Measurement of RF Emissions from a Orion CE Water Meter Transmitter

For	Badger Meter Corporation 4545 W. Brown Deer Road Milwaukee, WI 53223
P.O. Number	558114
Date Tested	November 18, 2011
Test Personnel	Richard King
Test Specification	FCC "Code of Federal Regulations" Title 47 Part15, Subpart C Industry Canada RSS-GEN Industry Canada RSS-210

Test Report By: Richard E. King

Richard King
EMC Engineer

Requested By:

Andy Davis
Badger Meter Corporation

Approved By: Raymond J. Klouda

Raymond J. Klouda
Registered Professional
Engineer of Illinois - 44894

Elite Electronic Engineering, Inc.
1516 Centre Circle
Downers Grove, IL 60515
Tel : (630) 495-9770
Fax: (630) 495-9785
www.elitetest.com

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REVISION HISTORY

Revision	Date	Description
—	December 27, 2011	Initial release

Measurement of RF Emissions from a Water Meter Endpoint, Model No. Orion CE Water Meter Transmitter

1. INTRODUCTION

1.1. Scope of Tests

This report presents the results of the RF emissions measurements performed on a Water Meter Endpoint, Model No. Orion CE Water Meter, No serial number assigned, (hereinafter referred to as the Equipment Under Test (EUT)).). The EUT was designed to transmit at approximately 916.45 MHz using an internal. The EUT was manufactured and submitted for testing by Badger Meter Corporation located in Milwaukee, WI.

1.2. Purpose

The test series was performed to determine if the EUT meets the radiated RF emission requirements of the FCC "Code of Federal Regulations" Title 47, Part 15, Subpart C, Sections 15.249 for Intentional Radiators. Testing was performed in accordance with ANSI C63.4-2003.

1.3. Deviations, Additions and Exclusions

There were no deviations, additions to, or exclusions from the test specification during this test series.

1.4. EMC Laboratory Identification

This series of tests was performed by Elite Electronic Engineering Incorporated of Downers Grove, Illinois. The laboratory is accredited by The American Association for Laboratory Accreditation (A2LA). A2LA Certificate Number: 1786.01.

1.5. Laboratory Conditions

The temperature at the time of the test was 23.3^{o}C and the relative humidity was 40%.

2. APPLICABLE DOCUMENTS

The following documents of the exact issue designated form part of this document to the extent specified herein:

- Federal Communications Commission "Code of Federal Regulations", Title 47, Part 15, Subpart C, dated 1 October 2011
- ANSI C63.4-2003, "American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz"
- Industry Canada Radio Standards Specification, RSS-Gen, “General Requirements and Information for the Certification of Radiocommunication Equipment”, Issue 3, December 2010
- Industry Canada Radio Standards Specification, RSS-210, “Low-power Licence-exempt Radiocommunication Devices (All Frequency Bands): Category I Equipment”, Issue 8, December 2010

3. EUT SETUP AND OPERATION

3.1. General Description

The EUT is a Badger Meter Corporation, Water Meter Endpoint, Model No. Orion CE Water Meter. A block diagram of the EUT setup is shown as Figure 1.

3.1.1. Power Input

The EUT typically obtains 3.3VDC from an internal battery. For testing purposes the EUT obtained 3.3VDC from a DC power supply.

3.1.2. Peripheral Equipment

No peripheral equipment was submitted with the EUT.

3.1.3. Signal Input/Output Leads

The EUTs does not utilize any interconnect cables.

3.1.4. Grounding

Since only two wires were used to provide the input power, the EUT was ungrounded during the tests.

3.2. Operational Mode

For all tests the EUT was placed on an 80cm high non-conductive stand. The EUT was energized. The EUT was set to transmit continuously at 916.45MHz.

3.3. EUT Modifications

No modifications were required for compliance to the FCC "Code of Federal Regulations" Title 47, Part 15, Subpart C, Sections 15.249 requirements.

4. TEST FACILITY AND TEST INSTRUMENTATION

4.1. Shielded Enclosure

All tests were performed in a 32ft. x 20ft. x 18ft. hybrid ferrite-tile/anechoic absorber lined test chamber. With the exception of the floor, the reflective surfaces of the shielded chamber are lined with ferrite tiles on the walls and ceiling. Anechoic absorber material is installed over the ferrite tile. The floor of the chamber is used as the ground plane. The chamber complies with ANSI C63.4-2003 for site attenuation.

4.2. Test Instrumentation

The test instrumentation and auxiliary equipment used during the tests are listed in Table 9-1. All equipment was calibrated per the instruction manuals supplied by the manufacturer.

Conducted and radiated emission measurements were performed with a spectrum analyzer. This receiver allows measurements with the bandwidths and detector functions specified by the FCC. The receiver bandwidth was 120kHz for the 30MHz to 1000MHz radiated emissions data and 1MHz for the 1000MHz to 5000MHz radiated emissions data.

4.3. Calibration Traceability

Test equipment is maintained and calibrated on a regular basis. All calibrations are traceable to the National Institute of Standards and Technology (NIST).

4.4. Measurement Uncertainty

All measurements are an estimate of their true value. The measurement uncertainty characterizes, with a specified confidence level, the spread of values which may be possible for a given measurement system.

The measurement uncertainty for these tests is presented below:

Conducted Emissions Measurements		
Combined Standard Uncertainty	1.07	-1.07
Expanded Uncertainty (95% confidence)	2.1	-2.1

Radiated Emissions Measurements		
Combined Standard Uncertainty	2.26	-2.18
Expanded Uncertainty (95% confidence)	4.5	-4.4

5. TEST PROCEDURES

5.1. Powerline Conducted Emissions

5.1.1. Requirements

Since the EUT was powered by internal batteries, no conducted emissions tests were required.

5.2. Duty Cycle Factor Measurements

5.2.1. Procedures

The duty cycle factor is used to convert peak detected readings to average readings. This factor is computed from the time domain trace of the pulse modulation signal.

With the transmitter set up to transmit for maximum pulse density, the time domain trace is displayed on the spectrum analyzer. This trace is obtained by tuning center frequency to the transmitter frequency and then setting a zero span width with 2 msec/div. The amplitude settings are adjusted so that the on/off transitions clear the 4th division from the bottom of the display. The markers are set at the beginning and end of a word period. If the word period exceeds 100 msec the word period is set to 100 msec.

5.2.2. Results

The plots of the duty cycle are shown on data pages 12 and 13. The EUT transmits a 2.4 msec pulse every 4.14 seconds. Since a word is greater than 100 msec long, the duty cycle factor was computed over a 100 msec interval. The duty cycle correction factor was calculated to be -32.3dB (-32.3dB = 20*log(2.4msec/100msec).

5.3. Radiated Measurements

5.3.1. Requirements

The EUT must comply with the requirements of FCC "Code of Federal Regulations Title 47", Part 15, Subpart C, Section 15.205 et seq.

