



Nemko Test Report: 5L0307RUS1_Rev2

Applicant: Sensonix
15755 32nd Avenue North
Plymouth, MN 55447

**Equipment Under Test:
(E.U.T.)** DX80

In Accordance With: **FCC Part 15, Subpart C, 15.247**
Frequency Hopping Transmitters

Tested By: Nemko Dallas Inc.
802 N. Kealy
Lewisville, Texas 75057-3136

Authorized By: 
Tom Tidwell, Frontline Group Manager

Date: 5 Aug, 2005

Table of Contents

Section 1.	Summary of Test Results	3
Section 2.	Equipment Under Test (E.U.T.)	5
Section 3.	Channel Separation.....	7
Section 4.	Time of Occupancy	9
Section 5.	Occupied Bandwidth	12
Section 6.	Peak Power Output.....	16
Section 7.	Spurious Emissions	17
Section 8.	Test Equipment List	19
ANNEX A - TEST DETAILS		20
ANNEX B - TEST DIAGRAMS		29

Section 1. Summary of Test Results

Manufacturer: Sensonix

Model No.: DX80

Serial No.: None – Marked as Sample #1

General: **All measurements are traceable to national standards.**

These tests were conducted on a sample of the equipment for the purpose of demonstrating compliance with Part 15, Subpart C, Paragraph 15.247 for Frequency Hopping Spread Spectrum devices. Radiated tests were conducted in accordance with ANSI C63.4-2003. Radiated emissions are made on an open area test site. A description of the test facility is on file with the FCC.



New Submission



Production Unit



Class II Permissive Change



Pre-Production Unit

THIS TEST REPORT RELATES ONLY TO THE ITEM(S) TESTED.

THE FOLLOWING DEVIATIONS FROM, ADDITIONS TO, OR EXCLUSIONS FROM THE TEST SPECIFICATIONS HAVE BEEN MADE. [All tests were performed radiated.](#)

See “ Summary of Test Data”.

**NVLAP LAB CODE: 100426-0**

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Summary Of Test Data

NAME OF TEST	PARA. NO.	SPEC.	RESULT
Powerline Conducted Emissions	15.207(a)	48 dB μ V	NA
Channel Separation	15.247(a)(1)	Greater of 25 kHz or 20 dB Bandwidth	Complies
Pseudorandom Hopping Algorithm	15.247(a)(1)		Complies
Time of Occupancy	15.247(a)(1)(ii)	≤ 0.4 sec in 30 sec	Complies
20 dB Occupied Bandwidth	15.247(a)(1)	≤ 1 MHz	Complies
Peak Power Output	15.247(b)	1 Watt	Complies
Spurious Emissions (Antenna Conducted)	15.247(c)	-20 dBc	Not tested
Spurious Emissions (Radiated)	15.247(c)	Table 15.209(a)	Complies

Footnotes:

- 1) The device is battery powered.
- 2) The device has a unique antenna connector. All tests were performed radiated.

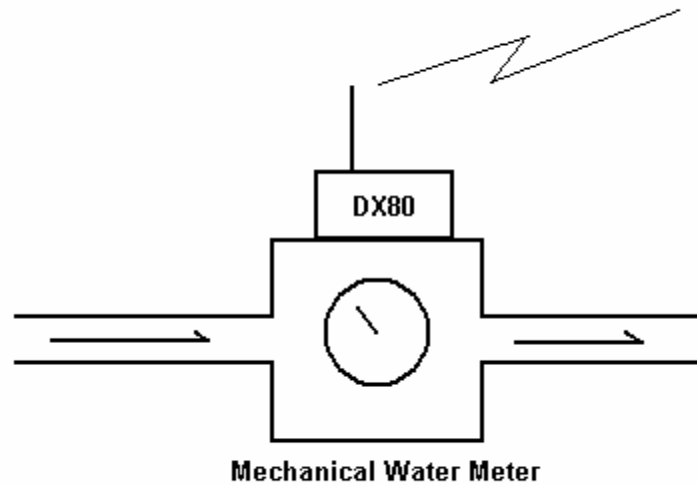
Section 2. Equipment Under Test (E.U.T.)

General Equipment Information

Frequency Band:	902.5 to 927.5 MHz
Standard Test Voltage:	4.5 Vdc battery (Tested with fully charged battery)
Number of Channels:	27
Channel Spacing:	500 kHz
User Frequency Adjustment:	Software controlled

Description of EUT

The DX80 is a TDMA frequency hopping transmitter used to transmit water meter data. The EUT can be configured with an integral antenna, a 1/2 wave dipole or a 1/4 wave dipole with reverse gender SMA connector.

System Diagram

Section 3. Channel Separation

NAME OF TEST: Channel Separation	PARA. NO.: 15.247(a)(1)
TESTED BY: David Light	DATE: 7/6/2005

Test Results: Complies.

