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Emissions Testing
Performed
on the
Saar Associates, Inc.
Water Meter Transmitter
Model: WMS
FCC ID: WMS001

To
FCC Part 15 Subpart C, 15.249

Date of Test: January 19, 2000

Page 1 of 18

Report Number: J99032529
MJP/Rbt

Contact: Mr. David Saar

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I – Introduction and Summary

TO: Mr. David Saar

FROM: Michael J. Peters, Senior Project Engineer

DATE: January 20, 2000

JOB #: J99032529

RE: Emissions Testing Performed on the Description, Model: Model

On January 19, 2000, we tested the Water Meter Transmitter, Model: WMS to determine if it was in compliance with the FCC Part 15 , Subpart C, Section 15.249 emissions requirements. A production version of the sample was received on January 18, 2000 in good condition. We found that the unit met the Part 15 requirements when tested as received.

The following Table summarizes the results of testing.

Test	Frequency (MHz)	Measurement	Requirement	Pass/Fail	Section of FCC Rules	Section of Test Report
Fundamental Field Strength	916.46	37.6 mV	50 mV	Pass	15.249	Table 1
Spurious Radiated Emissions	2749.4	166 μ V	500 μ V	Pass	15.249	Table 1
Line-conducted Emissions	Not applicable, device is battery powered.					
Bandwidth	Not applicable, there is no bandwidth requirement for this transmitter					
Antenna Conducted Emissions – Transmit	Not applicable, there are no antenna conducted emissions requirements for this transmitter					
Duty Cycle	A duty cycle was not applied to the measurements.					
Frequency Deviation Temperature	Not applicable, there is no frequency deviation requirements for this transmitter					
Frequency Deviation Voltage	Not applicable, there is no frequency deviation requirements for this transmitter					

In summary, this report confirms that the Model: WMS is compliant with the FCC Part 15, Subpart C Section 15.249 requirements when production units conform with the initial sample. Please address all questions and comments concerning this report to Peter Boers, Senior Staff Engineer.

II – Technical Requirements

15.1 Scope

The device is an intentional radiator intended to operate in accordance with

Section: 15.249 Operation within the bands 902 - 928 MHz, 2400 - 2483.5 MHz, 5725 - 5875 MHz, and 24.0 - 24.25 GHz.

Of Part 15 of the FCC rules without a license.

15.15 General Technical Requirements

There are no controls accessible to the user that would cause the device to operate in violation of the FCC rules.

15.27 Special Accessories

No special accessories are necessary to meet compliance requirements.

15.31 Measurement Standards

The measurement procedures specified by ANSI C63.4:1992 were used to setup and test the device. See Section IV of this test report for detailed description of the test procedure.

A new battery was used during testing.

The transmitter was tested standalone.

The transmitter was programmed to transmit continuously.

15.33 Frequency range of measurement

The device was scanned for spurious and harmonic emissions from 30 MHz to the 10th harmonic of the fundamental emission.

There are two clock frequencies in the device: 32 kHz (CPU) and 916.45 MHz (transmitter). The 32 kHz does not require radiated emissions measurements. Therefore radiated emissions investigation was performed from 900 MHz to 9,164.5 MHz.

15.35 Measurement detector functions and bandwidth

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The following table illustrates the detector functions and bandwidth used to test the device.

Frequency Range	Measurement Detector	Measurement Bandwidth
450 kHz to 30 MHz	Quasi-Peak	9 kHz
30 MHz to 1000 MHz	Quasi-Peak	120 kHz
1000 MHz to 10 th harmonic	Average	1 MHz

The quasi-peak detector meets the requirements of CISPR 16.

Deviation:

Measurements were made with a peak detector. Due to the transmitter transmitting 5 times per second, an average detector measurement could not be made.

An averaging factor was not used or determined for the device because, the device transmit a continuous FSK modulated emission.

15.36 Transition Provisions

Transition provisions were not applied to the device.

A receiver is not being certified with the device.

The device does not operate in the band 902-905 MHz.

15.201 Certification

The device is required to be certified in accordance with Part 2 of the FCC rules, Subpart J.

15.203 Antenna Requirements

The antenna is permanently attached to the device. It cannot be removed without de-soldering from the circuit board.

15.204 External Radio Amplifier

The device is not an amplifier.

15.205 Restricted bands of operation

Spurious emissions requirement for 15.249 is 500 μ V at 3 meters. This is identical to the general requirements of 15.209 which is specified by 15.205 to be the maximum field strength of emissions within restricted bands.

Below 1000 MHz a peak detector was employed to measure emissions. This results in a higher measured value than average or quasi-peak measurements.

Above 1000 MHz a peak detector was employed to measure emissions. Since peak measurements will always be higher than average only peak measurements need be performed.

