



Measurement of RF Interference from a Serial Interface Repeater Transmitter

For : Badger Meter
4545 W Brown Deer Rd
Milwaukee, WI 53223

P.O. No. : 542987
Date Tested : June 18, 2007 through June 20, 2007
Test Personnel : Mark E. Longinotti
Specification : FCC "Code of Federal Regulations" Title 47
Part 15, Subpart C, Section 15.249 for Intentional
Radiators Operating Within the 902MHz to 928MHz band
: Industry Canada RSS-210
: Industry Canada RSS-GEN

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REVISION HISTORY

Revision	Date	Description
—	June 22, 2007	Initial release

Measurement of RF Emissions from a Serial Interface Repeater Transmitter

1 INTRODUCTION

1.1 Scope of Tests

This document represents the results of the series of radio interference measurements performed on a Badger Meter Serial Interface Repeater transmitter, (hereinafter referred to as the test item). Unit Number FCC 8 was assigned to the test item. The test item was designed to transmit at approximately 916.45MHz using an internal antenna. The test item 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 test item meets the conducted and radiated RF emission requirements of the FCC "Code of Federal Regulations" Title 47, Part 15, Subpart C, Sections 15.249 and of Industry Canada RSS-210 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 National Institute of Standards and Technology (NIST) under the National Voluntary Laboratory Accreditation Program (NVLAP). NVLAP Lab Code: 100278-0.

1.5 Laboratory Conditions

The temperature at the time of the test was 23°C and the relative humidity was 37%.

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 2005
- 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 RSS-210, Issue 7, June 2007, "Spectrum Management and Telecommunications Radio Standards Specification, Low-power License-exempt radio communication devices (All Frequency Bands): Category I Equipment"
- Industry Canada RSS-GEN, Issue 2, June 2007, "Spectrum Management and Telecommunications Radio Standards Specification, General Requirements and Information for the Certification of radio communication equipment"

3 TEST ITEM SETUP AND OPERATION

3.1 General Description

The test item is a Serial Interface Repeater. A block diagram of the test item setup is shown as Figure 1. A photograph of the test item is shown as Figure 2.



3.1.1 Power Input

The test item obtained 3.6VDC from a lithium "D cell" internal battery.

3.1.2 Peripheral Equipment

The test item was submitted for testing with no peripheral equipment.

3.1.3 Interconnect Cables

The test item was submitted for testing with no interconnect cables.

3.1.4 Grounding

The test item was ungrounded during the tests

3.2 Operational Mode

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

3.3 Test Item 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 emission tests were performed with a spectrum analyzer in conjunction with a quasi-peak adapter.

Radiated emissions were performed with a spectrum analyzer. This receiver allows measurements with the bandwidths specified by the FCC and with the quasi-peak detector function. The receiver bandwidth was 120kHz for the 30MHz to 1000MHz 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 Emission Measurements		
Combined Standard Uncertainty	1.07	-1.07
Expanded Uncertainty (95% confidence)	2.1	-2.1

Radiated Emission 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 test item was powered by an internal battery, no conducted emissions tests were performed.

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 2msec/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. The on-time and off-time are then measured. The on-time is total time signal level exceeds the 4th division. Off-time is time under for the word period. The duty cycle is then computed as the (On-time/ word period) where the word period = (On-time + Off-time).

5.2.2 Results

The plots of the duty cycle are shown on data pages 14 and 15. The test item transmits a 1.96msec pulse every 3.96 seconds. Since a word is greater than 100 msec long, the duty cycle factor was computed over a 100msec interval. The duty cycle correction factor was calculated to be -34.15dB ($-34.15\text{dB} = 20 \cdot \log(1.96\text{msec}/100\text{msec})$).

5.3 Radiated Measurements

5.3.1 Requirements

The test item 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 strength of fundamental uV/m @ 3 meters	Field Strength of Harmonics uV/m @ 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

Radiated measurements were performed in a 32ft. x 20ft. x 14ft. high shielded enclosure. 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 test item. For the preliminary test, a broadband measuring antenna was positioned at a 3 meter distance from the test item. The entire frequency range from 30MHz to 10.0GHz 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 10.0GHz. 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 test item 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 test item was rotated through three orthogonal axes to determine which orientation produces the highest emission relative to the limit.

5.3.3

The preliminary plots, with the test item transmitting at 916.45MHz, are presented on pages 16 and 17. The plots are presented for a reference only, and are not used to determine compliance.

The final radiated levels, with the test item transmitting at 916.45MHz, are presented on pages 18 and 19. As can be seen from the data, all emissions measured from the test item were within the specification limits. The emissions level closest to the limit (worst case) occurred at 916.45MHz. The emissions level at this frequency was 0.7dB within the limit. Photographs of the test configuration which yielded the highest, or worst case, radiated emission levels are shown on Figures 3 and 4. A block diagram of the test item orientation position is shown in Figure 1.

