

Xecom Corporation

XE900SL10 Transceiver Module

CONDUCTED EMISSION TESTING



TITLE: XE900S-500 MODULE CONDUCTED TESTS		 L.S. RESEARCH, Inc. WIRELESS PRODUCT DEVELOPMENT		W66 N220 COMMERCE COURT CEDARBURG, WI 53012, USA (262)-375-4400 FAX: (262)-375-6731 email: eng@lsr.com, http://www.lsr.com		
PROJECT: XE900S-500 RADIO MODULE DEVELOPMENT						
DRAWN BY: John Lofgren		DATE: May 7, 2004		SIZE: A	DRAWING NUMBER: XE900SL10-PCT-1.0	REVISION: 1.1
CHECKED BY: BRIAN PETTED, VP ENG		DATE: May 10, 2004				
APPROVED BY: BRIAN PETTED, VP ENG		DATE: May 10, 2004				
FILENAME, FILES AFFECTED: Test Report - Conducted.doc		SCALE: NOT TO SCALE		SHEET: 1 OF 27		

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1.0 SIGNATURES

Manufacturer:	Xecom
Date(s) of Test:	May 7, 2004
Test Engineer:	John Lofgren
Model #:	XE900SL10
Serial #:	100
Operating Mode:	Hopping / CW, as required per individual test

Teresa A. White

Prepared By: _____ July 28, 2004

Teresa A. White, Document Coordinator

Date

Tested By: _____ July 28, 2004

John A. Lofgren, Senior Design Engineer

Date

Brian E. Petted

Approved By: _____ July 28, 2004

Brian E. Petted, VP Engineering

Date

Kenneth L. Boston


Approved By: _____ July 28, 2004

Kenneth L. Boston, EMC Lab Manager

Date

PE # 31926 Licensed Professional Engineer

Registered in the State of Wisconsin, United States


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2.0 SCOPE

This report presents the results associated with the conducted emission tests of the Xecom XE900SL10 RF Transceiver Module. This particular module is configured for 902-928 MHz operation. This report presents conducted test results required for pre-compliance for authorization under FCC Part 15.247 as a potential frequency hopping device.

3.0 REVISION CONTROL

DATE	CHANGES	REVISION
05/05/04	ORIGINAL RELEASE	1.0
07/27/04	MODIFY WORDING IN SECTIONS 5.1.2 AND 5.1.3	1.1

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4.0 APPLICABLE DOCUMENTS

[1] "Code of Federal Regulations Title 47, Volume 1, Sec. 1.1310 Radiofrequency radiation exposure limits" **47CFR1.1310**, Revised as of October 1, 2001, Page 297-298.

[2] "Code of Federal Regulations Title 47, Volume 1, Sec. 2.1091 Radiofrequency radiation exposure evaluation: mobile devices." **47CFR2.1091**, Revised as of October 1, 2001, Page 588-589.

[3] "Code of Federal Regulations Title 47, Volume 1, Sec. 15.31 "Measurement standards." **47CFR15.31**, Revised as of October 1, 2001, Page 677-681.

[4] "Code of Federal Regulations Title 47, Volume 1, Sec. 15.33 "Frequency range of radiated measurements." **47CFR15.33**, Revised as of October 1, 2001, Page 682-683.


[5] "Code of Federal Regulations Title 47, Volume 1, Sec. 15.35 "Measurement detector functions and bandwidths." **47CFR15.35**, Revised as of October 1, 2001, Page 683-684.

[6] "Code of Federal Regulations Title 47, Volume 1, Sec. 15.203 "Antenna requirement." **47CFR15.203**, Revised as of October 1, 2001, Page 720-721.

[7] "Code of Federal Regulations Title 47, Volume 1, Sec. 15.205 "Restricted Bands of Operation." **47CFR15.205**, Revised as of October 1, 2001, Page 721-722.


[8] "Code of Federal Regulations Title 47, Volume 1, Sec. 15.209 "Radiated emission limits; general requirements." **47CFR15.209**, Revised as of October 1, 2001, Page 723.

[9] "Code of Federal Regulations Title 47, Volume 1, Sec. 15.247 "Operation within the bands 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz." **47CFR15.247**, Revised as of October 1, 2001, Page 733-735.

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[10] American National Standards Institute (ANSI) C63.4-1992, ``Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz," **Electrical and Electronic Engineers, Inc.** July 17, 1992 , Document Number: SH15180.


[11] Federal Communications Commission Public Notice, ``PART 15 UNLICENSED MODULAR TRANSMITTER APPROVAL", June 26, 2000 , Document Number: DA 00-1407.

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5.0 EQUIPMENT UNDER TEST CONDITIONS (CONDUCTED EMISSIONS)

The Equipment Under Test (EUT) is the configured using the L.S. Research test tool and RS-232 interface cable. Unless otherwise indicated the settings for radiated measurements are as follows:

1. Nominal Transmit and Receive Frequencies: 902 MHz to 928 MHz
2. Nominal Bit Rate: 76.8 kbps
3. Transmitter Peak Frequency Deviation: 114 kHz CW Mode
4. Receiver Bandwidth: 600 kHz
5. Output Power Setting: 0 dBm and +10 dBm
6. Antenna: Temple Star C-522
7. Power Supply: +3.0 VDC Nominal, +3.6 VDC Maximum.

