Measurement of RF Interference from a Model Orion Repeater

For : Badger Meter, Inc.
Milwaukee WI

P.O. No. : 535639 & 535637
Date Received : April 6, 2005
Date Tested : April 6, 2005
Test Personnel : Richard E. King EMC Engineer
Specification : FCC "Code of Federal Regulations" Title 47 Part 15, Subpart C

Test Report By : Richard E. King
Richard King
EMC Engineer

Witnessed by : John Olson
Badger Meter, Inc.

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

TABLE OF CONTENTS

Measurement of RF Emissions from an Orion Repeater

1.0 INTRODUCTION:

1.1 Description of Test Item - This document represents the results of the series of radio interference measurements performed on a model Orion Repeater, no serial number was assigned (hereinafter referred to as the test item). The test item was designed to transmit at approximately 916.45MHz using an internal helical antenna. The test item was manufactured and submitted for testing by Badger Meter, Inc. 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 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 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 2004
- 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"

1.5 Subcontractor 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.

1.6 Laboratory Conditions - The temperature at the time of the test was 23.4ºC and the relative humidity was 24%.

2.0 TEST ITEM SETUP AND OPERATION:

The test item is an Orion Repeater used to re-transmit water meter readings. A block diagram of the test item setup is shown as Figure 1.

2.1 Power Input - The test item was powered with a 3.6VDC lithium thionylchloride internal battery.

2.2 Grounding - The test item was ungrounded during the tests.

2.3 Peripheral Equipment - No peripheral equipment was submitted with the test item.

2.4 Interconnect Cables - No interconnect cables were submitted with the test item.

2.5 Operational Mode - For all tests, the test item and all peripheral equipment were placed on an 80cm high non-conductive stand. The test item and all peripheral equipment were energized.

For all tests, the test item was setup to transmit continuously. The battery voltage was periodically checked to ensure proper operation at maximum level. The tests were performed with the test item transmitting at 916.45MHz.

3.0 TEST EQUIPMENT:

3.1 Test Equipment List - A list of the test equipment used can be found on Table I. All equipment was calibrated per the instruction manuals supplied by the manufacturer.

The fundamental, harmonics and spurious emissions were measured with a spectrum analyzer. All measurements were taken with the resolution and video bandwidth of the measuring instrument adjusted to 100kHz below 1GHz and 1MHz above 1GHz.

3.2 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).

3.3 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 budgets were based on guidelines in "ISO Guide to the Expression of Uncertainty in Measurements" and NAMAS NIS81 "The Treatment of Uncertainty in EMC Measurements".

4.0 REQUIREMENTS, PROCEDURES AND RESULTS:

4.1 Powerline Conducted Emissions

4.1.1 Requirements – Since the test item was powered by an internal battery, no conducted emissions tests were performed.

4.2 Radiated Measurements

4.2.1 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(a) has the following radiated emission limits:

Fundamental Frequency MHz	Field Intensity mV/m @ 3 meters	Field Strength Harmonics and Spurious uV/m @ 3 meters
902 to 928	50	500

In addition, emissions appearing in the Restricted Bands of Operation listed in paragraph 15.205(a) shall not exceed the general requirements shown in paragraph 15.209.

4.2.2 Procedures - All 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. The floor of the chamber is used as the ground plane. The chamber complies with ANSI C63.4-2003 for site attenuation.

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.

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.

4.2.3 Results - The preliminary plots, with the test item transmitting at 916.45MHz, are presented on data pages 11 and 12. 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 data page 13. As can be seen from the data, all emissions measured from the test item 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 1.1dB within the limit. See data page 13 for details. Photographs of the test configuration which yielded the highest or worst case, radiated emission levels are shown on Figure 2.

4.3 Occupied Bandwidth Measurements

4.3.1 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.

4.3.2 Procedures - The test item was placed on an 80cm high non-conductive stand. The unit was set to transmit continuously. With an antenna positioned 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.

4.3.3 Results - The plot of the emissions near the fundamental frequency is presented on data page 14. As can be seen from this data page, the transmitter met the occupied bandwidth requirements. The 99% emission bandwidth measurement was 298 kHz.

5.0 CONCLUSIONS:

It was determined that the Badger Meter, Inc. Orion Repeater, did 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.

6.0 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 as operated by Badger Meter, Inc. personnel. 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.

