Measurement of RF Emissions from an Ultrasonic Flow Meter with Two Wire Touch Transmitter

For	Badger Meter 4545 W. Brown Deer Road Milwaukee, WI 53223
P.O. Number	379559
Date Tested	November 14, 2019
Test Personnel	Mark Longinotti
Test Specification	FCC "Code of Federal Regulations" Title 47 Part15, Subpart C, Section 15.209 ISED Canada RSS-Gen

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REVISION HISTORY

Revision	Date	Description
—	18 Nov 2019	Initial release

Measurement of RF Emissions from an Ultrasonic Flow Meter with Two Wire Touch

1. INTRODUCTION

1.1. Scope of Tests

This report presents the results of the RF emissions measurements performed on an Ultrasonic Flow Meter with Two Wire Touch, Serial No. None Assigned, (hereinafter referred to as the Equipment Under Test (EUT)). The EUT was designed to transmit at approximately 50 kHz using an internal, non-removable antenna. The EUT was manufactured and submitted for testing by Badger Meter located in Milwaukee, WI.

1.2. Purpose

The test series was performed to determine if the EUT meets the conducted and radiated RF emission requirements of the FCC "Code of Federal Regulations" Title 47, Part 15, Subpart C, Section 207 and Section 209 for Intentional Radiators. Testing was performed in accordance with ANSI C63.10-2013.

The test series was also performed to determine if the EUT meets the conducted and radiated RF emission requirements of the Innovation, Science, and Economic Development Canada (ISED) RSS-Gen, Sections 8.8 and Section 8.9 for transmitters. Testing was performed in accordance with ANSI C63.10-2013.

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°C and the relative humidity was 18%.

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
- ANSI C63.10-2013, "American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices"
- Innovation, Science, and Economic Development (ISED) Canada RSS-Gen Radio Standards Specification, RSS-Gen, “General Requirements for Compliance of Radio Apparatus”, Issue 5, March 2019, Amendment 1

3. EUT SETUP AND OPERATION

3.1. General Description

The EUT is a Badger Meter, Ultrasonic Flow Meter with Two Wire Touch. A block diagram of the EUT setup is shown as Figure 1. A photograph of the EUT is shown as Figure 2.

3.1.1.Power Input

The EUT was powered by 3.3VDC from a battery source.

3.1.2.Peripheral Equipment

No peripheral equipment was submitted with the EUT.

3.1.3.Signal Input/Output Leads

The following interconnect cables were submitted with the EUT:

Item	Description
Encoder Cable	1.15 meter long cable used to connect the Ultrasonic Flow Meter to the Two Wire Touch

3.1.4.Grounding

The EUT was not grounded.

3.2. Software

For all tests, the EUT had Firmware Version 1.0.4139 loaded onto the device to provide correct load characteristics.

3.3. Operational Mode

For all tests, the EUT was placed on an 80cm high non-conductive stand. The EUT was powered up and programmed to operate in the transmit at 50kHz mode.

The cables were manually maximized during the preliminary emissions sweeps. The cable arrangement which resulted in the worst case emissions was utilized.

3.4. EUT Modifications

No modifications were required for compliance to the FCC 15C Sections 207 and 209 requirements or the ISED RSS-Gen Sections 8.8 and 8.9 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 C63.4-2014 for site attenuation.

4.2. Test Instrumentation

The test instrumentation and auxiliary equipment used during the tests are listed in Table 9-1.

4.3. Calibration Traceability

Test equipment is maintained and calibrated on a regular basis with a calibration interval not greater than two years. 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.

Values of Expanded Measurement Uncertainty (95% Confidence) are presented below:

Measurement Type	Expanded Measurement Uncertainty
Conducted disturbance (mains port) (150 kHz – 30 MHz)	2.7
Radiated disturbance (electric field strength on an open area test site or alternative test site) (30 MHz – 1000 MHz)	4.3
Radiated disturbance (electric field strength on an open area test site or alternative test site) (1 GHz – 6 GHz)	3.1
Radiated disturbance (electric field strength on an open area test site or alternative test site) (6 GHz – 18 GHz)	3.2

5. TEST PROCEDURES

5.1. Powerline Conducted Emissions

5.1.1.Requirements

Since the EUT is powered by internal batteries and has no connections for AC power, no conducted emissions tests are required.