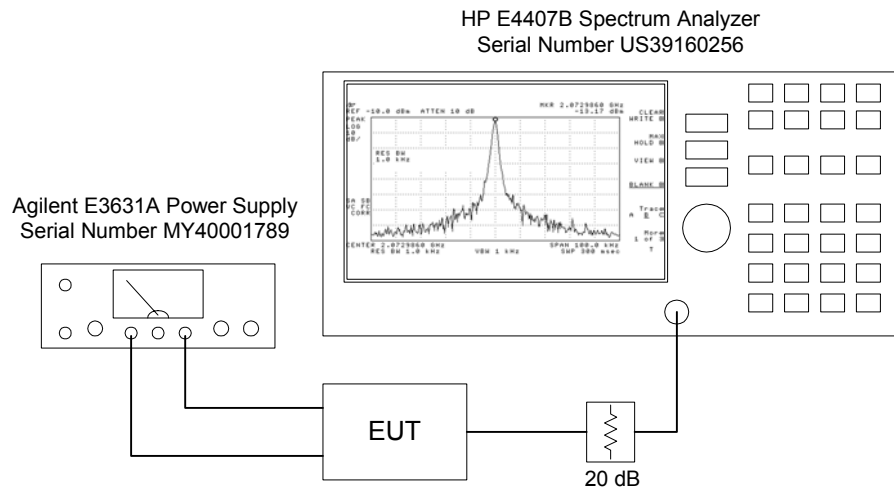
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5.1 Output Power and Occupied Bandwidths 15.247(a) (b) (c) :

Presented below is the measurement configuration for conducted output power and occupied bandwidths. The test configuration for this device is simply direct spectrum analysis using an Agilent E4407B spectrum analyzer, LSR Asset number CC000283, calibrated November 4, 2003 .

The EUT was connected directly to the input of the analyzer. No attenuators were used.

The channel power measurement feature of the E4407B is utilized where appropriate.



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5.1.1 Minimum Channel Separation (Part 15.247(a)(1))

Part 15.247(a)(1) requires a frequency spacing of at least 25 kHz or the 20dB emission bandwidth, which ever is greater.

The radio uses a channel plan with spacing of 525 kHz between 902 MHz and 907.5 MHz. It switches to a spacing of 430 kHz between 907.5 MHz and 922.5 MHz, then back to 525 kHz between 922.5 MHz and 928 MHz. This is necessary to accommodate some performance characteristics of the receiver circuit.

The widest 20 dB bandwidth of transmission (Section 4.1.8) is 385 kHz.

Minimum Channel Spacing of 430 kHz > 385 kHz. **PASS**

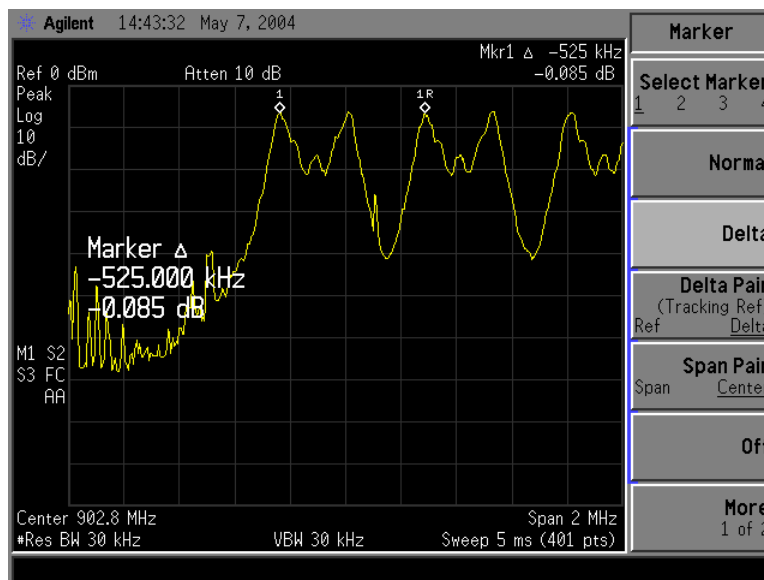



Figure 1. Channel separation at low band is 525 kHz

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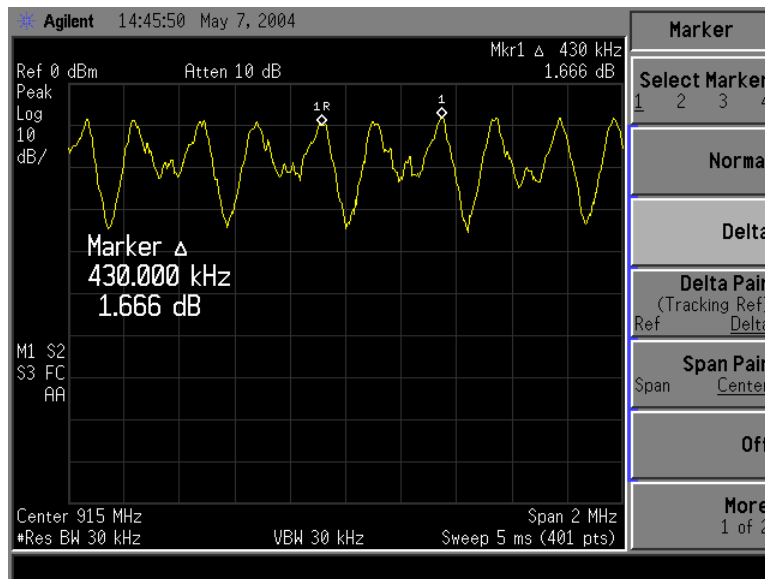


Figure 2. Channel separation at mid band is 430 kHz

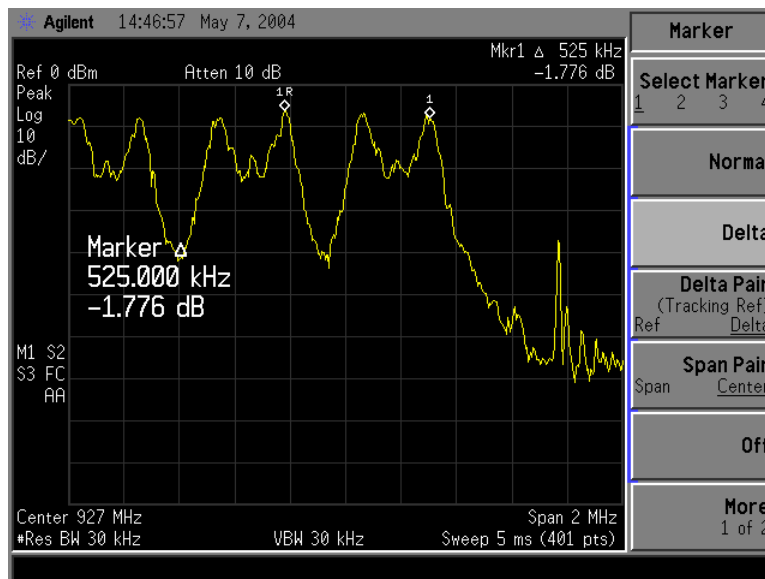



Figure 3. Channel separation at high band is 525 kHz

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5.1.2 Equal Channel Usage (Part 15.247(a)(1))

50 channels are chosen from a pool of 52 available frequencies. These channels are arrayed in a table which the system uses to determine the next hopping channel. Each time a transmission is made the system uses the next frequency in the table. The table is started over once the end has been reached. Thus, any given frequency will not be reused until all other frequencies have been accessed. This also addresses Part 15.247(g) concerns.