Measurement Data: See 20 dB BW plot
Measured 20 dB bandwidth: 317 kHz
Channel Separation: 500 kHz

Equipment Used: 1484-1485-1304-1464

Measurement Uncertainty: +/- 0.7 dB

Temperature: 22 °C

Relative Humidity: 40 %

Test Data - Channel Separation

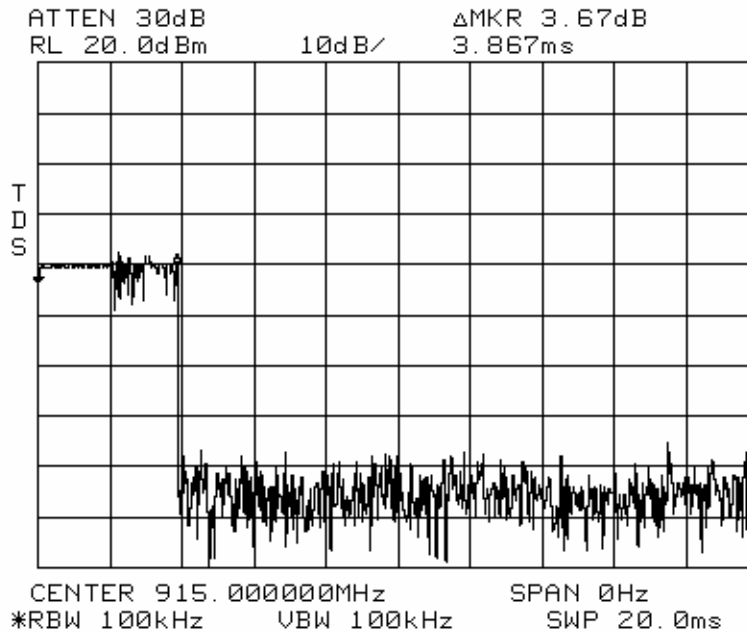
Data Plot	Channel Separation	
Page <u>1</u> of <u>5</u>		Complete <u>X</u>
Job No.: <u>5L0307</u>	Date: <u>7/6/2005</u>	Preliminary: _____
Specification: <u>15.247</u>	Temperature(°C): <u>22</u>	
Tested By: <u>David Light</u>	Relative Humidity(%): <u>40</u>	
E.U.T.: <u>900 MHz hopper</u>		
Configuration: <u>Tx</u>		
Sample Number: <u>1</u>		
Location: <u>AC 3</u>	RBW: <u>Refer to plots</u>	
Detector Type: <u>Peak</u>	VBW: <u>Refer to plots</u>	
Test Equipment Used		
Antenna: <u>1304</u>	Directional Coupler: _____	
Pre-Amp: _____	Cable #1: _____	
Filter: _____	Cable #2: <u>1485</u>	
Receiver: <u>1036</u>	Cable #3: _____	
Attenuator #1: _____	Cable #4: _____	
Attenuator #2: _____	Mixer: _____	
Additional equipment used: _____		
Measurement Uncertainty: <u>+/-1.7 dB</u>		
<p>ATTEN 10dB RL 0dBm 10dB/ ΔMKR 2.00dB 500kHz ΔMKR 500 kHz 2.00 dB START 914.250MHz STOP 915.250MHz *RBW 30kHz VBW 30kHz SWP 50.0ms</p>		
Notes: <u>Channel separation = 500 kHz</u> _____ _____ _____		

Section 4. Time of Occupancy

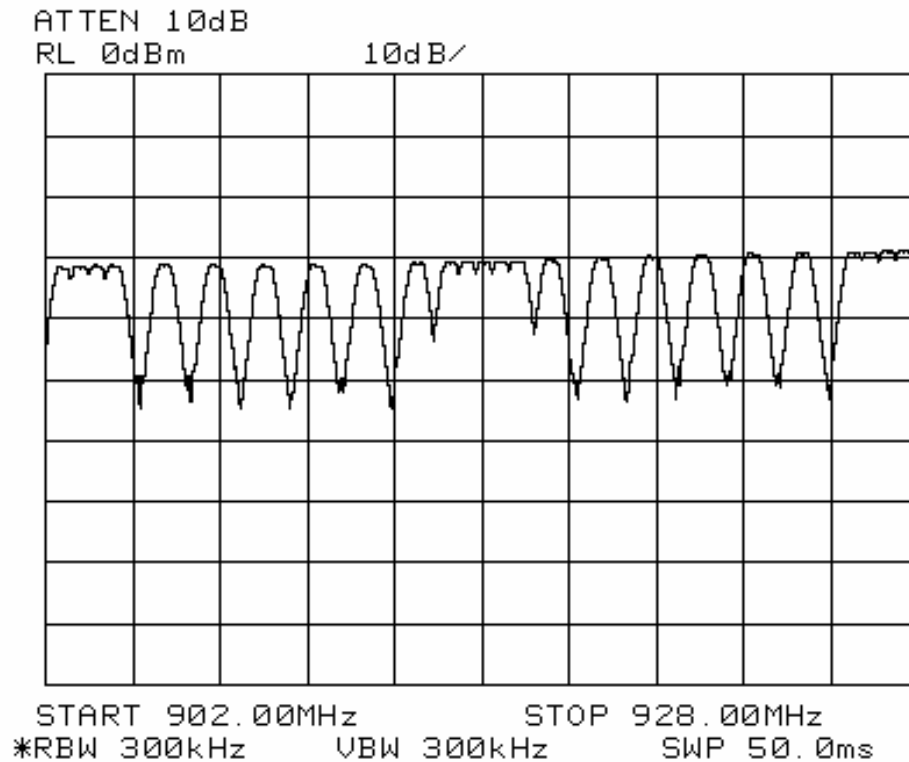
NAME OF TEST: Time of Occupancy	PARA. NO.: 15.247(a)(1)
TESTED BY: David Light	DATE: 7/6/2005

Test Results: Complies.