5.2. Radiated Measurements

5.2.1.Requirements

The EUT must comply with the requirements of FCC “Code of Federal Regulations Title 47” Part 15, Subpart C, Section 15.209. Paragraph 15.209(a) has the following radiated emissions limits:

Frequency MHz	Field Strength uV/m	Measurement Distance (meters)
0.009 – 0.490	2400/F(kHz)	300
0.490 – 1.705	24000/F(kHz)	30
1.705 – 30.0	30	30
30 – 88	100	3
88 – 216	150	3
216 -960	200	3
Above 960	500	3

The EUT must also comply with the requirements of ISED RSS-Gen, Section 8.9. has the following limits:

Frequency MHz	Magnetic Field Strength uA/m	Measurement Distance (meters)
0.009 – 0.490	6.37/F(kHz)	300
0.490 – 1.705	63.7/F(kHz)	30
1.705 – 30.0	0.08	30

Frequency MHz	Field Strength uV/m	Measurement Distance (meters)
30 – 88	100	3
88 – 216	150	3
216 -960	200	3
Above 960	500	3

5.2.2.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-ANSI year 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. Since the signal could not be detected at the 3 meter test distance, the loop antenna was first moved to a 1 foot test distance from the EUT. For the preliminary test, a loop antenna was positioned at a 1 foot distance from the EUT. The measurement antenna was vertically polarized. The test item was then rotated through 360° around its X, Y, and Z axis. The worst case position was noted. The entire frequency range from 10kHz to 30MHz was investigated using a peak detector function. The data was then processed by the computer to calculate equivalent field intensity.

The final emission tests were then manually performed over the frequency range of 50kHz to 500kHz at a test distance of 3 meters using a loop antenna as the pick-up device. 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.

5.2.3.Results

The preliminary plot, with the EUT transmitting at 50 kHz, is presented on page 13. The plot is presented for a reference only, and is not used to determine compliance.

The final open area radiated levels, with the EUT transmitting at 50 kHz, are presented on data pages 14 and 15. As can be seen from the data, all emissions measured from the EUT were within the specification limits. Photographs of the test configuration which yielded the highest or worst case, radiated emission levels are shown on Figure 3.

5.3. 99% Emission Bandwidth Measurements

5.3.1.Requirement

In accordance with paragraph 6.7 of RSS-Gen, the 99% bandwidth shall be reported for all equipment.

5.3.2.Procedures

A near field loop probe was placed next to the EUT. The near field probe was connected to the input of a spectrum analyzer. The unit was set to transmit continuously. The center frequency of the spectrum analyzer

was set to the transmit frequency of the EUT. The span was set large enough to capture all products of the modulation process. The RBW was set between 1% and 5% of the 99% bandwidth.

5.3.3.Results

The plot of the 99% emissions bandwidth is shown on page 16. As can be seen from this data page, the 99% bandwidth was measured to be 10.97kHz.

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 personnel.

6.2. Disposition of the EUT

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

7. CONCLUSIONS

It was determined that the Badger Meter Ultrasonic Flow Meter with Two Wire Touch, Serial No. None Assigned did fully meet the conducted and radiated emission requirements of the FCC "Code of Federal Regulations" Title 47, Part 15, Subpart C, Section 15.207 and Section 209 for Intentional Radiators, when tested per ANSI C63.10-2013.

It was also determined that the Badger Meter Ultrasonic Flow Meter with Two Wire Touch, Serial No. None Assigned did fully meet the conducted and radiated emission requirements of the ISED Canada RSS-Gen, Sections 8.8 and 8.9 for Transmitters, when tested per ANSI C63.10-2013.

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 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 certification, approval, or endorsement by A2LA, NIST or any agency of the Federal Government.

9. EQUIPMENT LIST

Table 9-1 Equipment List

Eq ID	Equipment Description	Manufacturer	Model No.	Serial No.	Frequency Range	Cal Date	Due Date
NLS0	24" ACTIVE LOOP ANTENNA	EMCO	6502	89979	10KHZ-30MHZ	8/22/2018	8/22/2020
RBG2	EMI ANALYZER	ROHDE & SCHWARZ	ESW44	101591	2HZ-44GHZ	2/21/2019	2/21/2020
WKA1	SOFTWARE, UNIVERSAL RCV EMI	ELITE	UNIV_RCV_EMI	1	---	I/O	

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.

