Intertek Testing Services
ETL SEMKO

TEST REPORT

Report Number: 0228460u.doc
Project Number: 3028460
August 12, 2002

Testing performed on the
Centeron RM Series Level Monitor
FCCID: NU9TX0669-0200
to

FCC Part 15.247 Direct Sequence Spread Spectrum

For Robertshaw Controls Company

Test Performed by:	**Test Authorized by:**
Intertek Testing Services	Robertshaw Controls Company
1950 Evergreen Blvd., Suite 100	1602 Mustang Drive
Duluth, GA 30096	Maryville, TN 37801

Prepared by: _____ Date: 8/22/02
Jeremy O. Pickens, Sr. Project Engineer

Reviewed by: _____ Date: 8/22/02
David J. Schramm, EMC Team Leader

TABLE OF CONTENTS

1 Summary of Tests

MODEL: Centeron RM Series Level Monitor
FCC ID: NU9TX0669-0200

TEST	REFERENCE	RESULTS
Output power	15.247(b)	Complies
6 dB Bandwidth	15.247(a)(2)	Complies
Power Density	15.247(d)	Complies
Out-of-band Antenna Conducted Emission	15.247(c)	Not applicable. The antenna is integrated within the PCB.
Out-of-band Radiated Emission (except emissions in restricted bands)	15.247(c)	Complies
Radiated Emission in Restricted Bands	15.209, 15.205	Complies
AC Line-conducted Emission	15.207	Not applicable. Only batteries power the EUT.
Radiated Emission from Digital Part	15.109	Complies to Class A limits
Radiated Emission from Receiver L.O.	15.109	Not Applicable. The EUT is a transmit only device.
RF Exposure Requirement	2.1091	Not applicable. The EUT is for fixed locations only.
Antenna Requirement	15.203	Complies. The EUT uses a permanently connected antenna

Test Engineer: _____ Date: 8/22/02
Jeremy D. Pickens, Sr. Project Engineer

Approved by: _____ Date: 8/22/02
David J. Schramm. EMC Team Leader

2 General Description

2.1 Product Description

Overview of Centeron RM Series Level Monitor

Applicant	Robertshaw Controls Company
Trade Name & Model No.	Centeron RM Series Level Monitor / Centeron RM Series Level Monitor
FCC Identifier	NU9TX0669-0200
Use of Product	Monitor the fluid level of a tank for industrial applications.
Manufacturer & Model of Spread Spectrum Module	Same
Type of Transmission	Direct Sequence Spread Spectrum
Rated RF Output	16 dBm
Frequency Range	923.58 MHz
Number of Channel(s)	1
Antenna(s) & Gain,	PCB trace, ¼ wave bent dipole
Antenna Requirement	[X] The EUT uses a permanently connected antenna. [ ] The antenna is affixed to the EUT using a unique connector which allows for replacement of a broken antenna, but DOES NOT use a standard antenna jack or electrical connector. [ ] The EUT requires professional installation (attach supporting documentation if using this option).
Manufacturer name & address	Robertshaw Controls Company, 1602 Mustang Drive, Maryville, TN 37801

A Pre-production version of the EUT was received on July 18, 2002 in good operating condition.

2.2 Related Submittal(s) Grants

This report is for use with an application for certification of a low power transmitter. One transmitter is included in the application.

2.3 Test Methodology

Both AC mains line-conducted and radiated emissions measurements were performed according to the procedures in ANSI C63.4 (1992). Radiated tests were performed at an antenna to EUT distance of 3 meters, unless stated otherwise in the **"Data Sheet"** of this Application. All other measurements were made in accordance with the procedures in part 2 of CFR 47.

2.4 Test Facility

The Duluth 10-meter chamber site is located at 1950 Evergreen Blvd., Suite 100, Duluth, Georgia. The test site is a 10-meter semi-anechoic chamber. The site meets the characteristics of CISPR 16-1: 1993 and ANSI C63.4: 1992. For measurements, a remotely controlled flush-mount metal-top turntable is used to rotate the EUT a full 360 degrees. A remote controlled non-conductive antenna mast is used to scan the antenna height from one to four meters.

