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-EMST-100**

II. DESCRIPTION OF EQUIPMENT UNDER TEST (EUT)

The Invensys FCC ID: **QI2-EMST-100**is a frequency hopping spread spectrum (FHSS) transceiver. The Invensys "RF Thermostat" unit provides monitoring, management and control of a residential HVAC system. It utilizes an iCon Thermostat transceiver module to communicate with the RF Gateway unit

The Thermostat Transceiver Module 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 29 July 2002
EMC Consultant/Agent for Invensys

1. Antenna connector requirement

The antenna is permanently attached to the product.

15.204 Antenna description

The thermostat transceiver module uses a printed circuit folded dipole antenna:

Antenna description	Gain	MFR name
HCST printed ckt antenna	5.64 dBi max	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 10^{th} 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).

24-26 July 2002 Engineer C. Pang
Compliance Certification Services, Morgan Hill Open Field Site Site A
Invensys Metering Systmes HCS
FCC ID: QI2-EMST-100
Thermostat

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								**111.99**							
1.810	300.0	35		27.9	2.9	-42.5	0.0	23.3		92.0	-68.7			vertical	15.247, -20dBc in 100 kHz
2.715	300.0	49.7	41	30.9	3.4	-42.3	0.0	41.7	33.0	74.0	-32.3	54.0	-21.0	vertical	15.205 restricted band
3.620	300.0	46.3	35	32.7	4.1	-42.0	0.0	41.1	29.8	74.0	-32.9	54.0	-24.2	horizontal	15.205 restricted band
4.525	300.0	45	33.7	34.4	4.7	-41.9	0.0	42.2	30.9	74.0	-31.8	54.0	-23.1	vertical	15.205 restricted band
5.430	300.0	45.2	33.7	36.2	5.3	-41.7	0.0	45.0	33.5	74.0	-29.0	54.0	-20.5	vertical	15.205 restricted band
6.335	300.0	44.5	33.7	36.9	5.7	-41.5	0.0	45.6		92.0	-46.4			vertical	15.247, -20dBc in 100 kHz
7.240	300.0	44.2	34.3	38.3	6.1	-41.2	0.0	47.4		92.0	-44.6			vertical	15.247, -20dBc in 100 kHz
8.145	300.0	44	34	39.1	6.5	-40.3	0.0	49.4	39.4	74.0	-24.6	54.0	-14.6	vertical	15.205 restricted band
9.050	300.0	44.8	33.7	39.8	6.9	-39.4	0.0	52.1	41.0	74.0	-21.9	54.0	-13.0	vertical	15.205 restricted band
915 MHz								**107.69**							
1.830	300.0	36.2		28.0	2.9	-42.5	0.0	24.6		87.7	-20.0			vertical	15.247, -20dBc in 100 kHz
2.745	300.0	47.5	36.7	31.0	3.4	-42.2	0.0	39.7	28.9	74.0	-34.3	54.0	-25.1	horizontal	15.205 restricted band
3.660	300.0	47.8	38	32.7	4.1	-42.0	0.0	42.6	32.8	54.0	-11.4	54.0	-21.2	vertical	15.205 restricted band
4.575	300.0	47.5	36	34.5	4.8	-41.8	0.0	44.9		87.7	-42.8			vertical	15.247, -20dBc in 100 kHz
5.490	300.0	46	35	36.3	5.3	-41.7	0.0	45.9		87.7	-41.8			vertical	15.247, -20dBc in 100 kHz
6.405	300.0	44.7	33.6	37.0	5.8	-41.5	0.0	46.0		87.7	-41.7			vertical	15.247, -20dBc in 100 kHz
7.320	300.0	44.5	34.2	38.4	6.2	-41.1	0.0	48.0	37.7	74.0	-26.0	54.0	-16.3	vertical	15.205 restricted band
8.235	300.0	44.8	34	39.2	6.6	-40.2	0.0	50.4	39.6	74.0	-23.6	54.0	-14.4	vertical	15.205 restricted band
9.150	300.0	44.7	33.3	39.8	7.0	-39.4	0.0	52.1	40.7	74.0	-21.9	54.0	-13.3	vertical	15.205 restricted band
924.6 MHz								**108.08**							
1.849	300.0	35		28.1	2.9	-42.5	0.0	23.5		88.1	-64.6			vertical	15.247, -20dBc
2.774	300.0	49	39	31.1	3.4	-42.2	0.0	41.3	31.3	74.0	-32.7	54.0	-22.7	vertical	15.205 restricted band
3.698	300.0	47	35	32.8	4.2	-42.0	0.0	41.9	29.9	54.0	-12.1	54.0	-24.1	vertical	15.205 restricted band
4.623	300.0	45	34	34.6	4.8	-41.8	0.0	42.6		88.1	-45.5			horizontal	15.247, -20dBc in 100 kHz
5.548	300.0	45.5	34.2	36.3	5.3	-41.7	0.0	45.5		88.1	-42.6			vertical	15.247, -20dBc in 100 kHz
6.472	300.0	45.5	35	37.2	5.8	-41.5	0.0	46.9		88.1	-41.1			vertical	15.247, -20dBc in 100 kHz
7.397	300.0	44.3	34.5	38.5	6.2	-41.0	0.0	48.0	38.2	99.6	-51.6	54.0	-15.8	vertical	15.205 restricted band
8.321	300.0	44	34	39.3	6.6	-40.1	0.0	49.8	39.8	99.6	-49.8	54.0	-14.2	vertical	15.205 restricted band
9.246	300.0	44.5	33.5	39.8	7.0	-39.4	0.0	52.0		88.1	-36.1			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.