5.1.3 Pseudorandom Hopping Pattern (Part 15.247(a)(1))


The hopping table is built using an 8 bit seed into an $X^{15}+1$ pseudorandom number generator giving the possibility of 256 unique pseudorandom hopping tables.. Output from the generator is used to pick frequencies from a pool of 52 available channels. This also addresses Part 15.247(h) concerns.

5.1.4 Receiver Synchronization (Part 15.247(a)(1))

Each receiver requires the same seed for the pseudorandom sequence generator as the transmitter it is operating with. The same seed will produce the same hop sequence in each device. Once the receiver scans and finds the transmitter on any given channel it will automatically be synchronized to go to the next correct channel by virtue of using the same hopping table.

5.1.5 Receiver Input Bandwidth (Part 15.247(a)(1))

The radio receiver is a direct conversion type with a baseband filter whose cutoff frequency is matched to the transmission spectrum. The bandwidth is 600 kHz for use at the 76.8 kbps rate. Two level frequency shift keying is used for modulation. The simple Carson bandwidth for this type of signal is given as the bit rate plus 2 times the deviation. This system uses 114 kHz deviation for the 76.8 kbps rate, giving a bandwidth of 304.8 kHz. The excess filter bandwidth allows for frequency tolerance errors between the transmitter and receiver.

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5.1.6 Number of Hopping Frequencies (Part 15.247(a)(1)(i))

Transmitted 20dB bandwidth is a maximum of 415 kHz. This gives a requirement of at least 25 hopping channels. Since the unit does not transmit at a power level over 250 mW it is only required to have 25 channels, but the software actually uses 50 channels.

Figures 4 through 14 show band usage captured in 2 and 3 MHz parts to make all channels visible. Channels have been counted and are presented below:

5+5+4.5+4.5+4.5+4.5+4+3.5+4.5+5+5=50 PASS

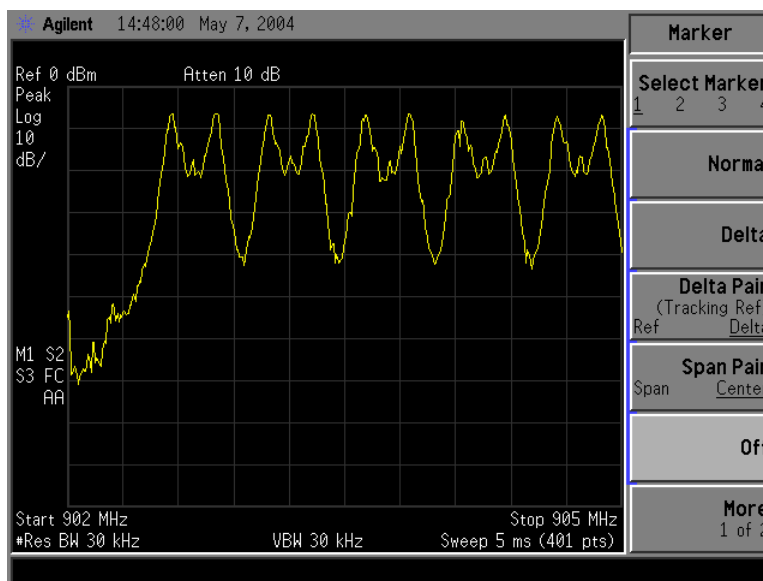



Figure 4. 5 channels from 902 MHz to 905 MHz

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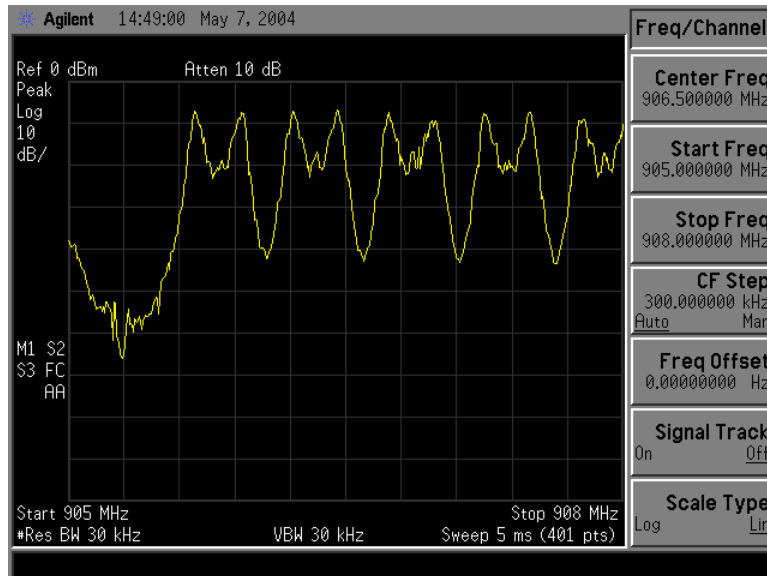