Measurement Data:
Maximum Dwell Time On Any Channel: 270.6 mS/10 seconds

Test Data – Time of Occupancy

Based on the number of channels (27), the number of time slots (128) in the TDMA system, each channel will be used 4.7 times in one frame (1 second). The maximum transmit time for a device in one second for any given channel will be: $3.8 \text{ ms} * 4.7 = 17.8 \text{ ms}$ or **0.18 seconds for every 10 seconds**.

Number of Channels

There are normally 27 channels utilized (see the technical description). The test mode only utilizes 25 channels. The lowest channel is centered at 902.5 MHz and the highest channel is centered at 927.5 MHz

Section 5. Occupied Bandwidth

NAME OF TEST: Occupied Bandwidth	PARA. NO.: 15.247(a)(1)(i)
TESTED BY: David Light	DATE: 7/6/2005

Test Results: Complies.

Measurement Data: See attached plots.

Equipment Used: 1464-1484-1485-1304

Measurement Uncertainty: +/- 0.7 dB

Temperature: 22 °C

Relative Humidity: 40 %

Test Data – Occupied Bandwidth

Data Plot**20 dB Bandwidth**

Page 2 of 5

Job No.: 5L0307

Date: 7/6/2005

Specification: 15.2

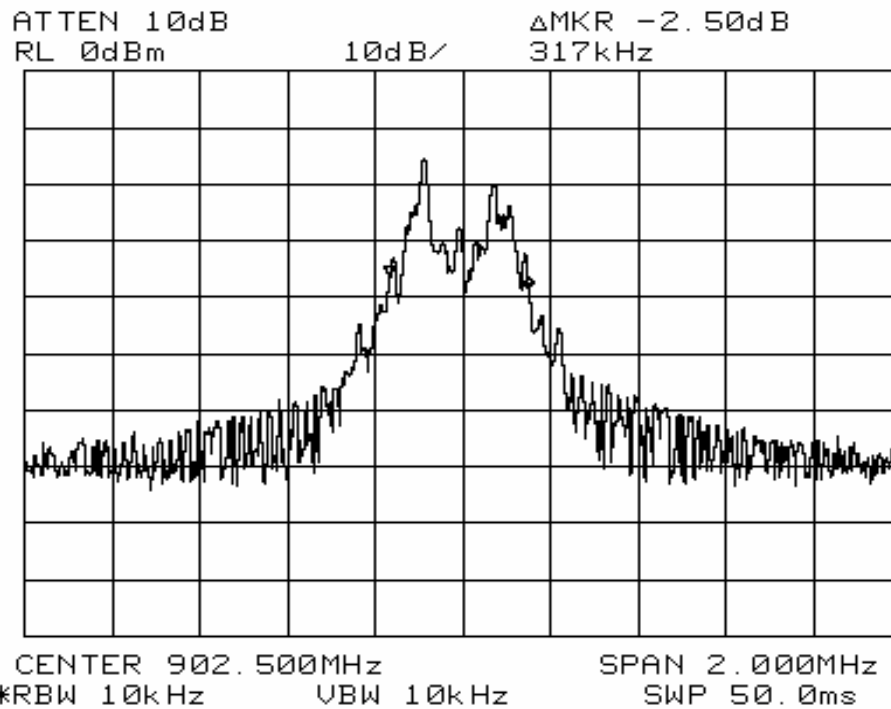
Temperature(°C): 22

Tested By: David Light

Relative Humidity(%) 40