Paragraph 15.249 has the following radiated emission limits:

Fundamental Frequency MHz	Field Intensity uV/m @ 3 meters	Field Strength Harmonics and Spurious @ 3 meters
902 – 928	50,000	500

For radiated emissions below 1GHz, the field strength limits are based on quasi-peak readings. For radiated emissions above 1GHz, the field strength limits are based on average readings. In addition, the peak field

strength of any emission shall not exceed the maximum permitted average limits by more than 20 dB under any condition of modulation.

5.3.2.Procedures

All tests were performed in a 32ft. x 20ft. x 18ft. hybrid ferrite-tile/anechoic absorber lined test chamber. The walls and ceiling of the shielded chamber are lined with ferrite tiles. Anechoic absorber material is installed over the ferrite tile. The floor of the chamber is used as the ground plane. The chamber complies with ANSI C63.4-2003 for site attenuation.

The shielded enclosure prevents emissions from other sources, such as radio and TV stations from interfering with the measurements. All powerlines and signal lines entering the enclosure pass through filters on the enclosure wall. The powerline filters prevent extraneous signals from entering the enclosure on these leads.

A preliminary radiated emissions test was performed to determine the emission characteristics of the EUT. For the preliminary test, a broadband measuring antenna was positioned at a 3 meter distance from the EUT. The entire frequency range from 30MHz to 10GHz was investigated using a peak detector function. The data was then processed by the computer to calculate equivalent field intensity.

The final open field emission tests were then manually performed over the frequency range of 30MHz to 10000MHz. Between 30MHz and 1000MHz, a tuned dipole antenna was used as the pick-up device. A broadband double ridged waveguide antenna was used as the pick-up device for all frequencies above 1GHz. All significant broadband and narrowband signals were measured and recorded. The peak detected levels were converted to average levels using a duty cycle factor which was computed from the pulse train.

To ensure that maximum or worst case, emission levels were measured, the following steps were taken:

1) The EUT was rotated so that all of its sides were exposed to the receiving antenna.
2) Since the measuring antenna is linearly polarized, both horizontal and vertical field components were measured.
3) The measuring antenna was raised and lowered from 1 to 4 meters for each antenna polarization to maximize the readings.
4) For hand-held or body-worn devices, the EUT was rotated through three orthogonal axes to determine which orientation produces the highest emission relative to the limit.

5.3.3.Results

The preliminary plots, with the EUT transmitting at 916.45MHz are presented on data pages 14 through 17. The plots are presented for a reference only, and are not used to determine compliance.

The final radiated levels, with the EUT transmitting at 916.45MHz are presented on data pages 18 and 19. As can be seen from the data, all emissions measured from the EUT were within the specification limits.

The emissions level closet to the limit (worst case) occurred at 916.45MHz. The emissions level at this frequency was 1.2dB within the limit. Photographs of the test configuration which yielded the highest, or worst case, radiated emission levels are shown on Figure 3.

5.4. Occupied Bandwidth Measurements

5.4.1.Requirement

In accordance with paragraph 15.249(d), all emissions radiated outside of the specified frequency bands, except for harmonics, shall be attenuate by at least 50dB below the level of the fundamental or to the general radiated emissions limits in 15.209, which ever is the lesser attenuation.

5.4.2.Procedures

The EUT was placed on an 80cm high non-conductive stand. The unit was set to transmit continuously. With

an antenna positioned nearby, occupied bandwidth emissions were displayed on the spectrum analyzer. The resolution bandwidth was set to 100 kHz and span was set to 30 MHz. The frequency spectrum near the fundamental was plotted.

5.4.3.Results

The plot of the emissions near the fundamental frequency, with the EUT transmitting at 916.45MHz is presented on data page 20. As can be seen from this data page, the transmitter met the occupied bandwidth requirements. The 99% bandwidth was measured to be 345 kHz.

6. OTHER TEST CONDITIONS

6.1. Test Personnel and Witnesses

All tests were performed by qualified personnel from Elite Electronic Engineering Incorporated. The test series was witnessed by Badger Meter Corporation personnel.

6.2. Disposition of the EUT

The EUT and all associated equipment were returned to Badger Meter Corporation upon completion of the tests.

7. CONCLUSIONS

It was determined that the Badger Meter Corporation Water Meter Endpoint, Model No. Orion CE Water Meter, did fully meet the radiated emission requirements of the FCC "Code of Federal Regulations" Title 47, Part 15, Subpart C, Section 15.205 et seq. for Intentional Radiators, when tested per ANSI C63.4-2003.

8. CERTIFICATION

Elite Electronic Engineering Incorporated certifies that the information contained in this report was obtained under conditions which meet or exceed those specified in the test specifications.

The data presented in this test report pertains to the EUT at the test date as operated by Badger Meter Corporation personnel. Any electrical or mechanical modification made to the EUT subsequent to the specified test date will serve to invalidate the data and void this certification.

This report must not be used to claim product endorsement by NVLAP or any agency of the US Government.

9. EQUIPMENT LIST

Table 9-1 Equipment List

Eq ID	Equipment Description	Manufacturer	Model No.	Serial No.	Frequency Range	Cal Date	Due Date
APW3	PREAMPLIFIER	PLANAR ELECTRONICS	PE2-35-120-5R0-10-12	PL2924	1GHZ-20GHZ	6/3/2011	6/3/2012
NDQ1	TUNED DIPOLE ANTENNA	EMCO	3121C-DB4	313	400-1000MHZ	4/20/2011	4/20/2012
NTA2	BILOG ANTENNA	TESEQ	6112D	28040	25-1000MHz	6/29/2011	6/29/2012
NWH0	RIDGED WAVE GUIDE	TENSOR	4105	2081	1-12.4GHZ	11/3/2011	11/3/2012
RBB0	EMI TEST RECEIVER 20HZ TO 40 GHZ	ROHDE & SCHWARZ	ESIB40	100250	20 HZ TO 40GHZ	3/24/2011	3/24/2012
XPQ2	HIGH PASS FILTER	K&L MICROWAVE	4IH30-1804/T10000-0	3	1.8-10GHZ	11/15/2011	11/15/2012

I/O: Initial Only
N/A: Not Applicable
Note 1: For the purpose of this test, the equipment was calibrated over the specified frequency range, pulse rate, or modulation prior to the test or monitored by a calibrated instrument.