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 test item was placed on an 80cm high non-conductive stand. The unit was set to transmit continuously. With an antenna positioned 3 meters away, 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 is presented on page 20. As can be seen from this data page, the transmitter met the occupied bandwidth requirements. The 99% bandwidth was measured to be 280.56 kHz.

6 OTHER TEST CONDITIONS

6.1 Test Personnel and Witnesses

All tests were performed by qualified personnel from Elite Electronic Engineering Incorporated.

6.2 Disposition of the Test Item

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

7 CONCLUSIONS

It was determined that the Badger Meter Serial Interface Repeater, Unit Number FCC 8 was assigned to the test item, did fully meet the conducted and radiated emission requirements of the FCC "Code of Federal Regulations" Title 47, Part 15, Subpart C, Sections 15.207 and 15.249 and of Industry Canada RSS-210 for Intentional Radiators Operating within the 902MHz -928MHz band, 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 test item at the test date. Any electrical or mechanical modification made to the test item 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

ELITE ELECTRONIC ENG. INC.								Page: 1
Eq ID	Equipment Description	Manufacturer	Model No.	Serial No.	Frequency Range	Cal Date	Cal Inv	Due Date
Equipment Type: ACCESSORIES, MISCELLANEOUS								
XPQ2	HIGH PASS FILTER	K&L MICROWAVE	4IH30-1804/T 3		1.8-10GHZ	11/27/06	12	11/27/07
Equipment Type: AMPLIFIERS								
APW3	PRE-AMPLIFIER	PLANAR ELECTRON	PE2-35-120-5	PL2924	1GHZ-20GHZ	11/27/06	12	11/27/07
Equipment Type: ANTENNAS								
NDQ1	TUNED DIPOLE ANTENNA	EMCO	3121C-DB4	313	400-1000MHZ	03/28/07	12	03/28/08
NTA1	BILOG ANTENNA	CHASE EMC LTD.	BILOG CBL611	2054	0.03-2GHZ	06/05/07	12	06/05/08
NWH0	RIDGED WAVE GUIDE	TENSOR	4105	2081	1-12.4GHZ	10/09/06	12	10/09/07
Equipment Type: CONTROLLERS								
CDS2	COMPUTER	GATEWAY	MFATXPNT NMZ	0028483108	1.8GHZ		N/A	
CMA0	MULTI-DEVICE CONTROLLER	EMCO	2090	9701-1213	---		N/A	
Equipment Type: POWER SUPPLIES								
SRA7	DC POWER SUPPLY	TEKPOWER	HY3005D	0023471			NOTE 1	
Equipment Type: PRINTERS AND PLOTTERS								
HRE1	LASER JET 5P	HEWLETT PACKARD	C3150A	USHB061052	---		N/A	
Equipment Type: RECEIVERS								
RBB0	EMI TEST RECEIVER 20HZ TO	ROHDE & SCHWARZ	ESIB40	100250	20 HZ TO 40GHZ	09/29/06	12	09/29/07

Cal. Interval: Listed in Months 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.