Figure 5. 5 channels from 905 MHz to 908 MHz

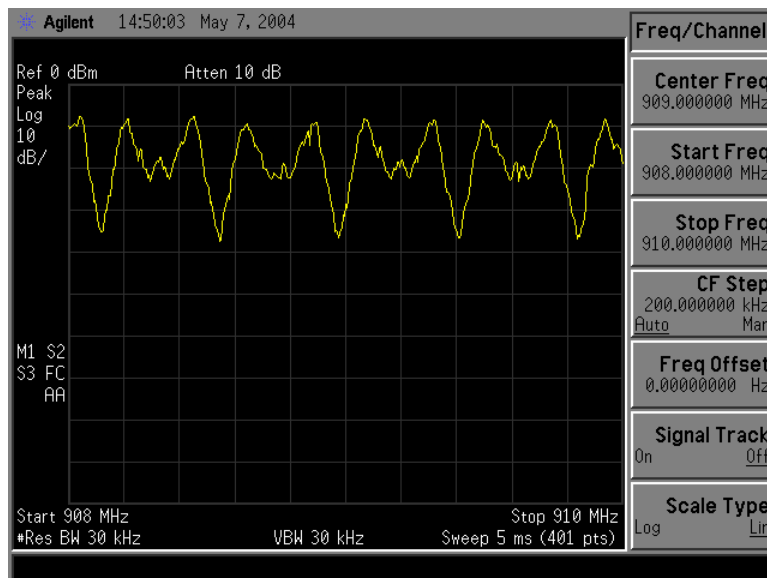



Figure 6. 4.5 channels from 908 MHz to 910 MHz

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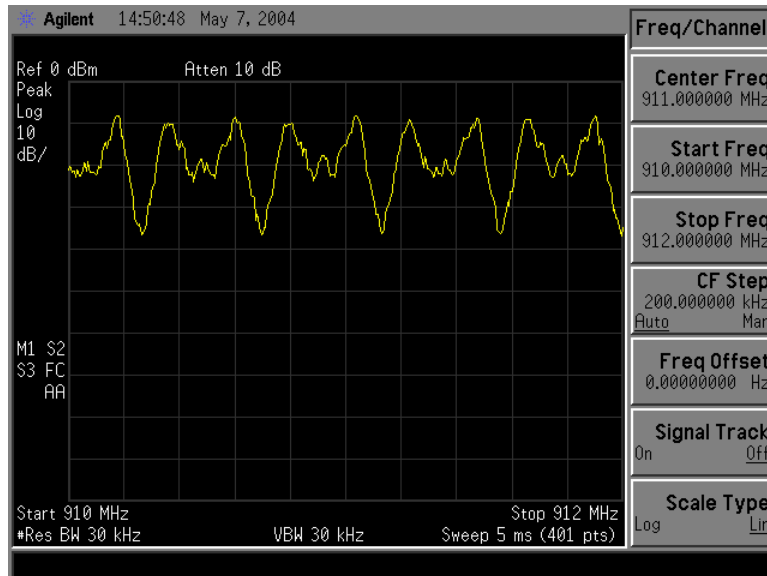


Figure 7. 4.5 channels from 910 MHz to 912 MHz

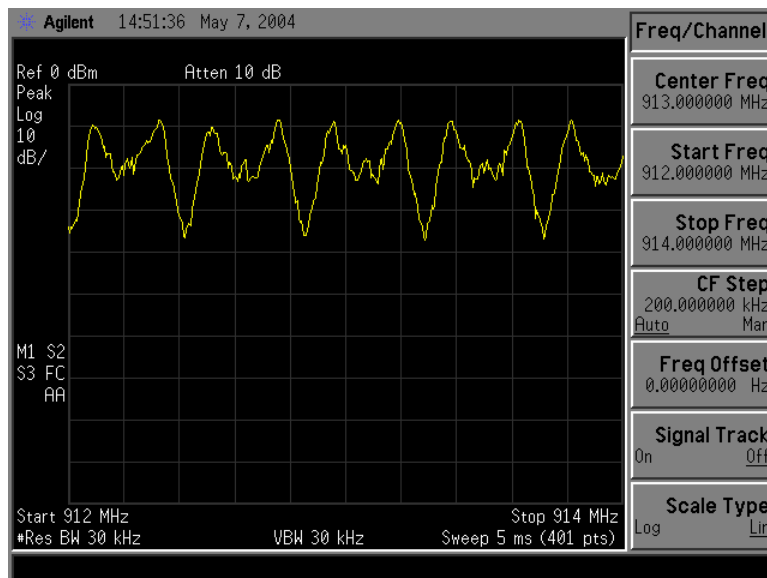



Figure 8. 4.5 channels from 912 MHz to 914 MHz

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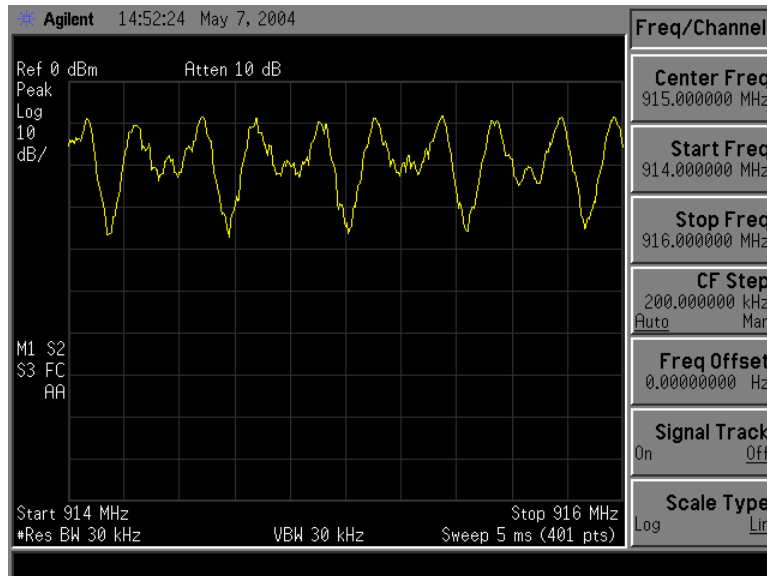