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.

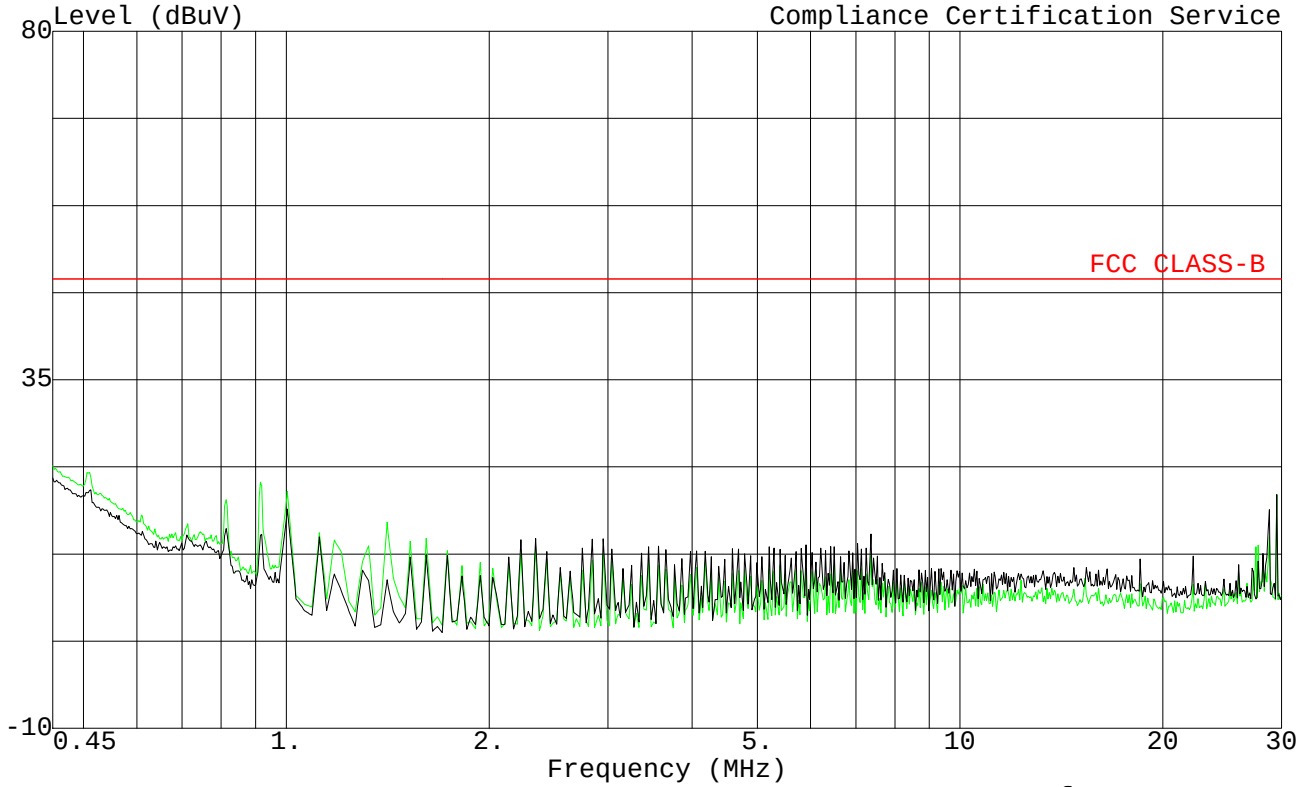
Test Results

PASS. Refer to data sheet below.