The A2LA accreditation code for this site is 121624 under certificate number 1455.01.
The Industry Canada file number for this site is IC 2077.

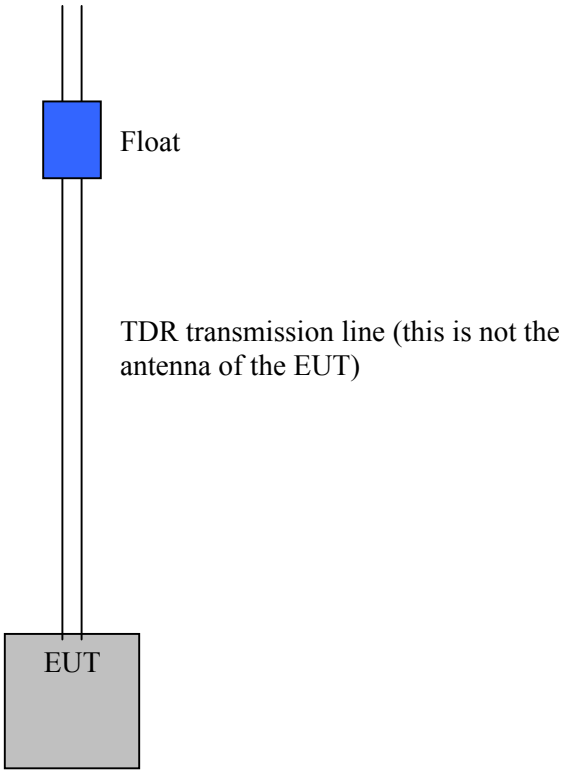
3 System Test Configuration

3.1 Support Equipment and description

There was no support equipment required to operate the transmitter.

3.2 Block Diagram of Test Setup

The transmitter was inverted for simplicity of testing. During normal operation, the EUT would be placed on top of the tank with the reflection strips hanging into the tank.



S = Shielded **U** = Unshielded	**F** = With Ferrite **M** = Length in Meters

3.3 Justification

For emissions testing, the test procedures described in American National Standards Institute C63.4-1992, were employed. The equipment under test (EUT) was configured for testing in a typical fashion (as a customer would normally use it with the exception that it was inverted to facilitate testing).

For simplicity of testing, the EUT was set to transmit continuously.

3.4 Software Exercise Program

There was no software required to operate the device. Once the unit was powered, it transmitted continuously.

3.5 Mode of Operation During Test

The EUT was set to transmission continuously at maximum power.

3.6 Modifications Required for Compliance

No modifications were installed by Intertek Testing Services during compliance testing in order to bring the product into compliance (Please note that this does not include changes made specifically by Robertshaw Controls Company prior to compliance testing)

3.7 Additions, deviations and exclusions from standards

No additions, deviations or exclusions from the standard were made.

4 Measurement Results

4.1 Conducted Output Power at Antenna Terminals
FCC Rules 15.247(b):

4.1.1 Requirements

Except for Systems that are used exclusively for fixed, point-to-point operations, the maximum peak output power shall not exceed 1 W for antennas with gain of 6 dBi or less. For antennas with gain greater than 6 dBi, the maximum peak output power must be reduced by an amount equal to (GAIN - 6) dB.

For Systems operating in the band 2400-2483.5 MHz that are used exclusively for fixed, point-to-point operations and employ antennas with gain greater than 6 dBi, maximum peak output power must be reduced below 1 W by an amount equal to (GAIN - 6) /3 dB.

For Systems operating in the band 5725-5850 MHz that are used exclusively for fixed, point-to-point operations and employ antennas with gain greater than 6 dBi, maximum peak output power shall not exceed 1 Watt.

4.1.2 Procedure

[ ] The antenna port of the EUT was connected to the input of a power meter. Power was read directly and cable loss correction was added to the reading to obtain power at the EUT antenna terminals.

[ ] The antenna port of the EUT was connected to the input of a spectrum analyzer. The analyzer was set for maximum RES BW and power was read directly in dBm. External attenuation and cable loss were compensated for using the OFFSET function of the analyzer.
Note: The Spectrum Analyzer can be used if its RES BW is greater than the signal bandwidth.