Figure 9. 4.5 channels from 914 MHz to 916 MHz

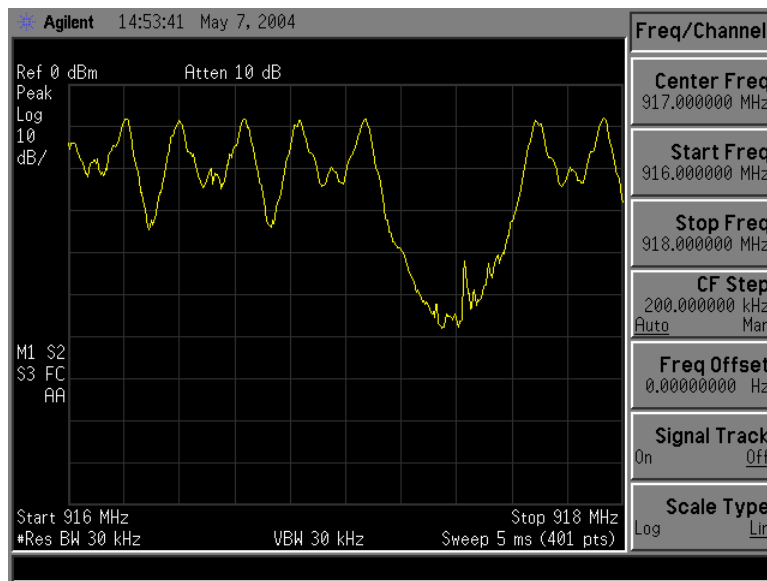



Figure 10. 4 channels from 916 MHz to 918 MHz

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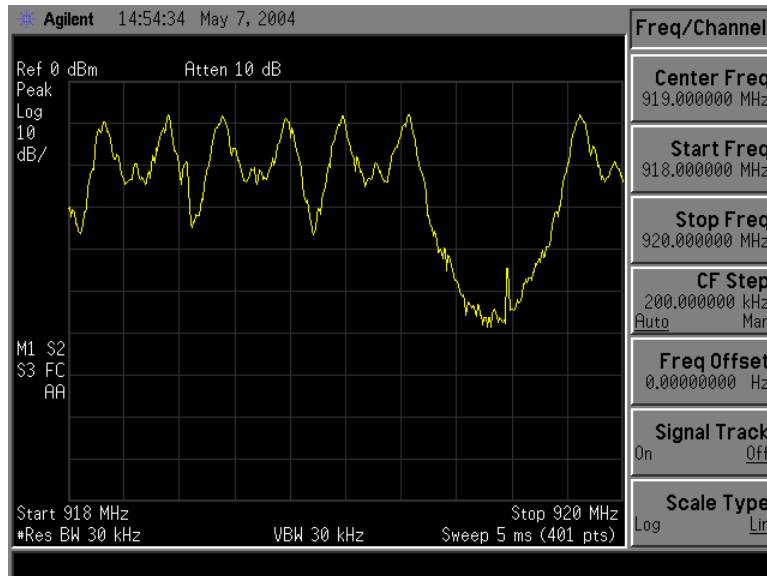


Figure 11. 3.5 channels from 918 MHz to 920 MHz

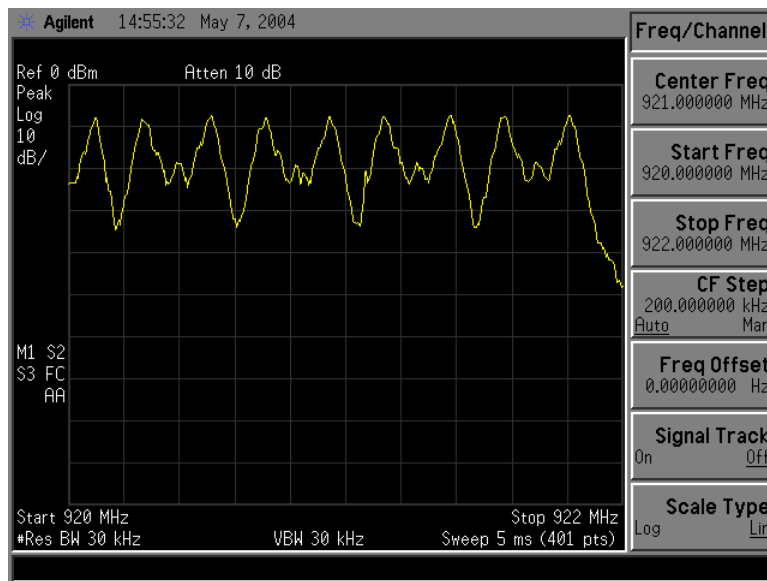



Figure 12. 4.5 channels from 920 MHz to 922 MHz

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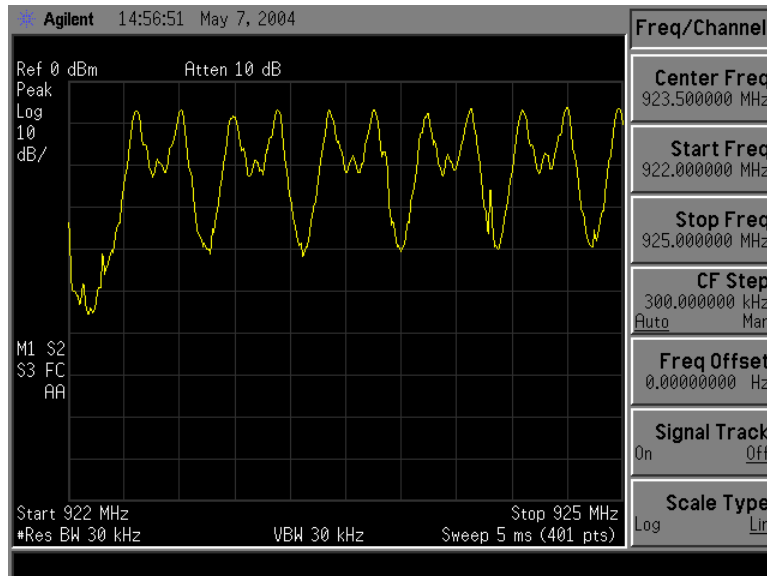