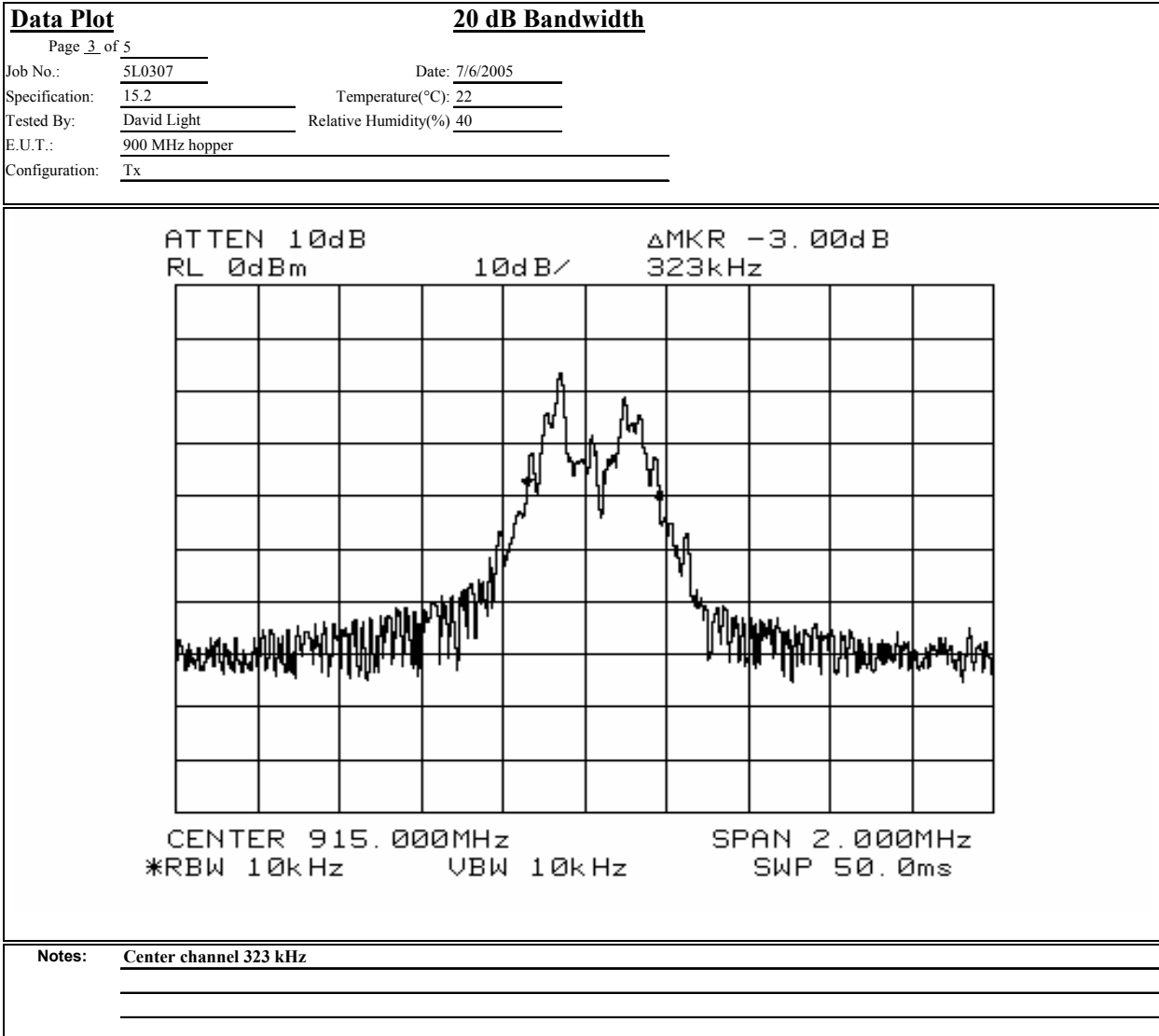
E.U.T.: 900 MHz hopper

Configuration: Tx

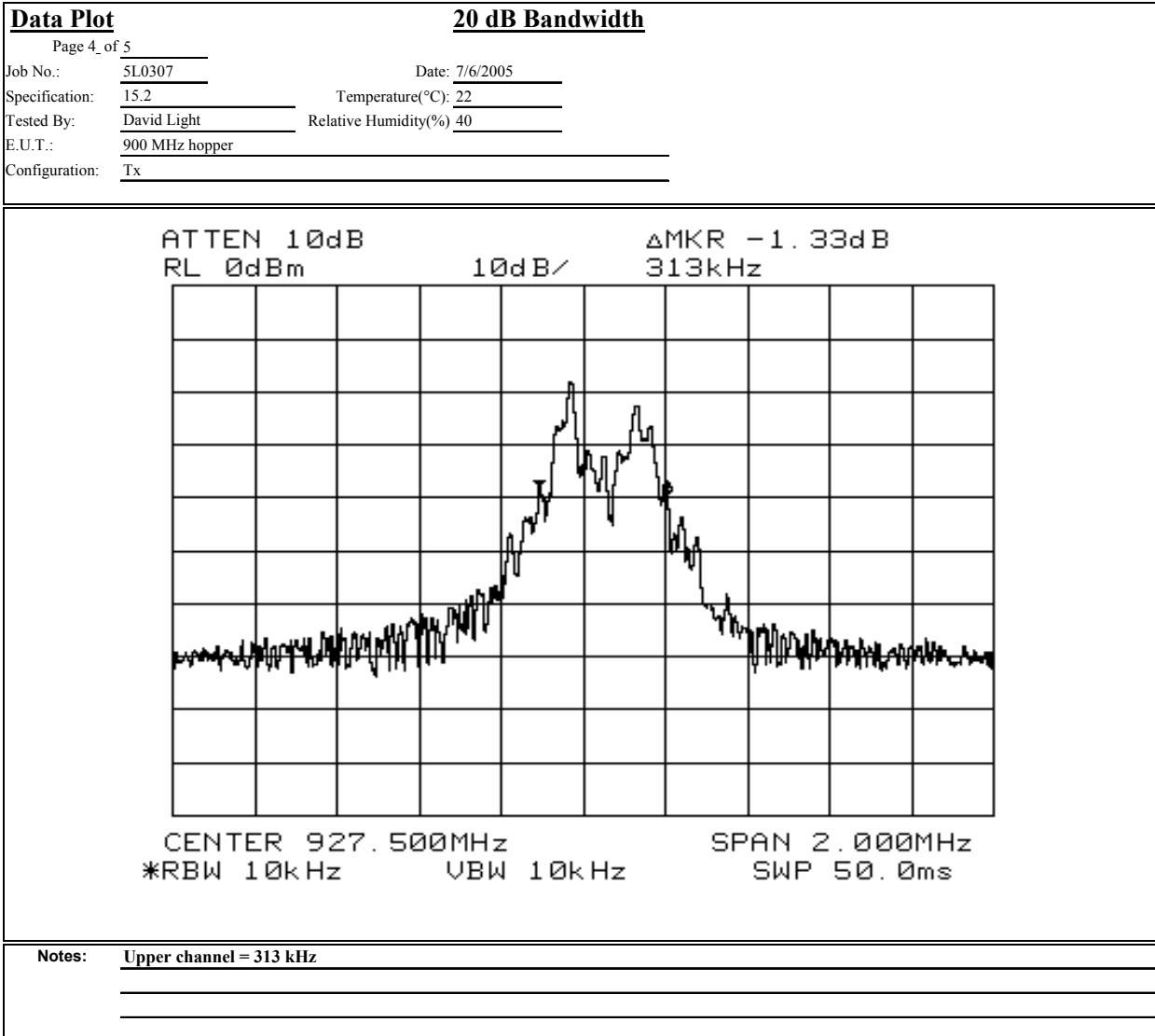


Notes: Lower channel = 317 kHz

Test Data – Occupied Bandwidth



Test Data – Occupied Bandwidth



Section 6. Peak Power Output

NAME OF TEST: Peak Power Output	PARA. NO.: 15.247 (b)
TESTED BY: David Light	DATE: 7/6/2005

Test Results: Complies.**Measurement Data:** See attached plots.Detachable antenna? ☒ Yes ☐ No

If yes, state the type of non-standard connector used: Reverse gender SMA

The radio can have either a detachable or integral antenna.

EIRP Substitution Method										
Page 1 of 1		Job No.: 5L0307		Date: 7/6/2005		Complete <u>X</u>				
Specification: 15.247		Temperature(°C): 22		Preliminary _____						
Tested By: David Light		Relative Humidity(%) 40								
E.U.T.: 900 MHz HOPPER										
Configuration: TX FULL POWER										
Sample No: 1 & 2										
Location: AC 3		RBW: 1 MHz		Measurement						
Detector Type: Peak		VBW: 1 MHz		Distance: 3 m						
Test Equipment Used										
Antenna: 1304		Directional Coupler: _____								
Pre-Amp: _____		Cable #1: 1484								
Filter: _____		Cable #2: 1485								
Receiver: 1464		Cable #3: _____								