15.207 Conducted limits

The device is battery powered, no line-conducted measurements are necessary.

15.209 Radiated emission limits; general requirements

The device meets the general emissions requirements in restricted bands.

Spurious and harmonics emissions limits are specified in Section 15.249 for this transmitter.

Part 2

2.201 Emission Modulation and transmission characteristics

The emission designator is determined as follows

The bandwidth is calculated as follows:

Baud Rate (B) = 8192 bps

Frequency Deviation (D) = 25 kHz

Quality Factor K (1.2)

Modulation Frequency M = B/2

Necessary Bandwidth (Bn) = 2M + 2DK

Using the formula $B_n = 2M + 2DK$

$$B_n = 2 * 8192/2 + 2 * (25,000) * (1.2) = 68.2 \text{ kHz}$$

The main carrier modulation is Frequency Shift Keying. Therefore the first symbol is [F].

There is a single channel containing digital information. Therefore the second symbol is [1]

The type of information transmitted is telemetry. Therefore the third symbol is [D]

The emissions designator is:

68K2F1D

2.1041 Measurement Procedures

Only the measurement procedures of Part 15 are required for this device. The device was not evaluated to the requirements of 2.1046 through 2.1057.

2.1091 Radiofrequency radiation exposure evaluation: Mobile Devices

The device does not fall under any of the categories that require routine RF exposure measurements and is therefore exempt from the requirements of this section.

2.1093 Radiofrequency radiation exposure evaluation: Portable Devices

The device does not meet the definition of a portable device .

That is it is not intended to operate within 20 cm of a persons body. The device is used to measure the flow and temperature of water in a turbine water meter, therefore making it exempt from these requirements.

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III - Attestation

LABORATORY MEASUREMENTS

**Pursuant To
Part 15, Subpart C
For
Intentional Radiators**

Company Name: Saar Associates, Inc.

Model: WMS

Date of Test(s): January 19, 2000

Test Site Location: INTERTEK TESTING SERVICES NA INC.
70 Codman Hill Road
Boxborough, MA 01719

Site: 3C

We attest to the accuracy of this report:



Signature

Michael J. Peters

Testing Performed By:

Senior Project Engineer

Title



Signature

Peter Boers

Reviewer

Senior Staff Engineer

Title

IV - Site Description

Introduction

The following is a description of the test procedure used by Intertek Testing Services in the measurements of transmitters operating under Part 15, Subpart C, General Requirements.

- A. **Test Set-Up:** The test set-up and procedures described below are designed to meet the requirements of ANSI C63.4 (1992).
1. The test site is a Plastic/Fiberglass structure with a groundplane. The site has attenuation characteristics which meet the requirements of ANSI C63.4 (1992). Information on the site has been filed with the FCC as required by Rule 2.948. The address of the site is 70 Codman Hill Road, Boxborough, MA 01719.
 2. Power to the site is nominal line voltage of 117 V_{AC} and 230 V_{AC}, 60 Hz.
 3. The equipment under test (EUT) is placed on a wooden turntable which is four feet in diameter and approximately one meter in height above the groundplane. During the radiated emissions test, the turntable is rotated 360 degrees and any cables leaving the EUT are manipulated to find the configuration resulting in maximum emissions. The antenna height and polarization are also varied during the search for maximum signal levels. The height of the antenna is varied from one meter to four meters. Body-worn, hand-held and small portable devices are mounted on a non-conductive box and emissions are investigated on three orthogonal axis.
 4. Detector function for radiated emissions is in peak or quasi-peak mode. Average readings, when required, are taken by measuring the duty cycle of the equipment under test and subtracting the corresponding amount in dB from the measured peak readings according to the following formula:

$$\text{Averaging Factor in dB} = 20 \text{ LOG (duty cycle)}$$

The time period over which the duty cycle is measured is 100 msec. The worst-case (highest percentage on) duty cycle is used and described specifically in the data section. The duty cycle is measured by placing the spectrum analyzer in zero scan (receiver mode) and linear mode at maximum bandwidth (3 MHz at 3 dB down) and viewing the resulting time domain signal output from the analyzer on a Tektronix 465 Oscilloscope. The oscilloscope is used because of its superior time base and triggering facilities.