Figure 13. 5 channels from 922 MHz to 925 MHz

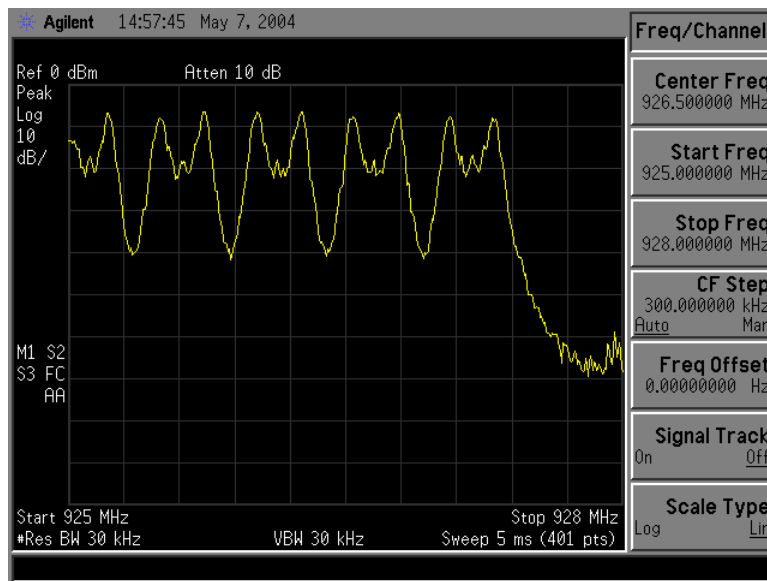



Figure 14. 5 channels from 925 MHz to 928 MHz

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5.1.7 Dwell Time (Part 15.247(a)(1)(i))

A system with a 20dB bandwidth greater than 250 kHz must not occupy a given channel for more than 400 mS in a 10 second window.

The longest time any transmission will occur on a single channel is 51 mS (Figure 15)

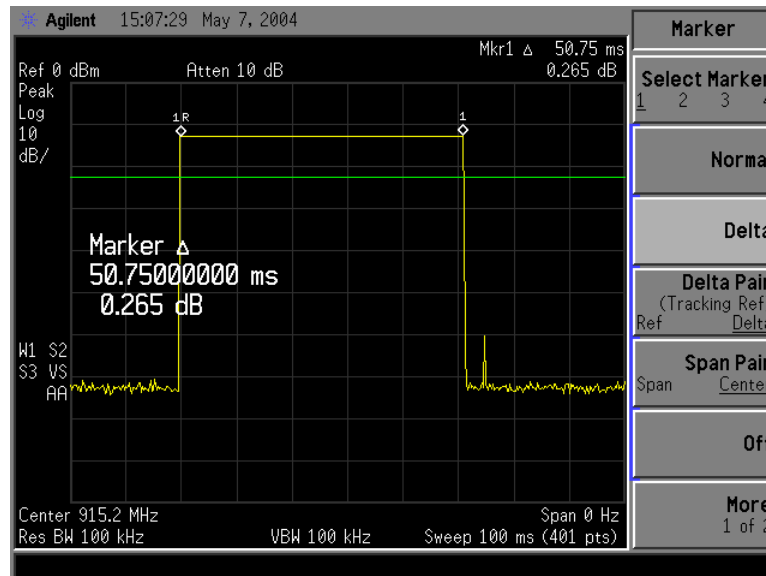



Figure 15. Longest channel dwell time is 50.75 mS.

A total of 50 channels are used. With each channel occupying 50.75 mS it will take 2.53 seconds for the sequence to repeat. 3.95 repetitions will fit into a 10 second window giving a maximum channel occupancy of 200.5 mS in a 10 second window.

200.5 mS < 400 mS PASS

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DRAWN BY: John Lofgren	DATE: May 7, 2004	SIZE: A	DRAWING NUMBER: XE900SL10-PCT-1.0		REVISION: 1.1
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5.1.8 20dB Bandwidth (Part 15.247(a)(1)(i))

Test Conditions	
EUT Mode	Hopping
Data Rate	76.8 kbps
EUT Power Setting	10 dBm
Span	1 MHz
RBW	30 kHz
VBW	30 kHz
Detector	Peak
Display Mode	Max Hold

Test Results			
Frequency (MHz)	Measured Bandwidth (kHz)	Bandwidth Limit (kHz)	Test Indication
902.77	358	500	PASS
914.85	375	500	PASS
927.21	385	500	PASS

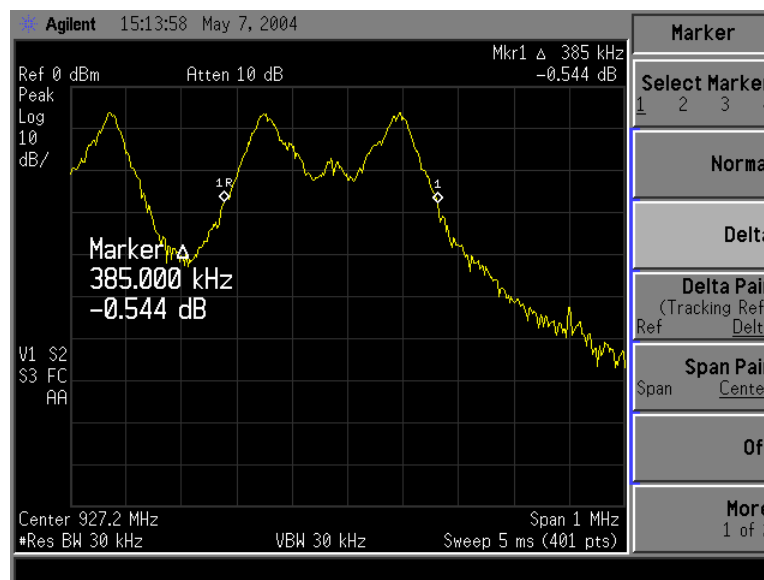



Figure 16. Widest 20 dB channel bandwidth is 385 kHz

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5.1.9 Peak Output Power (Part 15.247(b)(2))

A peak output power of 1 Watt is allowed by virtue of having 50 hopping channels.

Test Conditions	
EUT Mode	Single channel transmit
Data Rate	76.8 kbps
EUT Power Setting	0 dBm, +10 dBm
EUT Supply Voltage	+2.7, +3.0, +3.6 VDC
Span	2.25 MHz
RBW	10 kHz
VBW	100 kHz
Detector	Average
Display Mode	Channel Power

It is important to note that the "Channel Power" measurement function of the Agilent ESA series spectrum analyzer performs an integrated power measurement within the specified bandwidth. In this case the measurement bandwidth was set to 1.75 MHz, with the RBW at 10 kHz. This means that the analyzer will sum up the power spectral density in 10 kHz steps over a bandwidth of 1.75 MHz giving the total integrated power over that bandwidth. The 20 dB emission bandwidth of the signal is less than 500 kHz, so the 1.75 MHz bandwidth is more than sufficient to get the true output power.

