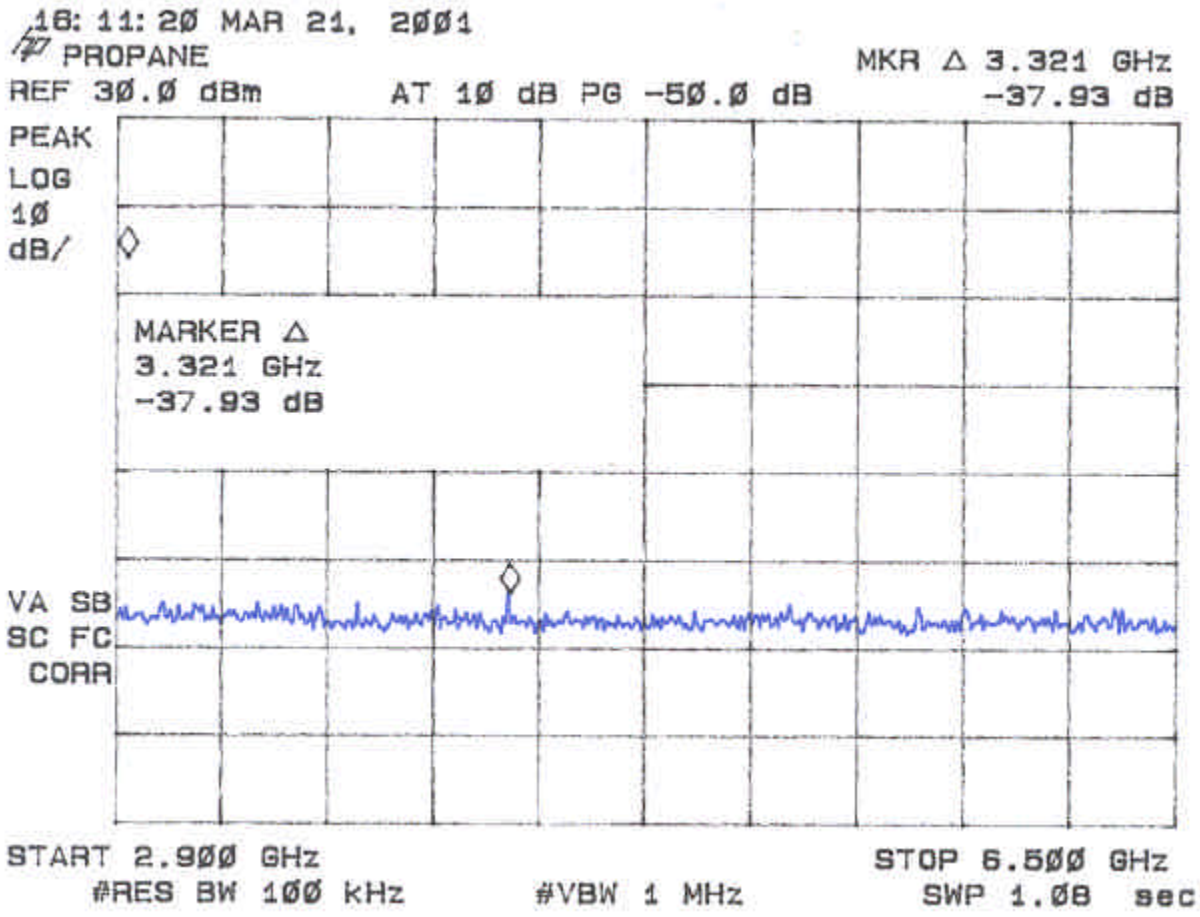
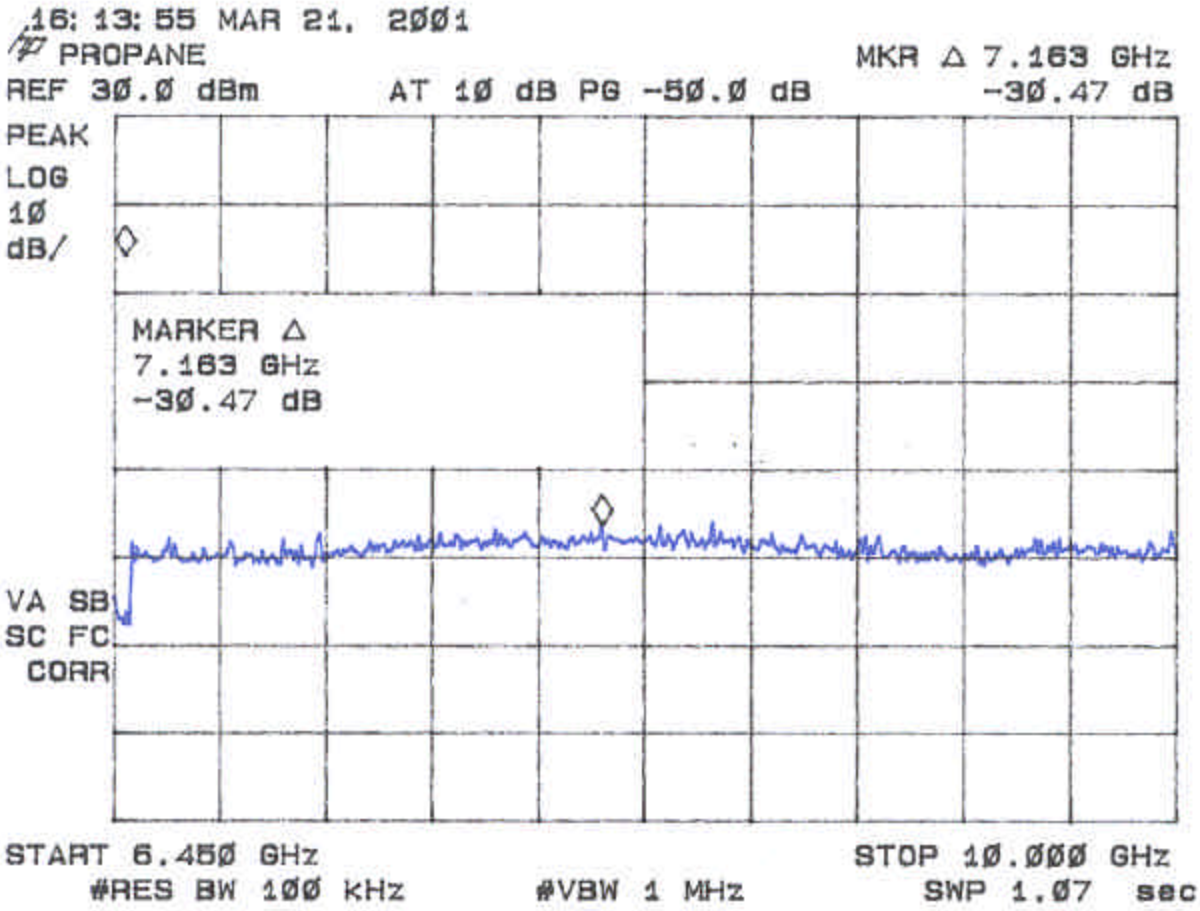


