REGULATORY TEST REPORT

TITLE: ERT Repeater DTS FCC Test Report
AUTHOR: Drew Rosenberg

REV	CCO	DESCRIPTION OF CHANGE	DATE	*APPROVALS*	
A		INITIAL RELEASE		(Function)	
				(Function)	

REVISION HISTORY

				(Function)	
				(Function)	
				(Function)	

Summary

Test Data Summary

FCC 15.247 DTS

FCC ID: EO9-SPIRIT
Device Model: ERT Repeater

Model Numbers:
Sleeve: SPI-0001-002
Pole: SPI-0005-002

Serial Numbers:
Sleeve: 50024
Pole: 60003

Rule	Description	Max. Reading	Pass/Fail
15.207	Powerline Conducted Emissions	> 10dB Margin	Pass
15.247(a)(2)	6dB Bandwidth	682.1 kHz	Pass
15.247(b)	Power Output	6.1 dB Margin	Pass
15.247(c)	Spurious Emissions	49.6 dB Margin	Pass
15.205	Restricted Bands – Sleeve	14.8 dB Margin	Pass
15.205	Restricted Bands – Pole mount	16.9 dB Margin	Pass
15.247(d)	Power Spectral Density	7.82 dBm	Pass
15.247(b)(5)	RF Safety	4.9 cm	Pass

Cognizant Personnel

Drew Rosenberg	Regulatory Engineer
Name	Title
Mark Kvamme	Senior Technician
Name	Title
Scott Cumeralto	Principal Engineer
Name	Title

FCC Part 15.207

Powerline Conducted Emissions

Measure the AC powerline conducted emissions from 150kHz to 30 MHz using a 50µH/50Ω line impedance stabilization network (LISN). Verify that no emissions exceed the following limits:

Frequency (MHz)	Quasi-Peak (dBuV)	Average (dBuV)
0.15-0.5	66 to 56*	56 to 46*
0.5-5	56	46
5-30	60	50

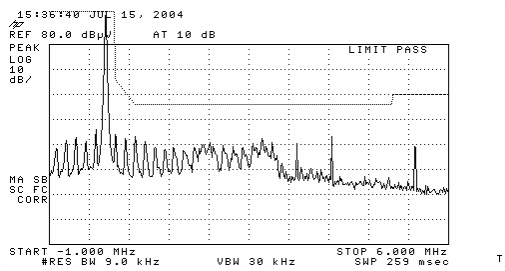
*Decreases with the logarithm of frequency

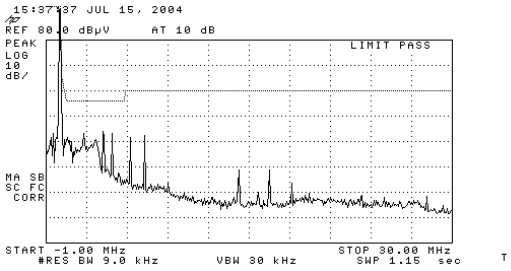
Equipment Used	Asset Number
LISN	8925
Spectrum Analyzer	6964

Date	Temp/Humidity ºF / %	Tested by
7/15/2004	78 / 71	Mark Kvamme

Unit tested: 50024

L1





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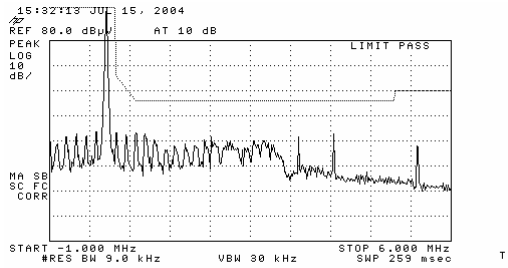
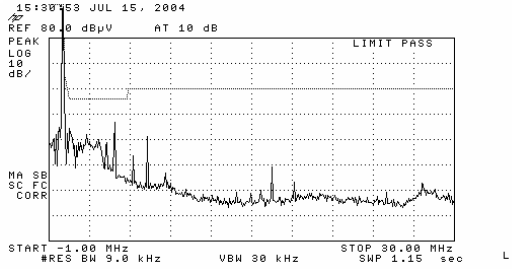




FCC Part 15.247(a)(2)