High Power Test Results				
Set Frequency (MHz)	Supply Voltage (Volts)	Measured Power (dBm)	Power Limit (dBm)	Test Indication
902.77	2.7	3.06	30.0	PASS
	3.0	3.02 (Hi Pwr)	30.0	PASS
		-6.35 (Lo Pwr)	30.0	PASS
	3.6	2.97	30.0	PASS
914.85	2.7	1.01	30.0	PASS
	3.0	0.94 (Hi Pwr)	30.0	PASS
		-8.33 (Lo Pwr)	30.0	PASS
	3.6	0.93	30.0	PASS
927.21	2.7	2.93	30.0	PASS
	3.0	2.81 (Hi Pwr)	30.0	PASS
		-6.42 (Lo Pwr)	30.0	PASS
	3.6	2.78	30.0	PASS

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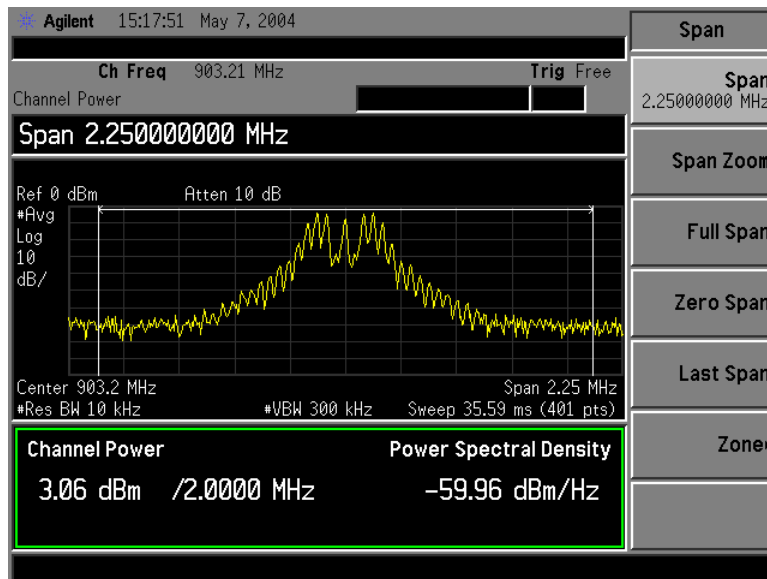



Figure 17. Highest channel power is +3.06 dBm on the lowest channel at 3.0 volt supply input.

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5.1.10 EIRP Limit (Part15.247(b)(3))

Parts 15.247(b)(2) and 15.247(b)(3) set maximum power limit of 1 watt (+30 dBm) conducted into an antenna with 6.0 dBi of gain, or less. This gives a maximum ERP of +36.0 dBm.

The XETI 915 MHz module has a maximum conducted output power of +3.06 dBm. The specified Temple Star Model C-522 antenna has a gain of 0 dBi yielding an ERP of +3.06 dBm which is less than the limit of +36.0 dBm.

5.1.11 Maximum Permissible Exposure (Part 15.247(b)(4)))

Prediction of MPE limit at a given distance

Equation from page 18 of OET Bulletin 65, Edition 97-01

$$S = \frac{PG}{4\pi R^2}$$

where: S = power density

P = power input to the antenna

G = power gain of the antenna in the direction of interest relative to an isotropic radiator


R = distance to the center of radiation of the antenna

Maximum peak output power at antenna input terminal: 3.1 (dBm)
Maximum peak output power at antenna input terminal: 2.02 (mW)
Antenna gain(typical): 0.0 (dBi)
Maximum antenna gain: 1.00 (numeric)
Prediction distance: 20 (cm)
Prediction frequency: 915 (MHz)
MPE limit for uncontrolled exposure at prediction frequency: 0.61 (mW/cm²)

Power density at prediction frequency: 0.00040 (mW/cm²)

Maximum allowable antenna gain: 31.81 (dBi)

Margin of Compliance at 20 cm = 31.81 dB

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5.1.12 Spurious Emission at Band Edges (Part 15.247(c))

Test Conditions	
EUT Mode	Hopping
Data Rate	76.8 kbps
EUT Power Setting	10 dBm
EUT Supply Voltage	+3.0 VDC
Span	10 MHz
RBW	100 kHz
VBW	100 kHz
Detector	Peak
Display Mode	Max Hold

Test Results			
Band Edge	Spur Level (dBc)	Spur Limit (dBc)	Test Indication
Lower	-45.32	-20	PASS
Upper	-44.53	-20	PASS

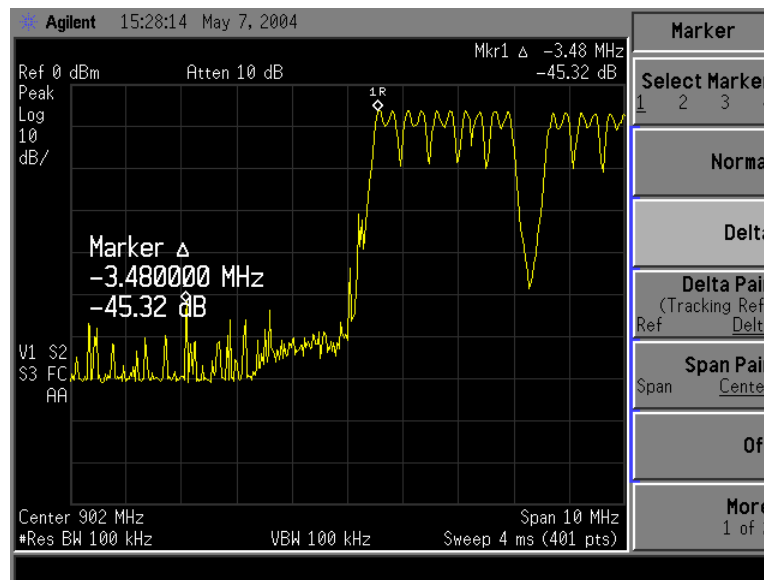



Figure 18. Spurious emission at lower band edge is -45.32 dBc.