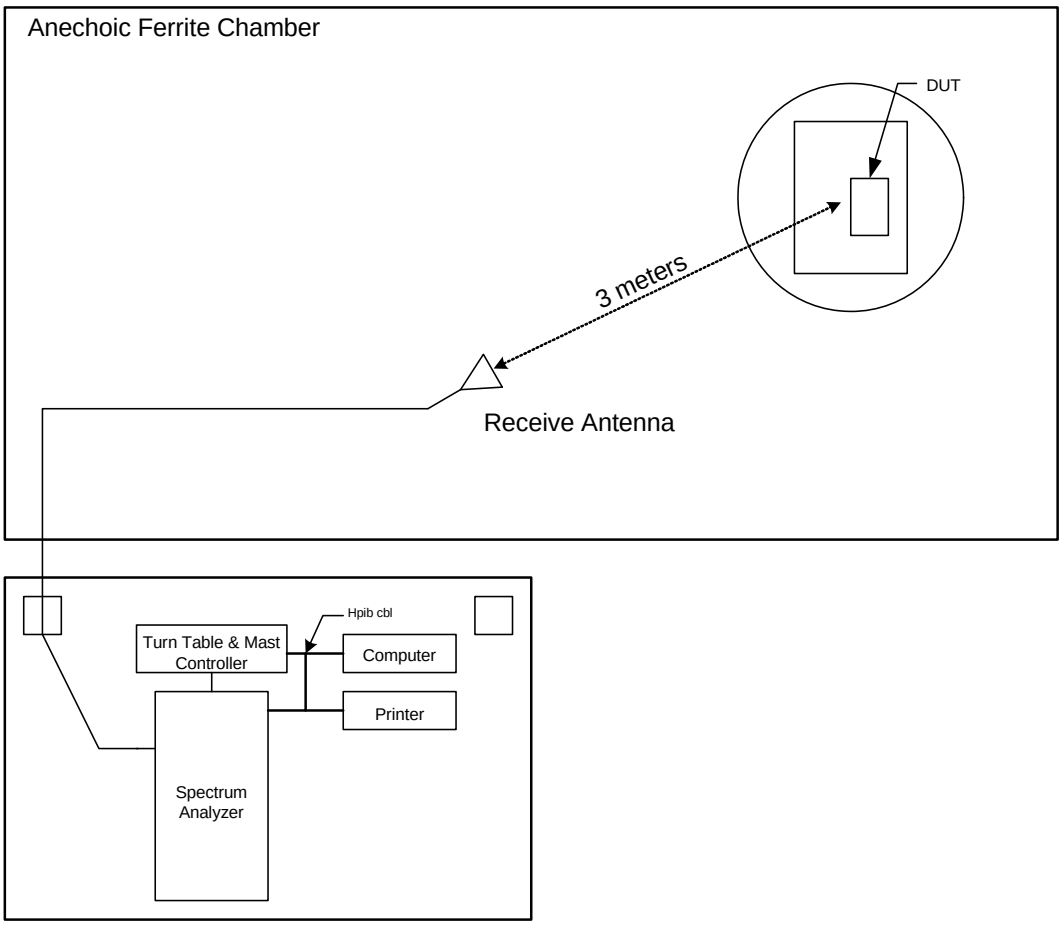
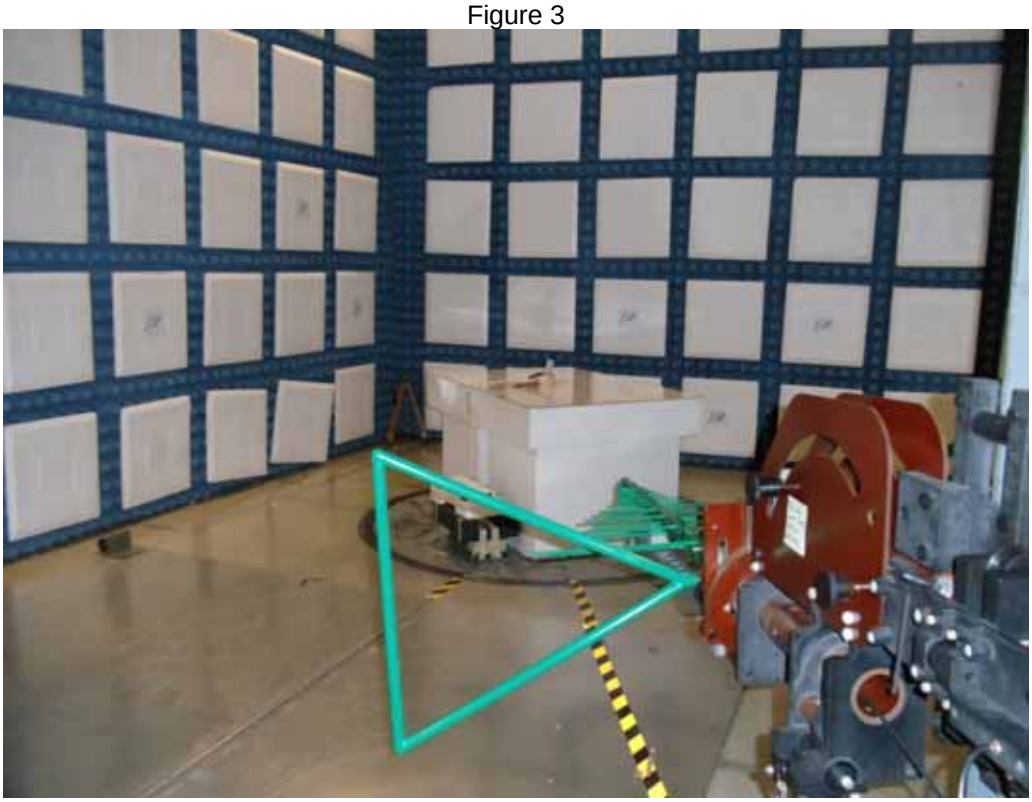