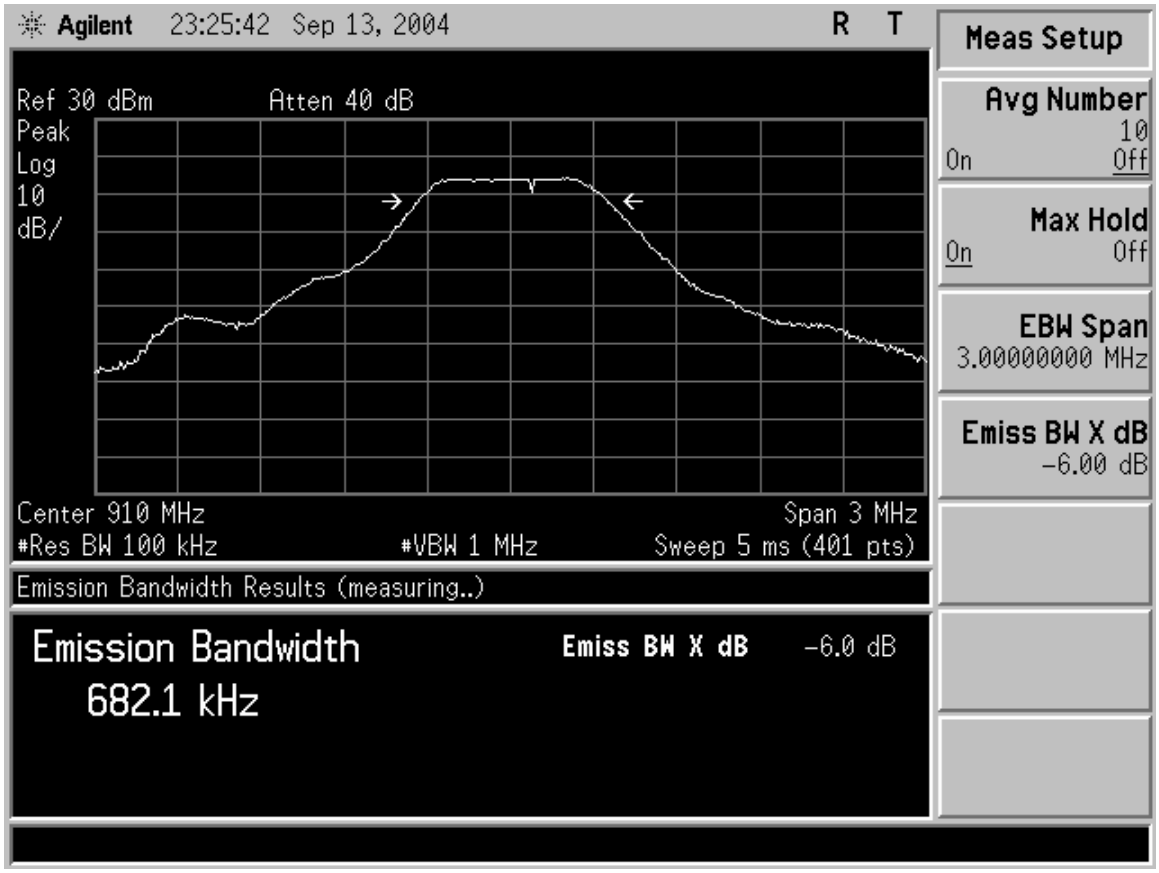
6dB Bandwidth

Set the resolution bandwidth of the analyzer to 100kHz. Measure the 6dB bandwidth of the transmitter's fundamental emissions. The 6dB bandwidth must be greater than 500kHz.

Equipment Used	Asset Number
Spectrum Analyzer	2064147

Date	Temp/Humidity ºF / %	Tested by
9/13/2004	75 / 56	Mark Kvamme

Unit Tested: 50024



FCC Part 15.247(b)

Power Output

This is an RF conducted test. Use a direct connection between the antenna port of the transmitter and the spectrum analyzer, through suitable attenuation. Set the RBW > 6dB bandwidth of the emission or use a peak power meter.

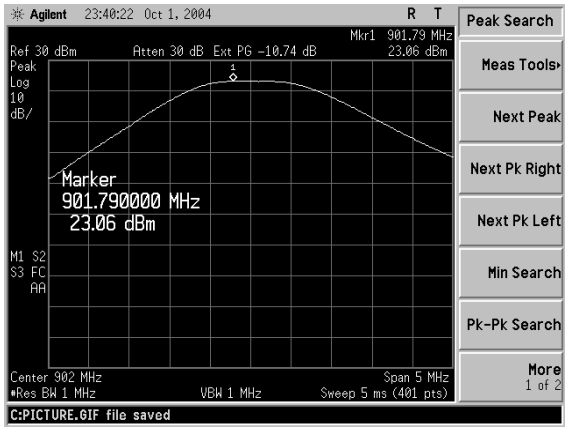
If the device has an integrated antenna, either measure the EIRP and divide by the antenna gain or solder a connector to the board and document how impedance matching is made to the test equipment.