5. Antennas used below 1000 MHz were EMCO Model 3142 Biconolog Antennas and Compliance Designe Inc. Model A100 tuned Dipole Antennas. For measurements between 1000 MHz and 18000 MHz above 1 GHz, an EMCO Model: 3115 Horn Antenna is used. The Antennas used are listed in the Test Equipment Summary in Section 6
6. The field strength measuring equipment used included:

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V - Measurement Equipment

EQUIPMENT LIST TABLE					
Abbr	Equipment	Manufacturer	Model	Serial	Cal Due
TEK1	Spectrum Analyzer	Tektronix	2784	B010153	11/26/00
HP1	Spectrum Analyzer	Hewlett Packard	8591E	3308A01445	6/16/00
HORN2	Double Ridge Horn Antenna	EMCO	3115	4675	11/4/00
LOG2	Biconolog Antenna	EMCO	3142	1223	10/12/00
PRE8	Preamplifier	Miteq	NSP4000-NF	507145	11/25/00

7. The frequency range to be scanned is from the lowest radio frequency signal generated in the device which is greater than 9 kHz to the tenth harmonic of the highest fundamental frequency, or 40 GHz, whichever is lower. For line-conducted emissions, the range scanned is 450 kHz to 30 MHz.
8. The EUT is warmed up for 15 minutes prior to the test. AC power to the unit is varied from 85% to 115% nominal and variation in the fundamental emission field strength is recorded. If battery powered, a new battery is used.
9. Conducted measurements were made as described in ANSI C63.4 (1992). An IF bandwidth of 9 kHz is used, and peak or quasi-peak detection is employed.
10. The IF bandwidth used for measurement of radiated signal strength was 100 kHz or greater below 1000 MHz. Where pulsed transmissions of short enough pulse duration warrant, a greater bandwidth is selected according to the recommendations of Hewlett Packard Application No. 150-2. A discussion of whether pulse desensitivity is applicable to this unit is included in this report. Above 1000 MHz, a bandwidth of 1 MHz is generally used.
11. Transmitter measurements are normally conducted at a measurement distance of three meters. However, to assure low enough noise floor in the forbidden bands and above 1 GHz (where no preamplifier is used), signals are acquired at a distance of one meter or less. All measurements are extrapolated to three meters using inverse scaling, but those measurements taken at a closer distance are so marked.
12. For measurements made in the 9 kHz to 30 MHz range, a distance of 30 meters was used unless a good signal-to-noise ratio could not be obtained. In that case, a closer distance was used and that distance is so marked in the data table.

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VI – Summary of Equipment Under Test

1	Manufacturer:	Saar Associates, Inc.
2	Grantee:	Water Management Services, Inc.
3	Model No.:	WMS
4	Trade Name:	
5	Serial No.:	Not labeled
6	Date of Test:	January 19, 2000
7	Frequencies to which device can be tuned:	916.45 MHz
8	Can customer tune device?	No
9	Detailed description of operation pursuant to 15.209:	See below
10	Applicable emissions limits:	15.205, 15.209 and 15.249
11	Additional Comments:	See below

9. Detailed description of operation pursuant to 15.209

The device is used to collect water flow and temperature information and transmit it to a remote receiver.

Power to the transmitter system is provided by a 3.6 or 4.5 volt battery. A low drop out voltage regulator is used to create a constant 3 volt source for the transmitter, the microcomputer, and the analog circuits.

The transmitter oscillator is a standard Colpitts configuration using a SAW resonator to set the transmitter frequency. The FSK modulation is carried out by varying the voltage on a varactor diode to change the capacitance, and hence the tuning, of the collector circuit. The oscillator operates at a nominal frequency of 916.5 MHz. The output of the oscillator is coupled to an amplifier stage that increases the power to the needed level and isolates the oscillator from antenna loading effects. The output of the amplifier goes to the antenna through a PI filter. The transmitter is enabled by a signal from the microcomputer, which provides the operating bias to both the oscillator and amplifier stages.

The microcomputer operates from a 32.768 kHz crystal. The microcomputer instruction rate is about 8 kHz (1/4 clock rate). All other timing such as A/D conversion rate are based on software timing from the instruction sequences. There are no other timing elements. The microcomputer controls the transmit functions and the data conversion. An EEPROM memory stores the data, the unique serial number for each transmitter, operating settings, and calibration tables for the A/D conversion. The microcomputer runs at this low clock rate all of the time. A reed switch is used to temporarily place the unit in test mode with transmissions every 2 seconds for up to 2 minutes to facilitate manufacturing test and installation.

The Hall cell output is a level transition for each rotation of the turbine of the water meter. The count is totaled by counters in the microcomputer. The analog to digital conversion for the thermistor is done by comparing the sensed voltage with a rising ramp from an RC circuit. The value of the voltage sensed is related to the time for the RC circuit voltage to charge to the

sensed and amplified voltage. A lookup table in the microcomputer's EEPROM memory converts the time value read from the A/D to the appropriate sensor value.

11. Additional Comments

The transmitter was tested standalone and placed in the center of the turntable.

The transmitter was programmed to transmit continuously (five times a second). Normally the transmitter would transmit once every eight hours.

