

EMISSIONS TEST REPORT FOR A LOW POWER TRANSMITTER**I. GENERAL INFORMATION**

Requirement: Federal Communications Commissions
Test Requirements: 15.205, 15.207, 15.209, 15.247

Applicant: Robertshaw Controls Company
d/b/a Invensys Home Control Systems

Product ID: FCC ID: **QI2-EMSL-200**

II. DESCRIPTION OF EQUIPMENT UNDER TEST (EUT)

The Invensys FCC ID: **QI2-EMSL-200** is a frequency hopping spread spectrum (FHSS) transceiver. The Invensys RF Load Control Meter (LCM) is a remote switching device that receives load control OFF and ON commands from the GoodWatts system. Commands are received via an RF Communications network. The LCM is available in 120 VAC and 240 VAC versions, identical except for transformer tap selection.

The LCM operates in the U.S. ISM band between 902 and 928 MHz. The module incorporates a microcontroller and an r.f. integrated circuit that form a frequency hopping spread spectrum transceiver operating under FCC part 15.247.

Transmitter Specification

TX Power	12dBm
Frequency Deviation (FSK)	+/- 20 kHz
Frequency of operation	905 – 924.6 MHz
Data Rate	19.2 kbps
Number of channels	50
Channel Separation	400 kHz
Typical 20dB occupied bandwidth	150 kHz

III. TEST LOCATION

All tests were performed at:

Compliance Certification Services
561F Monterey Road
Morgan Hill, CA 95037

T.N. Cokenias
EMC Consultant/Agent for Invensys

27 August 2002

1. Antenna connector requirement

The antenna is permanently attached to the product.

15.204 Antenna description

The load control module transceiver module uses a printed circuit folded dipole antenna:

Antenna description	Gain	MFR name
HCST printed ckt antenna	2.84 dBi max (z axia)	Invensys HCS

Measured antenna data and radiation patterns are presented in a separate pdf attachment.

15.247(a) Frequency hopping spread spectrum definition

Pseudorandom frequency hopping sequence:

The transmitter cannot coordinate its hopping sequence with the hopping sequence of other transmitters, or vice versa, for the purpose of avoiding the simultaneous occupancy of individual hopping frequencies by multiple transmitters

Each access unit has an individual ID number and there is no link or association between two access units so there is no simultaneous occupancy of individual hopping frequency transmission of two or more access units.

Equal hopping frequency use:

The EUT utilizes 50 hopping channels. Hopset is 50 channels long, then repeats. On average all channels are used equally.

System receiver input bandwidth and receiver hopping capability:

Receiver 26 dB bandwidth is 200 kHz, approximately equal to 26 dB bandwidth of TX. Receiver channel hops are synchronized to transmitter operating frequency.

TEST DATA and TEST PROCEDURES - CCS Laboratory

Radiated Emissions

Test Requirement: 15.205, 15.247

Out of Band Measurements

Test Requirement: 15.247

Measurement Equipment Used:

HP 8566 Spectrum Analyzer, 30-1000 MHz GHz

HP 8447D Pre-amplifier, .1 - 1300 MHz

Schaffner/Chase CBL6112B Bilog Antenna, 30 - 2000 MHz

HP 8593EM Spectrum Analyzer, 1 - 9.5 GHz

Miteq NSP2600-44 Microwave pre-amplifier, 1-26.5 GHz

EMCO 3115 Double Ridged Horn antenna, 1 - 18 GHz

Radiated emissions generated by the transmitter portion of the EUT were measured.

1. The EUT was placed on a wooden table resting on a turntable on the open air test site. The search antenna was placed 3m from the EUT. The EUT antenna was mounted vertically as per normal installation.
2. The turntable was slowly rotated to locate the direction of maximum emission at each emission falling in the restricted bands of 15.205.
3. Radiated emissions were investigated for a LOW channel, a MID channel, and HIGH channel. Emissions were investigated to the 10th harmonic.
4. Once maximum direction was determined, the search antenna was raised and lowered in both vertical and horizontal polarizations. The maximum readings so obtained are recorded in the data listed below.

Test Results: Worst case results are presented. Refer to data sheets in separate attachments. Restricted band emissions meet 54 dBuV/m. Other undesired emissions from the transmitter meet the -20 dBc requirement in 15.247(c).

22-26 August 2002
 Compliance Certification Services, Morgan Hill Open Field Site
 Invensys Metering Systmes HCS
 FCC ID: QI2-EMSL-200
 Load Control Module

Engineer; T.Nguyen
 Site A

Equipment for 1-18 GHz

HP8566B Analyzer
 MITEQ NSP2600-44 Preamp
 EMCO 3115 Antenna; S/N:2238
 Cable: 15.0 feet
 Conns: 4

Equipment for 18-26.5 GHz

HP8566B Analyzer
 HP11975A Preamp (LO)
 ARA MWH-1826B & HP11970K
 Cable: 3.0
 Conns: 4

Equipment for 26.5-40 GHz

HP8566B Analyzer
 HP 11975A Amplifier (LO)
 HP 11970A External mixer/antenna
 Cable: IF Only (321 MHz)