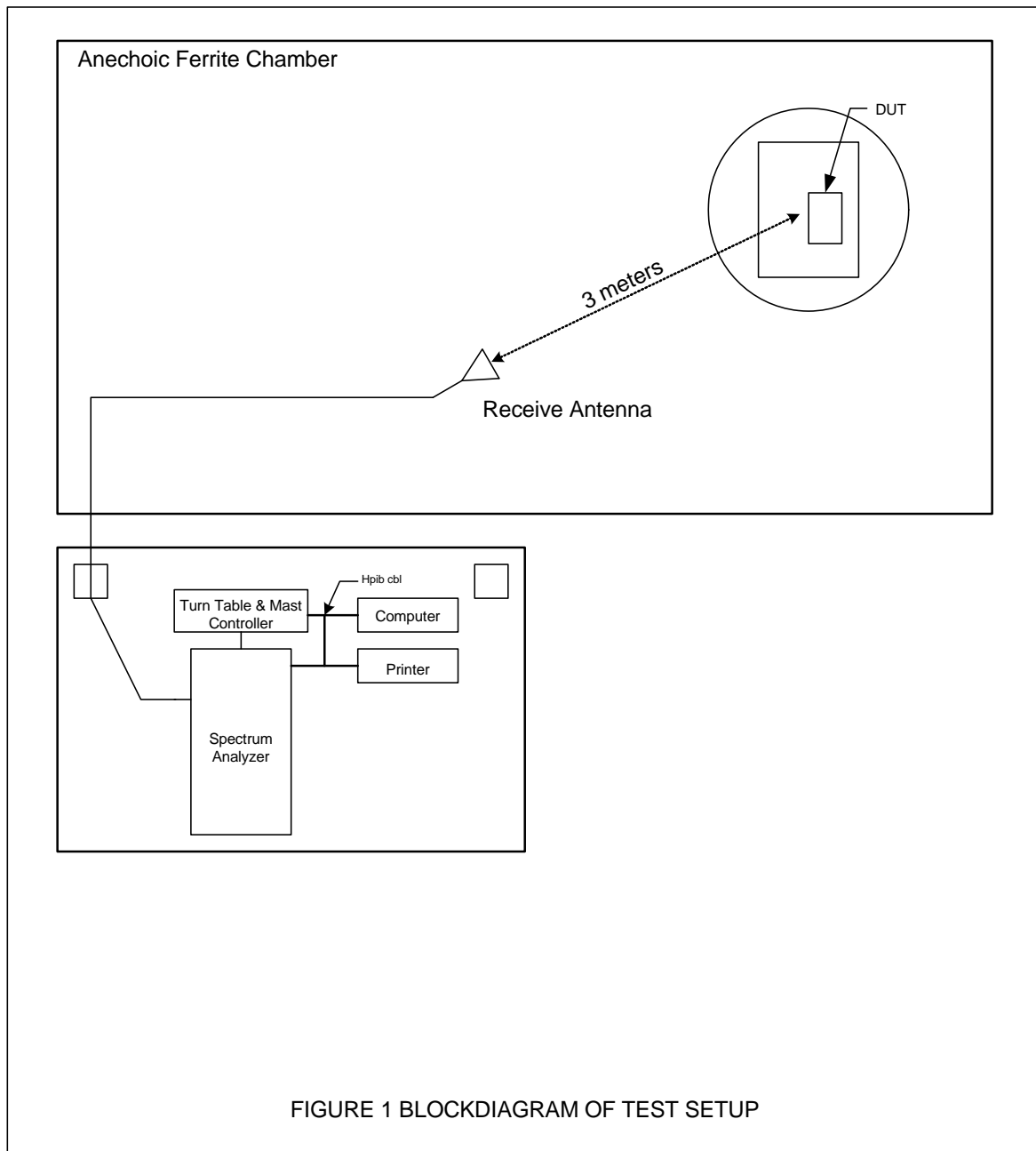


Figure 2



Test Item Setup

Figure 3



Test Setup for Radiated Emissions, 916.45MHz – Horizontal Polarity