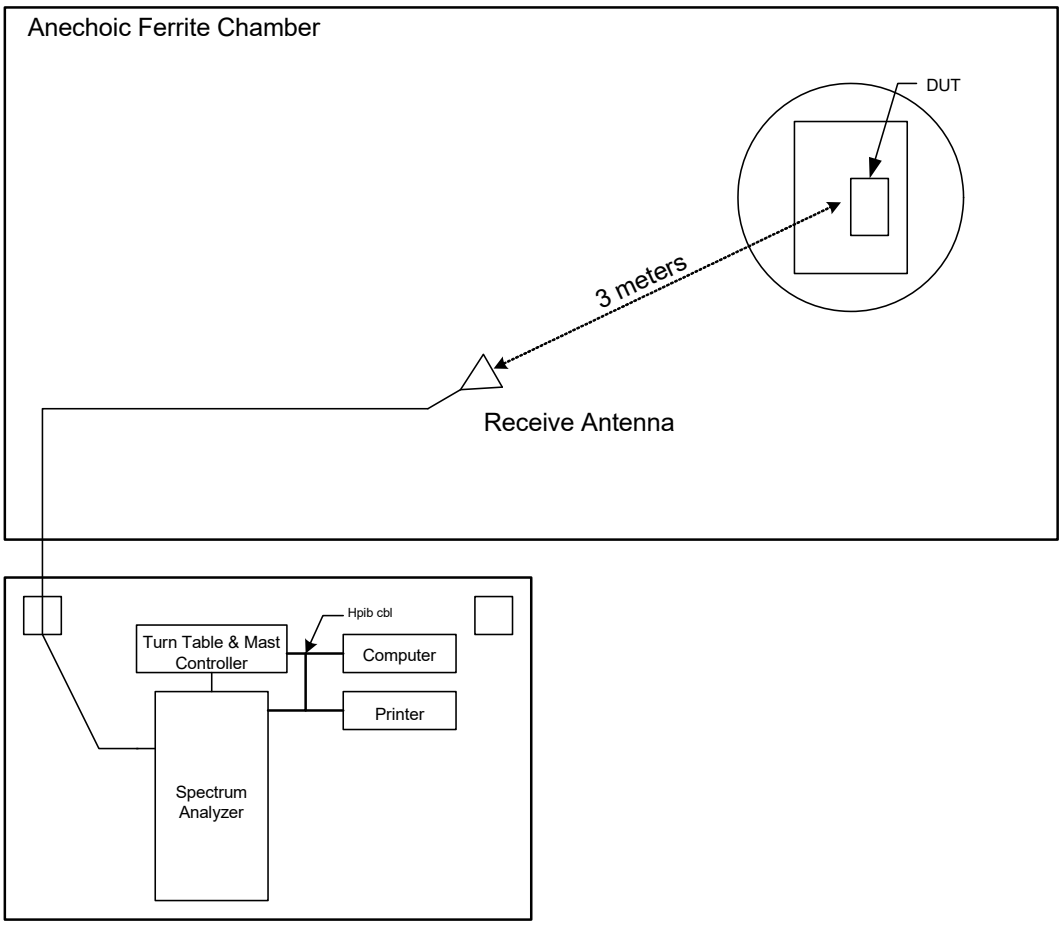
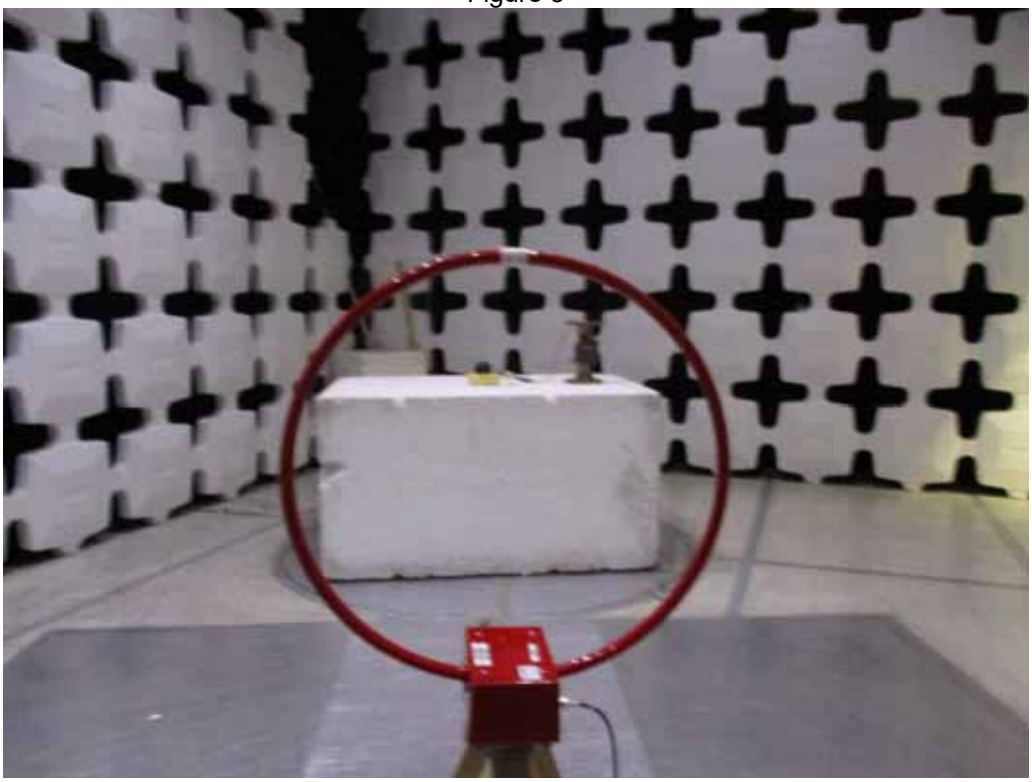