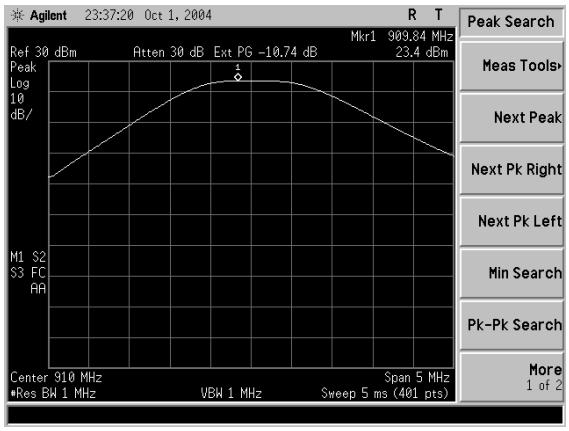
Equipment Used	Asset Number
Spectrum Analyzer	2064147

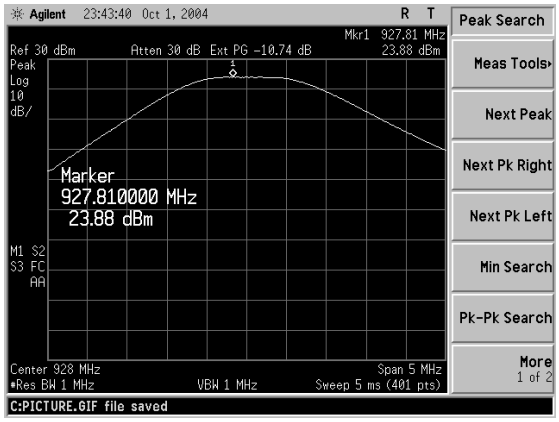
Date	Temp/Humidity ºF / %	Tested by
10/01/2004	56 / 65	Mark Kvamme

Unit Tested: 50024

Frequency (MHz)	Level (dBm)	Limit (dBm)	Margin (dBm)
909.84	23.4	30	6.60
901.79	23.06	30	6.94
927.81	23.88	30	6.12







FCC Part 15.247(c)

Spurious Emissions

This is an RF conducted test: Set RBW = 100 kHz, Video bandwidth (VBW) > RBW, scan up through 10th harmonic. All harmonics/spurs must be at least 20 dB down from the highest emission level within the authorized band *as measured with a 100 kHz RBW.*

Equipment Used	Asset Number
Spectrum Analyzer	2064147

Date	Temp/Humidity ºF / %	Tested by
9/14/2004	69 / 93	Mark Kvamme

Unit Tested: 50024

Only harmonics were found at the antenna port. NF stands for noise floor.

Frequency (MHz)	Level (dBm)
910 (fundamental)	22.5
1820	-27.14
2730	-44.7
3640	-68.42 (NF)
4550	-68 (NF)
5460	-68 (NF)
6370	-68 (NF)
7280	-68 (NF)
8190	-68 (NF)
9100	-68 (NF)

FCC Part 15.205

Restricted Bands – sleeve

Measure the field strength of all transmitter spurious emissions in the restricted bands listed below according to the procedure in Appendix A

Equipment Used	Asset Number
Spectrum Analyzer	2064147
Double Ridged Waveguide Antenna (Harmonics)	16256
Power Meter	6520
Power Sensor	6521
Signal Generator	12392

Date	Temp/Humidity ºF / %	Tested by
9/14/2004	69 / 93	Mark Kvamme

Unit Tested: 50024

MHz	MHz	MHz	GHz
0.090-0.110	16.42-16.423	399.9-410	4.5-5.15
0.495-0.505 1	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
6.215-6.218	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			

Prior to testing, the device emissions were checked with it oriented in three different orthogonal planes on the turntable. The worst case was found to be with the antenna pointing up.

Frequency (MHz)	Polarity	Level (dBµV)	ACF (dB)	Coax loss (dB)	Duty Cycle Relaxation	Final level (dBµV/m)	Limit (dBµV/m)	Margin (dB)
2730	V	12.0	31.5	3.2	12.4	34.3	54.0	19.7
5460	V	10.6	36.2	4.8	12.4	39.2	54.0	14.8

Note: Only harmonics were found during the radiated emissions test.
The levels shown above are an absolute peak level. The transmitter duty cycle is shown below:

Duty Cycling:

SCM messages:

7.8ms transmit – Manchester encoded, 3ms delay, 6ms receive, 3ms delay, repeat
The Manchester encoding gives a transmit duty cycle of 50% during each transmission
7.8+3+6+12 = 19.8ms < 100ms
Therefore, the SCM duty cycle is: (7.8/2)/(7.8+3+6+3) = *19.6%*

IDM messages:

46.33ms transmit – Manchester encoding, 3ms delay, 44.5 ms receive. 3ms delay
The Manchester encoding gives a transmit duty cycle of 50% during each transmission
46.33+3+44.5+3 = 96.83 ms < 100ms
Therefore, the SCM duty cycle is: (46.33/2)/(46.33+3+44.5+3) = *23.9%*

Since IDM is the worst case, the maximum relaxation allowed due to duty cycling is:
20*log(0.239) = *12.4dB of relaxation due to duty cycling*.