[X] The antenna of the EUT was permanently connected, therefore, conducted measurements could not be performed. This measurement was performed by measuring the field strength of the fundamental and converting the field strength to radiated power. The analyzer was set for maximum RES BW and power was read directly in dBm.
Note: The Spectrum Analyzer can be used if its RES BW is greater than the signal bandwidth.

4.1.3 Test Result

The field strength was found to 113.5 dB(uV/m) at a distance of 3 meters. This converts to 16 dBm.

4.2 6-dB Bandwidth
FCC Rule 15.247(a)(2)

4.2.1 Requirements

The minimum 6-dB bandwidth shall be at least 500 kHz

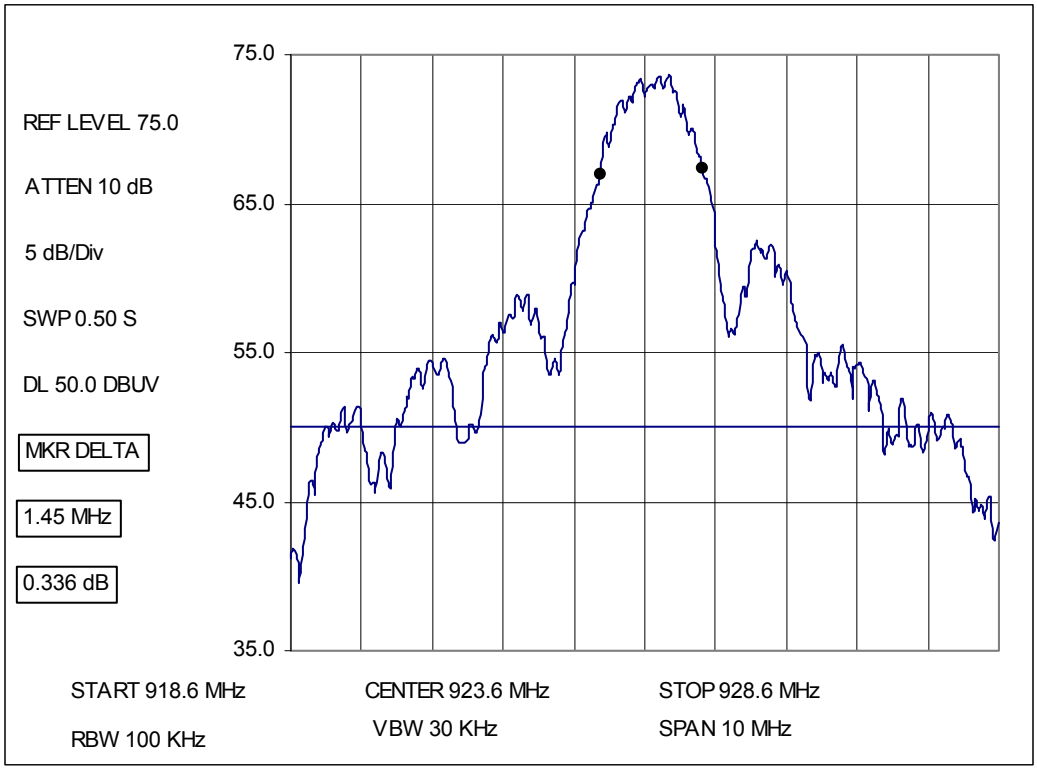
4.2.2 Procedure

The antenna port of the EUT was connected to the input of a spectrum analyzer. Analyzer RES BW was set to 100 kHz. For each RF output channel investigated, the spectrum analyzer center frequency was set to the channel carrier. A PEAK output reading was taken, a DISPLAY line was drawn 6 dB lower than PEAK level. The 6-dB bandwidth was determined from where the channel output spectrum intersected the display line.

