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-EMSM-101**

II. DESCRIPTION OF EQUIPMENT UNDER TEST (EUT)

The Invensys **FCC ID: QI2-EMSM-101** is a frequency hopping spread spectrum (FHSS) transceiver. The Invensys "vCon RF Meter" unit is a single phase electricity meter that utilizes an iCon Electric Meter transceiver module to communicate accumulated electricity readings to the RF Gateway unit.

The Electric Meter 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.
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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 13 June 2003
EMC Consultant/Agent for Invensys

1. Antenna connector requirement

The antenna is permanently attached to the product.

15.204 Antenna description

The electric meter transceiver module uses a permanently attached built-in antenna:

Antenna description	Gain	MFR name
electric meter antenna	-1.08 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 8593 Spectrum Analyzer, 30-9280 MHz
HP 8447D Pre-amplifier, .1 - 1300 MHz
EMCO biconical antenna, 30 - 200 MHz
EMCO log periodic antenna, 200-1000 MHz
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).

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.

Minimum 20 dB Bandwidth for FHSS
Test Requirement: 15.247

Measurement Equipment Used:

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

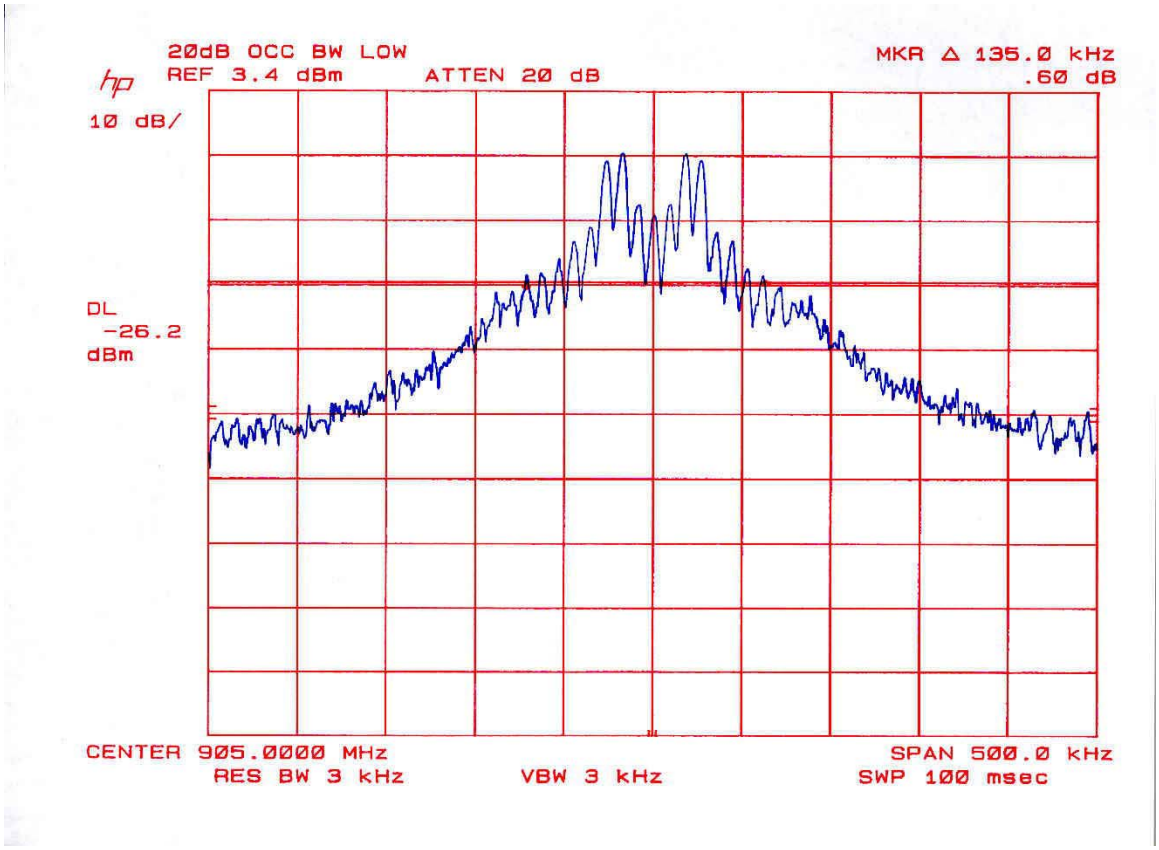
Test Procedures

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.