Figure 4d
Antenna Conducted Spurious Emissions 15.247(c)



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 through Figure 5f.

Figure 5a
Peak Radiated Spurious Emission 15.247(c)

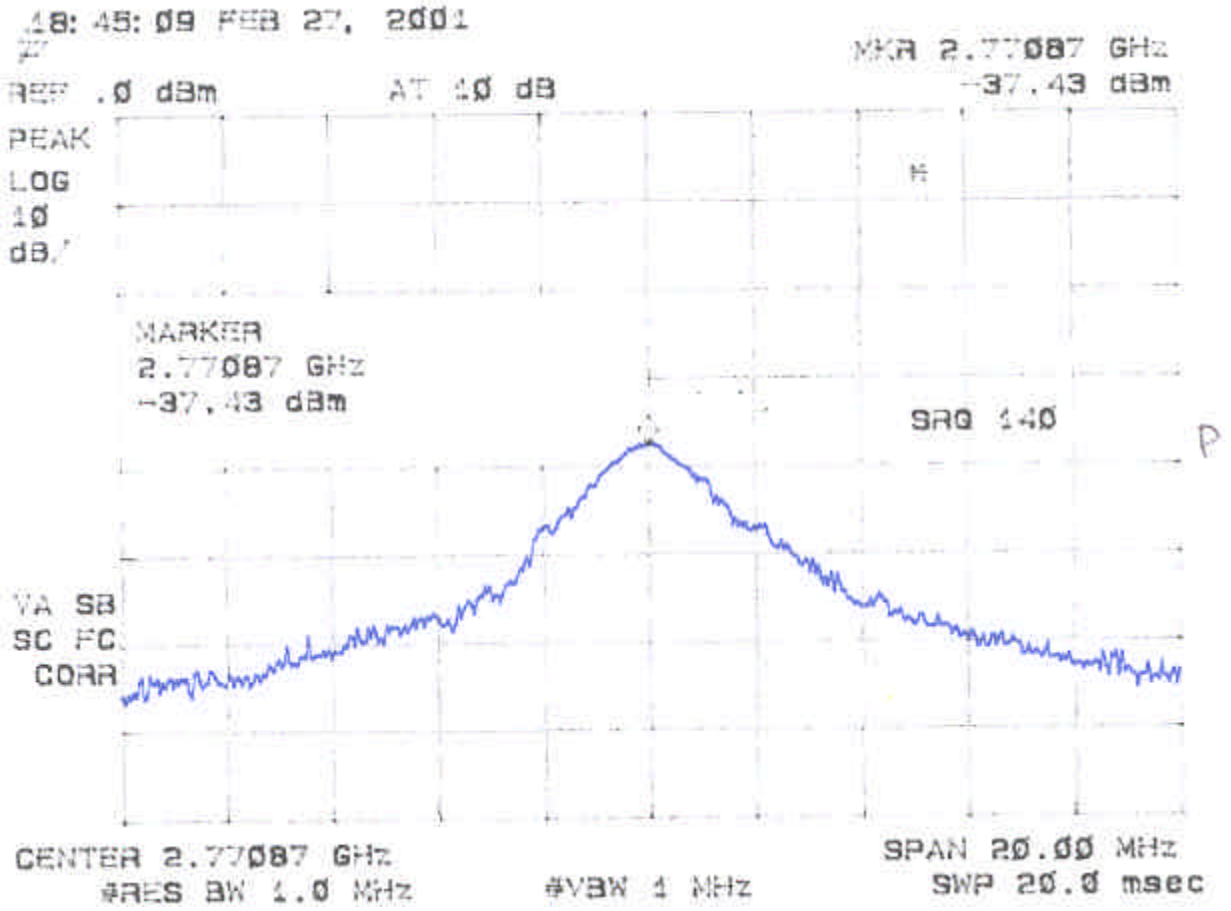


Figure 5b
Peak Radiated Spurious Emission 15.247(c)