FIGURE 1 BLOCKDIAGRAM OF TEST SETUP

Figure 2

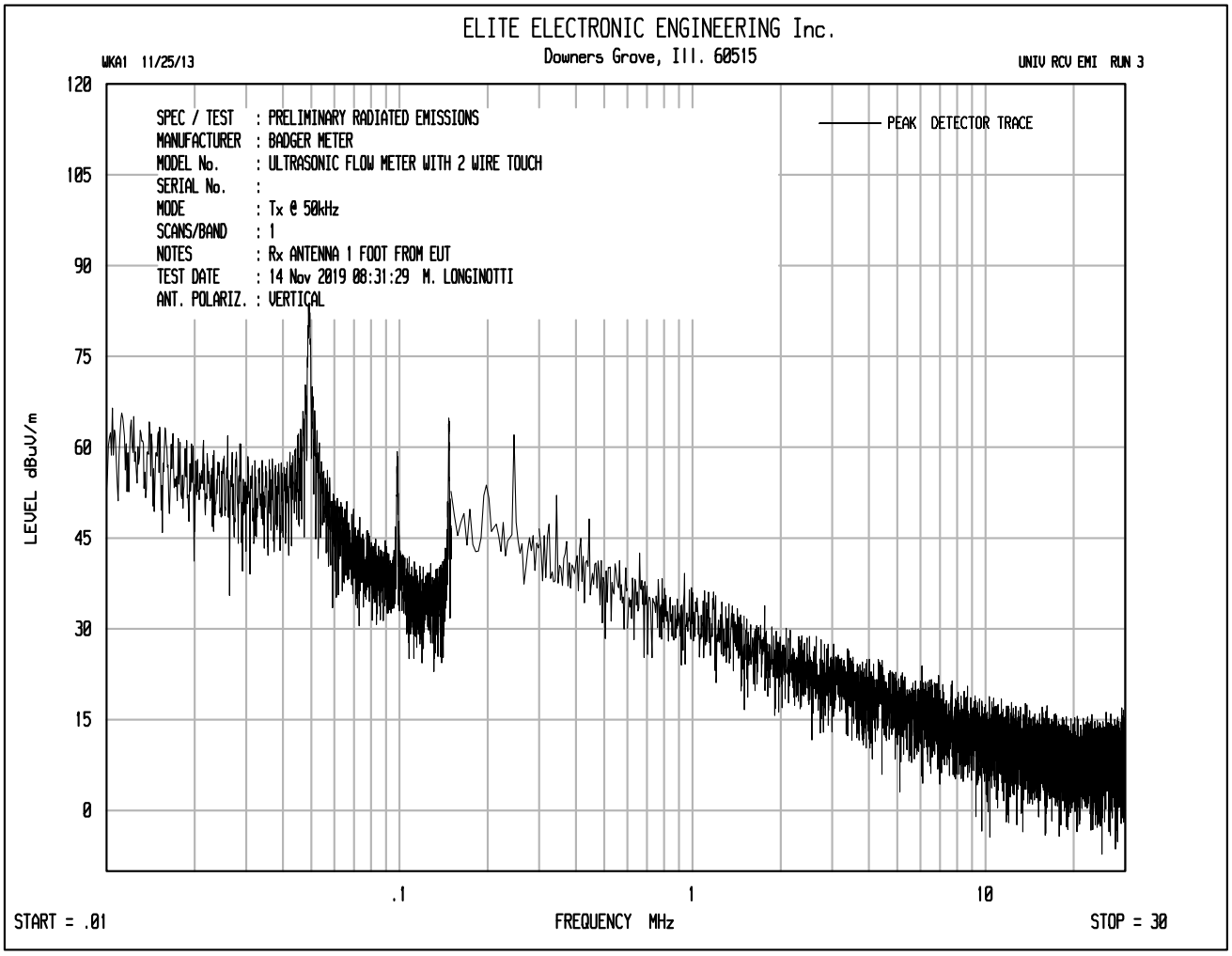
Photograph of EUT

Figure 3



Test Setup for Radiated Emissions – Vertical Polarization

Test Setup for Radiated Emissions – Horizontal Polarization


ELITE ELECTRONIC ENGINEERING Inc.
Downers Grove, Ill. 60515
WKA1 11/25/13
UNIV RCV EMI RUN 3
SPEC / TEST : PRELIMINARY RADIATED EMISSIONS
MANUFACTURER : BADGER METER
MODEL No. : ULTRASONIC FLOW METER WITH 2 WIRE TOUCH
SERIAL No. :
MODE : Tx @ 50kHz
SCANS/BAND : 1
NOTES : Rx ANTENNA 1 FOOT FROM EUT
TEST DATE : 14 Nov 2019 08:31:29 M. LONGINOTTI
ANT. POLARIZ. : VERTICAL
PEAK DETECTOR TRACE
LEVEL dBuV/m
120
105
90
75
60
45
30
15
0
.1
1
10
START = .01
FREQUENCY MHz
STOP = 30

Manufacturer : Badger Meter
Test Item : Ultrasonic Flow Meter with Two Wire Touch
Serial No. : None Assigned
Mode : Transmit at 50kHz
Test Specification : FCC 15.209, Spurious Radiated Emissions
Date : November 14, 2091
Test Distance : 3 meters
Notes : 200Hz RBW below 150kHz, 9kHz RBW above 150kHz

