REGULATORY TEST REPORT

TITLE: 53ESS FCC/IC Test Report
AUTHOR: Drew Rosenberg

REV	CCO	*DESCRIPTION OF CHANGE*	DATE	*APPROVALS*	
		INITIAL RELEASE		Engineering	
				Engineering	

REVISION HISTORY

				Engineering	
				Engineering	
				Engineering	

Summary

Test Data Summary

FCC Part 15.249 / IC RSS-210 Sec. 6.2.2(m2)
Field strength of low power Transmitters
902-928MHz Band

FCC ID: EO9-53ESS
IC ID: 864D-53ESS

Device Model:
53ESS

Model Numbers:
53ESS

Serial Numbers:
2028

Rule	Description	Max. Reading	Pass/Fail
15.31(e)	Variation of Supply Voltage	No change	Pass
15.207/RSS-210 Sec. 6.6(a)	Powerline conducted emissions	N/A	N/A
15.249(d)/RSS-210 sec. 6.6.2(m2)(3)	Out of band non-harmonic radiated emissions	Noise Floor	Pass
15.35(b)/RSS-210 sec. 6.5	duty cycle corrections	13dBm	N/A
15.249(a)/RSS-210 Sec. 6.2.2 (m2)(1)	Radiated emissions of transmitter fundamental and harmonics	0.5dB below limit	Pass
15.31(m)	Relative field intensities at high and low frequencies of transmitter	N/A	N/A
15.249(d)	Band Edge	Noise Floor	Pass
RSP-100 Appendix II	99% Bandwidth	420kHz	Information Only

Cognizant Personnel

Drew Rosenberg	Regulatory Engineer
Name	Title
Mark Kvamme	Senior Technician
Name	Title
Nick Wagner	Test Engineer
Name	Title

TCB Submittal Checklist

Item list for TCB evaluation

Item	Completed	Confidential
Test Report	Yes	No
Test Setup Photos – Powerline Conducted Emissions	N/A	No
Test Setup Photos – Radiated Emissions	Yes	No
Internal Pictures	Yes	Yes
External Pictures	N/A	No
Schematics	Yes	Yes
Block Diagram	Yes	Yes
Operational Description	Yes	Yes
Users Manual	Yes	No
Label Drawings	Yes	No
Request for Confidentiality	Yes	No
Industry Canada RSP-100 Appendices I and II	Yes	No

Test 1: 15.31(e)

Variation of Supply Voltage

Vary the supply voltage from 85% to 115% of the nominal voltage. If the power level of the fundamental signal varies with supply voltage, record the voltage level at which the fundamental signal is at its highest and use that voltage level for all further testing.

Equipment Used	Asset Number

Date	Temp/Humidity ºF / %	Tested by

The nominal voltage is 7.5V DC. This device uses a voltage regulator that keeps the circuit power at 5 Volts as long as the input voltage level does not dip below 5.5 Volts. There is no change to the fundamental signal level as long as the input voltage remains above 5.5 Volts.

Test 2: 15.207 / RSS-210 Sec. 6.6(a)

Powerline Conducted Emissions

Equipment Used	Asset Number

Date	Temp/Humidity ºF / %	Tested by

Measure the AC powerline conducted emissions from 150kHz to 30 MHz using a 50µH/50Ω line impedance stabilization network (LISN) according to the procedure specified in ANSI C63.4. Verify that no emissions exceed the following limits:

Frequency (MHz)	Quasi-Peak (dBµV)	Average (dBµV)
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

This device is a powered by DC voltage. No AC powerline emissions are required.

Test 3: 15.209 / RSS-210 sec. 6.2(m2)(3)

Out of band non-harmonic emissions

Measure the field strength of all spurious emissions that are not harmonics according to the procedure in Appendix A. The maximum field strength shall not exceed:

Frequency (MHz)	Field Strength (μV/m)	Distance (meters)
1.705-30	30*	30*
30-88	100	3
88-216	150	3
216-960	200	3
>960	500	3

* Adjust 40dB/decade when measuring at different distances than specified.

For emissions measurements below 30MHz, rotate the loop antenna about its horizontal and vertical positions to maximize emissions.