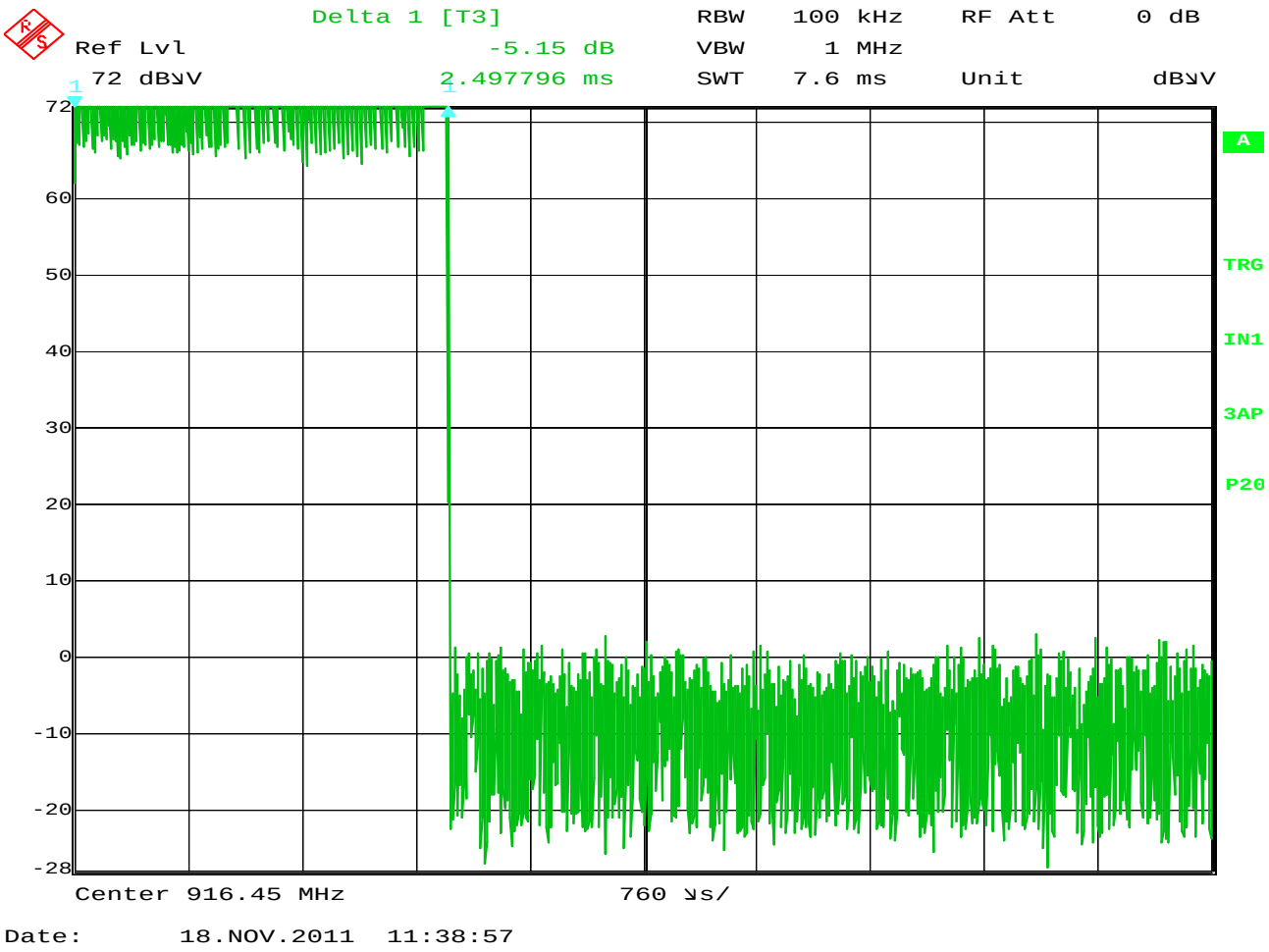
FIGURE 1 BLOCKDIAGRAM OF TEST SETUP

Figure 3



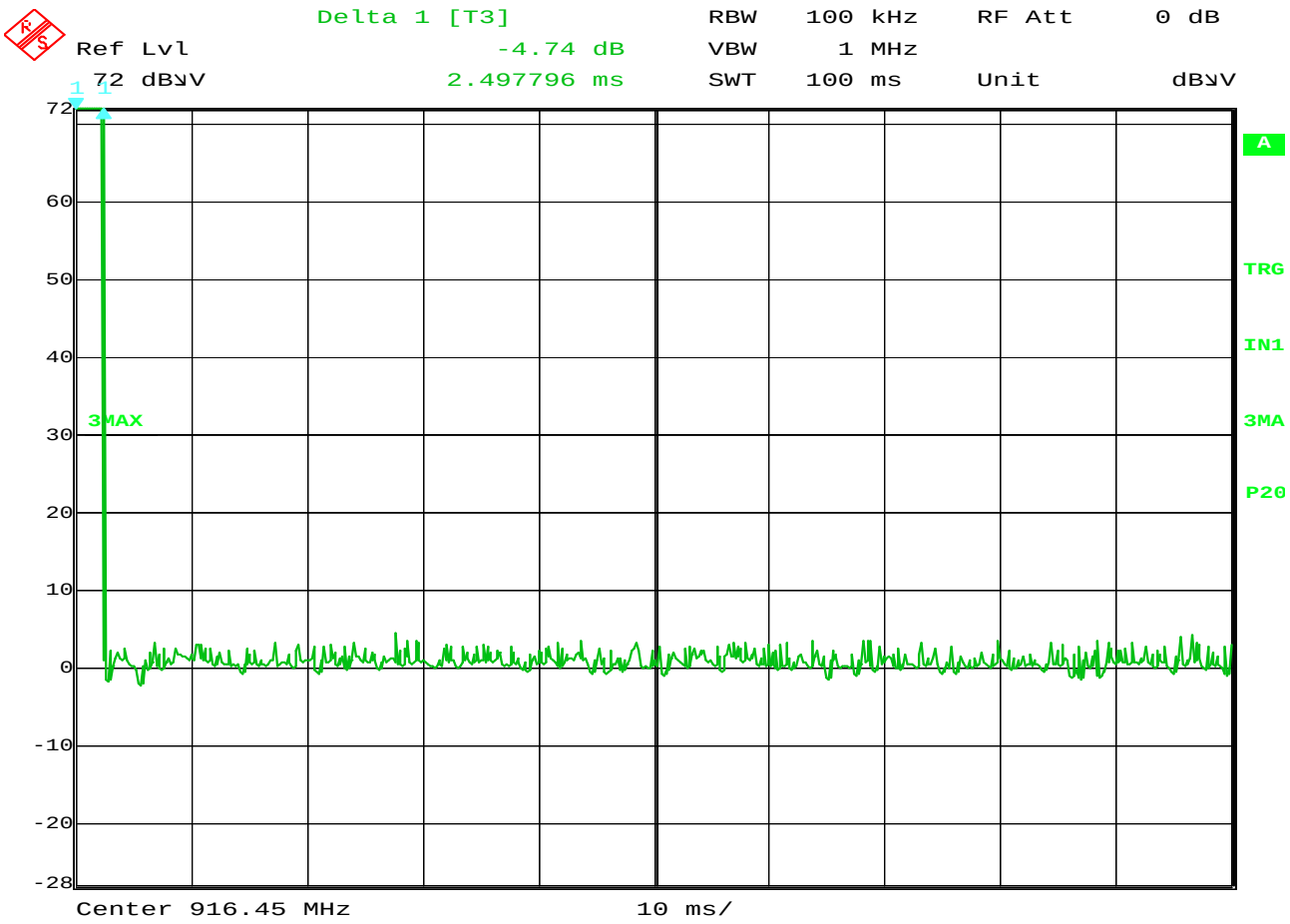
Test Setup for Radiated Emissions, 30MHz to 1GHz – Horizontal Polarization