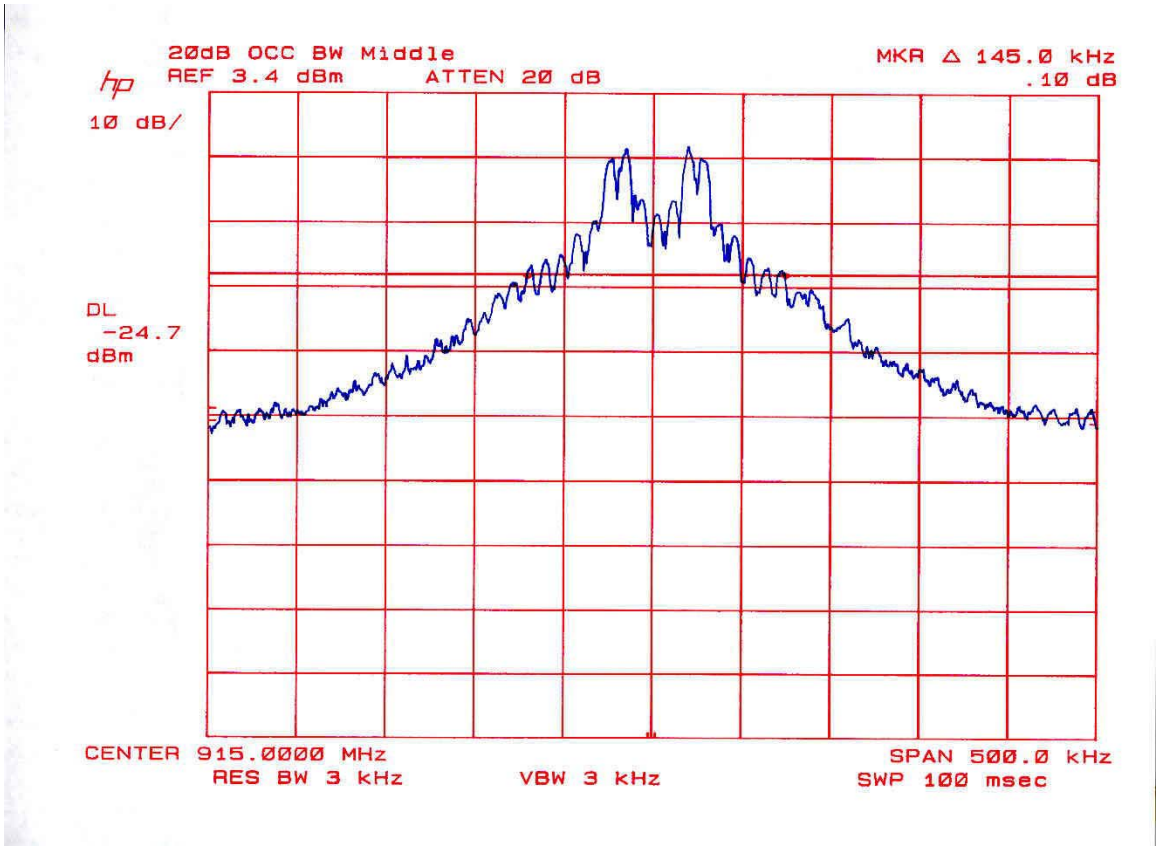
Test was repeated for MID and HIGH channels.