Equipment Used	Serial Number	Cal Date	Cal Due
EMCO 6502 Loop	9509-2970	10/22/04	10/22/06
Agilent E4408B	US40240538	4/21/05	4/21/07
EMCO 3148 Log Periodic	9901-1044	10/19/04	10/19/05
EMCO 3110B Biconical Antenna	9807-3129	1/23/04	1/23/06

Date	Temp/Humidity ºF / %	Tested by
6/30/05	82/33	Mark Kvamme & Drew Rosenberg

Radiated emissions were measured from 9.0304MHz, which is the lowest frequency oscillator on the board.

Radiated emissions below 30MHz were not detectable at distances greater than approximately 1 foot. The loop antenna was rotated about its horizontal and vertical positions to maximize emissions. The *noise floor of the test equipment used* is demonstrated below:

Freq. MHz	Ant. Pos.	Level dBm		Level dBuV	Ant. Factor dB	Cable Loss dB	Distance Adjustment	**Corrected Level dBuV/m**	Limit dBuV/m	Margin dB
9.8304	H	**-78.0**	P	**29.0**	10.8	0.1	40.0	**-0.1**	29.5	29.6
15.0000	H	**-77.6**	P	**29.4**	10.8	0.1	40.0	**0.3**	29.5	29.2
19.6608	H	**-75.5**	P	**31.5**	9.6	0.2	40.0	**1.3**	29.5	28.3
25.0000	H	**-78.5**	P	**28.5**	9.6	0.2	40.0	**-1.7**	29.5	31.3
30.0000	H	**-78.3**	P	**28.7**	8.1	0.2	40.0	**-3.0**	29.5	32.5

Note: These are noise floor measurements, not device emissions.

Non-harmonic radiated emissions were first scanned in a GTEM. None of these signals could be detected at the open are test site due to their low signal level. For reference, a list of the signals found during the prescan is provided below. The measured level of the fundamental is also provided for reference:

Frequency (Mhz)	**level (dBm)**
59.15	-68
78.8	-68
226.25	-70
294.95	-69
447.45	-66
437.5	-67
452.19	-65.19
915	-1.88

Test 4: 15.35(b) / RSS-210 sec. 6.5

Pulsed Operation

Calculate the maximum duty cycle of the transmitter that will occur in any 100ms. Perform the following calculation:

$$\text{Duty Cycle}_{dB} = |20*\log(\text{Duty Cycle \%})|$$

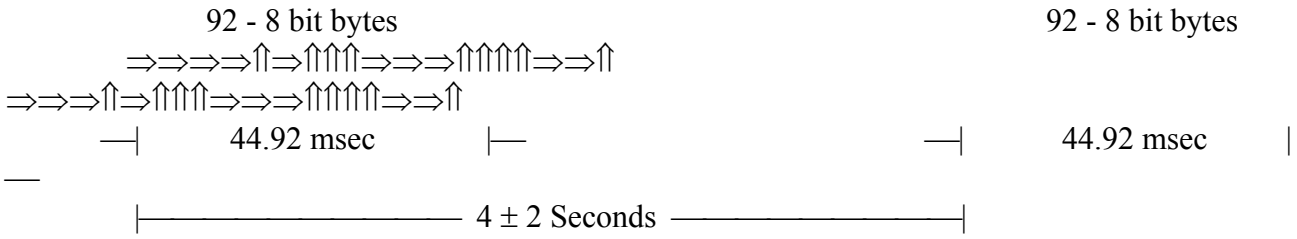
If the calculated result is less than 20dB, use that number as the relaxation factor for test 4 of this report. Otherwise, use 20dB.

Equipment Used	Asset Number

Date	Temp/Humidity ºF / %	Tested by

The Unit Transmits Manchester Encoded Messages separated by a two to six second period of time. Each of the messages is 92 bytes (736 bits) long. Each message is broadcast on a different frequency within the Transmit Band.

Zooming in on a message length:



Bit rate is: 16.384 Kbits/Second.
Message Period is: 736/16.384 Kbits / sec = 44.92 msec

During the transmission of messages, the Transmit Duty Cycle can be computed.

% Duty Cycle Transmit = (736 bits) (1/16.384 Kbits/Sec) (.5) (100%) / (100 msec)

% Duty Cycle Transmit =22.46 %

Note: The .5 factor is a result of Manchester Encoded Data.