Spectrum Analyzer Settings

Average Peak
 RBW 1 Mhz 1 MHz
 VBW 10 Hz 1 MHz

f GHz	Dist cm	Read Pk dBuV	Read Av dBuV	AF dB/m	CL dB	Amp dB	D Corr dB	Pk E dBuV/m	Av E dBuV/m	Pk Limit dBuV/m	Margin Pk dB	Av Limit dBuV/m	Margin Av dB	Polarity	Notes	
905 MHz								108.50								
	1.810	200.0	41.8	27.9	2.9	-42.5	-3.5	26.5		88.5	-62.0			vertical	15.247, -20dBc in 100 kHz	
	2.715	200.0	60.8	57.8	3.4	-42.3	-3.5	49.3	46.3	74.0	-24.7	54.0	-7.7	vertical	15.205 restricted band	
	3.620	200.0	48.3	40.8	32.7	4.1	-42.0	-3.5	39.5	32.0	74.0	-34.5	54.0	horizontal	15.205 restricted band	
	4.525	200.0	48.3	41	34.4	4.7	-41.9	-3.5	42.0	34.7	74.0	-32.0	54.0	vertical	15.205 restricted band	
	5.430	200.0	48.8	37.5	36.2	5.3	-41.7	-3.5	45.1	33.8	74.0	-28.9	54.0	vertical	15.205 restricted band	
	6.335	200.0	48.3	37.8	36.9	5.7	-41.5	-3.5	45.9		92.0	-46.1		horizontal	15.247, -20dBc in 100 kHz	
	7.240	200.0	48.5	34.3	38.3	6.1	-41.2	-3.5	48.2		92.0	-43.8		vertical	15.247, -20dBc in 100 kHz	
	8.145	200.0	45.2	34.2	39.1	6.5	-40.3	-3.5	47.0	36.0	74.0	-27.0	54.0	vertical	15.205 restricted band	
	9.050	200.0	43.5	33.7	39.8	6.9	-39.4	-3.5	47.3	37.5	74.0	-26.7	54.0	vertical	15.205 restricted band	
915 MHz								108.00								
	1.830	200.0	41.6	28.0	2.9	-42.5	-3.5	26.5		88.5	-19.5			vertical	15.247, -20dBc in 100 kHz	
	2.745	200.0	60.9	59.2	31.0	3.4	-42.2	-3.5	49.5	47.8	74.0	-24.5	54.0	horizontal	15.205 restricted band	
	3.660	200.0	49.5	43.2	32.7	4.1	-42.0	-3.5	40.8	34.5	54.0	-13.2	54.0	vertical	15.205 restricted band	
	4.575	200.0	48.3	40.7	34.5	4.8	-41.8	-3.5	42.2		87.7	-45.5		horizontal	15.247, -20dBc in 100 kHz	
	5.490	200.0	47.7	39.8	36.3	5.3	-41.7	-3.5	44.1		87.7	-43.6		vertical	15.247, -20dBc in 100 kHz	
	6.405	200.0	47	36	37.0	5.8	-41.5	-3.5	44.8		87.7	-42.9		vertical	15.247, -20dBc in 100 kHz	
	7.320	200.0	46	35.2	38.4	6.2	-41.1	-3.5	45.9	35.1	74.0	-28.1	54.0	vertical	15.205 restricted band	
	8.235	200.0	45.2	34.2	39.2	6.6	-40.2	-3.5	47.2	36.2	74.0	-26.8	54.0	vertical	15.205 restricted band	
	9.150	200.0	43.5	33.7	39.8	7.0	-39.4	-3.5	47.4	37.6	74.0	-26.6	54.0	vertical	15.205 restricted band	
924.6 MHz								108.50								
	1.849	200.0	44.8	28.1	2.9	-42.5	-3.5	29.8		88.5	-58.7			horizontal	15.247, -20dBc	
	2.774	200.0	58.2	54.8	31.1	3.4	-42.2	-3.5	46.9	43.5	74.0	-27.1	54.0	horizontal	15.205 restricted band	
	3.698	200.0	47	38.3	32.8	4.2	-42.0	-3.5	38.4	29.7	54.0	-15.6	54.0	vertical	15.205 restricted band	
	4.623	200.0	47.3	37.3	34.6	4.8	-41.8	-3.5	41.3		88.1	-46.7		horizontal	15.247, -20dBc in 100 kHz	
	5.548	200.0	46.7	37.8	36.3	5.3	-41.7	-3.5	43.2		88.1	-44.9		vertical	15.247, -20dBc in 100 kHz	
	6.472	200.0	47.3	38.2	37.2	5.8	-41.5	-3.5	45.2		88.1	-42.9		horizontal	15.247, -20dBc in 100 kHz	
	7.397	200.0	44.3	34.5	38.5	6.2	-41.0	-3.5	44.5	34.7	99.6	-55.1	54.0	vertical	15.205 restricted band	
	8.321	200.0	45.2	34.2	39.3	6.6	-40.1	-3.5	47.4	36.4	99.6	-52.2	54.0	vertical	15.205 restricted band	
	9.246	200.0	43.5	33.7	39.8	7.0	-39.4	-3.5	47.5		88.1	-40.6		vertical	15.247, -20dBc in 100 kHz	

f Measurement Frequency
 Dist Distance to Antenna
 Read Analyzer Reading
 AF Antenna Factor

CL Cable Loss
 Amp Preamp Gain
 D Corr Distance Correct to 3 meters

Radiated Emissions

Test Requirement: 15.109

Measurement Equipment Used:

HP 8566 Spectrum Analyzer, 30-1000 MHz GHz

HP 8447D Pre-amplifier, .1 - 1300 MHz

Schaffner/Chase CBL6112B Bilog Antenna, 30 - 2000 MHz

Radiated emissions generated by the digital portion of the EUT were measured.

1. The EUT was placed on a wooden table resting on a turntable on the open air test site. The search antenna was placed 3m from the EUT. The EUT antenna was mounted vertically as per normal installation. The EUT was set to transmit continuously on the MID channel.
2. The turntable was slowly rotated to locate the direction of maximum emission at each emission falling in the restricted bands of 15.205.
3. Once maximum direction was determined, the search antenna was raised and lowered in both vertical and horizontal polarizations. The maximum readings so obtained are recorded in the data listed below.