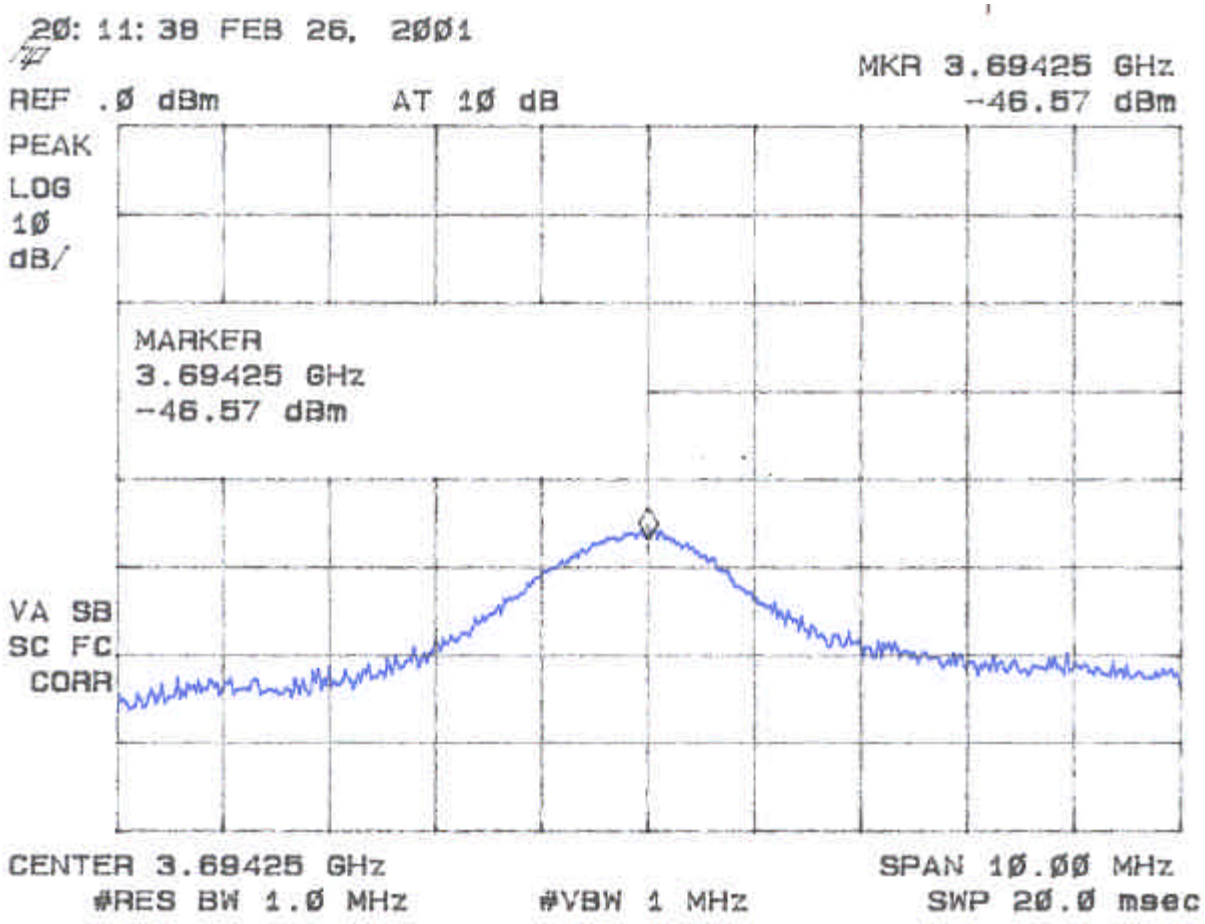


Figure 5c
Peak Radiated Spurious Emission 15.247(c)

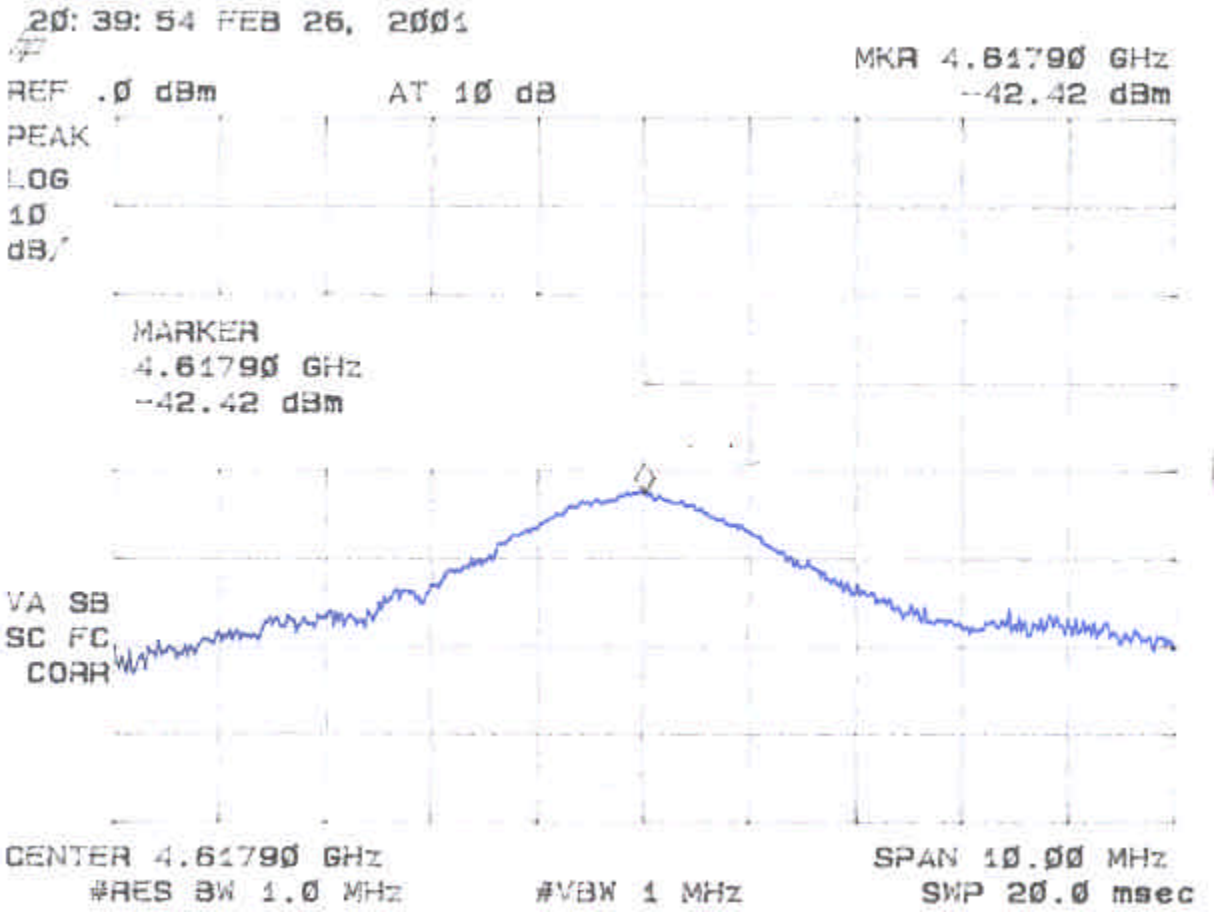


Figure 5d
Peak Radiated Spurious Emission 15.247(c)