4.2.3 Test Result

Frequency MHz	6-dB Bandwidth MHz
923.58	1.45

Figure 4-1: Bandwidth Plot



4.3 Power Density
FCC Rule 15.247(d)

4.3.1 Requirements

The peak power spectral density shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

4.3.2 Procedure

The spectrum analyzer RES BW was set to 3 kHz. The START and STOP frequencies were set to the band edges of the maximum output passband. If there is no clear maximum amplitude in any given portion of the band, it may be necessary to make measurements at a number of bands defined by several START and STOP frequency pairs. Total SWEEP TIME is calculated as follows:

SWEEP TIME (SEC) = (Fstop, kHz - Fstart, kHz)/3 kHz

Since antenna conducted tests could not be performed on this device, radiated tests were performed to show compliance. The peak field strength in a 3 kHz band was determined. Using Equation 1 below, the power level was calculated for comparison to the +8 dBm limit.

Equation 1 $$P = \frac{(Ed)^2}{30G}$$

Where; E = the measured maximum field strength in V/m
G = the numeric gain of the transmitting antenna over an isotropic radiator
d = the distance in meters from which the field strength was measured
P = the power in Watts

4.3.3 Test Result

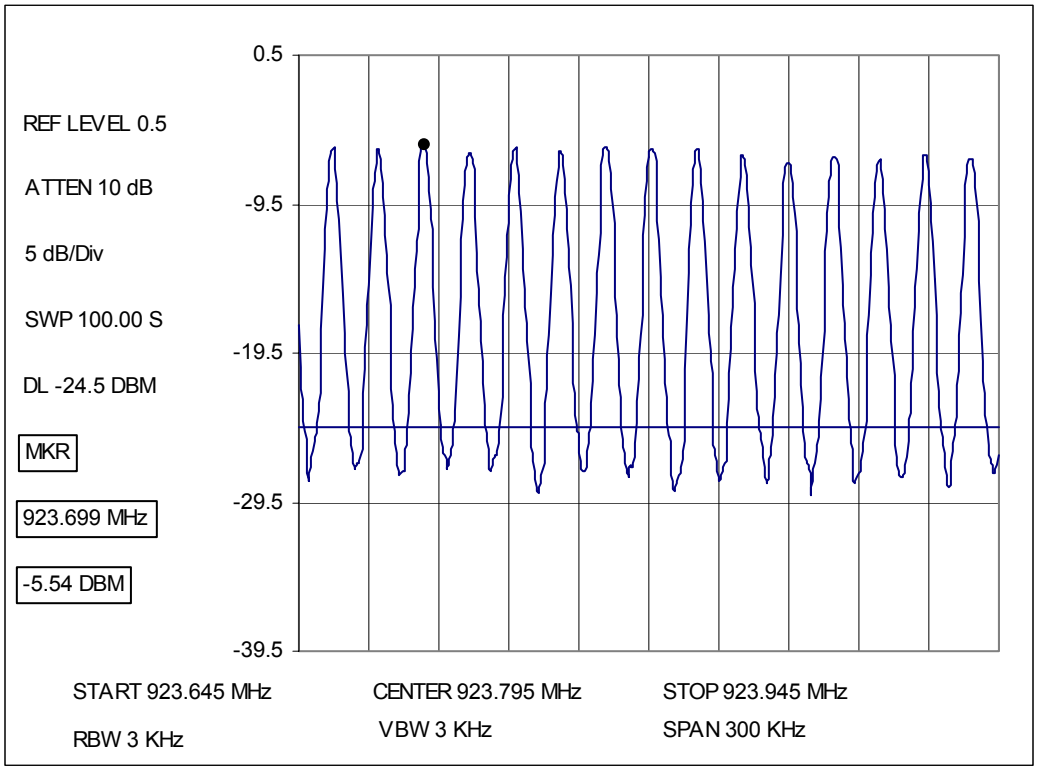
Frequency MHz	Power Density dBm
923.795	-5.5

Frequency Span = 300 kHz

Sweep Time = Frequency Span/3 kHz
= 100 Seconds

Refer to Figure 4-2 for power density data:

Figure 4-2: Power Spectral Density Plot



4.4 Out-of-Band Conducted Emissions
FCC Rule 15.247(c)

4.4.1 Requirements

In any 100 kHz bandwidth outside the EUT passband, the RF power shall be at least 20 dB below that of the maximum in-band 100 kHz emission.