Test Results: Worst case results are presented. Refer to data sheets in separate attachment.

Freq.	Reading	AF	Closs	Pre-amp	Level	Limit	Margin	Pol	Az	Height	Mark
(MHz)	(dBuV)	(dB)	(dB)	(dB)	(dBuV/m)	FCC_B	(dB)	(H/V)	(Deg)	(Meter)	(P/Q/A)
32.77	35.70	15.83	1.45	29.73	23.24	40.00	-16.76	3mV	360.00	1.00	P
163.84	32.70	9.84	2.70	29.33	15.91	43.50	-27.59	3mV	360.00	1.00	P
196.60	37.40	8.78	2.94	29.15	19.97	43.50	-23.53	3mV	360.00	1.00	P
229.37	35.50	10.75	3.21	29.01	20.45	46.00	-25.55	3mV	360.00	1.00	P
393.22	33.10	15.65	4.51	29.30	23.96	46.00	-22.04	3mV	360.00	1.00	P
425.99	38.00	16.23	4.74	29.45	29.52	46.00	-16.48	3mV	360.00	1.00	P
30.74	33.20	16.63	1.40	29.74	21.49	40.00	-18.51	3mV	360.00	1.00	P
40.98	38.10	12.75	1.62	29.69	22.78	40.00	-17.22	3mV	360.00	1.00	P
61.48	34.50	5.62	1.89	29.64	12.37	40.00	-27.63	3mV	360.00	1.00	P
122.94	34.20	11.80	2.38	29.50	18.88	43.50	-24.62	3mV	360.00	1.00	P
133.16	31.90	11.34	2.45	29.46	16.24	43.50	-27.26	3mV	360.00	1.00	P
143.43	35.10	10.81	2.53	29.42	19.02	43.50	-24.48	3mV	360.00	1.00	P
153.68	36.30	10.28	2.63	29.38	19.82	43.50	-23.68	3mV	360.00	1.00	P
163.92	34.30	9.84	2.70	29.33	17.51	43.50	-25.99	3mV	360.00	1.00	P
174.23	33.80	9.33	2.77	29.30	16.60	43.50	-26.90	3mV	360.00	1.00	P
32.22	34.40	16.05	1.43	29.74	22.14	40.00	-17.86	3mV	360.00	1.00	P
35.84	34.60	14.68	1.52	29.72	21.08	40.00	-18.92	3mV	360.00	1.00	P
39.38	33.70	13.55	1.60	29.69	19.15	40.00	-20.85	3mV	360.00	1.00	P
42.96	35.40	11.53	1.65	29.68	18.89	40.00	-21.11	3mV	360.00	1.00	P
46.54	37.20	9.40	1.70	29.68	18.62	40.00	-21.38	3mV	360.00	1.00	P
Total data #: 20											
V.2b											

[illegible]

AC Line Conducted Emissions

Test Requirement: 15.107, 15.207

Measurement Equipment Used:

Rohde & Schwarz EMI Receiver ESHS-20

Fischer Custom Communication LISN, FCC-LISN-50/250-25-2

Test Procedure

1. The EUT was placed on a wooden table 40 cm from a vertical ground plane and approximately 80 cm above the horizontal ground plane on the floor. The EUT was set to transmit in normally.
2. Line conducted data was recorded for both NEUTRAL and HOT lines.

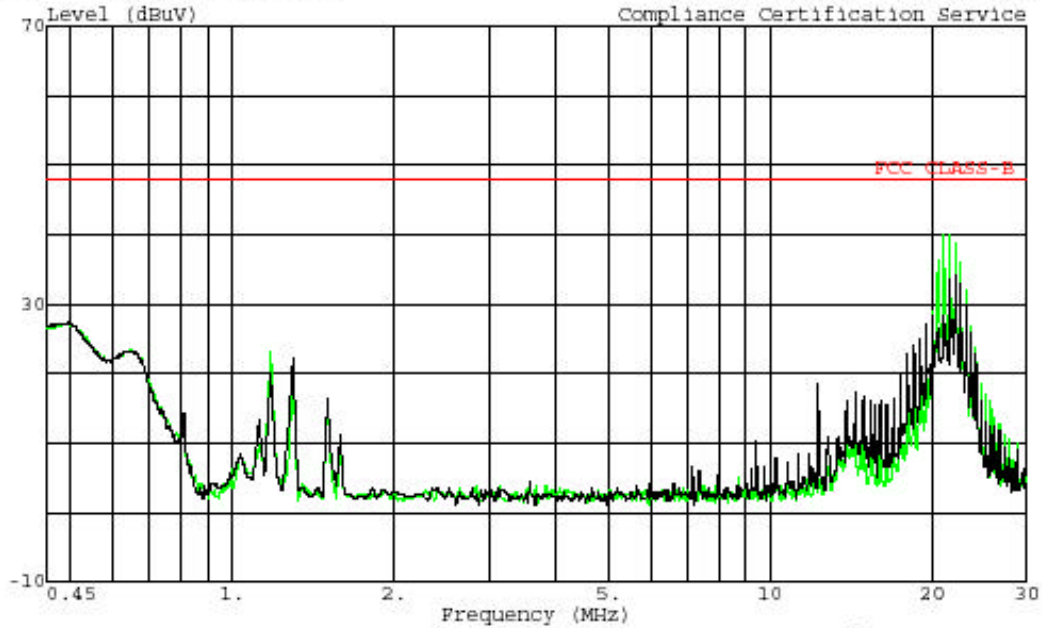
Test Results

PASS. Refer to data sheets below. Data is presented for 120 VAC and 240 VAC models.