Expressing the correction factor for Duty Cycle in dB:

dB Duty Cycle Transmit = 20 Log (Duty Cycle)
dB Duty Cycle Transmit = 20 Log (.2246)
dB Duty Cycle Transmit = -12.97 dB

Test 5: 15.249(a)/RSS-210 sec. 6.2(m2)(1)

Transmitter Fundamental and Harmonics

Measure the field strength of the transmitter fundamental and harmonic emissions at three meters according to the procedure in Appendix A. Record emissions levels with the transmitter near its lowest, middle, and highest frequencies. The maximum field strength of emissions may not exceed:

Fundamental (µV/m)	Harmonics (µV/m)
50,000	500

For harmonics, adjust for the proper duty cycle correction of up to 20dB in accordance with the results from test 3.

Equipment Used	Serial Number	Cal Date	Cal Due
Roberts Dipole	4106	09/13/04	09/13/06
EMCO 3115 Horn	9205-3878	04/13/04	04/13/06
Agilent E4408B	US40240538	4/21/05	4/21/07

Date	Temp/Humidity ºF / %	Tested by
6/17/05	82/33	Drew Rosenberg & Nick Wagner
6/20/05	83/52	Mark Kvamme
6/24/05	82/52	Mark Kvamme
6/27/05	82/64	Mark Kvamme
6/28	75/89	Mark Kvamme
6/29	82/58	Mark Kvamme
7/11	82/59	Mark Kvamme

Fundamental Emissions

The Fundamental emissions were measured in three orthogonal planes.
Receiver Bandwidths were: RBW = 120kHz. VBW = 300kHz.

This device transmits in a frequency hopping pattern. To take vertical and horizontal measurements, the receiver was set to a max hold with the span set to include the full bandwidth of emissions on the screen. After a full transmit pattern was displayed on the screen, the peak was recorded. Afterward, low, middle, and high frequency data was recorded for the normal and sideways configurations.

Freq. MHz	Ant. Pos.	Level dBm		Level dBuV	Ant. Factor dB	Cable Loss dB	**Corrected Level dBuV/m**	Limit dBuV/m	Margin dB
Sideways Configuration									
915	H	**-44.2**	P	**62.8**	29.1	1.6	**93.5**	94	0.5
915	V	**-51.3**	P	**55.7**	29.1	1.6	**86.4**	94	7.6
915.90	V	**-44.3**	P	**62.7**	29.1	1.6	**93.4**	94	0.6
914.50	V	**-44.5**	P	**62.5**	29.1	1.6	**93.2**	94	0.8
913.36	V	**-44.8**	P	**62.2**	29.1	1.6	**92.9**	94	1.1
Normal Configuration									
915	V	**-45.0**	P	**62.0**	29.1	1.6	**92.7**	94	1.3
915	H	**-47.5**	P	**59.5**	29.1	1.6	**90.2**	94	3.8
915.90	H	**-45.7**	P	**61.3**	29.1	1.6	**92.0**	94	2.0
914.78	H	**-45.7**	P	**61.3**	29.1	1.6	**92.0**	94	2.0
913.35	H	**-46.0**	P	**61.0**	29.1	1.6	**91.7**	94	2.3
laying on it's back Configuration									
915	H	**-46.7**	P	**60.3**	29.1	1.6	**91.0**	94	3.0
915	V	**-52.0**	P	**55.1**	29.1	1.6	**85.8**	94	8.2

Harmonic Emissions

Harmonic emissions were initially measured in three orthogonal planes, but only maximized in two of them, since the emissions of the unit laying on its back were significantly lower than the others.
Receiver Bandwidths were: RBW = 1MHz, VBW=3MHz. Emissions above the fourth harmonic were below the noise floor of the measurement equipment.