COMPLIANCE Engineering Service, Inc.
FCC,VCCI,CISPR,CE
UL,CSA,TUV

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

Data#: 7 File#: 1426LC.EMI Date: 07-24-2002 Time: 14:21:29



Trace: 3 Ref Trace:

Project # : 02U1426-1
Test Engineer: chin pang
Company : INVENSYS
EUT : Wall Thermal Stat
: TBD
Test Config : EUT only
Type of Test : FCC Class B
Mode of Op. : Continous Transmit
: L1: Peak: (Green) , L2: Peak (Black)
: 115Vac, 60Hz

Minimum 20 dB Bandwidth for FHSS
Test Requirement: 15.247

Measurement Equipment Used:

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

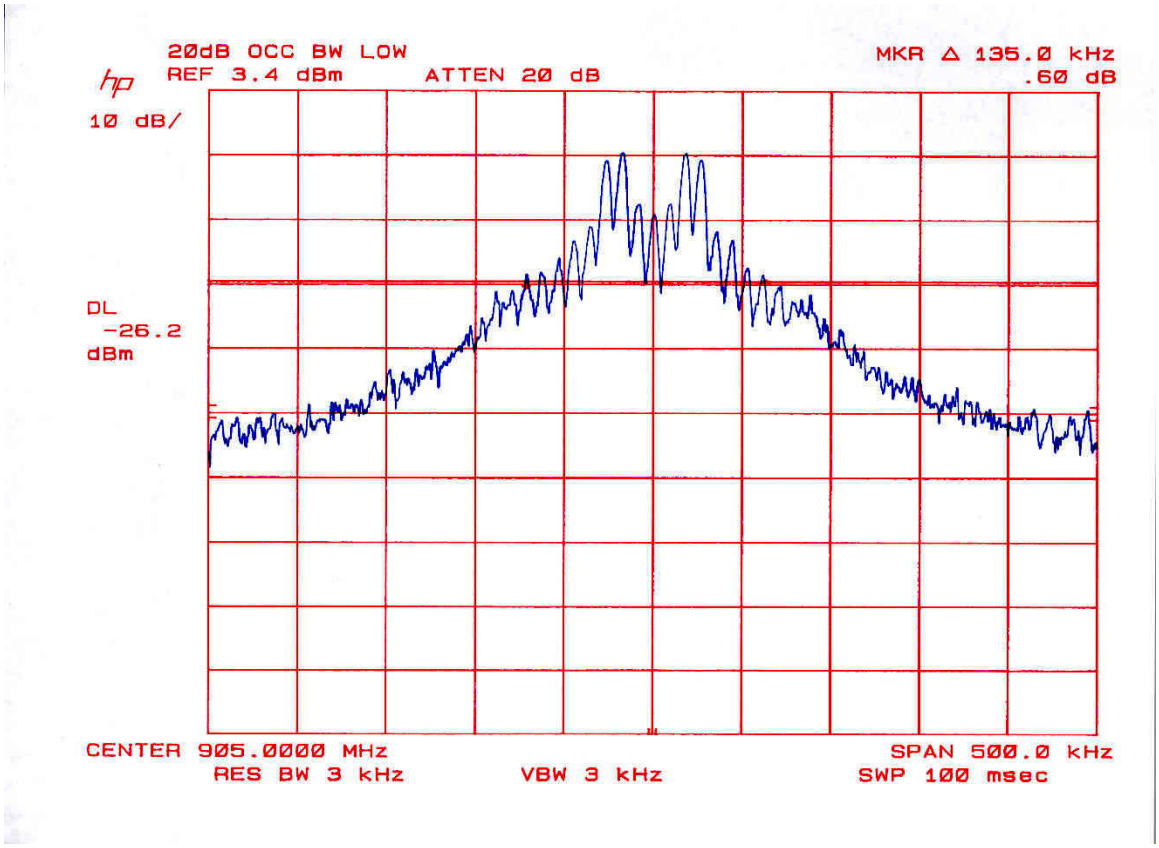
Test Procedures

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.