561F Monterey Road,
San Jose, CA 95037 USA
Tel: (408) 463-0885
Fax: (408) 463-0888

Data#: 7 File#: 0822LC1.EMI Date: 08-22-2002 Time: 11:37:59



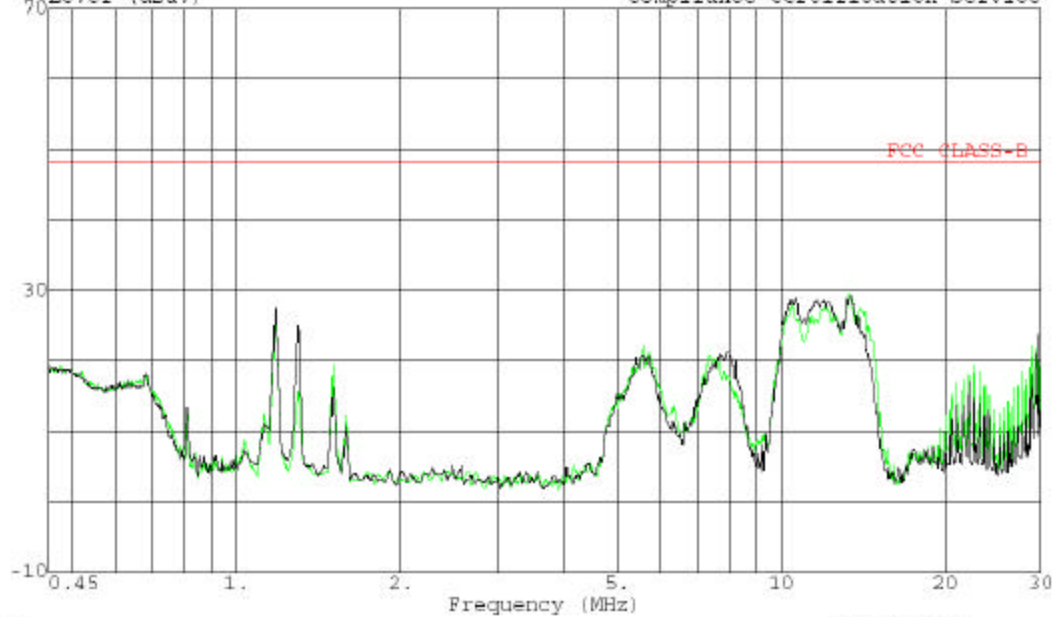
Trace: 3
Project # : 02U1490-1
Test Engineer: Mike Heckrotte
Company : Invensys
EUT : Load Control Module
Model: TBA (120V)
Test Config. : EUT with 75 Watt Load
Mode of Op. : Normal Operation
Peak: L1 (Black), L2 (Green)
: 115Vac, 60Hz

Ref Trace:



561F Monterey Road,
San Jose, CA 95037 USA
Tel: (408) 463-0885
Fax: (408) 463-0888

Data#: 7 File#: 0822LC3.EMI Date: 08-22-2002 Time: 12:24:06
Level (dBuV) Compliance Certification Service



Trace: 3
Project # : 0201490-1
Test Engineer: Mike Heckrotte
Company : Invensys
EUT : Load Control Module
: Model: TBA (240V)
Test Config.: EUT with 150 Watt Load
Mode of Op. : Normal Operation
: Peak: L1(Black), L2(Green)
: 240Vac, 60Hz

Ref Trace:

Minimum 20 dB Bandwidth for FHSS

Test Requirement: 15.247

Measurement Equipment Used:

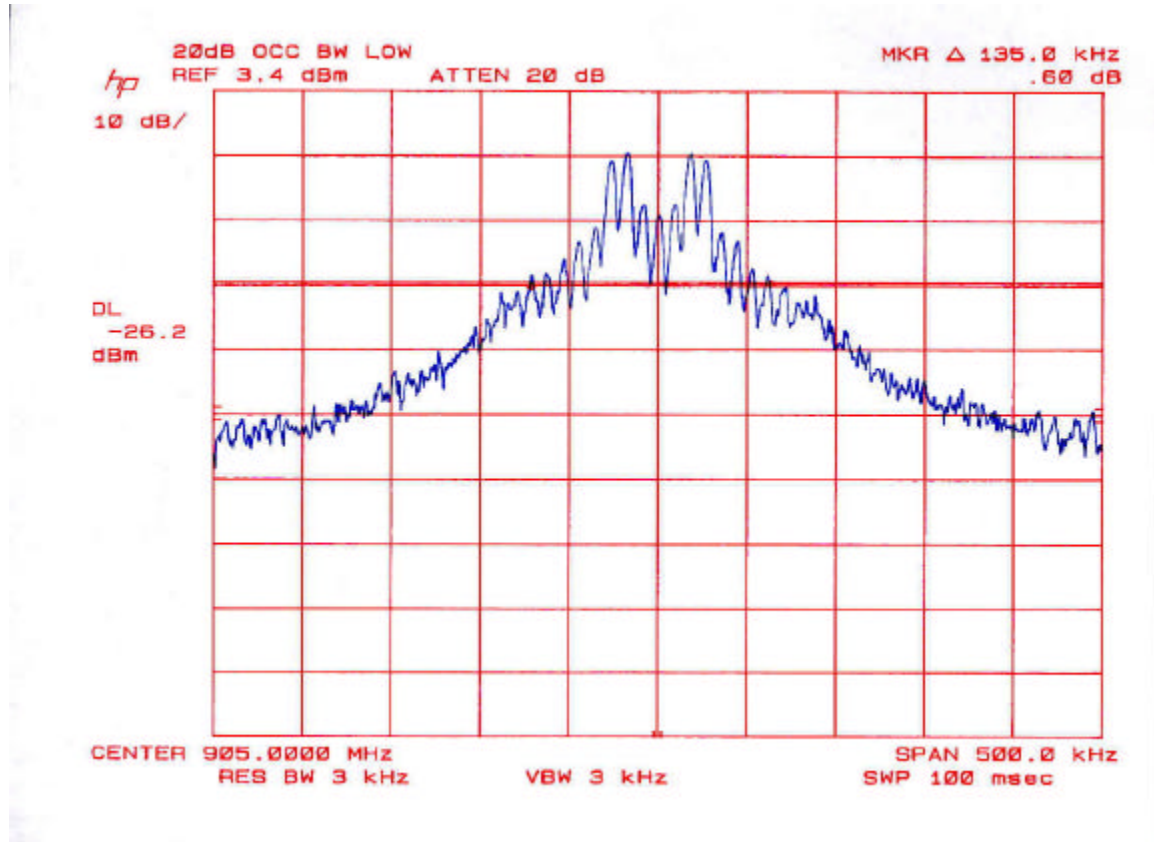
HP 8593EM Spectrum Analyzer
6' length cable with loop pickup