4.4.2 Procedure

The antenna port of the EUT was connected to the input of a spectrum analyzer. Analyzer RES BW was set to 100 kHz. For each RF output channel investigated, the measurements were performed in the EUT operating frequency band and outside the band from 10 MHz to the 10^{th} harmonic of the fundamental frequency.

4.4.3 Test Result

This measurement could not be performed because the antenna is a trace on the circuit board. All out of band measurements were performed as radiated measurements.

4.5 Out-of-Band Radiated Emissions (except emissions in Restricted Bands) FCC Rule 15.247(c)

4.5.1 Requirements

In any 100 kHz bandwidth outside the EUT passband, the radiated emission shall be at least 20 dB below that of the maximum in-band 100 kHz emission.

Note: this requirement is not applicable if the EUT pass the Out-of-Band Conducted Emissions.

4.5.2 Procedure

For out-of-band conducted emissions that are close to or that exceed the 20 dB attenuation requirement described in the Section 4.4, radiated measurements were performed at a 3 m separation distance to determine whether these emissions complied with the 20 dB attenuation requirement.

4.5.3 Test Result

Company: **Robertshaw**
Model: **Radar 35**
Project No.: **3028459**
Date: 07/18/02
Standard: FCC Part 15, Subpart C (DSSS)

Notes: Limit = Max field strength at fundamental - 20dB

Tested by: Jeremy O. Pickens
Location: Duluth
Detector: HP8546
Antenna: AH571
PreAmp: None
Cable(s): HS7000 N-SM TW3 + HS4000 N-N
Distance: **3**

Ant. Pol. (V/H)	Frequency MHz	Reading dB(uV)	Antenna Factor dB(1/m)	Cable Loss dB	Pre-amp Factor dB	Average Factor dB	Net dB(uV/m)	Limit dB(uV/m)	Margin dB
No preamp No Filters (RBW: 100 kHz, VBW: 10 Hz)									
V	820.969	59.5	21.0	5.4	0.0	15.1	70.8	93.5	-22.7
H	820.969	54.4	21.0	5.4	0.0	15.1	65.7	93.5	-27.8
1GHz High Pass Filter Installed before preamp (RBW: 1 MHz, VBW: 10 Hz)									
h	1847.200	64.8	28.9	8.3	37.3	15.1	49.6	93.5	-43.9
v	1847.200	56.8	28.9	8.3	37.3	15.1	41.6	93.5	-51.9
v	3078.500	43.1	31.1	12.0	37.0	0.0	49.3	93.5	-44.2
h	3078.500	47.5	31.1	12.0	37.0	0.0	53.7	93.5	-39.8
2GHz High Pass Filter Installed before preamp (RBW: 1 MHz, VBW: 10 Hz)									
h	6465.000	36.8	37.1	17.4	36.5	0.0	54.8	93.5	-38.7
v	6465.000	41.1	37.1	17.4	36.5	0.0	59.1	93.5	-34.4

Table 4-1: Out of band radiated emissions (except emission within restricted bands)

4.6 Transmitter Radiated Emissions in Restricted Bands
FCC Rules 15.205, 15.209

4.6.1 Requirements

The emission shall not exceed the Field Strength levels specified in 15.209.

4.6.2 Procedure

For radiated emission measurements, the EUT is attached to a cardboard box (if necessary) and placed on the wooden turntable. The signal is maximized through rotation and placement in the three orthogonal axes.

During the test the EUT is rotated and the antenna height and polarization are varied during the search for maximum signal level. The antenna height is varied from 1 to 4 meters.

Radiated emissions are taken at three meters unless the signal level is too low for measurement at that distance. If necessary, a pre-amplifier is used and/or the test is conducted at a closer distance. All readings are extrapolated back to the equivalent three-meter reading using inverse scaling with distance.

Radiated emission measurements were performed from 30 MHz to 10,000 MHz.
Analyzer resolution is:

- 100 kHz or greater for frequencies 1000 MHz and below,
- 1 MHz for frequencies above 1000 MHz. For those frequencies peak and average values were measured.