Attenuator #1: _____		Cable #4: _____								
Attenuator #2: _____		Mixer: _____								
Additional equipment used: _____										
Measurement Uncertainty: +/-1.7 dB										
Frequency (MHz)	Meter Reading (dBm)	Correction Factor (dB)		Pre-Amp Gain (dB)	Substitution Antenna Gain (dBi)		EIRP (dBm)	EIRP (mW)	Polarity	Comments
902.5	-14.0	29.3		0	7.1		22.4	175.12	V	1/2 Wave dipole
915	-14.5	29.3		0	7.1		21.9	156.074996	V	1/2 Wave dipole
927.5	-14.5	29.3		0	7.1		21.9	156.074996	V	1/2 Wave dipole
902.5	-29.0	29.3		0	7.1		7.4	5.537750	V	Integral
915	-28.0	29.3		0	7.1		8.4	6.97	V	Integral
927.5	-26.5	29.3		0	7.1		9.9	9.85	V	Integral
Notes: _____										

Note: Conducted Peak RF output power is: 22.4 dBm – 2 dBi = 20.4 dBm (98 mW).

Section 7. Spurious Emissions

NAME OF TEST: Spurious Emissions	PARA. NO.: 15.247(c)
TESTED BY: David Light	DATE: 7/6/2005

Test Results: Complies.

There were no emissions detected above the noise floor which was at least 20 dB below the spec limit. The spectrum was searched from 30 MHz to 10 GHz while EUT was transmitting at 902.5, 915 and 927.5 MHz. The unit was transmitting a continuous TDMA carrier. The radio was tested with the integral antenna and the half wave dipole.