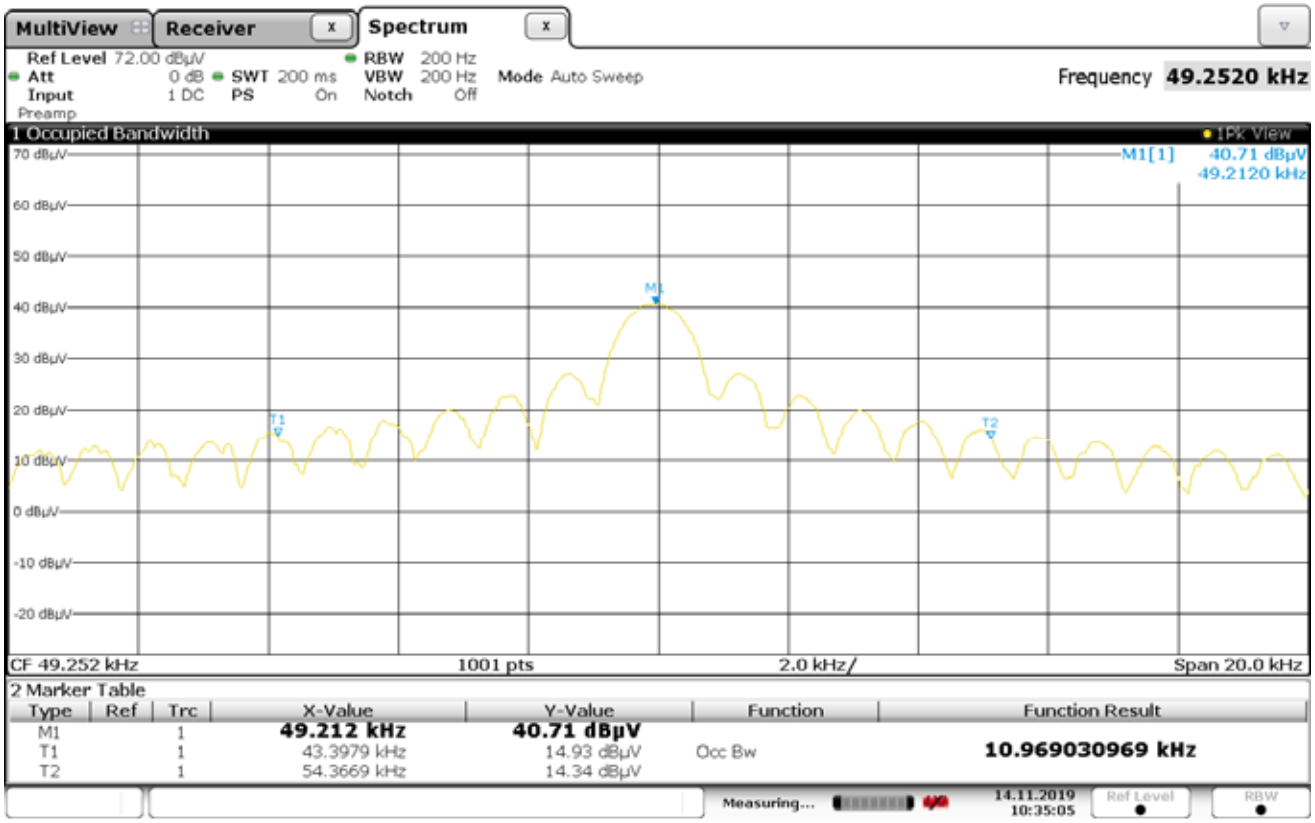
Freq. (MHz)	Ant Pol	Meter Reading (dBuV)	Ambient	CBL Fac (dB)	Ant Fac (dB/m)	Dist. Corr. (dB)	Total (dBuV/m)	Total (uV/m)	Limit (uV/m)	Specified Test Distance (meters)	Margin (dB)
0.050	H	41.3	Ambient	0.0	11.6	-80.0	-27.1	0.0	48.0	300.0	-60.8
0.050	V	40.4	Ambient	0.0	11.6	-80.0	-28.0	0.0	48.0	300.0	-61.7
0.100	H	36.4	Ambient	0.0	11.1	-80.0	-32.5	0.0	24.0	300.0	-60.1
0.100	V	35.0	Ambient	0.0	11.1	-80.0	-33.9	0.0	24.0	300.0	-61.5
0.150	H	48.3	Ambient	0.0	11.0	-80.0	-20.7	0.1	16.0	300.0	-44.7
0.150	V	49.8	Ambient	0.0	11.0	-80.0	-19.2	0.1	16.0	300.0	-43.2
0.200	H	48.0	Ambient	0.0	11.1	-80.0	-20.9	0.1	12.0	300.0	-42.5
0.200	V	47.8	Ambient	0.0	11.1	-80.0	-21.1	0.1	12.0	300.0	-42.7
0.250	H	45.4	Ambient	0.0	11.1	-80.0	-23.5	0.1	9.6	300.0	-43.2
0.250	V	46.1	Ambient	0.0	11.1	-80.0	-22.8	0.1	9.6	300.0	-42.5
0.300	H	44.2	Ambient	0.0	11.1	-80.0	-24.7	0.1	8.0	300.0	-42.8
0.300	V	43.6	Ambient	0.0	11.1	-80.0	-25.3	0.1	8.0	300.0	-43.4