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

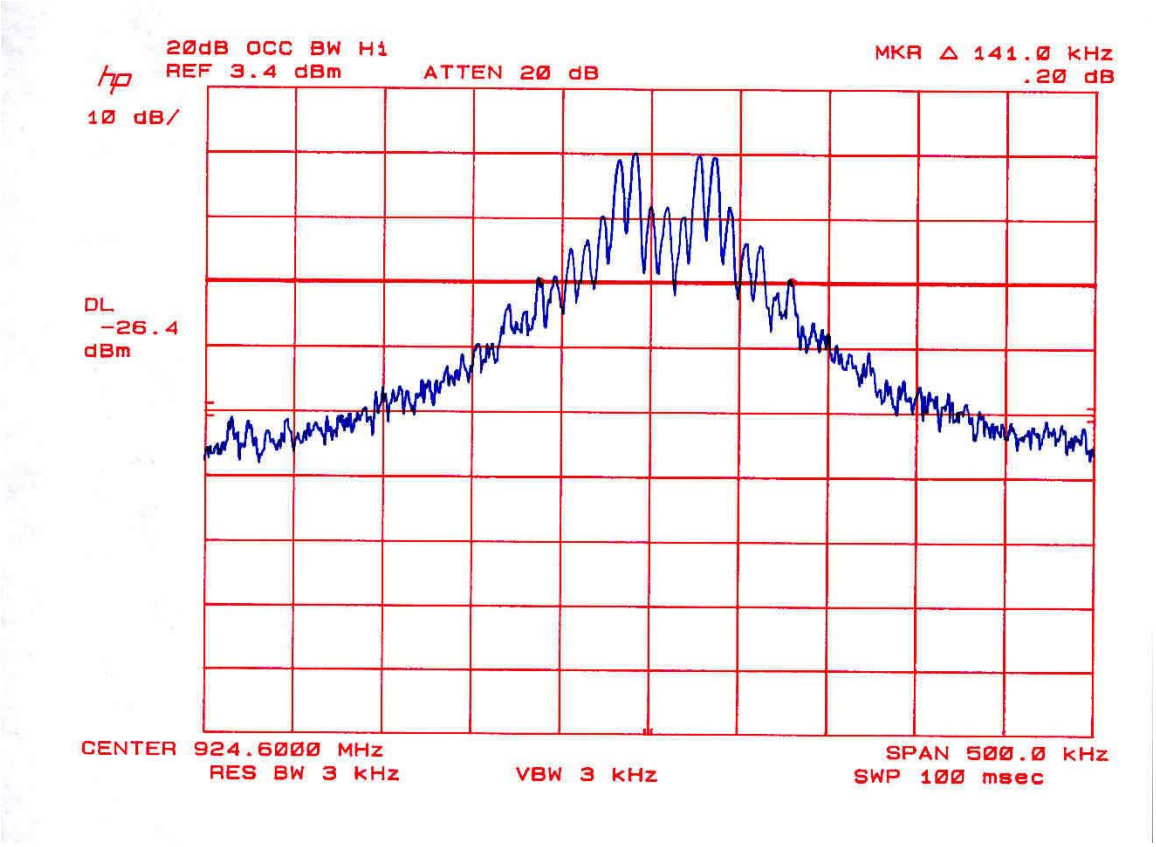
15.247 Minimum 20 dB FHSS Channel Bandwidth LOW channel



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	105.17	-1.08	11.15
26	915	105.54	-1.08	11.52

50	9243.6	104.61	-1.08	10.59

Calculated output power is within 1.5 dB of design typical maximum 12 dBm. Radiated emissions measurement uncertainty +/- 2 dB typical.