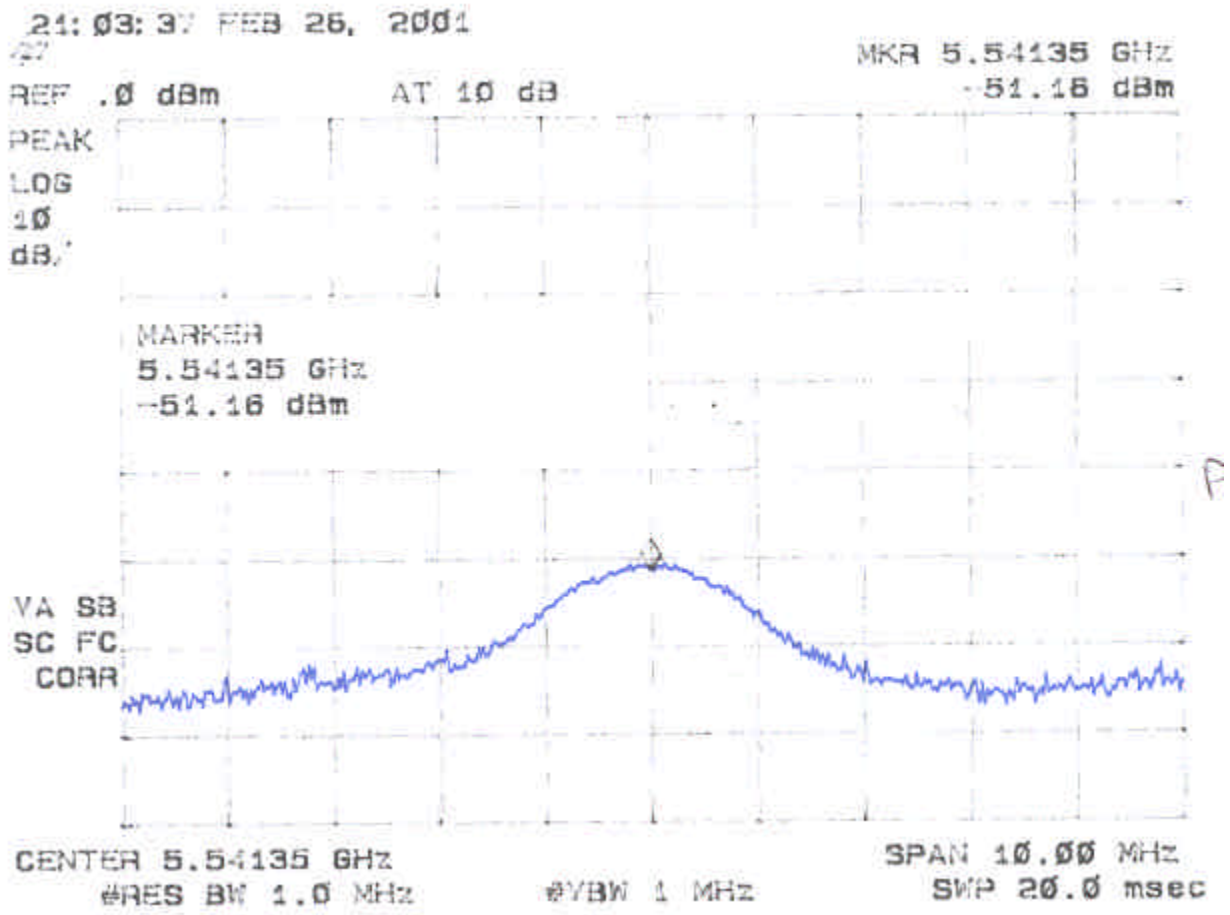


Figure 5e
Peak Radiated Spurious Emission 15.247(c)