Test Setup for Radiated Emissions, 30MHz to 1GHz – Vertical Polarization



15.35 Duty Cycle

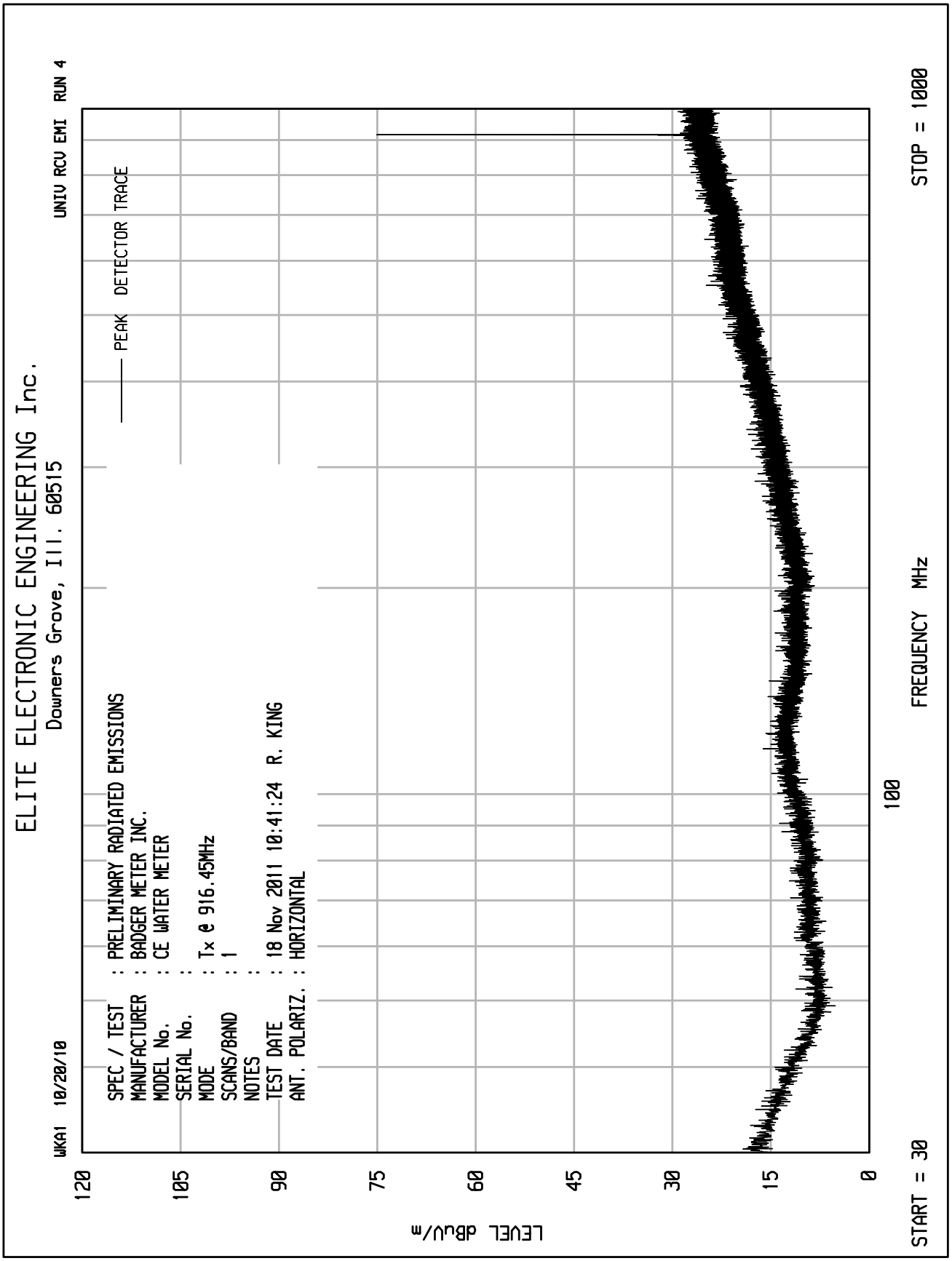
MANUFACTURER : Badger Meter Corporation
MODEL NUMBER : Orion CE Water Meter
TEST MODE : Transmit
TEST PARAMETERS : Pulse Width
NOTES : 2.4mS