Test Setup for Radiated Emissions, 916.45MHz – Vertical Polarity

Figure 4

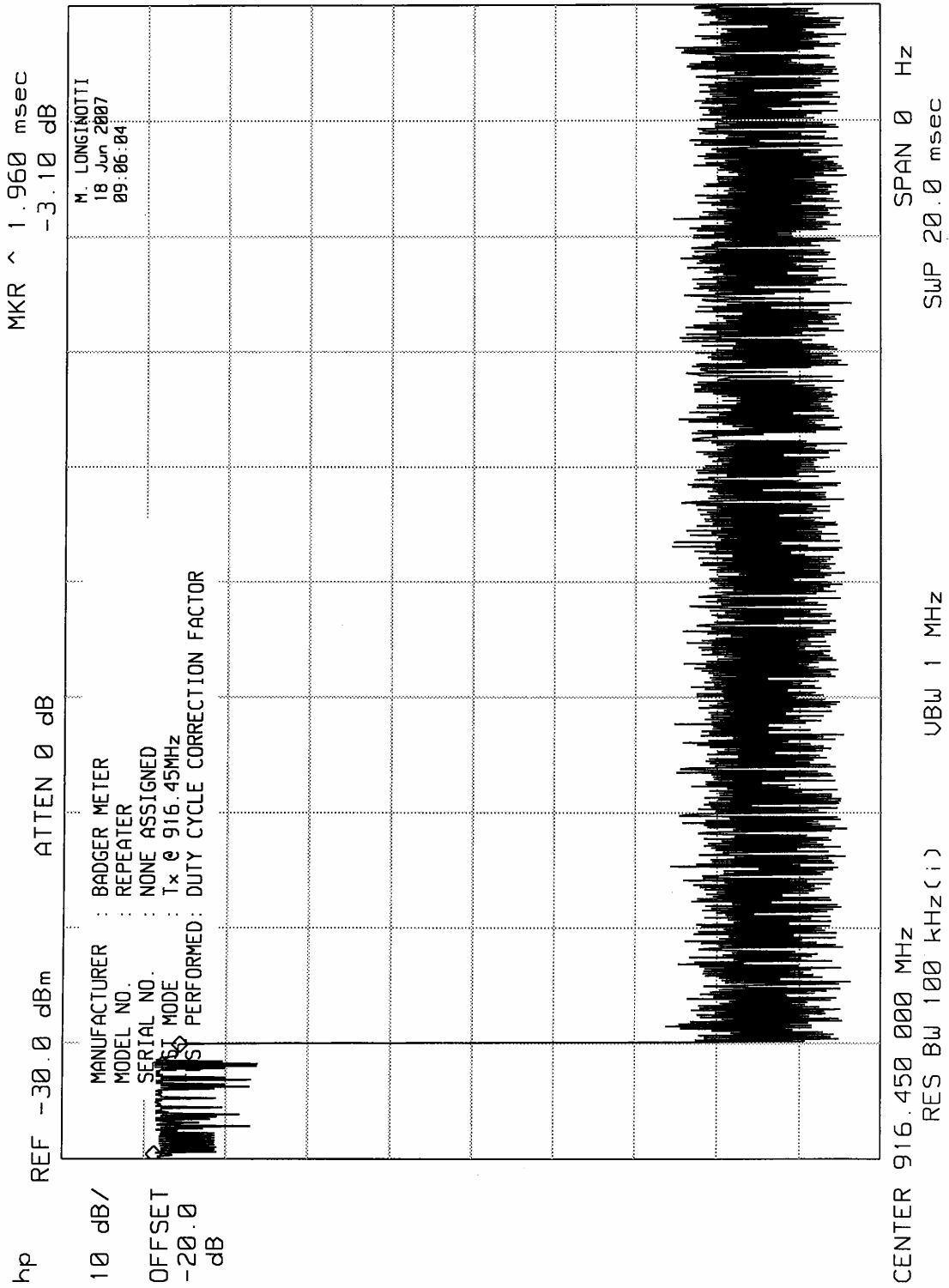


Test Setup for Radiated Emissions, 1GHz to 10GHz – Horizontal Polarity