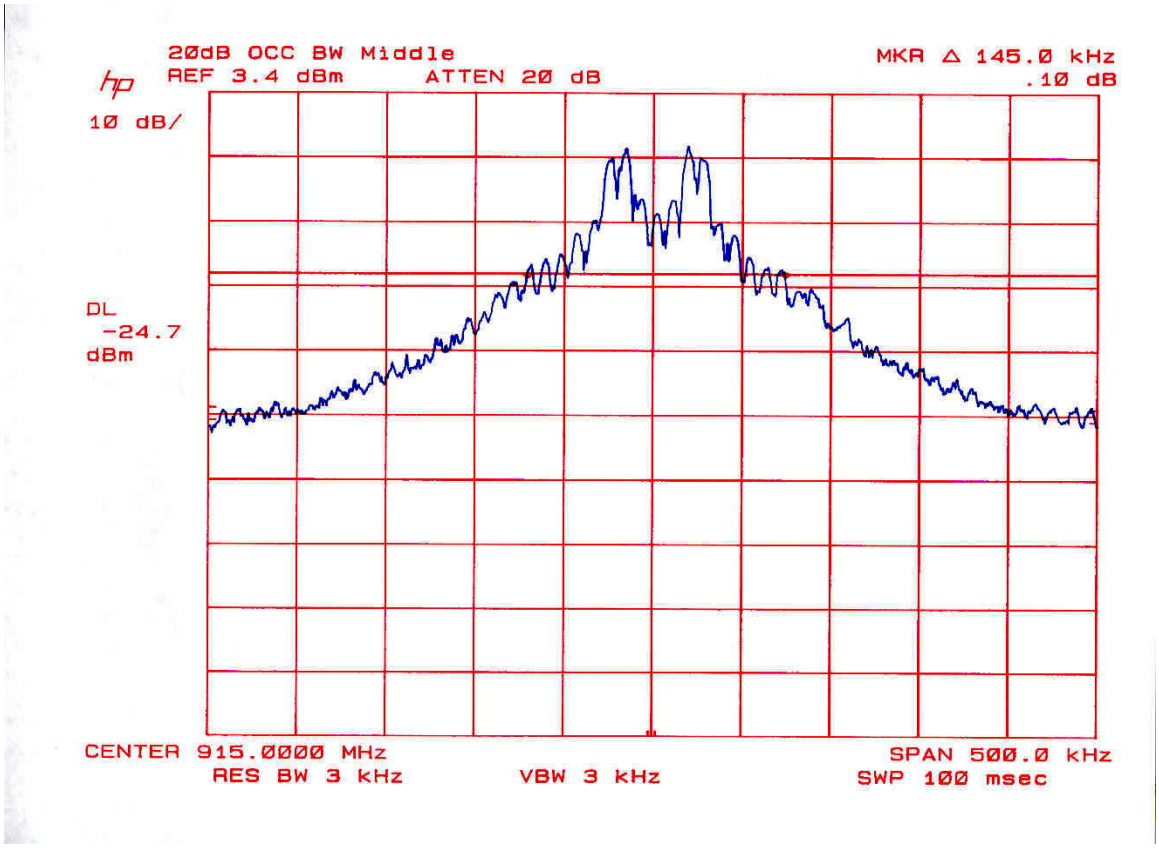
Test was repeated for MID and HIGH channels.