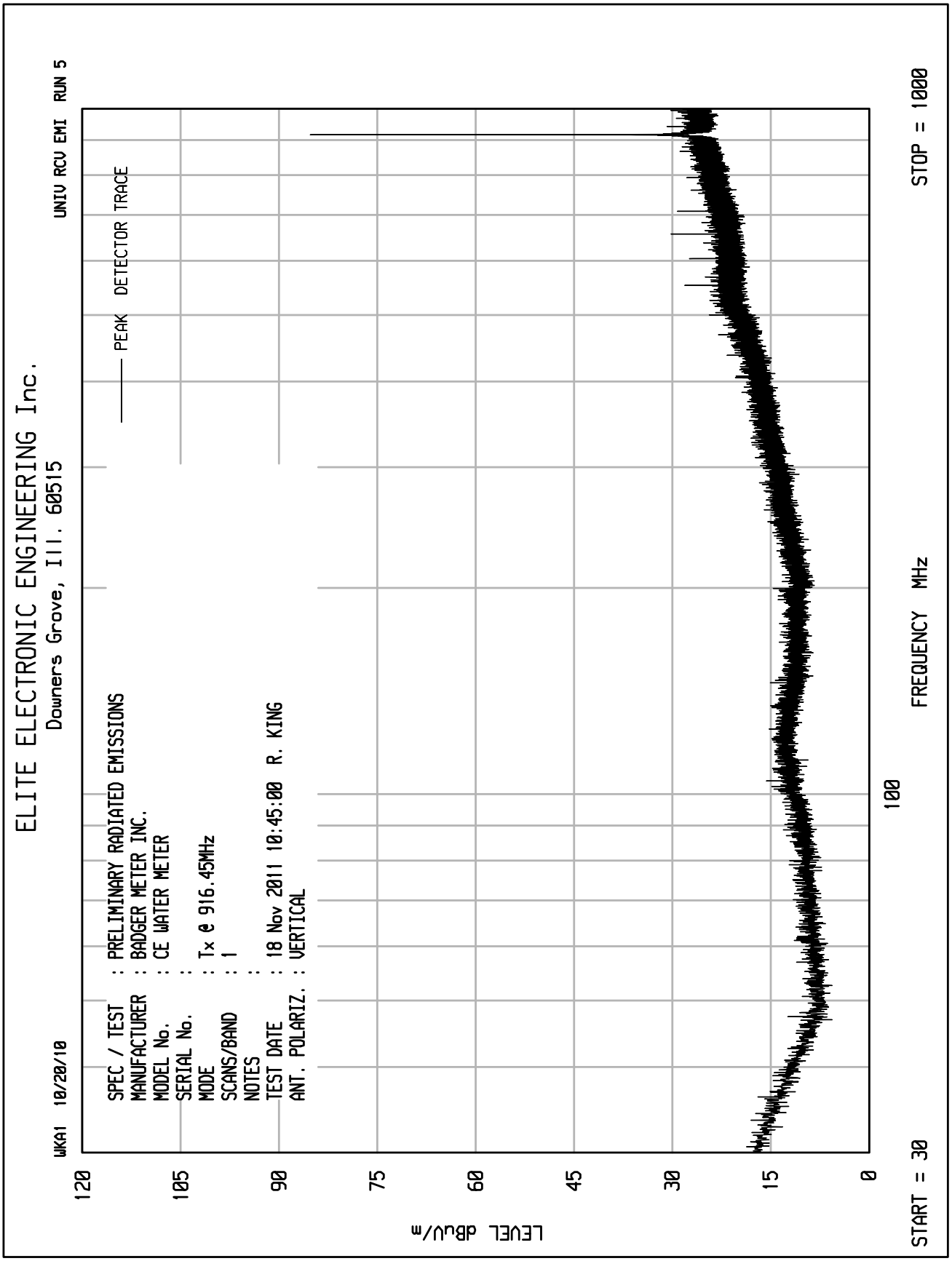


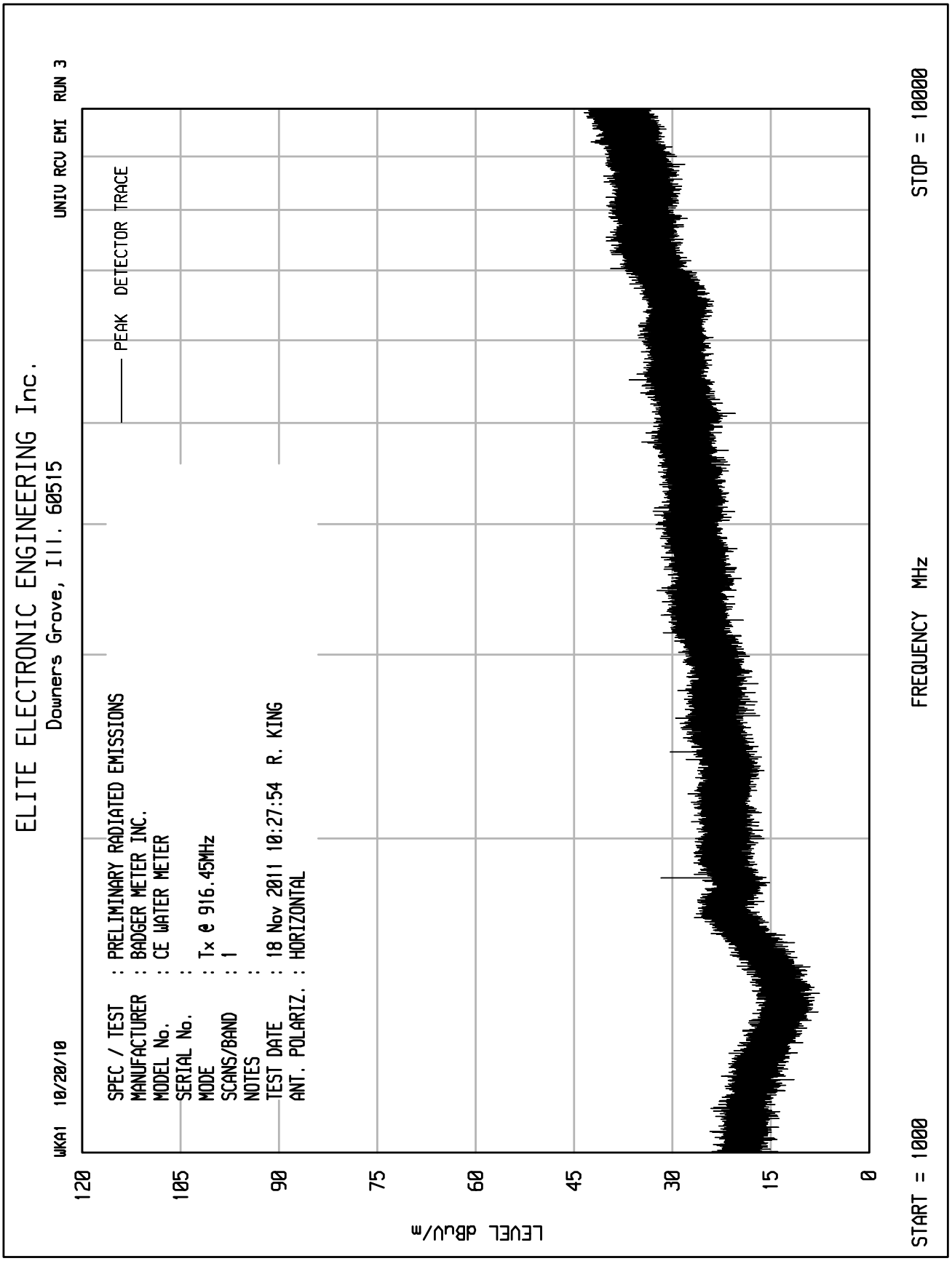
Date: 18.NOV.2011 11:40:12

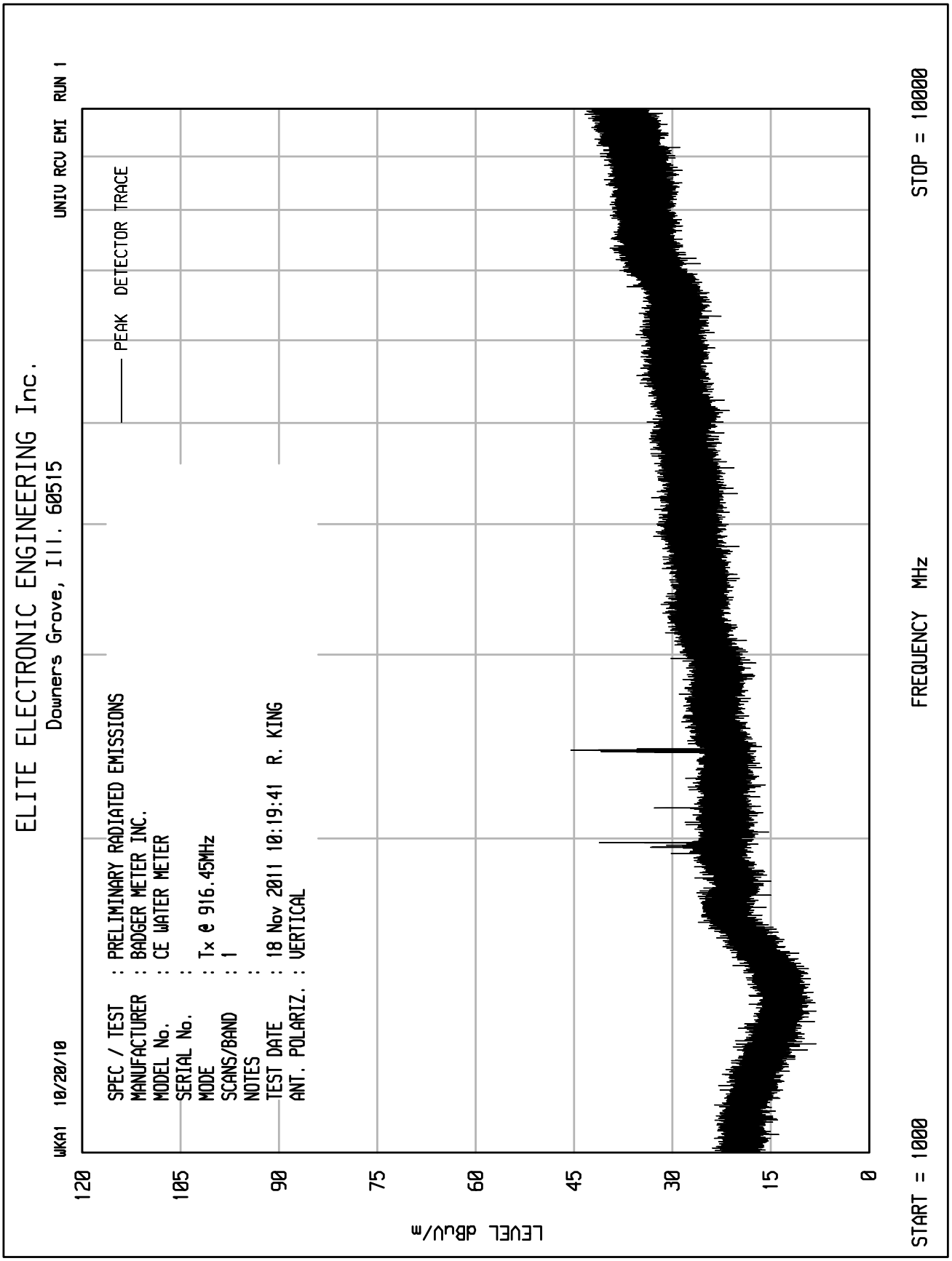
15.35 Duty Cycle

MANUFACTURER : Badger Meter Corporation
MODEL NUMBER : Orion CE Water Meter
TEST MODE : Transmit
TEST PARAMETERS : Duty Cycle in 100mSec.
NOTES : 20*Log((2.4mS/100mS))= -32.3 dB


ELITE ELECTRONIC ENGINEERING Inc.
Downers Grove, Ill. 60515
UNIV RCV EMI RUN 4
WKA1 10/20/10
SPEC / TEST : PRELIMINARY RADIATED EMISSIONS
MANUFACTURER : BADGER METER INC.
MODEL No. : CE WATER METER
SERIAL No. :
MODE : Tx @ 916.45MHz
SCANS/BAND : 1
NOTES :
TEST DATE : 18 Nov 2011 10:41:24 R. KING
ANT. POLARIZ. : HORIZONTAL
PEAK DETECTOR TRACE
LEVEL dBuV/m
120
105
90
75
60
45
30
15
0
START = 30
100
FREQUENCY MHz
STOP = 1000


ELITE ELECTRONIC ENGINEERING Inc.
Downers Grove, Ill. 60515
UNIV RCV EMI RUN 5
WKA1 10/20/10
SPEC / TEST : PRELIMINARY RADIATED EMISSIONS
MANUFACTURER : BADGER METER INC.
MODEL No. : CE WATER METER
SERIAL No. :
MODE : Tx @ 916.45MHz
SCANS/BAND : 1
NOTES :
TEST DATE : 18 Nov 2011 10:45:00 R. KING
ANT. POLARIZ. : VERTICAL
PEAK DETECTOR TRACE
LEVEL dBuV/m
120
105
90
75
60
45
30
15
0
START = 30
100
FREQUENCY MHz
STOP = 1000


ELITE ELECTRONIC ENGINEERING Inc.
Downers Grove, Ill. 60515
UNIV RCV EMI RUN 3
WKA1 10/20/10
SPEC / TEST : PRELIMINARY RADIATED EMISSIONS
MANUFACTURER : BADGER METER INC.
MODEL No. : CE WATER METER
SERIAL No. :
MODE : Tx @ 916.45MHz
SCANS/BAND : 1
NOTES :
TEST DATE : 18 Nov 2011 10:27:54 R. KING
ANT. POLARIZ. : HORIZONTAL
PEAK DETECTOR TRACE
LEVEL dBuV/m
120
105
90
75
60
45
30
15
0
START = 1000
FREQUENCY MHz
STOP = 10000


ELITE ELECTRONIC ENGINEERING Inc.
Downers Grove, Ill. 60515
UNIV RCV EMI RUN 1
WKA1 10/20/10
SPEC / TEST : PRELIMINARY RADIATED EMISSIONS
MANUFACTURER : BADGER METER INC.
MODEL No. : CE WATER METER