The transmitter was tested in three orientations. The three orientations were the three orthogonal axis of the device.

VII - Configuration Information

Equipment Under Test: Water Meter Transmitter

Model: WMS

Serial No.: Not labeled

FCC Identifier: WMS001

Support Equipment:

none

Cables:

none

VIII - Configuration Photographs

Worst-Case Radiated Emissions

Orientation 1



Orientation 2



Orientation 3



IX - Sample Calculation

The following is how net field strength readings were determined:

$$NF = RF + AF + CF + PF + DF$$

Where,

NF = Net Reading in dB μ V/m

RF = Reading from receiver in dB μ V/m

AF = Antenna Correction Factor in dB

CF = Cable Correction Factor in dB

PF = Preamplifier Correction Factor in dB

DF = Distance Factor in dB (using 20 dB/decade), from 3 to 1 meters 10.5 dB was added for measurements performed at 1 meter

To convert from dB μ V/m to μ V/m or mV/m the following was used:

$$UF = 10^{(NF / 20)}$$

Where,

UF = Net Reading in μ V/m

$$MF = UF / 1000$$

Where,

MF = Net Reading in mV/m

Example:

For the fundamental field strength measurement at 916.46 (distance = 3 meters) see table 1.

$$NF = 61.9 \text{ dB}\mu\text{V} + 24.4 \text{ dB} + 5.2 \text{ dB} + 0 \text{ dB} + 0 \text{ dB} = 91.5 \text{ dB}\mu\text{V/m at 3 meters}$$

$$UF = 10^{(91.5 \text{ dB}\mu\text{V} / 20)} = 37,583.7 \mu\text{V/m}$$

$$MF = 37,583.7 \mu\text{V} / 1000 = 37.6 \text{ mV/m}$$

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X - Data Tables

Radiated Emissions / Interference

Table: 1

Company: SAAR Associates

Model: WMS

Job No.: J99032529

Date: 01/19/00

Standard: FCC 15

Class: B

Group: None

Notes: Reading made with peak detector

Resolution Bandwidth 120 kHz < 1 GHz, 1 MHz > 1 GHz

Video Bandwidth 300 kHz

Tested by: Michael Peters

Location: Site 3

Detector: HP 8591E

Antenna: EMCO HORN 4675

PreAmp: NONE

Cable(s): S1 S2

Distance: 3

Transmitter Orientation Number	Ant. Pol. (v h)	Frequency (MHz)	Reading (dBuV)	Antenna Factor Antenna	Cable Loss (dB)	Pre-amp Factor (dB)	Distance Factor (dB)	Net dBuV/m	Limit dBuV/m	Margin (dB)
1	v	916.46	60.1	24.4	5.2	0.0	0.0	89.7	94.0	- 4.3
1	h	916.46	55.8	24.4	5.2	0.0	0.0	85.4	94.0	- 8.6
2	h	916.46	61.9	24.4	5.2	0.0	0.0	91.5	94.0	- 2.5
2	v	916.46	45.6	24.4	5.2	0.0	0.0	75.2	94.0	- 18.8
3	v	916.46	55.4	24.4	5.2	0.0	0.0	85.0	94.0	- 9.0
3	h	916.46	61.0	24.4	5.2	0.0	0.0	90.6	94.0	- 3.4
3	v	1832.90	32.7	28.2	2.6	22.0	0.0	41.6	54.0	- 12.4
2	h	1832.90	32.4	28.2	2.6	22.0	0.0	41.3	54.0	- 12.7
1	h	1832.90	32.5	28.2	2.6	22.0	0.0	41.4	54.0	- 12.6
1	v	1832.90	33.9	28.2	2.6	22.0	0.0	42.8	54.0	- 11.2
2	v	1832.90	35.1	28.2	2.6	22.0	0.0	44.0	54.0	- 10.0
3	v	2749.40	29.4	33.0	3.3	22.0	0.0	43.7	54.0	- 10.3
2	v	2749.40	29.8	33.0	3.3	22.0	0.0	44.1	54.0	- 9.9
1	v	2749.40	30.0	33.0	3.3	22.0	0.0	44.3	54.0	- 9.7
1	v	2749.40	30.1	33.0	3.3	22.0	0.0	44.4	54.0	- 9.6
2	v	2749.40	30.1	33.0	3.3	22.0	0.0	44.4	54.0	- 9.6
3	v	2749.40	30.1	33.0	3.3	22.0	0.0	44.4	54.0	- 9.6

Emissions were investigated from 900 MHz to 9,160 MHz. No other emissions were detected above the measurement equipment noise floor.

Position Numbers:

- 1 - With the antenna pointing upwards.
- 2 - With the transmitter lying on its widest side.
- 3 - With the transmitter lying on its narrow side.