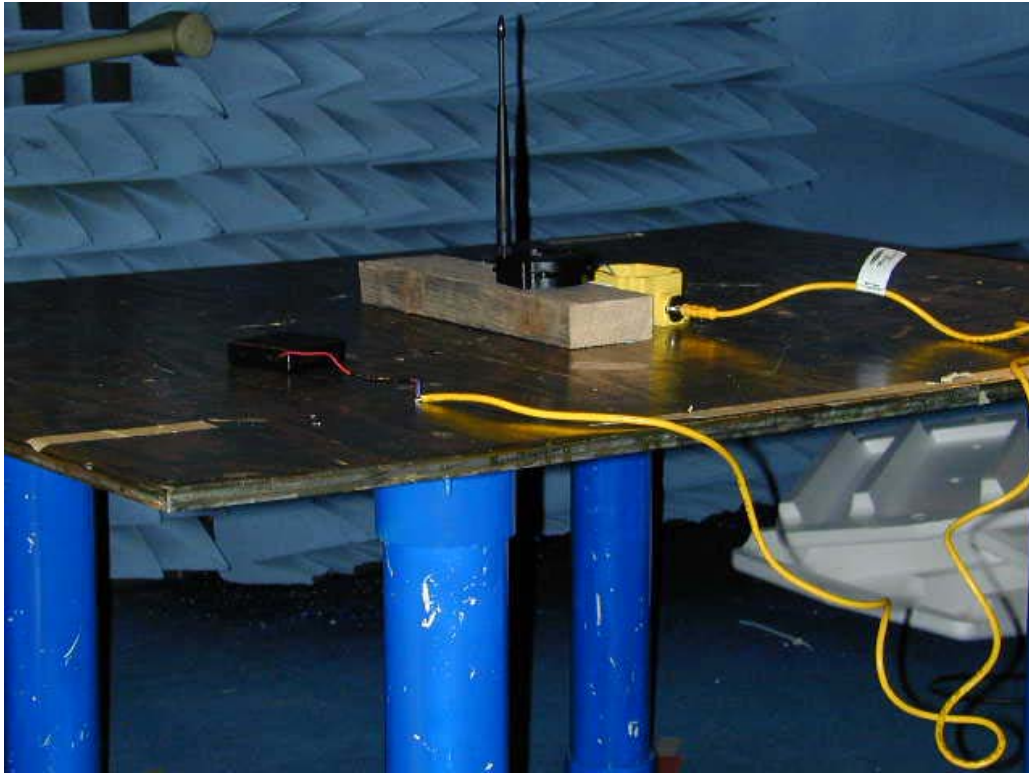
Restricted Bands: RBW 1 MHz/VBW 1 MHz Peak
RBW 1 MHz/VBW 10 kHz Average

Unrestricted Bands: RBW 100 kHz/VBW 100 kHz

Equipment Used: 1464-1484-1485-1304-1016-1481-1195-759-791-1481

Measurement Uncertainty: +/- 0.7 dB

Radiated Photographs (Worst Case Configuration)



Section 8. Test Equipment List

Nemko ID	Description	Manufacturer Model Number	Serial Number	Calibration Date	Calibration Due
1484	Cable 2.0-18.0 Ghz	Storm PR90-010-072	N/A	08/26/04	08/26/05
1485	Cable 2.0-18.0 Ghz	Storm PR90-010-216	N/A	08/02/04	08/02/05
1464	Spectrum analyzer	Hewlett Packard 8563E	3551A04428	01/14/05	01/15/07
1481	Microwave Highpass Filter	K & L 3DH1-2000/T8000-0/0	4	Cal B4 Use	N/A
1304	HORN ANTENNA	ELECTRO METRICS RGA-60	6151	09/22/03	09/22/05
1016	Pre-Amp	HEWLETT PACKARD 8449A	2749A00159	11/12/04	11/12/05
759	ANTENNA, LOG PERIODIC	A.H. SYSTEMS SAS-200/510	556	07/23/04	07/23/05
1195	ANTENNA,BICONICAL	A.H. SYSTEMS SAS-200/542	235	07/09/04	07/09/05
791	PREAMP, 25dB	ICC LNA25	398	11/12/04	11/12/05

ANNEX A - TEST DETAILS

NAME OF TEST: Channel Separation	PARA. NO.: 15.247(a)(1)
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Minimum Standard:

Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater.

NAME OF TEST: Pseudorandom Hopping Algorithm	PARA. NO.: 15.247(a)(1)
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Minimum Standard:

The system shall hop to channel frequencies that are selected from a pseudorandomly ordered list of hopping frequencies. Each frequency must be used equally on average by each transmitter. The system receivers shall have input bandwidths that match the hopping channel bandwidths of their transmitters and shall shift frequencies in synchronization with the transmitted signals.

NAME OF TEST: Time of Occupancy

PARA. NO.: 15.247(a)(1)(ii)

Minimum Standard:

Frequency Band (MHz)	20 dB Bandwidth	No. of Hopping Channels	Average Time of Occupancy
902 - 928	<250 kHz	50	=<0.4 sec. in 20 sec.
902 - 928	=>250 kHz	25	=<0.4 sec. in 10 sec.
2400 - 2483.5	-----	75	=<0.4 sec. in 30 sec.
5725 - 5850	-----	75	=<0.4 sec. in 30 sec.

Method Of Measurement:

The spectrum analyzer is set as follows:

RBW: 1 MHz

VBW: = RBW

Span: 0 Hz

LOG dB/div.: 10 dB

Sweep: Sufficient to see one hop time sequence.

Trigger: Video

The occupancy time of one hop is measured as above. The average time of occupancy is calculated over the appropriate period of time from above table (10, 20, or 30 seconds).

Avg. time of occupancy = (period from table/duration of one hop)/no. of channels multiplied by the duration of one hop.

For instance:

If a 2.4 GHz system has a measured hop duration time of 1 msec. and uses 75 channels, then the average time of occupancy would be:

$(30 \text{ sec.} / .001 \text{ sec.}) / 75 \text{ chan.} = 400 \times 1 \text{ msec.} = 400 \text{ msec. or } 0.4 \text{ sec. in } 30 \text{ sec.}$

NAME OF TEST: Occupied Bandwidth

PARA. NO.: 15.247(a)(2)

Minimum Standard:

Frequency Band (MHz)	Maximum 20 dB Bandwidth
902 - 928	500 kHz
2400 – 2483.5	1 MHz
5725 – 5850	1 MHz

Method Of Measurement:

The spectrum analyzer is set as follows:

RBW: At least 1% of span/div.