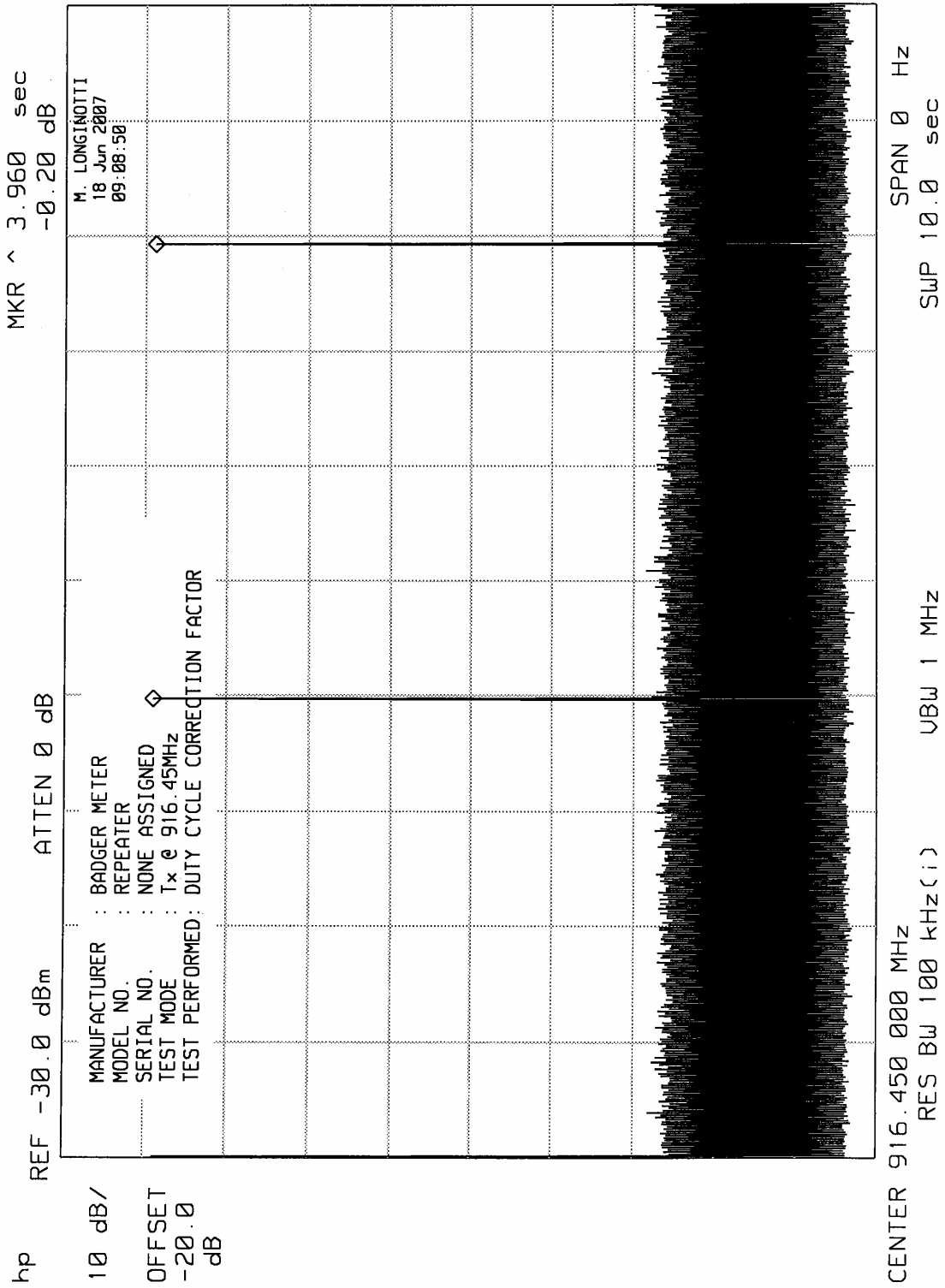


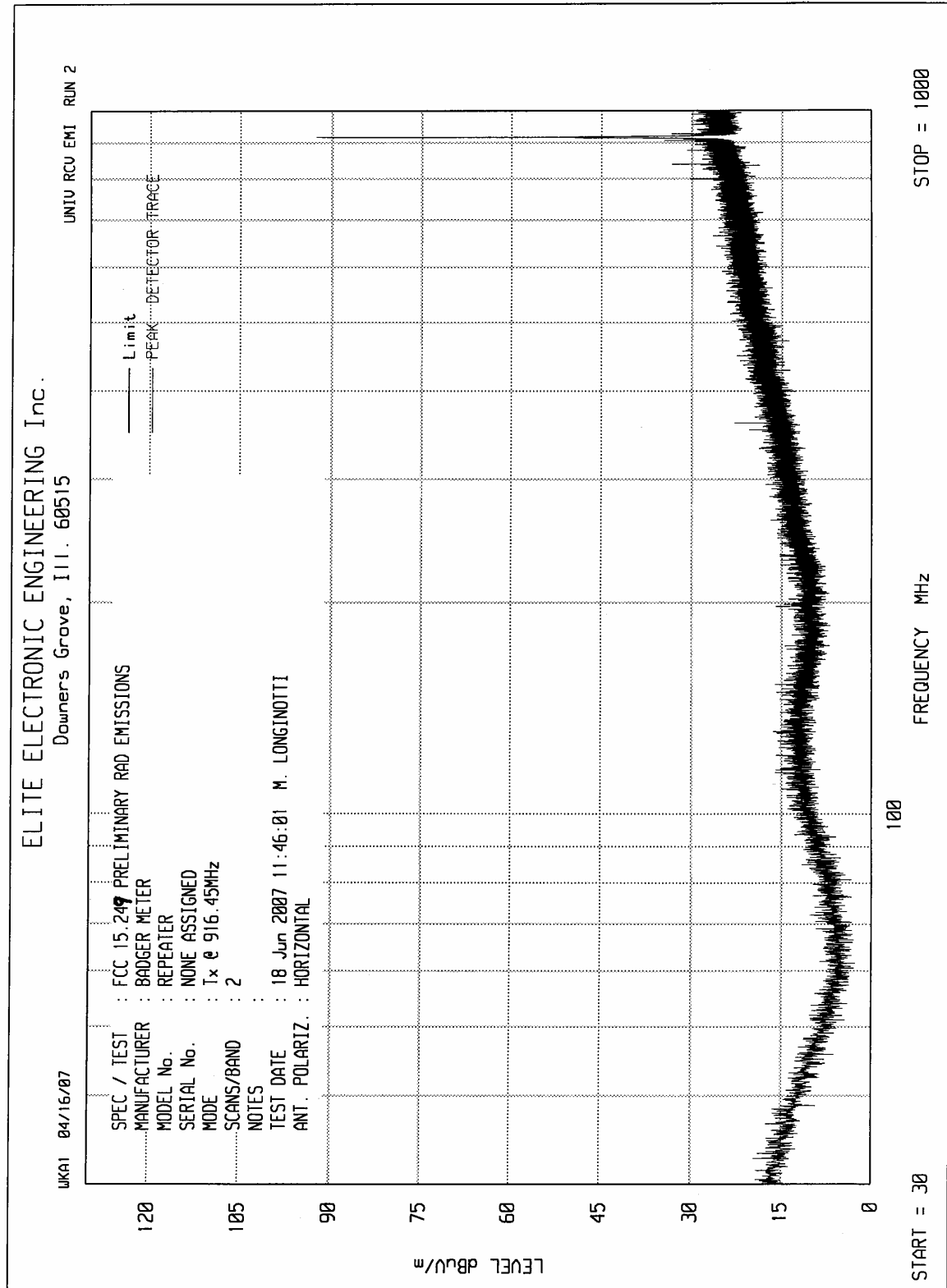
Test Setup for Radiated Emissions, 1GHz to 10GHz – Vertical Polarity