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

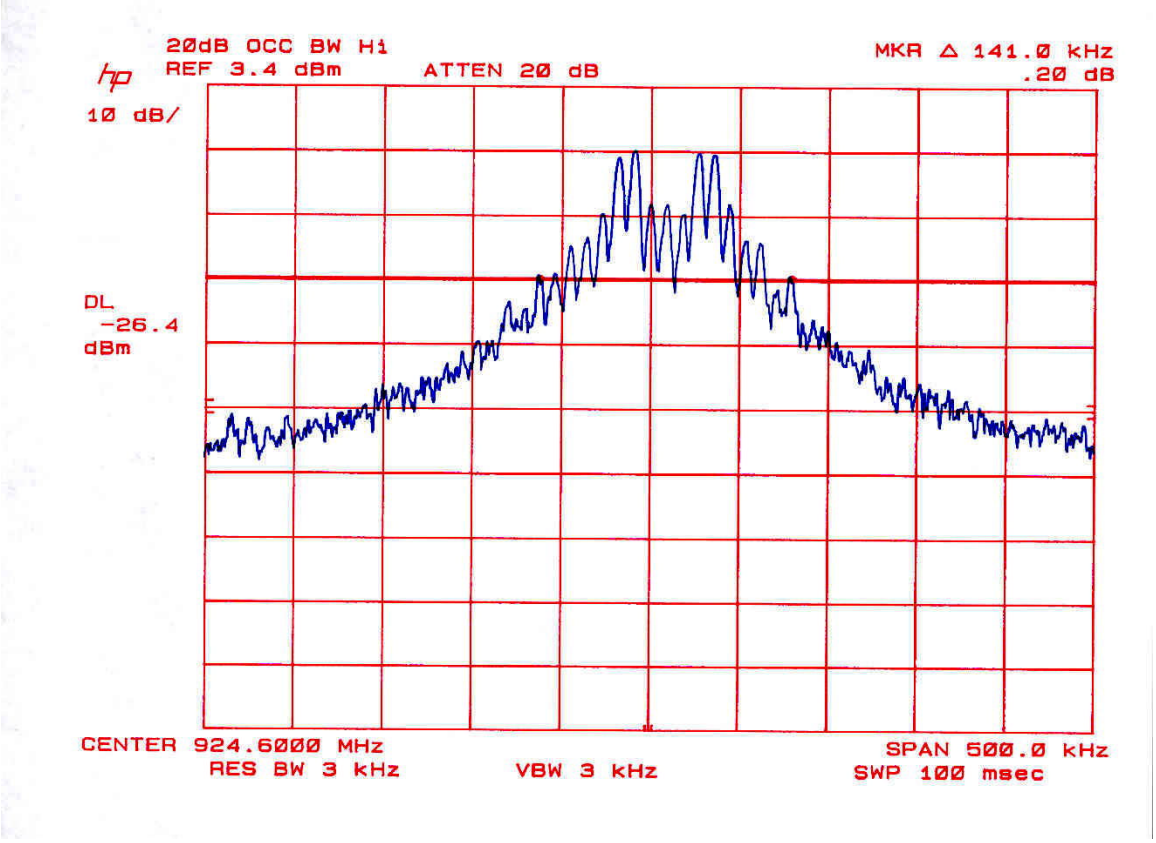
15.247 Minimum 20 dB FHSS Channel Bandwidth LOW channel



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 V/m = (√(30*PW*G))/3 meters (E in volts/m, P in watts, G numeric gain over isotropic)

Converting to logarithms and combining terms,

E@3m, dBuV/m = (95.1 dB + PdBm + GdBi) dBuV/m

Re-arranging terms:

PdBm = E@3m, dBuV/m - 95.1dB - 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	111.9	5.64	11.16
26	915	107.7	5.64	6.96
50	9243.6	108.1	5.64	7.36

Maximum output power is within 0.84 dBm of design typical maximum 12 dBm.

COMPLIANCE Certification Services

FCC, VCCI, CISPR, CE, AUSTEL, NZ
UL, CSA, TUV, BSMI, DHHS, NVLAP

561F MONTEREY ROAD, SAN JOSE, CA 95037-9001
PHONE: (408) 463-0885 FAX: (408) 463-0888

Project #: 02U1426-1
Report #: 020726A1
Date& Time: 07/26/02 1:49 PM
Test Engr: Chin Pang

Company: Invensys
EUT Description: Thermal Stat
Test Configuration : EUT only
Type of Test: FCC Part 15.247
Mode of Operation: Tx/Rcv