VBW: >RBW

Span: Sufficient to display 20 dB bandwidth

LOG dB/div.: 10 dB

Sweep: Auto

Number of channels tested:

Tuning range	Number of channels tested	Channel location in band
1 MHz or less	1	middle
1 to 10 MHz	2	top and bottom
more than 10 MHz	3	top, middle, bottom

NAME OF TEST: Peak Power Output

PARA. NO.: 15.247(b)

Minimum Standard:

Frequency Band (MHz)	No. of Hopping Channels	Maximum Peak Power Output at Antenna Port
902 - 928	at least 50	1 watt
902 – 928	25 - 49	0.25 watts
2400 – 2483.5	75	1 watt
5725 – 5850	75	1 watt

If transmitting antennas of directional gain greater than 6 dBi are used, the power shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

Systems operating in the 2400-2483.5 MHz band that are used exclusively for fixed, point to point operation may employ transmitting antennas with directional gain greater than 6 dBi provided the maximum peak output power is reduced by 1 dB for every 3 dB that the directional gain of the antenna exceed 6 dBi.

Systems operating in the 5725 – 5850 MHz band that are used exclusively for fixed, point-to-point operation may employ transmitting antennas with directional gain greater than 6 dBi without any corresponding reduction in transmitter peak output power.

Direct Measurement Method For Detachable Antennas:

If the antenna is detachable, a peak power meter is used to measure the power output with the transmitter operating into a 50 ohm load. The dBi gain of the antenna(s) employed shall be reported.

Calculation Of EIRP For Integral Antenna:

If the antenna is not detachable from the circuit then the Peak Power Output is derived from the peak radiated field strength of the fundamental emission by using the plane wave relation $GP/4\pi R^2 = E^2/120\pi$ and proceeding as follows:

$$P = \frac{E^2 R^2}{30G} = \frac{E^2 3^2}{30G}$$

where,

P = the equivalent isotropic radiated power in watts

E = the maximum measured field strength in V/m

R = the measurement range (3 meters)

G = the numeric gain of the transmit antenna in relation to an isotropic radiator

The RBW of the spectrum analyzer shall be set to a value greater than the measured 20 dB occupied bandwidth of the E.U.T.

Number of channels tested:

Tuning range	Number of channels tested	Channel location in band
1 MHz or less	1	middle
1 to 10 MHz	2	top and bottom
more than 10 MHz	3	top, middle, bottom

NAME OF TEST: Spurious Emissions at Antenna Terminals	PARA. NO.: 15.247(c)
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Minimum Standard:

In any 100kHz bandwidth outside the frequency band in which the transmitter is operating, emissions shall be at least 20 dB below the fundamental emission or shall not exceed the following field strength limits. Emissions falling in the restricted bands of 15.205 shall not exceed the following field strength limits:

Frequency (MHz)	Field Strength ($\mu\text{V/m}$ @ 3m)	Field Strength (dB @ 3m)
30 - 88	100	40.0
88 - 216	150	43.5
216 - 960	200	46.0
Above 960	500	54.0

THE SPECTRUM WAS SEARCHED TO THE 10th HARMONIC**Method Of Measurement:**30 MHz - 10th harmonic plot

RBW: 100 kHz

VBW: 300 kHz

Sweep: Auto

Display line: -20 dBc

Lower Band Edge

RBW: At least 1% of span/div.

VBW: >RBW

Span: As necessary to display any spurious at band edge.

Sweep: Auto

Center Frequency: 902 MHz, 2400 MHz, or 5725 MHz

Marker: Peak of fundamental emission

Marker Δ : Peak of highest spurious level below center frequency.Upper Band Edge

RBW: At least 1% of span/div.

VBW: >RBW

Span: As necessary to display any spurious at band edge.

Sweep: Auto

Center Frequency: 928 MHz, 2483.5 MHz, or 5850 MHz

Marker: Peak of fundamental emission

Marker Δ : Peak of highest spurious level above center frequency.

Number of channels tested:

Tuning range	Number of channels tested	Channel location in band
1 MHz or less	1	middle
1 to 10 MHz	2	top and bottom
more than 10 MHz	3	top, middle, bottom

NAME OF TEST: Radiated Spurious Emissions

PARA. NO.: 15.247(c)

Minimum Standard: In any 100kHz bandwidth outside the frequency band in which the transmitter is operating, emissions shall be at least 20 dB below the fundamental emission or shall not exceed the following field strength limits:

Emissions falling in the restricted bands of 15.205 shall not exceed the following field strength limits:

Frequency (MHz)	Field Strength ($\mu\text{V/m}$ @ 3m)	Field Strength (dB @ 3m)
30 - 88	100	40.0
88 - 216	150	43.5
216 - 960	200	46.0
Above 960	500	54.0