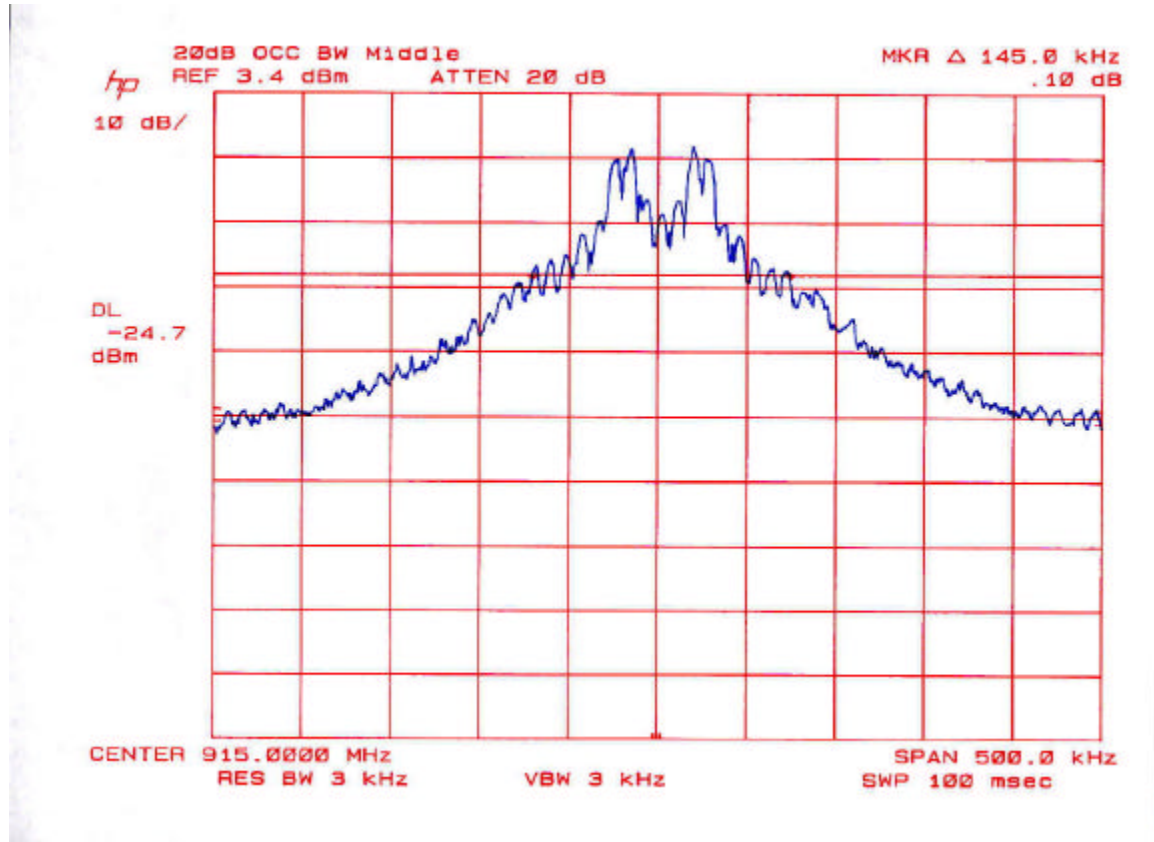
Test Procedures

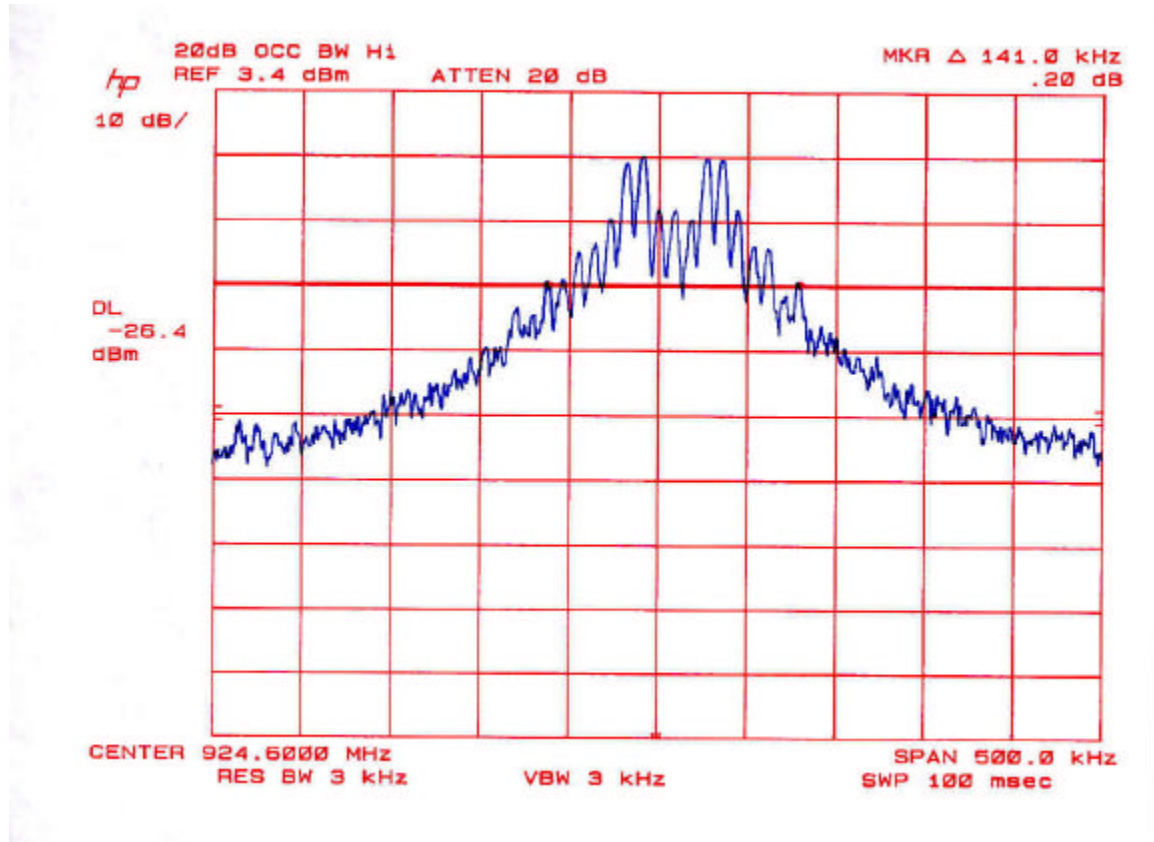
The EUT was configured on a test bench. The EUT's hopping function was stopped, transmission was continuous at 915 MHz (LOW channel). While the transmitter broadcast a steady stream of digital data, the loop was placed around the antenna of the EUT, while the analyzer MAX HOLD function was used to capture the envelope of the transmission occupied bandwidth.

Test was repeated for MID and HIGH channels.

Test Results: Measured 145 kHz, design 150 kHz. Refer to data sheets below.

15.247 Minimum 20 dB FHSS Channel Bandwidth LOW channel

15.247 Minimum 20 dB FHSS Channel Bandwidth MID channel

15.247 Minimum 20 dB FHSS Channel Bandwidth HIGH channel

RF Power Output**Test Requirement: 15.247****Measurement Equipment Used:**

HP 8566 Spectrum Analyzer, 30-1000 MHz GHz

HP 8447D Pre-amplifier, .1 - 1300 MHz

Test Procedures

Because the EUT antenna is permanently attached, RF output power was calculated from radiated emissions data taken at 3m. The relationship between transmitter power, antenna gain, and field strength at 3m is

$E \text{ V/m} = ((30 \cdot PW \cdot G)) / 3 \text{ meters}$ (E in volts/m, P in watts, G numeric gain over isotropic)