FCC Part 15.205

Restricted Bands – pole mount

Measure the field strength of all transmitter spurious emissions in the restricted bands listed below according to the procedure in Appendix A.

MHz	MHz	MHz	GHz
0.090-0.110	16.42-16.423	399.9-410	4.5-5.15
0.495-0.505 1	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
6.215-6.218	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			

Equipment Used	Asset Number
Spectrum Analyzer	2064147
Double Ridged Waveguide Antenna (Harmonics)	16256
Power Meter	6520
Power Sensor	6521
Signal Generator	12392

Date	Temp/Humidity ºF / %	Tested by
09/28/2004	71 / 41	Mark Kvamme

Unit Tested: 60003

Prior to testing, the device emissions were checked with it oriented in three different orthogonal planes on the turntable. The worst case was found to be with the antenna pointing up.

Frequency (MHz)	Polarity	Level (dBµV)	ACF (dB)	Coax loss (dB)	Final level (dBm)	Limit (dBm)	Margin (dBm)
74.3	V	13.9	8.8	0.4	23.1	40.0	16.9
149.4	V	10.0	12.6	0.8	23.4	43.5	20.1

Notes:

- No radiated harmonic emissions were found in the pole mount configuration.
- All measurements shown above are peak measurements.

FCC Part 15.247(d)

Power Spectral Density

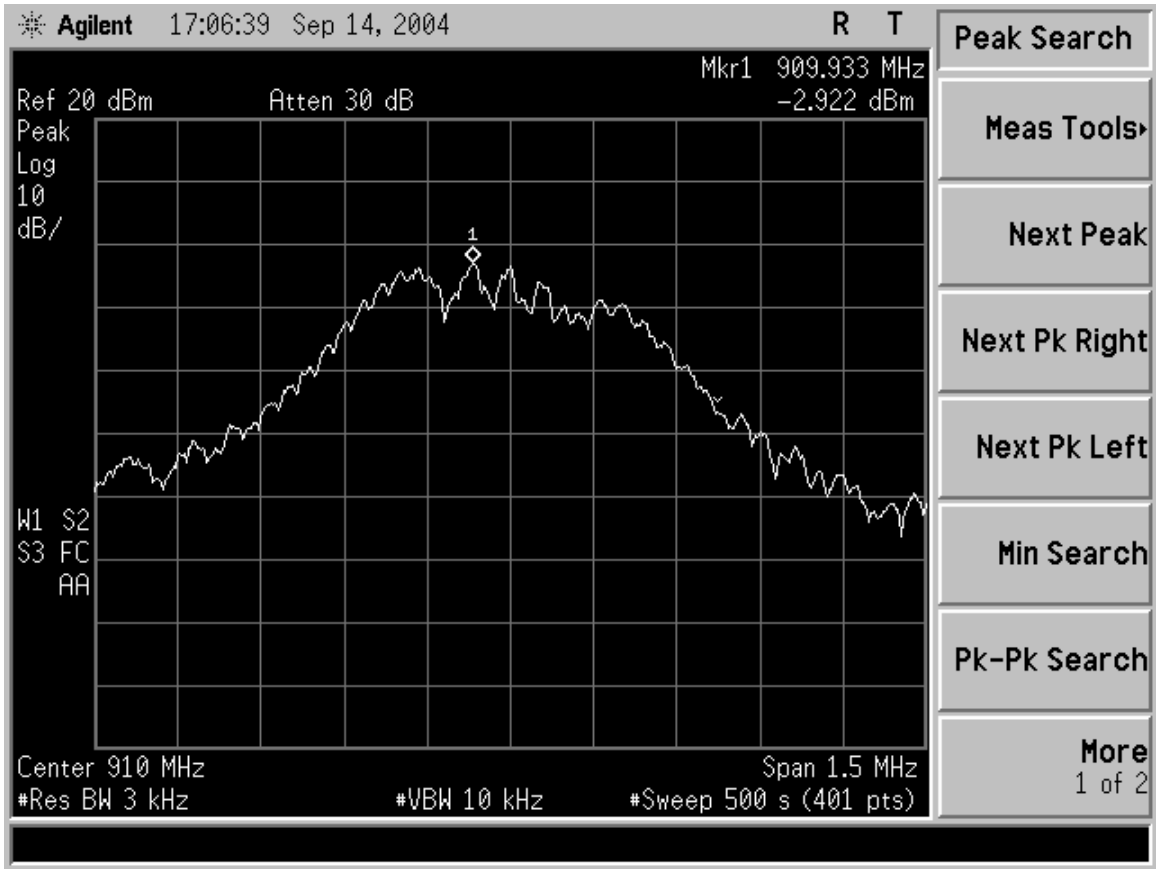
This is an RF conducted test. Locate and zoom in on emission peak(s) within the passband. Set RBW = 3 kHz, VBW > RBW, sweep= (SPAN/3 kHz) e.g., for a span of 1.5 MHz, the sweep should be 1.5 x 10^6 ÷ 3 x 10^3 = 500 seconds. The peak level measured must be no greater than + 8 dBm. If external attenuation is used, don't forget to add this value to the reading.