Data is included of the worst case configuration (the configuration which resulted in the highest emission levels). A sample calculation, configuration photographs and data tables of the emissions are included.

Field Strength Calculation

The field strength is calculated by adding the Antenna Factor and Cable Factor, and subtracting the Amplifier Gain (if any) from the measured reading. The basic equation is as follows:
FS = RA + AF + CF - AG
Where FS = Field Strength in dB (μV/m)
RA = Receiver Amplitude (including preamplifier) in dB (μV)
CF = Cable Attenuation Factor in dB
AF = Antenna Factor in dB(1/m)
AG = Amplifier Gain in dB

If the EUT is operating in the 2.4 - 2.4835 GHz band, the Band-edge radiated emission measurements were performed using the "Marker-delta" method.

4.6.3 Test Result

The data on the following pages list the significant emission frequencies, the limit and the margin of compliance.

Company:	**Robertshaw**	Tested by:	Jeremy O. Pickens
Model:	**Radar 35**	Location:	Duluth
Project No.:	**3028459**	Detector:	HP8546
Date:	07/18/02	Antenna:	AH571
Standard:	FCC Part 15, Subpart C (DSSS)	PreAmp:	None
		Cable(s):	HS7000 N-SM TW3 + HS4000 N-N
Notes:		Distance:	**3**

Ant. Pol. (V/H)	Frequency MHz	Reading dB(uV)	Antenna Factor dB(1/m)	Cable Loss dB	Pre-amp Factor dB	Average Factor dB	Net dB(uV/m)	Limit dB(uV/m)	Margin dB
2GHz High Pass Filter Installed before preamp (RBW: 1 MHz, VBW: 10 Hz)									
h	2770.700	53.3	30.7	10.6	37.0	15.1	42.6	54.0	-11.4
v	2770.700	53.2	30.7	10.6	37.0	15.1	42.5	54.0	-11.5
h	3694.300	50.6	32.5	12.6	36.5	15.1	44.1	54.0	-9.9
v	3694.300	44.2	32.5	12.6	36.5	15.1	37.7	54.0	-16.3
h	4617.900	49.6	34.1	14.4	36.5	15.1	46.6	54.0	-7.4
v	4617.900	49.9	34.1	14.4	36.5	15.1	46.9	54.0	-7.1
h	5541.400	46.9	35.2	15.8	36.0	15.1	46.8	54.0	-7.2
v	5541.400	47.1	35.2	15.8	36.0	15.1	47.0	54.0	-7.0
h	7388.600	39.5	37.5	18.5	36.4	15.1	44.0	54.0	-10.0
v	7388.600	42.5	37.5	18.5	36.4	15.1	47.0	54.0	-7.0

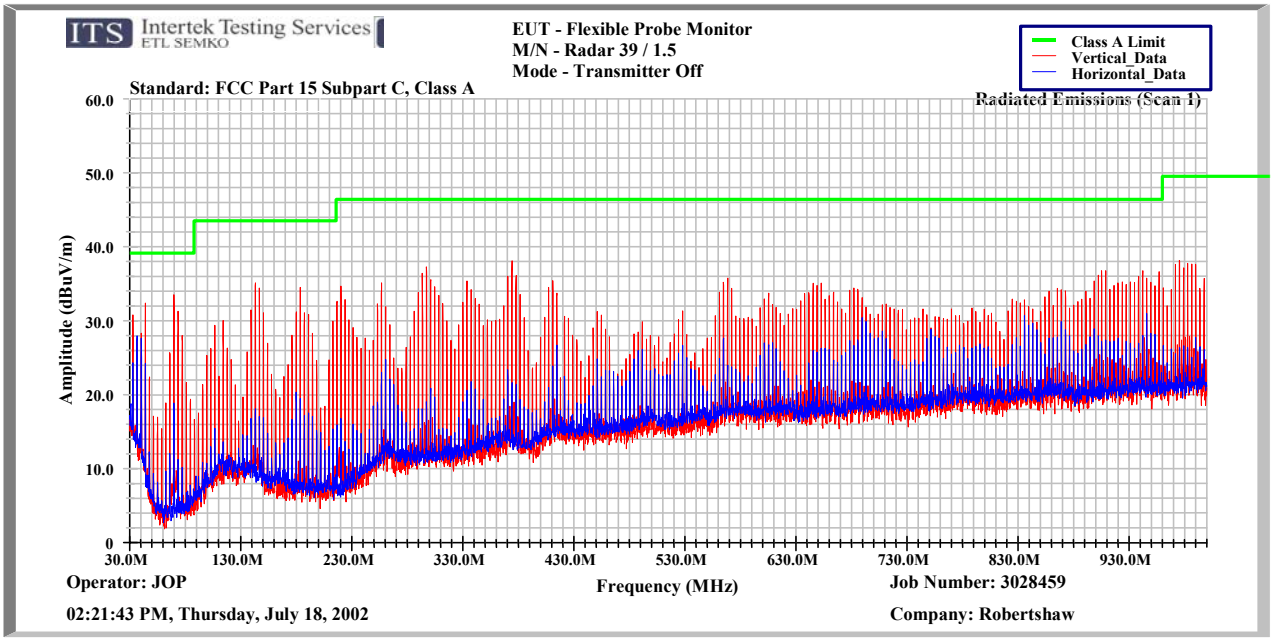
Table 4-2: Transmitter radiated spurious emission in the restricted bands