SERIAL No. :
MODE : Tx @ 916.45MHz
SCANS/BAND : 1
NOTES :
TEST DATE : 18 Nov 2011 10:19:41 R. KING
ANT. POLARIZ. : VERTICAL
PEAK DETECTOR TRACE
LEVEL dBuV/m
120
105
90
75
60
45
30
15
0
START = 1000
FREQUENCY MHz
STOP = 10000

DATA PAGE

Manufacturer : Badger Meter Corporation
Model No. : Orion CE Water Meter
Test Specification : FCC Part 15, Subpart C, Section 15.249, Radiated Emissions
Date : November 18, 2011
Mode : Transmit @ 916.45MHz
Test Distance : 3 meters
Notes : Quasi-Peak Detector <1 GHz; Peak Detector >1GHz
: Total = Meter Reading + Cable Loss + Antenna Factor + Preamp Gain

Freq (MHz)	Ant Pol	Meter Reading (dBuV)	CBL Fac (dB)	Ant Fac (dB)	Pre Amp (dB)	Total dBuV/m at 3 M	Total uV/m at 3M	Limit uV/m at 3M	Margin (dB)
916.45	H	62.0	2.0	21.7	0.0	85.7	19273.2	50000.0	-8.3
916.45	V	69.1	2.0	21.7	0.0	92.8	43697.1	50000.0	-1.2
1832.90	H	48.9	2.9	27.3	-40.6	38.5	84.0	5000.0	-35.5
1832.90	V	51.2	2.9	27.3	-40.6	40.8	109.4	5000.0	-33.2
2749.35	H	45.0	3.7	29.9	-40.3	38.3	82.0	5000.0	-35.7
2749.35	V	46.6	3.7	29.9	-40.3	39.9	98.6	5000.0	-34.1
3665.80	H	46.1	4.3	32.4	-40.1	42.7	136.2	5000.0	-31.3
3665.80	V	46.1	4.3	32.4	-40.1	42.7	136.2	5000.0	-31.3
4582.25	H	44.9	4.8	33.2	-40.0	42.8	138.8	5000.0	-31.1
4582.25	V	45.2	4.8	33.2	-40.0	43.2	144.5	5000.0	-30.8
5498.70	H	50.7	5.3	35.0	-40.1	50.8	347.4	5000.0	-23.2
5498.70	V	46.7	5.3	35.0	-40.1	46.9	220.2	5000.0	-27.1
6415.15	H	43.4	5.7	35.5	-39.9	44.7	171.2	5000.0	-29.3
6415.15	V	44.0	5.7	35.5	-39.9	45.3	184.6	5000.0	-28.7
7331.60	H	45.7	6.2	37.4	-39.7	49.5	297.3	5000.0	-24.5
7331.60	V	45.8	6.2	37.4	-39.7	49.6	302.1	5000.0	-24.4
8248.05	H	46.3	6.5	37.8	-39.5	51.1	360.1	5000.0	-22.9
8248.05	V	45.5	6.5	37.8	-39.5	50.3	328.8	5000.0	-23.6
9164.50	H	45.8	6.6	38.3	-39.0	51.6	382.0	5000.0	-22.3
9164.50	V	46.3	6.6	38.3	-39.0	52.2	405.1	5000.0	-21.8