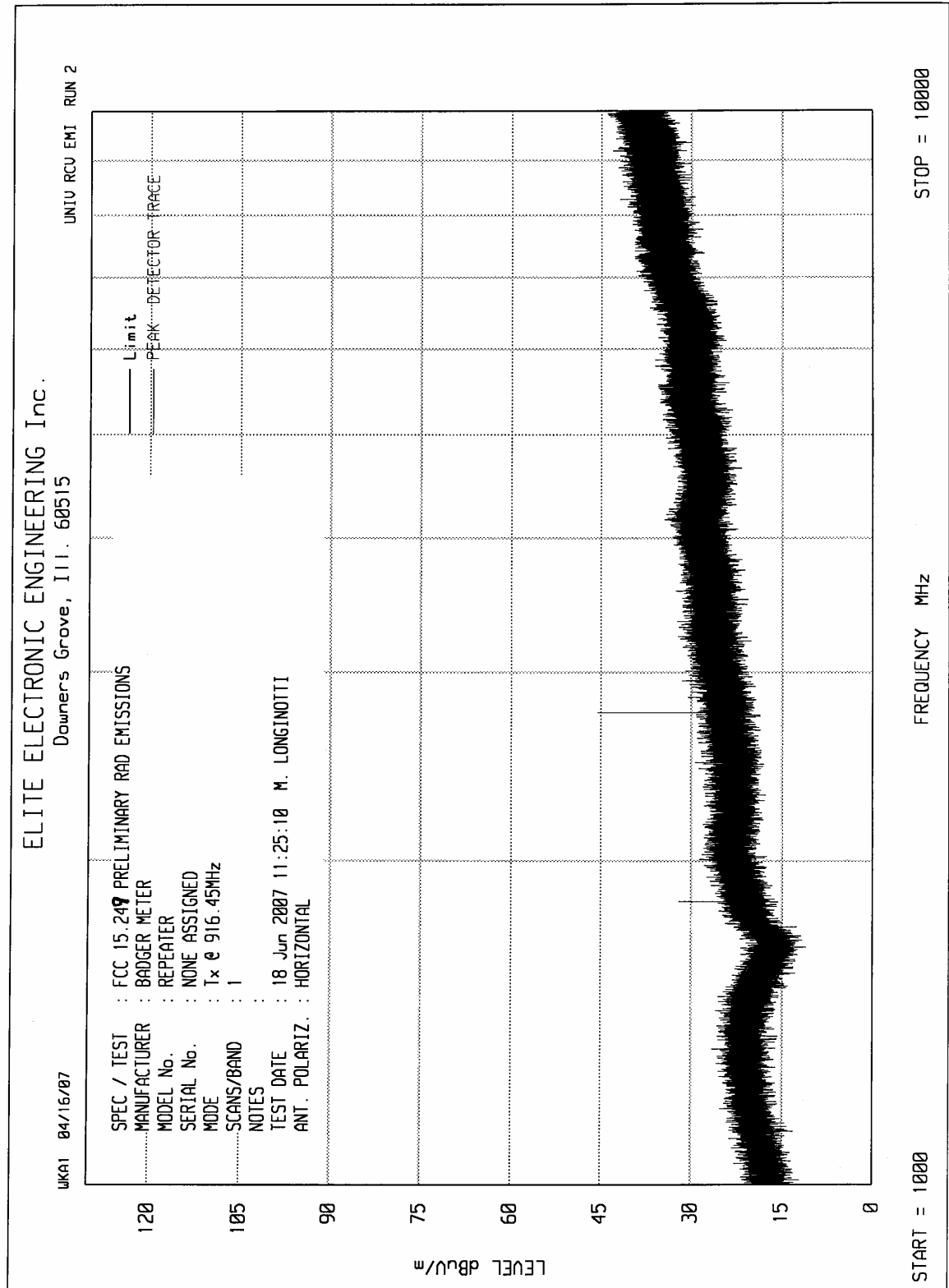
ELITE ELECTRONIC ENGINEERING Inc.



ELITE ELECTRONIC ENGINEERING INC.