0.350	H	43.0	Ambient	0.0	11.1	-80.0	-25.9	0.1	6.9	300.0	-42.7
0.350	V	42.6	Ambient	0.0	11.1	-80.0	-26.3	0.0	6.9	300.0	-43.1
0.400	H	41.8	Ambient	0.0	11.1	-80.0	-27.1	0.0	6.0	300.0	-42.7
0.400	V	41.7	Ambient	0.0	11.1	-80.0	-27.2	0.0	6.0	300.0	-42.8
0.450	H	39.9	Ambient	0.0	11.1	-80.0	-29.0	0.0	5.3	300.0	-43.6
0.450	V	40.6	Ambient	0.0	11.1	-80.0	-28.3	0.0	5.3	300.0	-42.9
0.500	H	38.8	Ambient	0.0	11.1	-40.0	9.9	3.1	48.0	30.0	-23.8
0.500	V	39.3	Ambient	0.0	11.1	-40.0	10.4	3.3	48.0	30.0	-23.3

Distance Correction Factor: Per CFR 15.31(f)(2), at frequencies below 30MHz measurements may be performed at a distance closer than that specified in the regulations. The results may be extrapolated to the specified distance by using the square of an inverse linear distance extrapolation factor (40dB/decade). Distance correction factor (300 meters to 3 meters) = 80dB (2 decades @ 40dB per decade) Distance correction factor (30 meters to 3 meters) = 40dB (1 decade @ 40dB per decade).