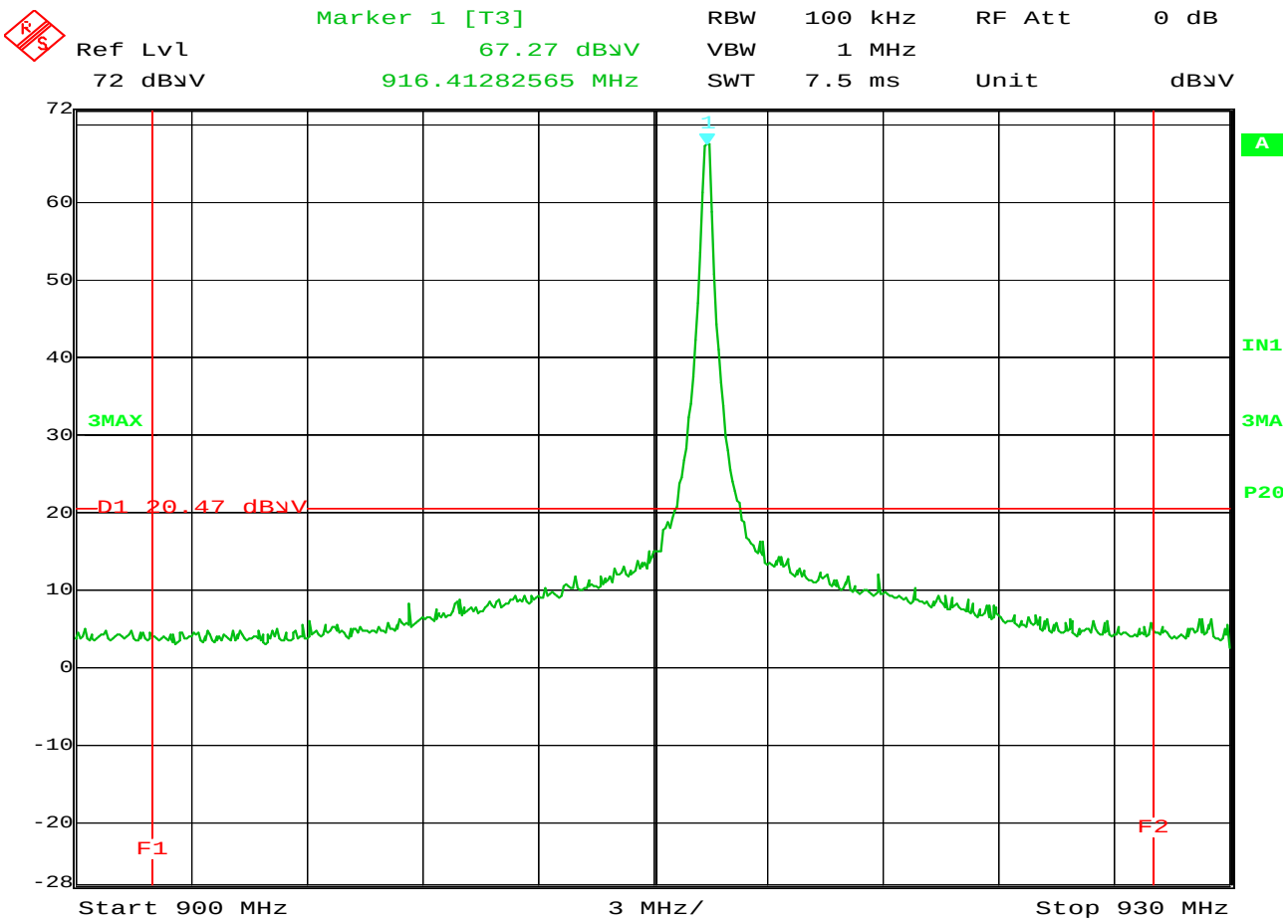
Checked By: Richard E. King

DATA PAGE

Manufacturer : Badger Meter Corporation
Model No. : Orion CE Water Meter
Test Specification : FCC Part 15, Subpart C, Section 15.247, Radiated Emissions
Date : November 18, 2011
Mode : Transmit @ 911.25MHz
Test Distance : 3 meters
Notes : Peak readings converted to average readings using the duty cycle correction factor.
: Total = Meter Reading + Cable Loss + Antenna Factor + Preamp Gain + Duty Cycle Factor

Frequency MHz	Antenna Polarity	Meter Reading dBuV	Ambient	Cable Loss dB	Antenna Factor dB	Pre Amp Gain dB	Duty Cycle Factor dB	Total dBuV/m	Total uV/m	Limit uV/m
1832.9	H	48.9	2.9	27.3	-40.6	-32.3	6.2	2.0	500	-47.8
1832.9	V	51.2	2.9	27.3	-40.6	-32.3	8.5	2.7	500	-45.5
2749.4	H	45.0	3.7	29.9	-40.3	-32.3	6.0	2.0	500	-48.0
2749.4	V	46.6	3.7	29.9	-40.3	-32.3	7.6	2.4	500	-46.4
3665.8	H	46.1	4.3	32.4	-40.1	-32.3	10.4	3.3	500	-43.6
3665.8	V	46.1	4.3	32.4	-40.1	-32.3	10.4	3.3	500	-43.6
4582.3	H	44.9	4.8	33.2	-40.0	-32.3	10.5	3.4	500	-43.4
4582.3	V	45.2	4.8	33.2	-40.0	-32.3	10.9	3.5	500	-43.1
5498.7	H	50.7	5.3	35.0	-40.1	-32.3	18.5	8.4	500	-35.5
5498.7	V	46.7	5.3	35.0	-40.1	-32.3	14.6	5.3	500	-39.4
6415.2	H	43.4	5.7	35.5	-39.9	-32.3	12.4	4.2	500	-41.6
6415.2	V	44.0	5.7	35.5	-39.9	-32.3	13.0	4.5	500	-41.0
7331.6	H	45.7	6.2	37.4	-39.7	-32.3	17.2	7.2	500	-36.8
7331.6	V	45.8	6.2	37.4	-39.7	-32.3	17.3	7.3	500	-36.7
8248.1	H	46.3	6.5	37.8	-39.5	-32.3	18.8	8.7	500	-35.2
8248.1	V	45.5	6.5	37.8	-39.5	-32.3	18.0	8.0	500	-35.9
9164.5	H	45.8	6.6	38.3	-39.0	-32.3	19.3	9.3	500	-34.6
9164.5	V	46.3	6.6	38.3	-39.0	-32.3	19.9	9.8	500	-34.1

Checked By: Richard E. King



15.249 Occupied Bandwidth

MANUFACTURER	:	Badger Meter Corporation
MODEL NUMBER	:	Orion CE Water Meter
TEST MODE	:	Transmit
TEST PARAMETERS	:	Occupied Bandwidth
NOTES	:	92.8 dBuV/m – 46 dBuV/m = 46.8 dB
NOTES	:	General Limit (20.47 dBuV= 67.27 dBuV – 46.8 dB)
	:	Display Line equals the general limit.
	:	F1 = 902MHz; F2=928MHz