Equipment Used	Asset Number
Spectrum Analyzer	2064147

Date	Temp/Humidity ºF / %	Tested by
9/14/2004	69 / 93	Mark Kvamme

Unit Tested: 50024

Analyzer Reading (dBm)	Attenuator (dB)	Cable Loss (dB)	Final Reading (dBm)
-2.92	10	0.74	7.82



FCC Part 1.1310

Maximum Permissible Exposure (MPE)

Note: This evaluation is not needed if the device has been tested and found to meet the minimum SAR requirements in test 6b of this document.

Determine the minimum safe distance from the transmitter where a power density of (f_{MHz}/1500) mW/cm^2 is not exceeded.

The power density is calculated as:

$P_d = (Duty\ Cycle)*P_t*G/4\pi r^2$

Where P_d = power density in watts
P_t = transmit power in watts
G = numeric antenna gain
r = distance between body and transmitter in centimeters.

P_{dMAX} = 928/1500 = .619mW/cm^2

P_t = 23.88 dBm = 244.34 mW
Worst case duty cycle =23.9% (from the restricted bands section)

As mentioned earlier, there are two types of antennas for this product. The sleeve repeater has a gain of 2.1dBi and the pole mount repeater has a gain of 5.1dBi:
G_{sleeve} = 2.1dBi
G_{pole} = 5.1dBi
G = G_{max} = 5.1dBi = 3.24 numeric gain

Solving for r:
0.619mW/cm^2 = 0.239*244.34mW*3.24/4πr^2
r = [0.239*244.34mW*3.24/(4π∗0.619mW/cm^2)]$^{1/2}$ = *4.9 cm*

The users manual will state that a maximum safe distance of 20cm must be maintained during transmit.

Appendix A

Field Strength Measurement Procedure

This test measures the field strength of radiated emissions using a spectrum analyzer and a receiving antenna in accordance with ANSI C63.4-2003. During the test, the EUT is to be placed on a non-conducting support at 80 cm above the horizontal ground plane of the OATS. The horizontal distance between the antenna and the DUT is to be exactly 3 meters. Levels below 1 GHz are to be measured with the spectrum analyzer resolution bandwidth at 120 kHz and levels at or above 1 GHz are to be measured with the spectrum analyzer resolution bandwidth at 1 MHz.

1) Monitor the frequency range of interest at a fixed antenna height and EUT azimuth.
2) If appropriate, manipulate the system cables to produce the highest amplitude signal relative to the limit. Note the amplitude and frequency of the suspect signal.
3) Rotate the EUT 360° to maximize the suspected highest amplitude signal. If the signal or another at a different frequency is observed to exceed the previously noted highest amplitude signal by 1 dB or more, go back to the azimuth and repeat step b). Otherwise, orient the EUT azimuth to repeat the highest amplitude observation and proceed.
4) Move the antenna over its fully allowed range of travel to maximize the suspected highest amplitude signal. If the signal or another at a different frequency is observed to exceed the previously noted highest amplitude signal by 1 dB or more, return to step b) with the antenna fixed at this height. Otherwise, move the antenna to the height that repeats the highest amplitude observation and proceed.
5) Change the polarity of the antenna and repeat step b), step c), and step d). Compare the resulting suspected highest amplitude signal with that found for the other polarity. Select and note the higher of the two signals. This signal is termed the highest observed signal with respect to the limit for this EUT operational mode.