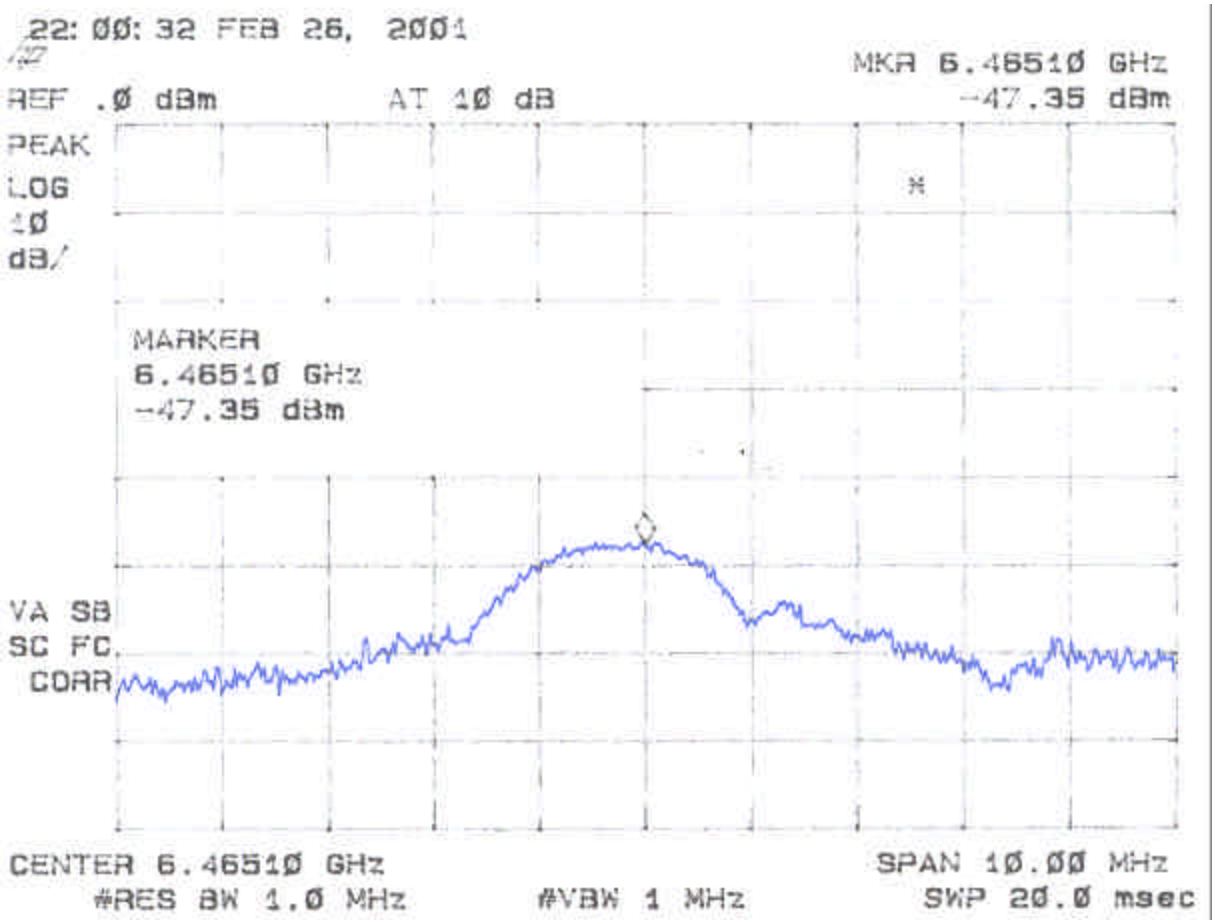


Figure 5f
Peak Radiated Spurious Emission 15.247(c)

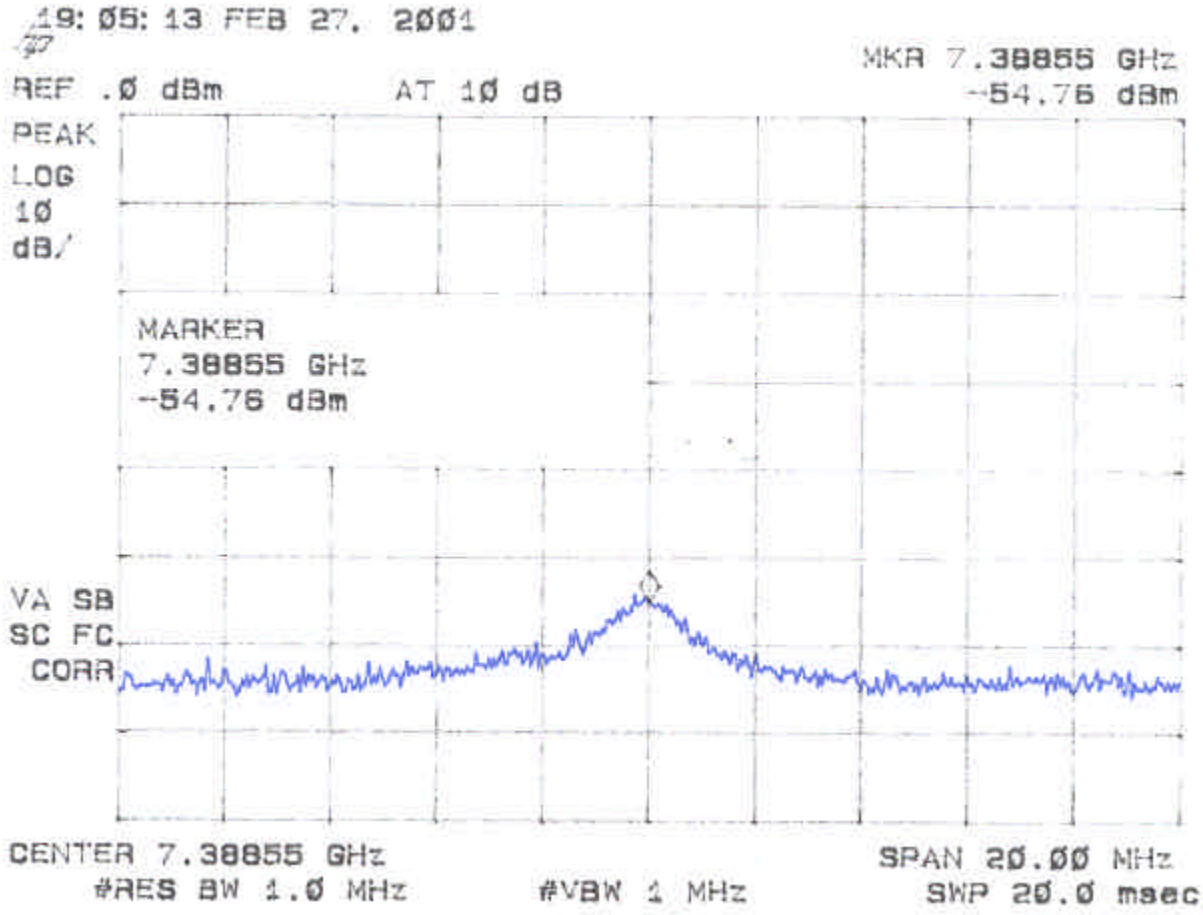


TABLE 4 PEAK RADIATED SPURIOUS EMISSIONS

Freq. (GHz)	Test Data* (dBm) @3m	Amp. Gain (dB)	Antenna Factor (dB)	Cable Loss (dB)	Results (uV/m) @3m	FCC Limits (uV/m) @3m
0.322	-89.0	-	15.2	3.9	45.7	200
0.961	-91.0	-	24.0	7.7	242.7	500
2.771	-36.4	34.8	31.0	2.2	2814.7	5000
3.694	-45.1	34.1	33.5	2.9	1606.4	5000
4.618	-41.4	33.9	34.0	3.3	2836.9	5000
5.541	-50.2	33.7	36.2	3.9	1454.8	5000
6.465	-46.4	33.5	36.4	4.5	2519.0	5000
7.389	-52.4	33.7	37.5	4.7	1415.1	5000

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

SAMPLE CALCULATION:
RESULTS (uV/m @ 3m) = Antilog ((-36.4 - 34.8 + 31.0 + 2.2 + 107)/20) = 2814.7
CONVERSION FROM dBm TO dBuV = 107 dB

Test Results
Reviewed By
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 6a – 6b. Only certain measurements close to the limits were remeasured using an average detector (RBW= 1 MHz, VBW = 10 Hz). All other readings utilized the peak readings and adjusted by the duty cycle as given below.

Duty Cycle Correction During 100 msec:

The following information was provided by Axonn L.L.C. regarding the duty cycle of the transmitter.