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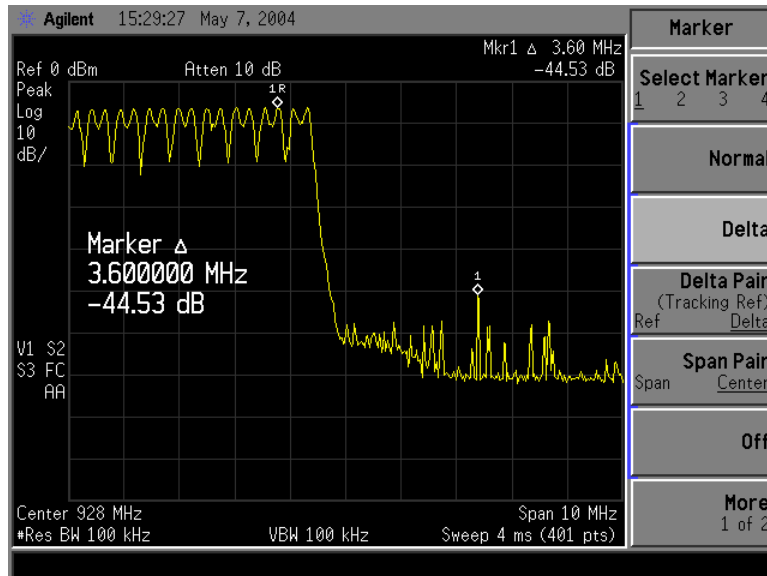



Figure 19. Spurious emission at upper band edge is -44.53 dBc.

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5.1.13 Spurious Emission, Wideband (Part 15.247(c))

Test Conditions	
EUT Mode	Hopping
Data Rate	76.8 kbps
EUT Power Setting	10 dBm
EUT Supply Voltage	+3.0 VDC
Span	As Required
RBW	100 kHz
VBW	100 kHz
Detector	Peak
Display Mode	Max Hold

Test Results			
Frequency Span	Spur Level (dBc)	Spur Limit (dBc)	Test Indication
9 kHz to 902 MHz	-59.97	-20	PASS
928 MHz to 10 GHz	-55.93	-20	PASS

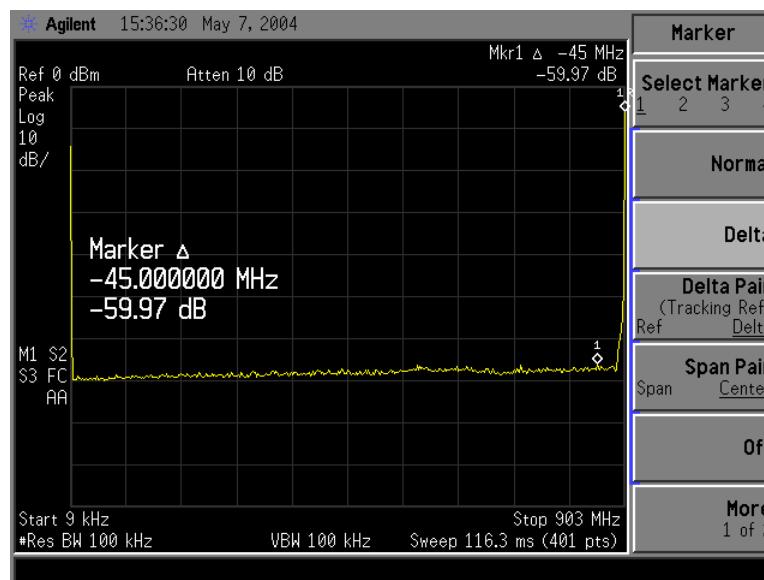



Figure 20. Spurious emission between 9 kHz and 902 MHz is -59.97 dBc.

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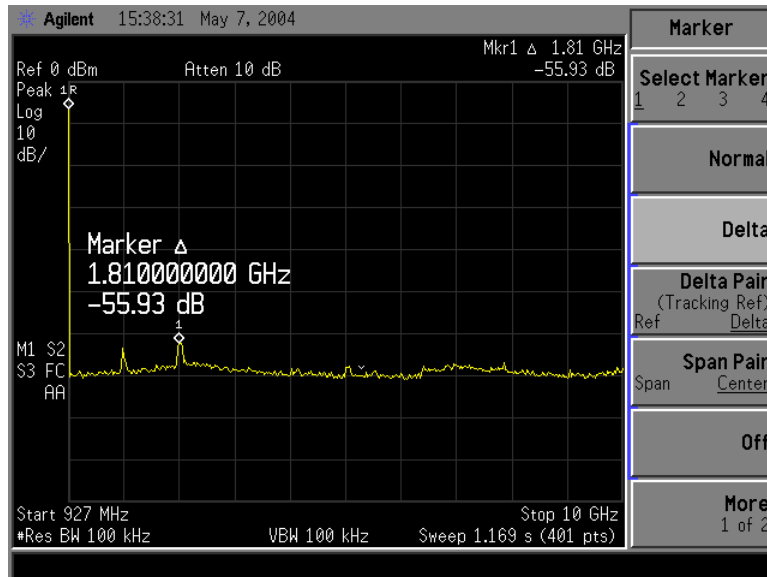




Figure 21. Spurious emission between 902 MHz and 10 GHz is -55.93 dBc.

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TITLE: XE1202 RADIO MODULE PRE-COMPLIANCE TESTS		 L.S. RESEARCH, Inc. WIRELESS PRODUCT DEVELOPMENT W66 N220 COMMERCE COURT CEDARBURG, WI 53012, USA (262)-375-4400 FAX: (262)-375-6731 email: eng@lsr.com, http://www.lsr.com		
PROJECT: XE1202 RADIO MODULE DEVELOPMENT				
DRAWN BY: BRIAN PETTED , VP ENG	DATE: February 7, 2003	SIZE: A	DRAWING NUMBER: XE1202-915-PCT-0.0	REVISION: 0.0
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FILENAME, FILES AFFECTED: Test Report - Conducted.doc		SCALE: NOT TO SCALE		SHEET: 27 OF 27