(•) A-Site ( ) B-Site ( ) C-Site ( ) F-Site [6 Worst Data] 07/26/02

Freq. (MHz)	Reading (dBuV)	AF (dB)	Closs (dB)	Pre-amp (dB)	Level (dBuV/m)	Limit FCC_B	Margin (dB)	Pol (H/V)	Az (Deg)	Height (Meter)	Mark (P/Q/A)
7.3727Mhz(CPU) & 10.245Mhz (RF Board)											
44.24	43.70	12.25	1.02	27.63	29.34	40.00	-10.66	3mV	180.00	1.00	P
140.48	43.90	14.80	1.83	27.46	33.07	43.50	-10.43	3mV	90.00	1.20	P
192.00	44.00	15.85	2.19	27.27	34.77	43.50	-8.73	3mV	90.00	1.20	P
43.65	44.50	12.34	1.01	27.63	30.22	40.00	-9.78	3mH	90.00	2.00	P
80.32	44.20	7.46	1.37	27.61	25.42	40.00	-14.58	3mH	180.00	1.75	P
190.87	44.10	15.75	2.18	27.27	34.76	43.50	-8.74	3mH	180.00	2.00	P
398.00	47.50	15.60	3.24	27.80	38.55	46.00	-7.45	3mV	180.00	1.20	P
450.00	46.60	16.80	3.47	28.11	38.76	46.00	-7.25	3mV	90.00	1.20	P
479.20	47.60	17.48	3.59	28.28	40.39	46.00	-5.61	3mV	180.00	1.00	P
670.00	44.70	20.69	4.28	28.59	41.09	46.00	-4.91	3mV	180.00	1.00	P
950.00	40.00	23.18	5.22	28.31	40.09	46.00	-5.91	3mV	0.00	1.00	P
Fundamental Frequency: 905, 915 & 924.6Mhz											
905.00	112.80	22.57	5.05	28.43	111.99	46.00	65.99	3mV	150.00	1.75	P
905.00	105.50	22.57	5.05	28.43	104.69	46.00	58.69	3mH	0.00	1.70	P
705.70	44.20	21.40	4.40	28.60	41.40	46.00	-4.60	3mH	180.00	1.20	P
735.30	43.80	20.80	4.50	28.59	40.51	46.00	-5.49	3mH	180.00	1.00	
915.00	108.30	22.70	5.09	28.40	107.69	46.00	61.69	3mV	0.00	1.70	P
915.00	106.00	22.70	5.09	28.40	105.39	46.00	59.39	3mH	0.00	1.75	P
924.60	108.50	22.83	5.12	28.37	108.08	46.00	62.08	3mV	0.00	1.65	P
924.60	106.60	22.83	5.12	28.37	106.18	46.00	60.18	3mH	0.00	1.70	P
Completed scan 30-1000Mhz, Verticak & Horizontal											
Total data #: 19											
V.2a											