TX MESSAGE PARAMETERS FOR RSIPD TRANSMITTER

Long Length Leader?	N		(Y or N)
Preamble bits=	92		
Crystal Frequency=	14.66	MHz	
Time per bit=	51.57	usec	
Total Preamble time=	4.74	ms	
Repo ON?	Y		(Y or N)
Bytes Data=	15		
Bytes CRC=	2		
Bytes Sync/Repo=	2		
Bytes Property Code=	2		
Bytes Vendor Code=	1		
Bytes Transmitter ID=	2		
Bytes Axonn Data=	3		
Bytes Repo=	4		
Total Bytes (not incl Preamble)=	31		
Data length=	12.79	ms	
% RF on for data=	100%		
Total Packet Length=	17.53	ms	
Dead time between xmsns=	102	ms	
overall DC relative 100 ms=	17.53%		
20 Log (DC)=	-15.12	dB	(use for FCC averaging)
Overall duty cycle=	0.15		
20 Log (DC)=	-16.67	dB	
Desired Bit Error Rate:	1.00E-03		
Number of data bits:	216		
Equivalent packet success rate =	80.56%		Note: PSR = 1-Packet error rate = 1-(1-BER)^Number of bits

Figure 6a
Average Radiated Spurious Emission 15.247(c)

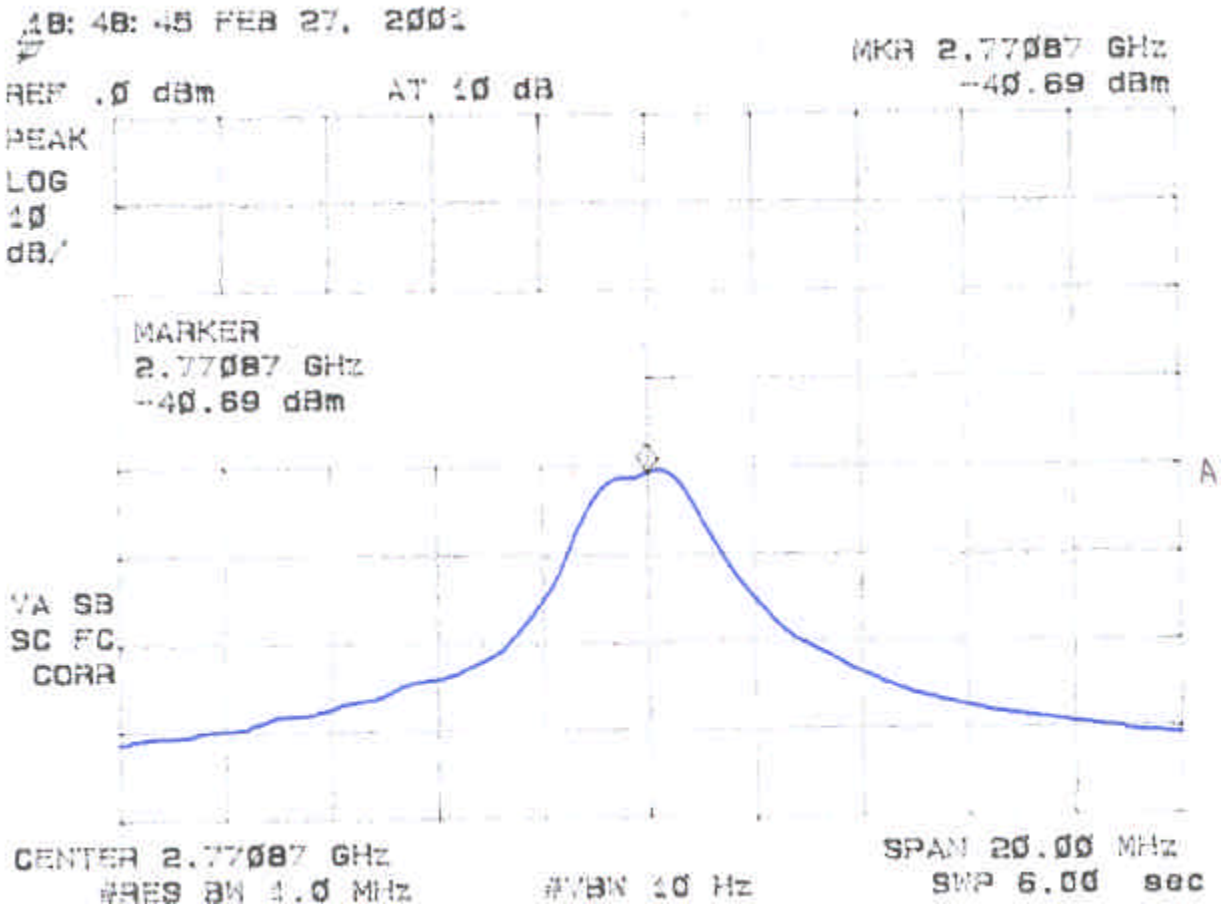


Figure 6b
Average Radiated Spurious Emission 15.247(c)

Plot Not Available

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
2.771	-54.8**	34.8	31.0	2.2	338.8	500
3.694	-60.2*	34.1	33.5	2.9	285.1	500
4.618	-61.0**	33.9	34.0	3.3	295.1	500
5.541	-65.3*	33.7	36.2	3.9	254.1	500
6.465	-61.5*	33.5	36.4	4.5	441.6	500
7.389	-67.5*	33.7	37.5	4.7	252.1	500

*** = Peak Data adjusted by + 1dB for high pass filter and 20 log (0.1753) = -15.12 for worse case duty cycle.**

*** = Average Data taken and adjusted by +1 dB for high pass filter and 20 log (0.1753) = -15.12 for worse case duty cycle**

SAMPLE CALCULATION:

RESULTS (uV/m @ 3m) =
Antilog ((-54.8 - 34.8 + 31.0 + 2.2 + 107)/20) = 338.8
CONVERSION FROM dBm TO dBuV = 107 dB