Manufacturer : Badger Meter
Product Name : Repeater
Serial No. : None Assigned
Test Specification : FCC Part 15, Subpart C, Section 15.249, Radiated Emissions
Date : June 18, 2007
Mode : Transmit @ 916.45MHz
Test Distance : 3 meters
Notes : Quasi-Peak Detector Used Below 1GHz, Peak Detector Used Above 1GHz

Frequency MHz	Antenna Polarity	Meter Reading dBuV	Ambient	Cable Loss dB	Antenna Factor dB	Pre Amp Gain dB	Total dBuV/m	Total uV/m	Limit uV/m
916.45	H	62.2		2.0	27.8	0.0	91.9	39577.8	50000.0
916.45	V	63.5		2.0	27.8	0.0	93.2	45967.6	50000.0
1832.90	H	17.1		2.9	27.6	0.0	47.6	239.0	5011.9
1832.90	V	18.2		2.9	27.6	0.0	48.7	271.3	5011.9
2749.35	H	22.3		3.8	30.3	0.0	56.4	661.0	5011.9
2749.35	V	21.4		3.8	30.3	0.0	55.5	595.9	5011.9
3665.80	H	16.1	Ambient	4.4	34.0	0.0	54.4	527.8	5011.9
3665.80	V	15.9	Ambient	4.4	34.0	0.0	54.2	515.8	5011.9
4582.25	H	15.7	Ambient	4.8	34.1	0.0	54.7	541.8	5011.9
4582.25	V	16.2	Ambient	4.8	34.1	0.0	55.2	573.9	5011.9
5498.70	H	18.9	Ambient	5.3	36.5	0.0	60.6	1074.9	5011.9
5498.70	V	18.4	Ambient	5.3	36.5	0.0	60.1	1014.7	5011.9
6415.15	H	19.2	Ambient	5.9	36.1	0.0	61.3	1156.3	5011.9
6415.15	V	18.7	Ambient	5.9	36.1	0.0	60.8	1091.7	5011.9
7331.60	H	46.0	Ambient	6.7	38.3	-39.7	51.2	362.4	5011.9
7331.60	V	45.2	Ambient	6.7	38.3	-39.7	50.4	330.5	5011.9
8248.05	H	46.1	Ambient	7.1	37.9	-39.5	51.6	379.6	5011.9
8248.05	V	46.7	Ambient	7.1	37.9	-39.5	52.2	406.8	5011.9
9164.50	H	46.4	Ambient	7.5	38.5	-39.0	53.4	468.7	5011.9
9164.50	V	45.4	Ambient	7.5	38.5	-39.0	52.4	417.7	5011.9