4.7 AC Line Conducted Emission
FCC Rule 15.207

This test was not applicable because the EUT does not connect to the ac mains. Only batteries power it.

4.8 Radiated Emissions from Digital Section of Transceiver

[ ] Not required - No digital part
[X] Test results are attached
[ ] Included in the separate DOC report.



4.9 Radiated Emissions from Receiver Section of Transceiver (L.O. Radiation)
FCC Rule 15.109, 15.111

[ ] Not required - EUT operation above 960 MHz only
[X] Not required - EUT is transmitter only
[ ] Test results are attached

4.10 Transmitter Duty Cycle Calculation and Measurements
FCC Rule 15.35(b), (c)

The EUT antenna output port was connected to the input of the spectrum analyzer. The analyzer center frequency was set to EUT RF channel carrier. The SWEEP function on the analyzer was set to ZERO SPAN. The transmitter ON time was determined from the resultant time-amplitude display:

Duty Cycle = Maximum ON time in a 100 msec period divided by 100 msec.

Duty Cycle Correction Factor, dB = 20 * log(DC)
= 20 * log (0.176)

The duty cycle for the maximum on-time was determined to be 0.176. Therefore, the duty cycle correction factor was calculated to be 15.1 dB.

5 Antenna Requirement

X	The transmitter uses a permanently connected antenna.
	The antenna is affixed to the EUT using a unique connector, which allows for replacement of a broken antenna, but does NOT use a standard antenna jack or electrical connector.
	The EUT requires professional installation.

Please refer to the attached documentation for details.

6 List of test equipment

Description	Make	Model	Serial #	Cal Date
EMI Receiver	HP	85462A	3410A00173	3/28/02
RF Filter Selector	HP	85460A	3348A00203	3/28/02
Spectrum Analyzer	HP	8566B	2134A01032 / 2344A05843	12/4/01
PreAmp	HP	8449B	3008A0089	10/24/02
PreAmp	HP	8447D	2648A04296	2/22/02
BiLog Antenna	Chase	CBL6112B	2622	8/14/01
Horn Antenna	EMCO	3115	9208-3919	2/20/02
Horn Antenna	AH Systems	SAS200/571	246	1/21/02
Cable	Huber-Suhner	HS7kNN		6/11/02
Cable	Huber-Suhner	HS4kNN		6/11/02
Cable	Andrews	CableTW3		6/11/02

*** All calibrations are on 12-month cycles unless otherwise indicated**

7 Document History

Revision/ Job Number	Writer Initials	Date	Change
1.0 / 3028460	djs	August 12, 2002	Original document
1.1 / 3028460	Djs	September 10, 2002	Corrected table in Section 2.1 – Added radiated power information. Corrected company name to agree with FCC records. Changed product name to agree with CIB information.