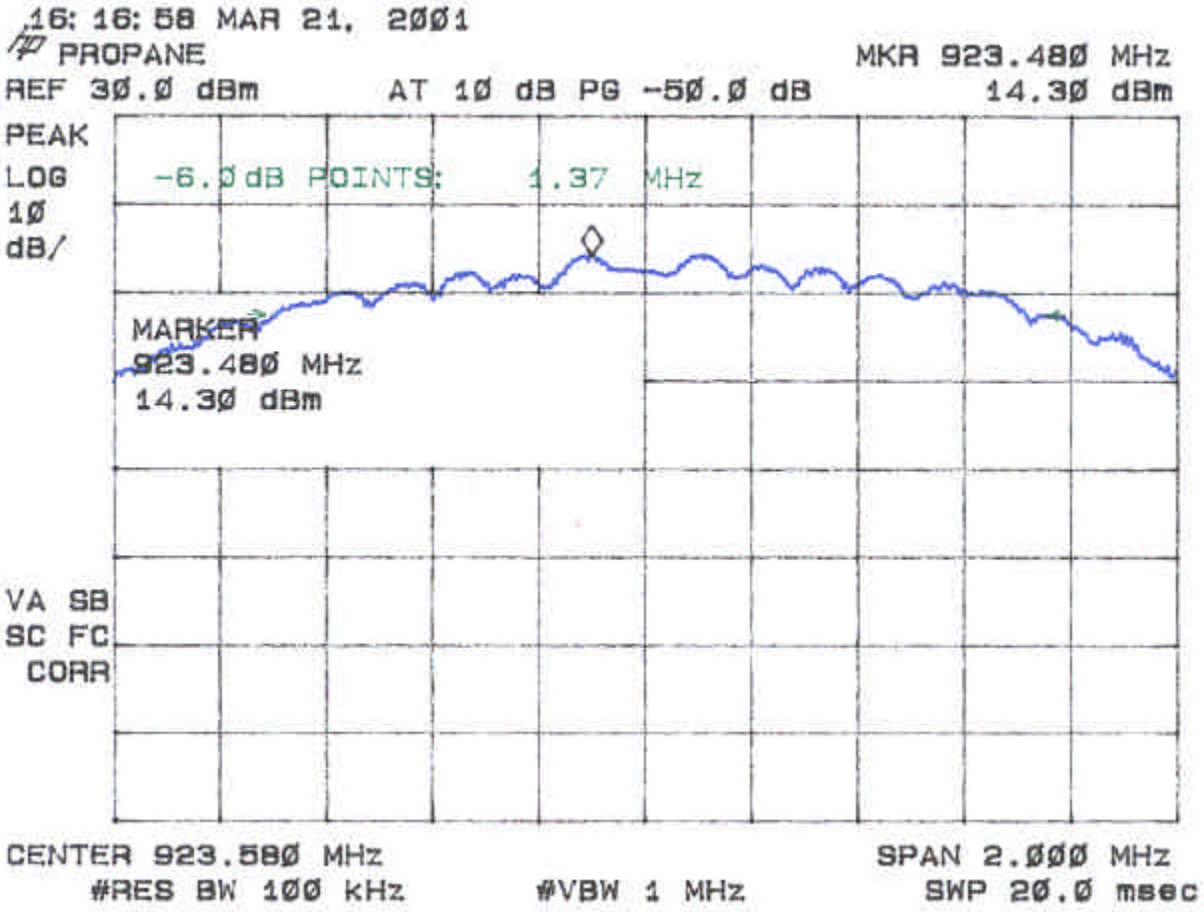
Tester
Signature: _____ Name: Tim R. Johnson

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.

The manufacturer provided a sample with a pigtail connected across the antenna leads on the PCB . This test was performed by connecting the pigtail directly to the spectrum analyzer.

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.

The manufacturer provided a sample with a pigtail connected across the antenna leads on the PCB . This test was performed by connecting the pigtail directly to the spectrum analyzer and measured utilizing the noise marker mode of the spectrum analyzer. A 34.8 dBm adjustment has been added to the measurement to correct from 1 Hz to 3 kHz measurement.

TABLE 6
POWER SPECTRAL DENSITY

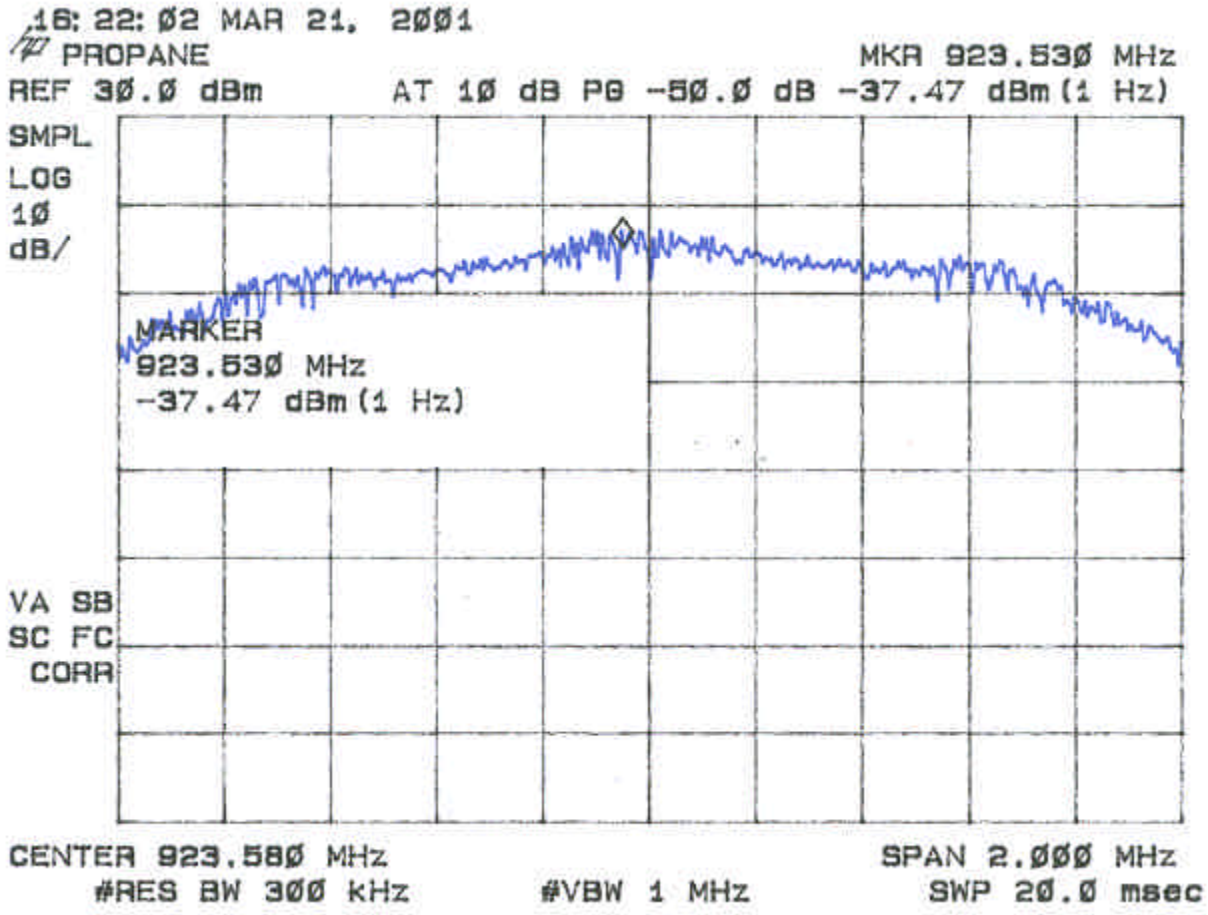
Test Date: **March 21, 2001**
UST Project: **01-0121**
Customer: **Robertshaw Industrial Products Division**
Model: **Centeron Propane Gauge Monitor**