Freq. MHz	Ant. Pos.	Level dBm		Level dBuV	Ant. Factor dB	Cable Loss dB	Duty Cycle Factor dB	**Corrected Level dBuV/m**	Limit dBuV/m	Margin dB
Normal Configuration										
1830	V	**-77.8**	P	**29.2**	26.8	2.4	13	**45.4**	54	8.6
	H	**-74.0**	P	**33.0**	26.8	2.4	13	**49.2**	54	4.8
2745	V	**-86.7**	P	**20.3**	29.4	2.4	13	**39.1**	54	14.9
	H	**-88.3**	P	**18.7**	29.4	2.4	13	**37.5**	54	16.5
3660	V	**-91.7**	P	**15.3**	31.7	3.7	13	**37.7**	54	16.3
	H	**-88.7**	P	**18.3**	31.8	3.7	13	**40.8**	54	13.2
Sideways Configuration										
1830	V	**-73.6**	P	**33.4**	26.8	2.4	13	**49.6**	54	4.4
	H	**-81.5**	P	**25.5**	26.8	2.4	13	**41.7**	54	12.3
2745	V	**-91.9**	P	**15.1**	29.4	2.4	13	**33.9**	54	20.1
	H	**-85.4**	P	**21.6**	29.4	2.4	13	**40.4**	54	13.6
3660	V	**-93.4**	P	**13.6**	31.7	3.7	13	**36.0**	54	18.0
	H	**-92.8**	P	**14.2**	31.8	3.7	13	**36.7**	54	17.3

Test 6: FCC Part 15.31(m)

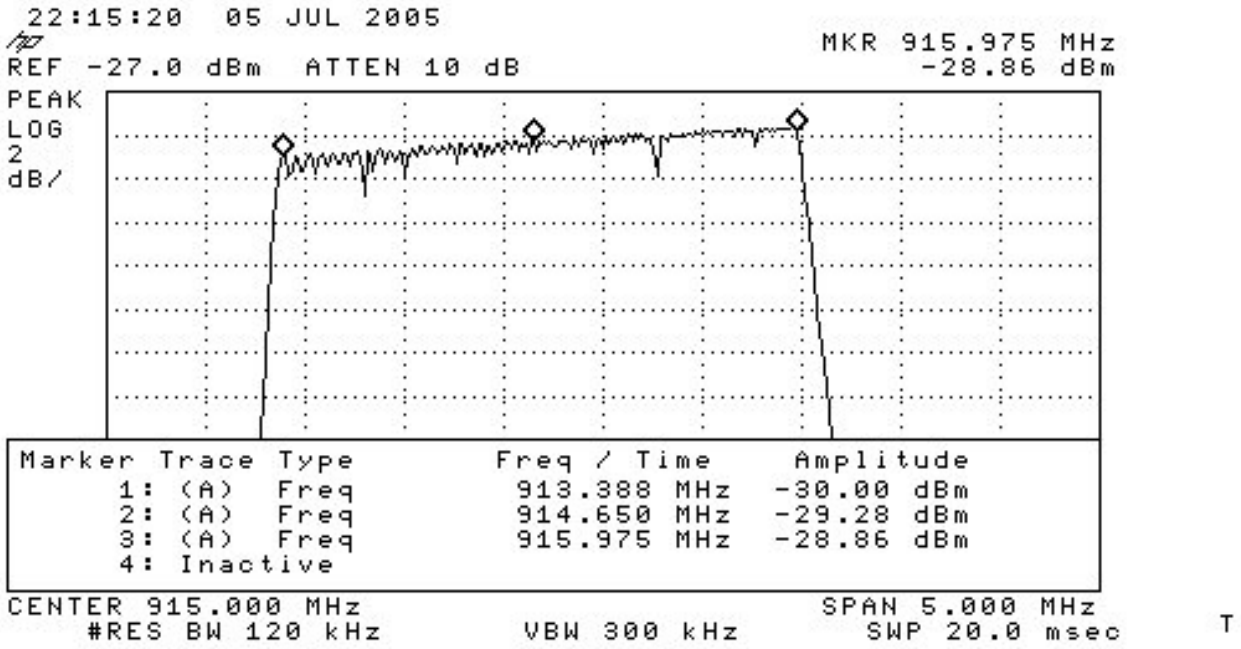
Relative Field Intensities over frequency

Use the max hold feature of the analyzer to capture the full bandwidth of transmissions. Place markers near the highest and lowest transmission frequencies to demonstrate the relative field strengths of each.

Equipment Used	Serial Number	Cal Date	Cal Due
HP 8591E	3229A00239	04/05/04	04/05/06

Date	Tested by
7/5/2005	Mark Kvamme

The unit was placed inside a GTEM® and measured to show the relative field intensities over the transmitter's hopping frequency range:



Test 7: FCC Part 15.249(d)

Band Edge

Demonstrate that the transmitter's emissions at the 902-928MHz band edge are at least 50dB below the carrier or less than 200uV/m at 3 meters, whichever is the lesser attenuation.