Total = Meter Reading + Cable Loss + Antenna Factor + Preamp Gain

Checked By: MARK E. LONGINOTTI

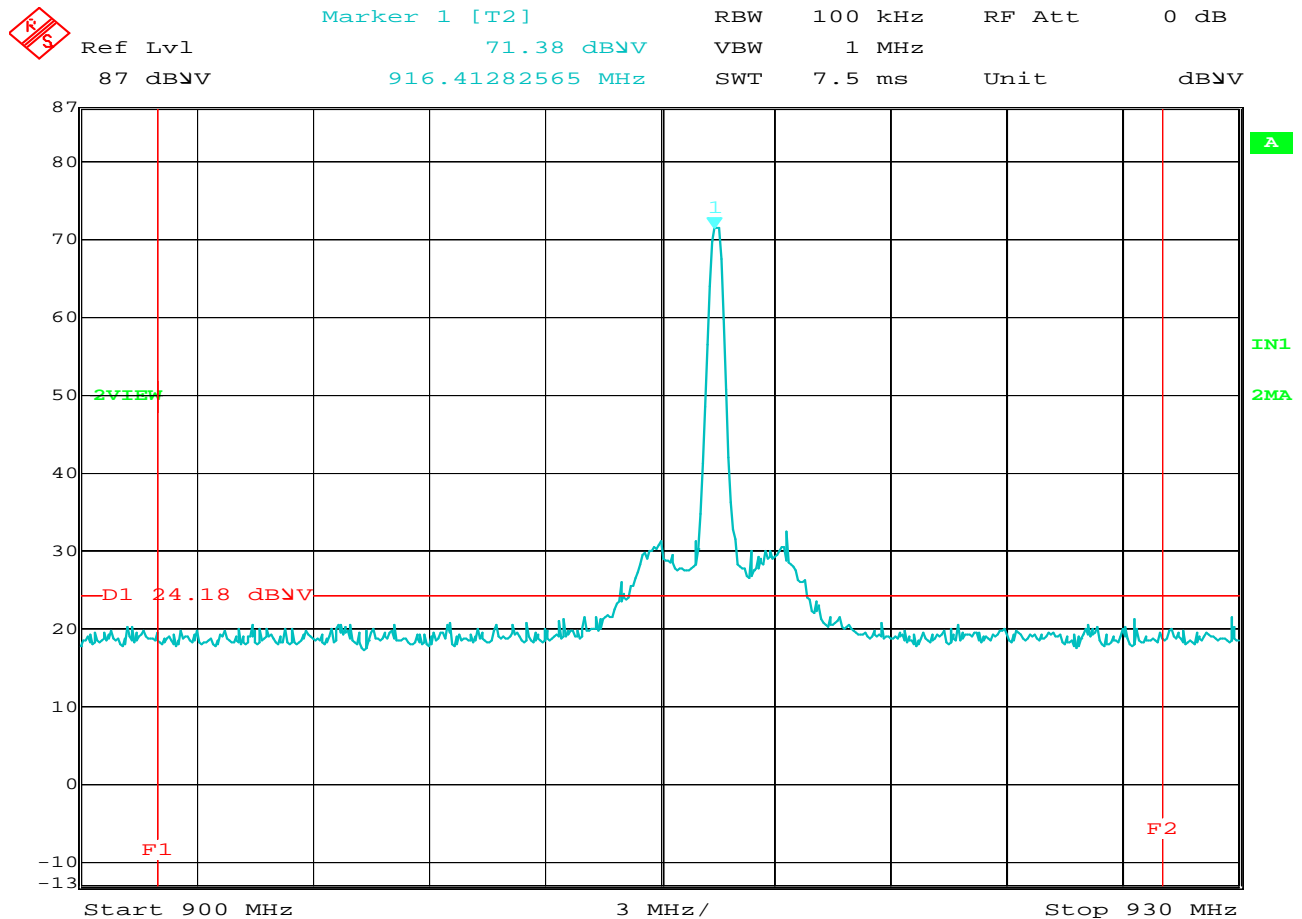


Manufacturer : Badger Meter
Product Name : Repeater
Serial No. : None Assigned
Test Specification : FCC Part 15, Subpart C, Section 15.249, Radiated Emissions
Date : June 18, 2007
Mode : Transmit @ 916.45MHz
Test Distance : 3 meters
Notes : Quasi-Peak Detector Used Below 1GHz, Peak Detector Used Above 1GHz
: Peak readings converted to average readings using the duty cycle correction
: 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
916.5	H	62.2		2.0	27.8	0.0	0.0	91.9	39577.8	50000.0
916.5	V	63.5		2.0	27.8	0.0	0.0	93.2	45967.6	50000.0
1832.9	H	17.1		2.9	27.6	0.0	-34.2	13.4	4.7	500.0
1832.9	V	18.2		2.9	27.6	0.0	-34.2	14.5	5.3	500.0
2749.4	H	22.3		3.8	30.3	0.0	-34.2	22.3	13.0	500.0
2749.4	V	21.4		3.8	30.3	0.0	-34.2	21.4	11.7	500.0
3665.8	H	16.1	Ambient	4.4	34.0	0.0	-34.2	20.3	10.4	500.0
3665.8	V	15.9	Ambient	4.4	34.0	0.0	-34.2	20.1	10.1	500.0
4582.3	H	15.7	Ambient	4.8	34.1	0.0	-34.2	20.5	10.6	500.0
4582.3	V	16.2	Ambient	4.8	34.1	0.0	-34.2	21.0	11.3	500.0
5498.7	H	18.9	Ambient	5.3	36.5	0.0	-34.2	26.5	21.1	500.0
5498.7	V	18.4	Ambient	5.3	36.5	0.0	-34.2	26.0	19.9	500.0
6415.2	H	19.2	Ambient	5.9	36.1	0.0	-34.2	27.1	22.7	500.0
6415.2	V	18.7	Ambient	5.9	36.1	0.0	-34.2	26.6	21.4	500.0
7331.6	H	46.0	Ambient	6.7	38.3	-39.7	-34.2	17.0	7.1	500.0
7331.6	V	45.2	Ambient	6.7	38.3	-39.7	-34.2	16.2	6.5	500.0
8248.1	H	46.1	Ambient	7.1	37.9	-39.5	-34.2	17.4	7.4	500.0
8248.1	V	46.7	Ambient	7.1	37.9	-39.5	-34.2	18.0	8.0	500.0
9164.5	H	46.4	Ambient	7.5	38.5	-39.0	-34.2	19.3	9.2	500.0
9164.5	V	45.4	Ambient	7.5	38.5	-39.0	-34.2	18.3	8.2	500.0

Total = Meter Reading + Cable Loss + Antenna Factor + Preamp Gain + Duty Cycle Factor

Checked By: MARK E. LONGINOTTI



Date: 18.JUN.2007 18:27:39

FCC 15.249 Occupied Bandwidth

MANUFACTURER : Badger Meter
PRODUCT NAME : Repeater
SERIAL NUMBER : None Assigned
TEST MODE : Transmit @ 916.45MHz
TEST PARAMETER : Display Line (F1) represents the low frequency band-edge
(902MHz). Display line (F2) represents the high frequency
band-edge (928MHz). The peak reading represents the
93.2dBuV/m radiated emissions level at 916.45MHz. Display
Line (D1) represents the general limit of 46 dBuV/m.
24.18dBuV is 47.2dB (47.2dB = 93.2dBuV/m - 46dBuV/m) down from
the peak level of 71.38dB (24.18dB = 71.38dB - 47.2dB).
EQUIPMENT USED : RBB0, NTA1

NOTES