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

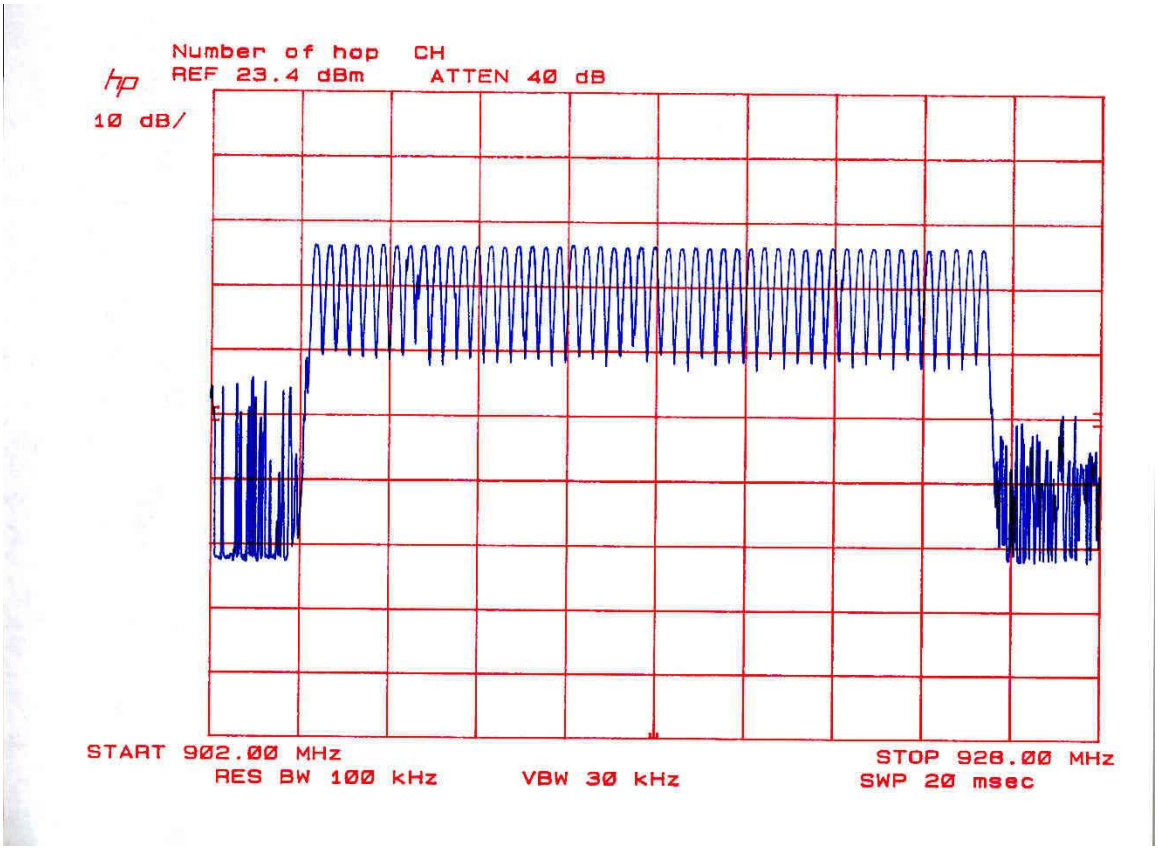
Test Procedures

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.

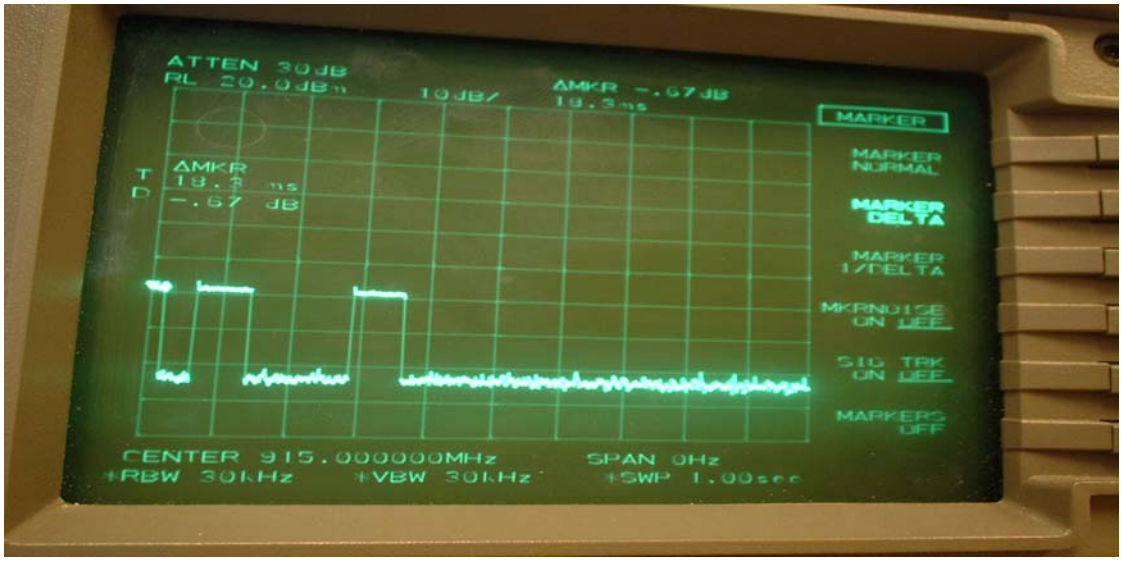
15.247(a)(1)(ii) Minimum number of hopping channels