Equipment Used	Serial Number	Cal Date	Cal Due
Roberts Dipole	4106	09/13/04	09/13/06
Agilent E4408B	US40240538	4/21/05	4/21/07

Date	Temp/Humidity ºF / %	Tested by
07/11/05	82/59	Mark Kvamme

The transmitter does not leave the 910-920MHz range. There are no measurable emissions at the 902MHz and 928MHz band edges. Radiated emissions were measured at the FCC site to show the *noise floor of the measurement equipment* at 902MHz and 928MHz.

Freq. MHz	Ant. Pos.	Level dBm		Level dBuV	Ant. Factor dB	Cable Loss dB	**Corrected Level dBuV/m**	Limit dBuV/m	Margin dB
915	H	**-100.0**	P	**7.0**	29.1	1.6	**37.7**	54	16.3
915	V	**-100.8**	P	**6.2**	29.1	1.6	**36.9**	54	17.1

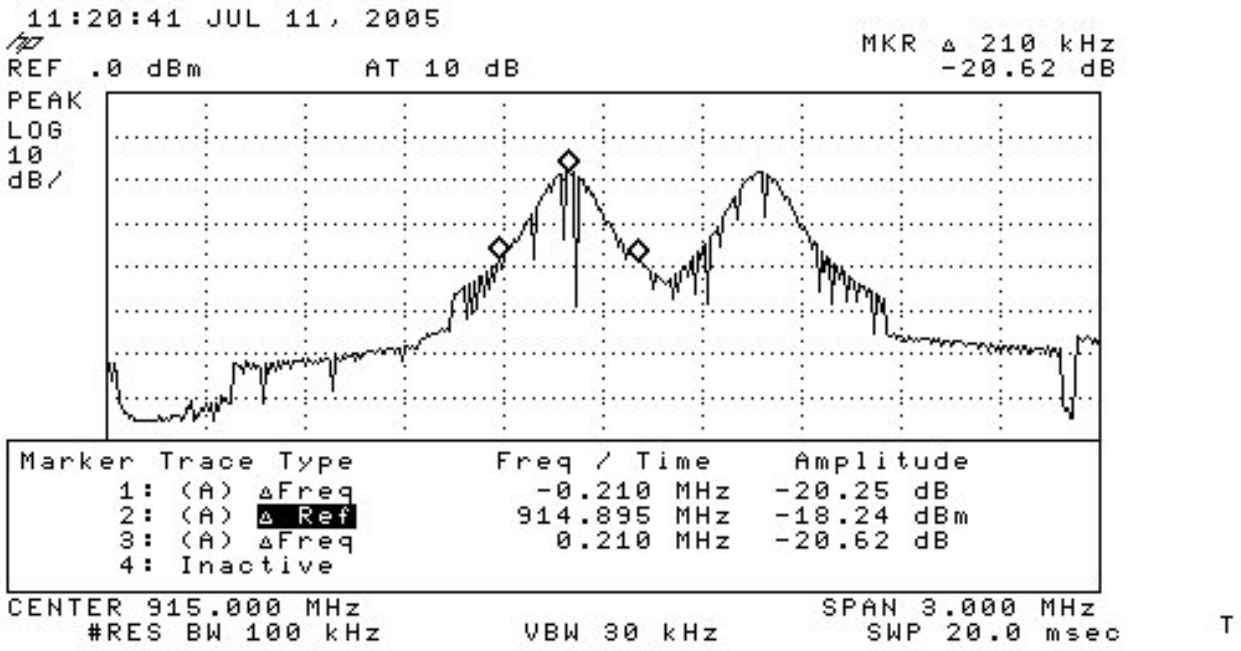
Test 8: RSP-100 Appendix II

99% Bandwidth

Capture a plot of the 99% bandwidth of a single transmission.

Equipment Used	Serial Number	Cal Date	Cal Due
Agilent E4408B	US40240538	4/21/05	4/21/07

Date	Temp/Humidity ºF / %	Tested by
07/11/05	82/59	Mark Kvamme



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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.