Manufacturer : Badger Meter
Test Item : Ultrasonic Flow Meter with Two Wire Touch
Serial No. : None Assigned
Mode : Transmit at 50kHz
Test Specification : RSS-Gen, Section 8.9, Spurious Radiated Emissions
Date : November 14, 2091
Test Distance : 3 meters
Notes : 200Hz RBW below 150kHz, 9kHz RBW above 150kHz

Freq. (MHz)	Ant Pol	Meter Reading (dBuV)	Ambient	CBL Fac (dB)	Ant Fac (dB/m)	Dist. Corr. (dB)	Total (dBuA/m)	Total (uA/m)	Limit (uA/m)	Specified Test Distance (meters)	Margin (dB)
0.050	H	41.3	Ambient	0.0	-39.9	-80.0	-78.6	0.0001	0.1274	300.0	-60.7
0.050	V	40.4	Ambient	0.0	-39.9	-80.0	-79.5	0.0001	0.1274	300.0	-61.6
0.100	H	36.4	Ambient	0.0	-40.4	-80.0	-84.0	0.0001	0.0637	300.0	-60.1
0.100	V	35.0	Ambient	0.0	-40.4	-80.0	-85.4	0.0001	0.0637	300.0	-61.5
0.150	H	48.3	Ambient	0.0	-40.5	-80.0	-72.2	0.0002	0.0425	300.0	-44.7
0.150	V	49.8	Ambient	0.0	-40.5	-80.0	-70.7	0.0003	0.0425	300.0	-43.2
0.200	H	48.0	Ambient	0.0	-40.4	-80.0	-72.4	0.0002	0.0319	300.0	-42.5
0.200	V	47.8	Ambient	0.0	-40.4	-80.0	-72.6	0.0002	0.0319	300.0	-42.7
0.250	H	45.4	Ambient	0.0	-40.4	-80.0	-75.0	0.0002	0.0255	300.0	-43.2
0.250	V	46.1	Ambient	0.0	-40.4	-80.0	-74.3	0.0002	0.0255	300.0	-42.5
0.300	H	44.2	Ambient	0.0	-40.4	-80.0	-76.2	0.0002	0.0212	300.0	-42.8
0.300	V	43.6	Ambient	0.0	-40.4	-80.0	-76.8	0.0001	0.0212	300.0	-43.4
0.350	H	43.0	Ambient	0.0	-40.4	-80.0	-77.4	0.0001	0.0182	300.0	-42.6
0.350	V	42.6	Ambient	0.0	-40.4	-80.0	-77.8	0.0001	0.0182	300.0	-43.0
0.400	H	41.8	Ambient	0.0	-40.4	-80.0	-78.6	0.0001	0.0159	300.0	-42.7
0.400	V	41.7	Ambient	0.0	-40.4	-80.0	-78.7	0.0001	0.0159	300.0	-42.8
0.450	H	39.9	Ambient	0.0	-40.4	-80.0	-80.5	0.0001	0.0142	300.0	-43.6
0.450	V	40.6	Ambient	0.0	-40.4	-80.0	-79.8	0.0001	0.0142	300.0	-42.9
0.500	H	38.8	Ambient	0.0	-40.4	-40.0	-41.6	0.0083	0.1274	30.0	-23.7
0.500	V	39.3	Ambient	0.0	-40.4	-40.0	-41.1	0.0088	0.1274	30.0	-23.2

Distance Correction Factor: Per RSS-Gen section 6.5, when field strength measurements are specified for frequencies below 30 MHz, the field strength may be measured in the near field (i.e. at a distance of less than two wavelengths). The measured field strength shall be extrapolated to the distance specified using the formula indicating that the field strength varies as the inverse distance square (40 dB per decade of distance).



Date: 14.NOV.2019 10:35:05

Manufacturer	: Badger Meter
Test Item	: Ultrasonic Flow Meter with Two Wire Touch
Serial No.	: None Assigned
Mode	: Transmit at 50kHz
Test Specification	: RSS-Gen, Section 6.7, 99% Emission Bandwidth
Date	: November 14, 2091
Test Distance	: 3 meters
Notes	: 99% bandwidth = 10.97kHz