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

Average Time of Channel Occupancy
Test Requirement: 15.247

1) Maximum channel occupancy in 1 second

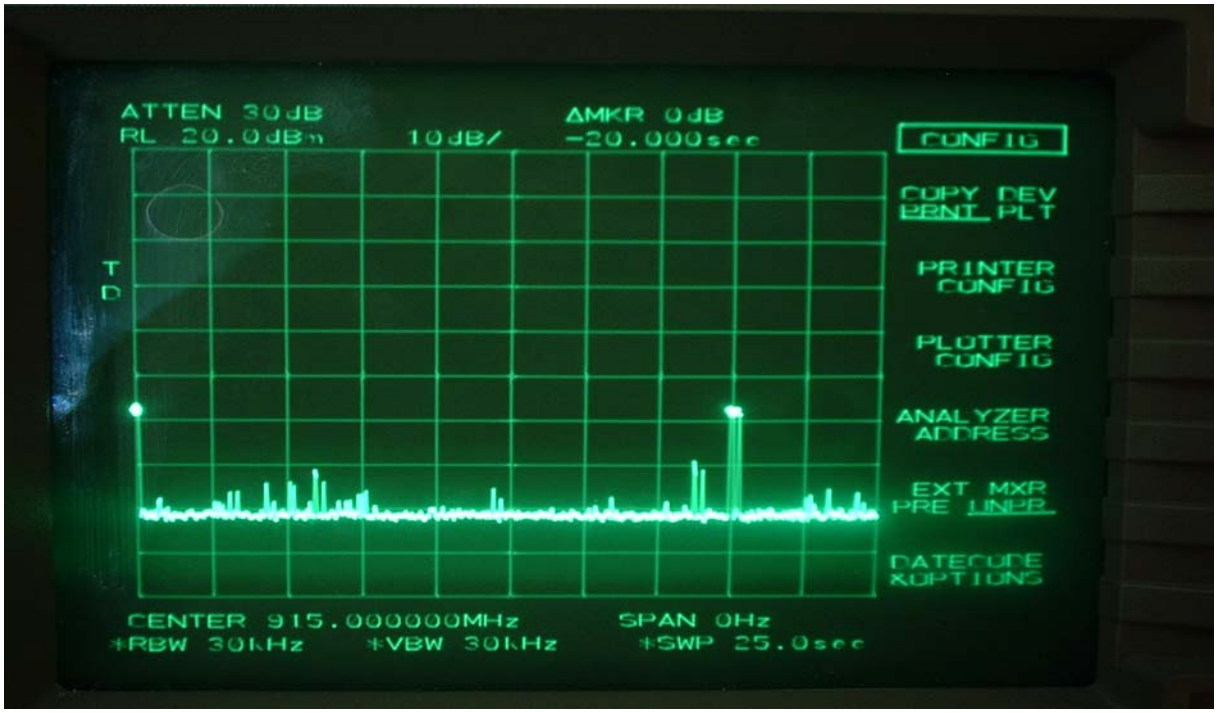


Three rf pulses :-

1) Beacon frame 18mS
2) Wait 45mS (transmitter off)
3) Maximum payload data packet 75mS
4) Wait 148mS (transmitter off)
5) Maximum payload data packet 75mS (retry)
6) Total maximum ON time per TX: 75+75+18 = 168 max msec per transmission

2) Channel occupancy in 25 seconds

The hop sequence repeats every 20 seconds. Spectrum analyzer plot below show 1 transmission sequence every 20 seconds, so maximum channel occupancy will be no greater than 168 msec in 20 seconds.



Hop sequence repeats every 20 seconds.

RF Exposure Information
MPE Calculations

Invensys HCS Electric Meter
Model vCon II
FCC ID: QI2-EMSM-101

RF Hazard Distance Calculation

mW/cm2 from Table1: 0.60

Max RF Power P, dBm	TX Antenna G, dBi	MPE Safe Distance, cm
11.5	**-1.1**	**1.2**

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