Frequency (GHz)	Test Data (dBm) Normalized to 1 Hz	Results (dBm)	FCC Limit (dBm)
8.0	-37.5	-2.7	8.0

Note: 34.8 dBm has been added to correct from 1 Hz to 3 kHz

Tester
Signature: _____ Name: Tim R. Johnson

Figure 8
Power Spectral Density 15.247(d)



2.13 Processing Gain

Data regarding processing gain has been provided on the following page from Axonn L.L.C.

AXONN CORPORATION 101 West Robert E. Lee Boulevard Suite 202 New Orleans, Louisiana 70124 (504) 282-8119 FAX 282-9989

March 26, 2001

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 NU9RX06250200, which is the Spread Spectrum Receiver that can be used to receive the Propane Gauge Monitor Transmitters.

Process Gain information is being supplied for the transmitter as requested, although it is not required for transmit-only devices for FCC CFR 15.247 testing or submission.

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 Propane Gauge Monitor 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:

$$10 \log (2.44\text{MHz} / 110\text{kHz}) = 13.46 \text{ dB}$$

Implementation losses and worst-case filter bandwidths are then appended to this theoretical receiver process gain value. The report shows worst-case theoretical process gain plus the implementation losses exceed the FCC's 10 dB process gain requirement.

Best regards,

Lee Williams
Axonn Corporation

ANALOG DSSS RECEIVER
FCC ID: NU9RX06250200
SYSTEM PROCESSING GAIN CALCULATIONS

PROCESSING GAIN FORMULA:

Processing Gain PG (dB) = 10 * LOG (RF Bandwidth/Information Rate)

SYSTEM CONSTANTS:

Chip Clock	=	14.66 MHz / 12 =	1.2217 MHz	
Chip Duration	=	1 / Chip Clock	=	0.8186 µSec
Bit Time	=	63 * 0.8186 µSec (One Code Repetition Per Bit, 63 Chip Code)	=	51.5689 µSec
Bit Rate	=	1 / Bit Time	=	19.3915 kHz
Narrowest Filter Bandwidth After Correlator (Worst Case 110 kHz filter Bandwidth)			=	116.35 kHz

STATED PROCESSING GAIN:

Since the system utilizes a nominal 110kHz bandpass filter after the correlator it is correct to express the process gain derived from the worst-case bandwidth of this filter. This gives a correct answer (which is less) than using the system data rate from the "textbook".

For RF Bandwidth	=	2 * 1.2217 MHz	=	2.4433 MHz
PG (dB)	=	10 * LOG (2.4433 / 0.11635)	=	13.2 dB

IMPLEMENTATION LOSSES:

Eighth Chip Acquisition Ambiguity.....1.0 dB
Elliptic Filter on PRC.....0.9 dB

Total.....1.9 dB

13.2 – 1.9 dB yields minimal PG of 11.3 dB for worse case acquisition ambiguity. Theoretical differs from laboratory measured by approximately 1 dB in as much as the Analog DSSS receiver system produces a measured processing gain of 10.2 dB.

Source:
"Spread Spectrum Systems" Robert C. Dixon, John Wiley and Sons © 1984, pp 258 and 259.

2.14 Power Line Conducted Emissions for Transmitter FCC Section 15.207

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: March 10, 2001
UST Project: 01-0121
Customer: Robertshaw Industrial Products Division
Product: Centeron Propane Gauge Monitor

Frequency (MHz)	Test Data (dBm) Phase	Test Data (dBm) Neutral	Results (uV) Phase	Results (uV) Neutral	FCC Limits (uV)
Conducted Emissions were considered not applicable since the EUT is battery powered.					

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 for measurements made 1 GHz and higher. Results for less than 1 GHz are shown in Table 8a. Measurements made over 1 GHz results are shown in Table 8b.

TABLE 8a. RADIATED EMISSIONS DATA

Test Date: March 10, 2001
UST Project: 01-0121
Customer: Robertshaw Industrial Products Division
Product: Centeron Propane Gauge Monitor

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

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

TABLE 8b

RADIATED EMISSIONS

Test Date: March 10, 2001
UST Project: 01-0121
Customer: Robertshaw Industrial Products Division
Model: Centeron Propane Gauge Monitor

Measurements >1GHz

FREQ. (GHz)	TEST DATA (dBm) @ 3m	AMP GAIN (dB)	ANT. FACTOR (dB)	CABLE LOSS (dB)	RESULTS (uV/m) @ 10m	FCC LIMITS (uV/m) @ 3m
Since the EUT's digital devices circuitry is used only to enable operation of the transmitter and does not control additional functions or capability, testing of the digital device emissions was deemed not necessary.						

Tested By
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: March 10, 2001
UST Project: 01-0121
Customer: Robertshaw Industrial Products Division
Product: Centeron Propane Gauge Monitor

Frequency (MHz)	Test Data (dBm) Phase Neutral	RESULTS (uV) Phase Neutral	FCC Limits (uV)
Conducted Emissions were considered not applicable since the EUT is battery powered.			

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