Converting to logarithms and combining terms,

$E@3m, \text{ dBuV/m} = (95.1 \text{ dB} + \text{PdBm} + \text{GdBi}) \text{ dBuV/m}$

Re-arranging terms:

$\text{PdBm} = E@3m, \text{ dBuV/m} - 95.1\text{dB} - \text{GdBi}$

1. The EUT was placed on a wooden table resting on a turntable on the open air test site. The search antenna was placed 3m from the EUT. The EUT antenna was mounted vertically as per normal installation.
2. Radiated emissions at the fundamental frequency were investigated for a LOW channel, a MID channel, and HIGH channel.
- 3 Once maximum direction was determined, the search antenna was raised and lowered in both vertical and horizontal polarizations. The maximum readings so obtained are recorded in the data listed below.

Test Results

Radiated field level readings converted to power in dBm shown below:

Channel No.	Frequency	E@3m, dBuV/m	Gain, dBi	Pcalc., dBm
1	905	108.5	2.84(z)	10.56
26	915	108	2.84(z)	10.06
50	924.6	108.5	2.84(z)	10.56

Maximum output power is within 2dBm of design typical maximum 12 dBm.

Minimum Number of Hopping Channels

Test Requirement: 15.247(a)(1)(ii)

Measurement Equipment Used:

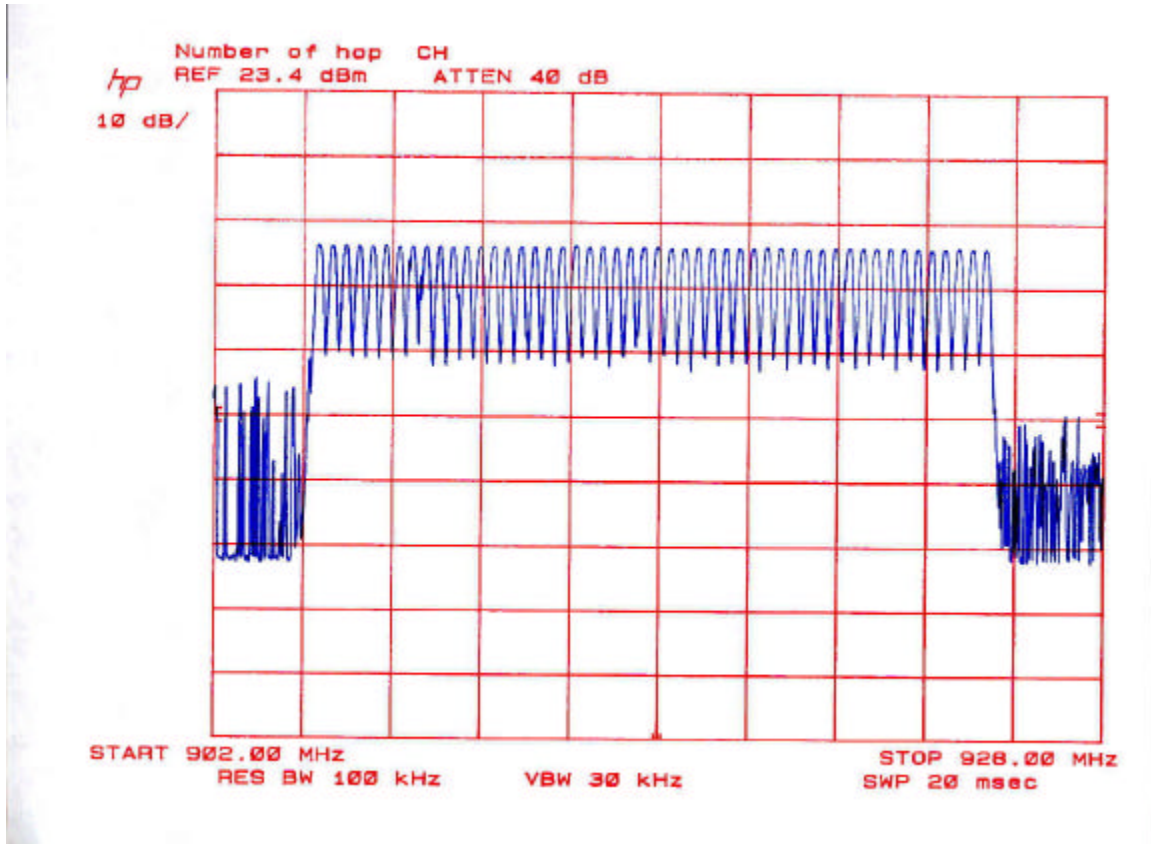
HP 8593EM Spectrum Analyzer
6' length cable with loop pickup

Test Procedures

1. The EUT was configured on a test bench. The EUT's hopping function was activated.
2. While the transmitter broadcast a steady stream of digital data, the loop was placed around the antenna of the EUT, while the analyzer MAX HOLD function was used to capture the emissions over a 3 minute period.

Test Results

A total of 50 hopping channels were counted. This corresponds to design. Refer to attached data sheet.

15.247(a)(1)(ii) Minimum number of hopping channels

Channel separation: 400 kHz (minimum separation = 25 kHz or 20 dB BW)

Average Time of Channel Occupancy

Test Requirement: 15.247

Measurement Equipment Used:

HP 8593EM Spectrum Analyzer
6' length cable with loop pickup

Test Procedure

1. The EUT was configured on a test bench. The EUT's hopping function was activated.
2. Spectrum analyzer center frequency was set to 915 MHz, one of the EUT hopping frequency. SWEEP TIME was adjusted until an accurate hop duration time could be displayed. VIDEO TRIGGER was used to capture the signal. The loop was placed over the EUT antenna.
3. Spectrum analyzer center frequency was set to 915 MHz, span 0 Hz, sweep time 20 sec, the loop was placed around the antenna of the EUT.
4. While the transmitter broadcast a steady stream of digital data, spectrum analyzer captured the ON time of the 905 MHz transmission during 20 seconds.
5. Step 3 was repeated 5 times. The channel occupancy time was determined as being the average of the 5 data runs.

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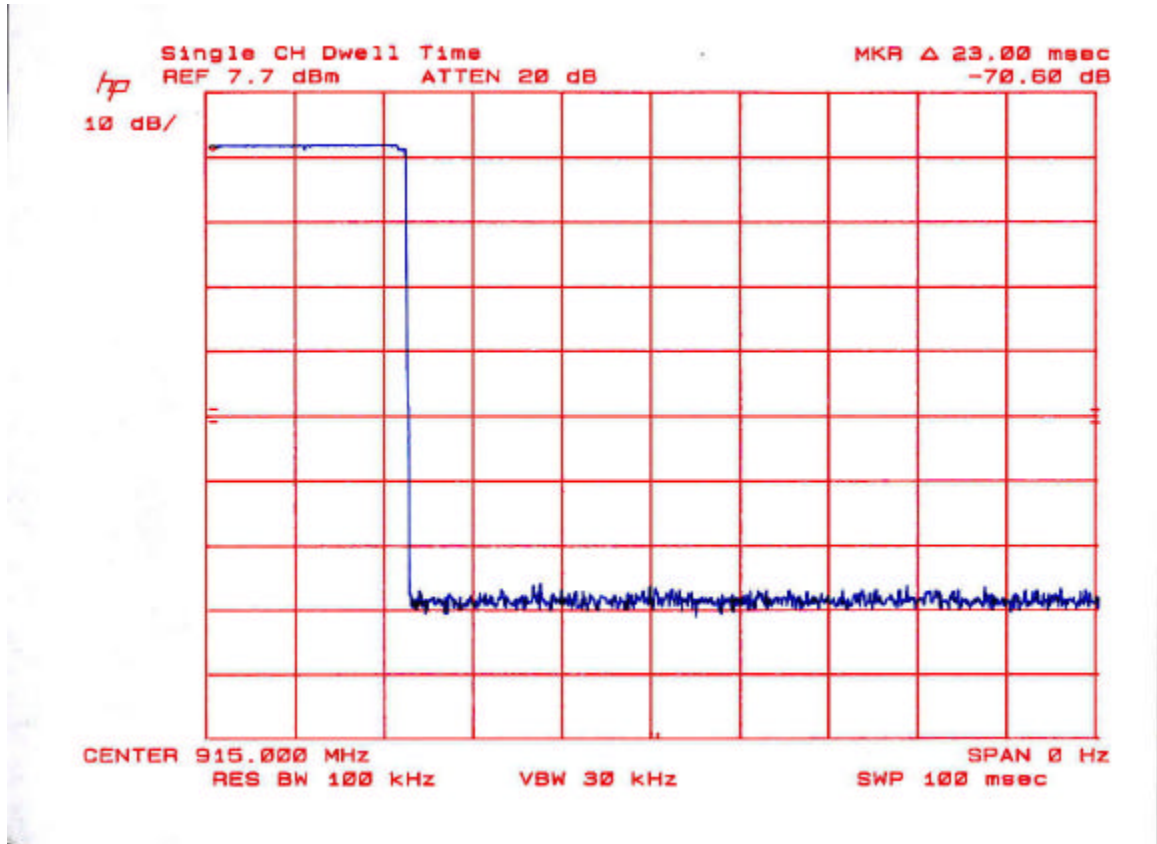
Test Results