THE SPECTRUM WAS SEARCHED TO THE 10th HARMONIC

15.205 Restricted Bands

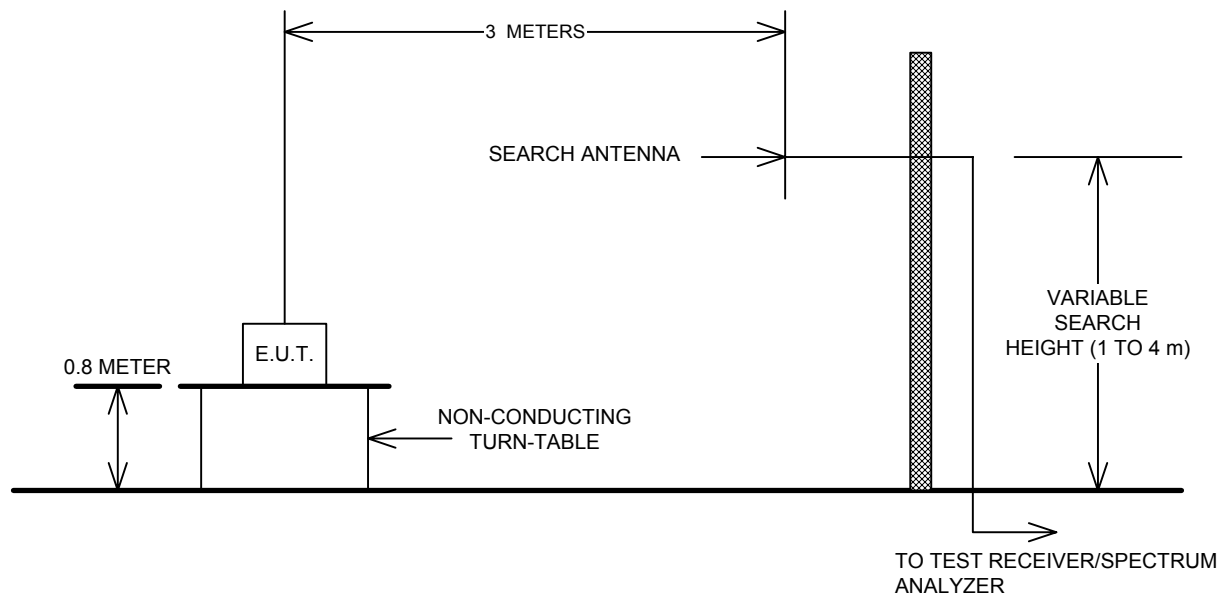
MHz	MHz	MHz	GHz
0.09-0.11	16.42-16.423	399.9-410	4.5-5.25
0.495-0.505	16.69475-16.69525	608-614	5.35-5.46
2.1735-2.1905	16.80425-16.80475	960-1240	7.25-7.75
4.125-4.128	25.5-25.67	1300-1427	8.025-8.5
4.17725-4.17775	37.5-38.25	1435-1626.5	9.0-9.2
4.20725-4.20775	73-74.6	1645.5-1646.5	9.3-9.5
6.125-6.218	74.8-75.2	1660-1710	10.6-12.7
6.26775-6.26825	108-121.94	1718.8-1722.2	13.25-13.4
6.31175-6.31225	123-138	2200-2300	14.47-14.5
8.291-8.294	149.9-150.05	2310-2390	15.35-16.2
8.362-8.366	156.52475-156.52525	2483.5-2500	17.7-21.4
8.37625-8.38675	156.7-156.9	2655-2900	22.01-23.12
8.41425-8.41475	162.0125-167.17	3260-3267	23.6-24.0
12.29-12.293	167.72-173.2	3332-3339	31.2-31.8
12.51975-12.52025	240-285	3345.8-3358	36.43-36.5
12.57675-12.57725	322-335.4	3600-4400	Above 38.6
13.36-13.41	1718		

Number of channels tested:

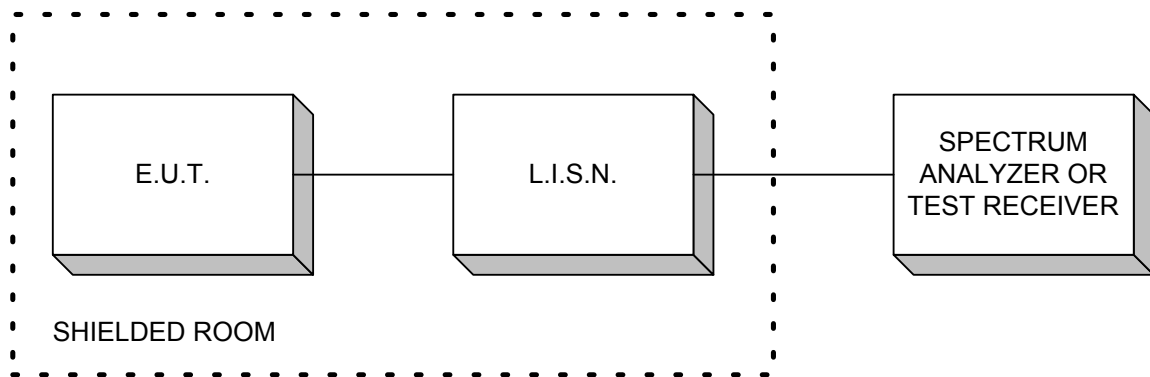
Tuning range	Number of channels tested	Channel location in band
1 MHz or less	1	middle
1 to 10 MHz	2	top and bottom
more than 10 MHz	3	top, middle, bottom

ANNEX B - TEST DIAGRAMS

Test Site For Radiated Emissions



Conducted Emissions



Peak Power At Antenna Terminals