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

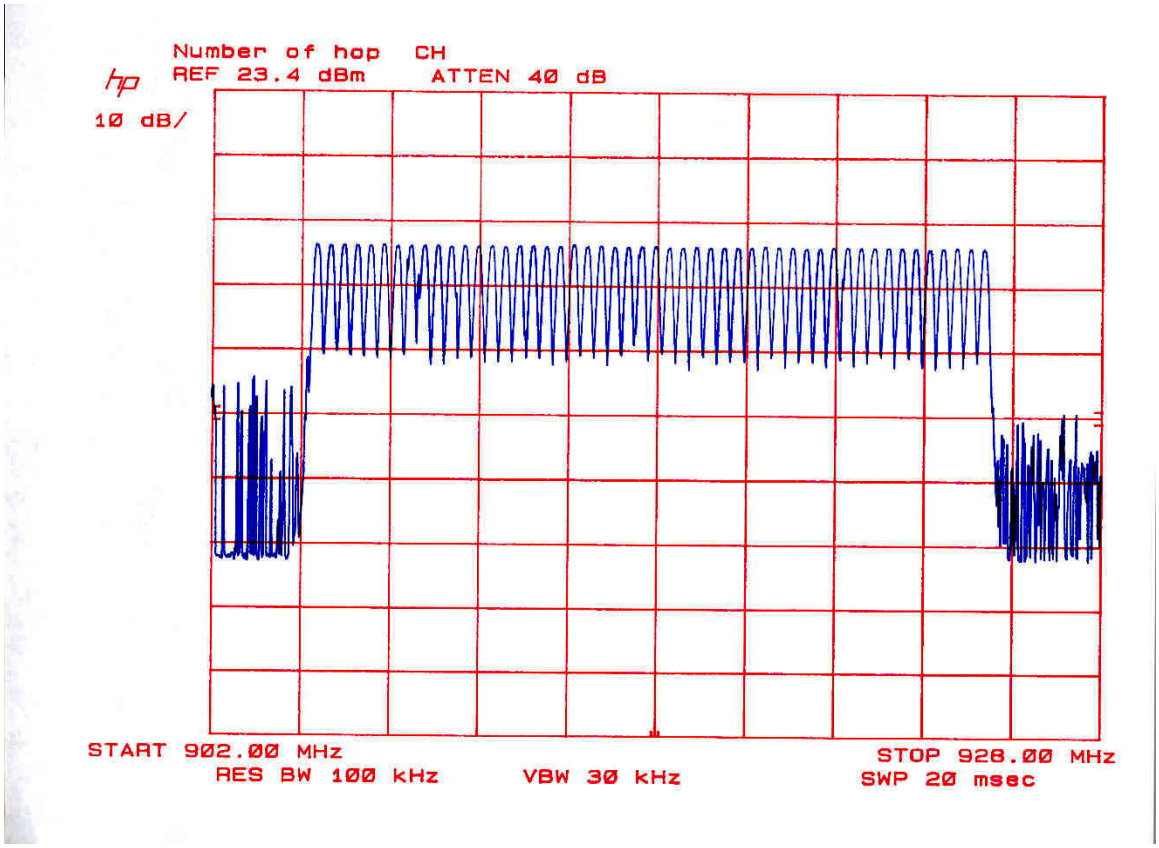
Test Procedures

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

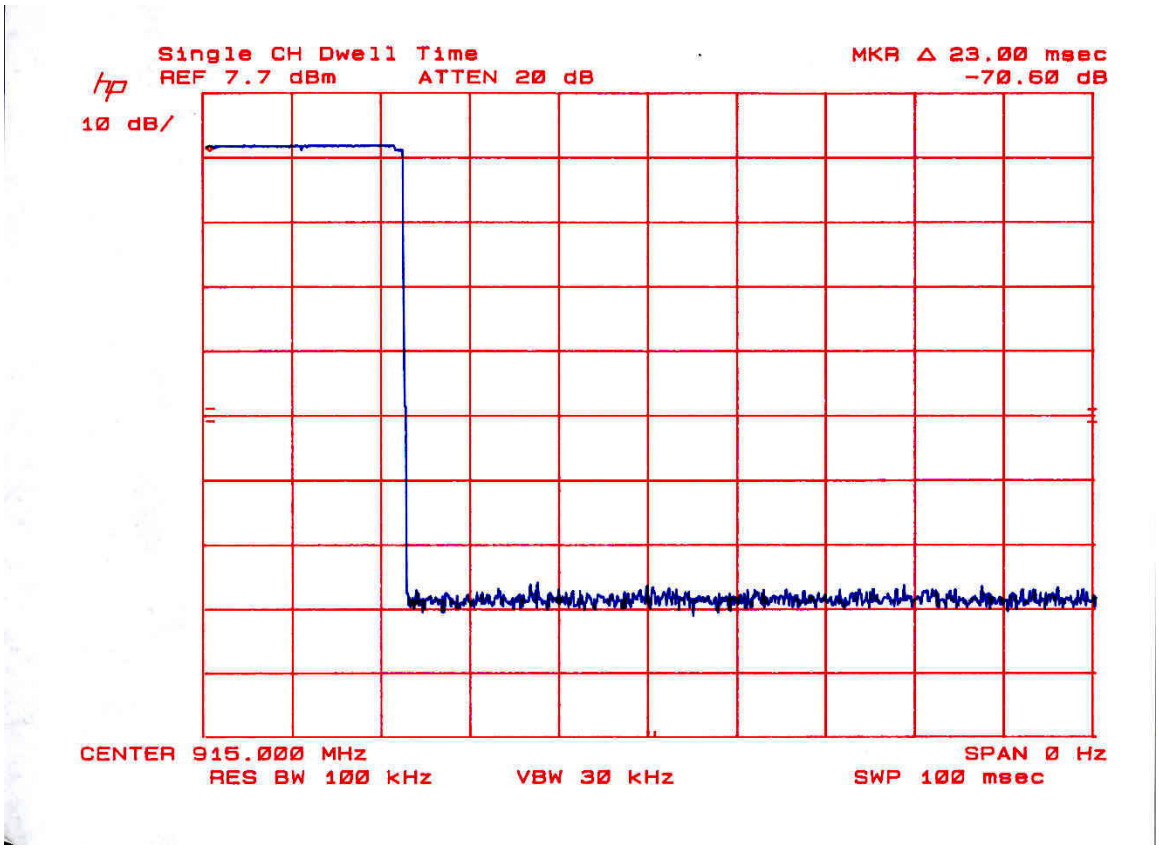
1. The EUT was configured on a test bench. The EUT's hopping function was activated.
2. Spectrum analyzer center frequency was set to 915 MHz, one of the EUT hopping frequency. SWEEP TIME was adjusted until an accurate hop duration time could be displayed. VIDEO TRIGGER was used to capture the signal. 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.