Refer to graphs below.

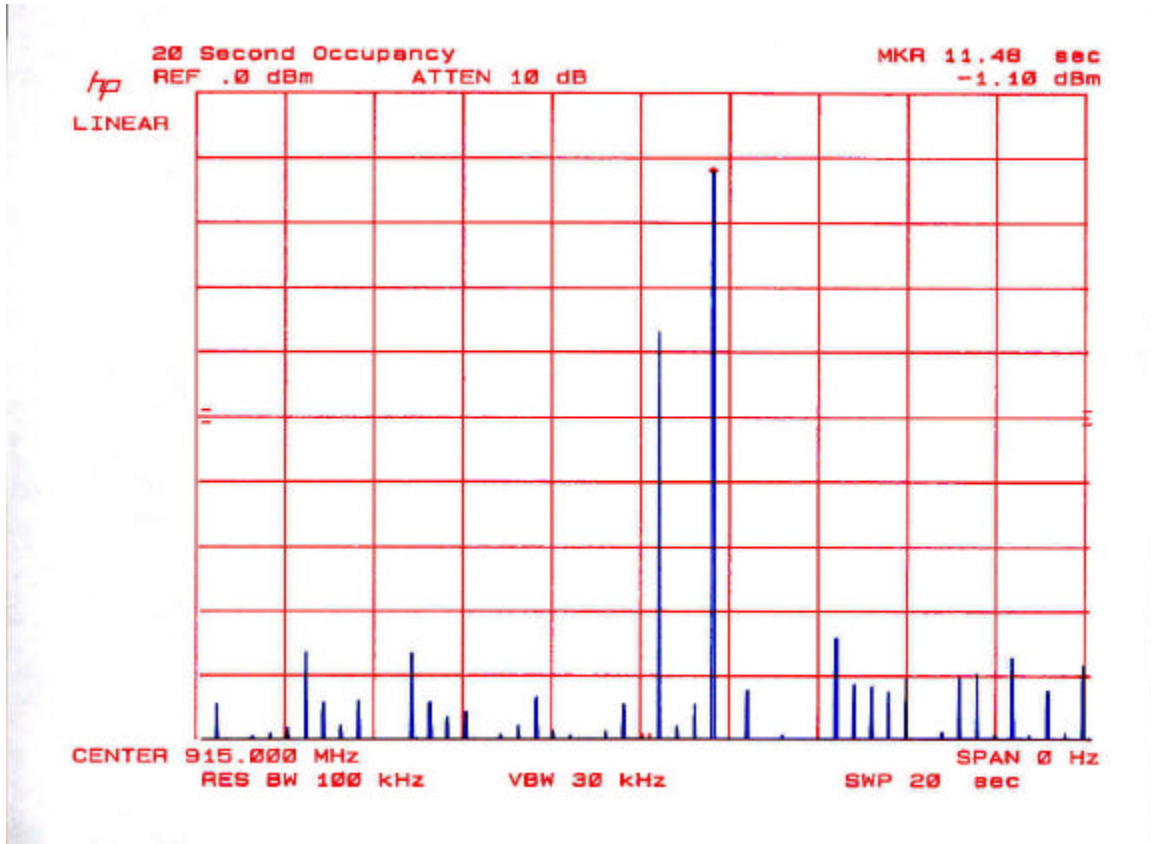
Occupancy in 20 second period is 23 msec x 2 hits = 46 msec total.

Maximum allowed: 400 msec in 20 seconds

TX Time per Hop



TX Hops in 20 seconds



RF Exposure (MPE) Calculations

905 - 924.6 MHz Frequency Hopping Spread Spectrum Radio

Applicant: Robertshaw Controls Company

FCC ID: QI2-EMSL-200

RF Hazard Distance Calculation (worst case)

mW/cm2 from Table1: 0.60

Max RF Power P, dBm	TX Antenna G, dBi	MPE Safe Distance, cm
10.56	2.84	1.3

Basis of Calculations:

$$E^2/3770 = S, \text{ mW/cm}^2$$

$$E, \text{ V/m} = (P_{\text{watts}} * G_{\text{gain}} * 30)^{.5} / d, \text{ meters}$$

$$d = ((P_{\text{watts}} * G * 30) / (3770 * S))^{0.5}$$

$$P_{\text{watts}} * G_{\text{gain}} = 10^{(P_{\text{dBm}} - 30 + G_{\text{dBi}}) / 10}$$

NOTE: For mobile or fixed location transmitters, minimum separation distance is 20 cm, even if calculations indicate MPE distance is less