.

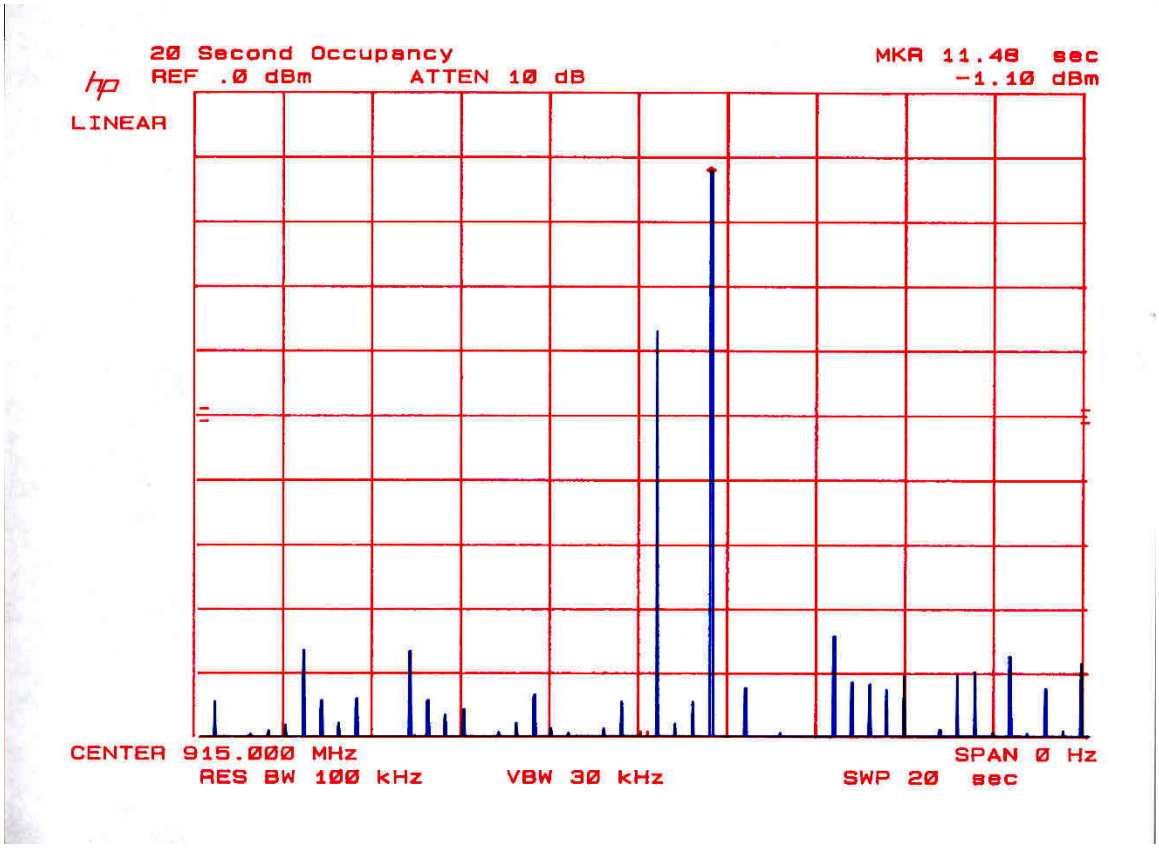
Test Results

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-EMST-100**

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
11.16	**5.64**	**2.5**

Basis of Calculations:

E^2/3770 = S, mW/cm2
E, V/m = (Pwatts*Ggain*30)^.5/d, meters
d = ((Pwatts*G*30)/3770*S))^0.5 Pwatts*Ggain = 10^(PdBm-30+GdBi)/10)

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