7.0 ENDORSEMENT DISCLAIMER:

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

TABLE I: TEST 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								
XZG0	ATTENUATOR/SWITCH DRIVER	HEWLETT PACKARD	11713A	3439A02724	---		N/A	
Equipment Type: ANTENNAS								
NDQ1	TUNED DIPOLE ANTENNA	EMCO	3121C-DB4	313	400-1000MHZ	03/02/05	12	03/02/06
NTA0	BILOG ANTENNA	CHASE EMC LTD.	BILOG CBL611	2057	0.03-2GHZ	07/12/04	12	07/12/05
NWF0	RIDGED WAVE GUIDE	EMCO	3105	2035	1-12.4GHZ	09/05/04	12	09/05/05
Equipment Type: CONTROLLERS								
CDS2	COMPUTER	GATEWAY	MFATXPNT NMZ	0028483108	1.8GHZ		N/A	
Equipment Type: PRINTERS AND PLOTTERS								
HRE1	LASER JET 5P	HEWLETT PACKARD	C3150A	USHB061052	---		N/A	
Equipment Type: RECEIVERS								
RAC1	SPECTRUM ANALYZER	HEWLETT PACKARD	85660B	3407A08369	100HZ-22GHZ	02/04/05	12	02/04/06
RACB	RF PRESELECTOR	HEWLETT PACKARD	85685A	3506A01491	20HZ-2GHZ	02/07/05	12	02/07/06
RAF3	QUASIPEAK ADAPTER	HEWLETT PACKARD	85650A	3303A01775	0.01-1000MHZ	02/04/05	12	02/04/06

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.

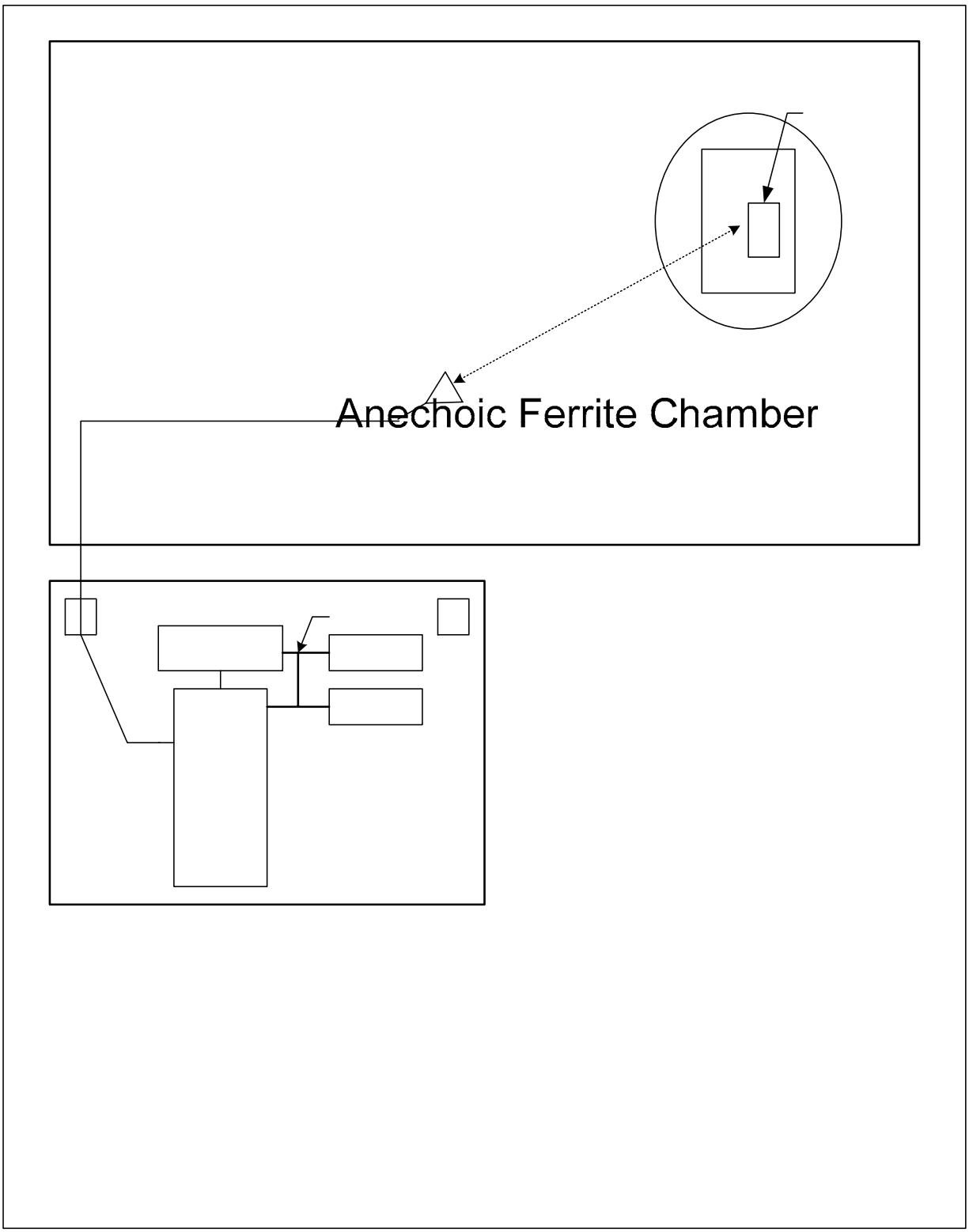
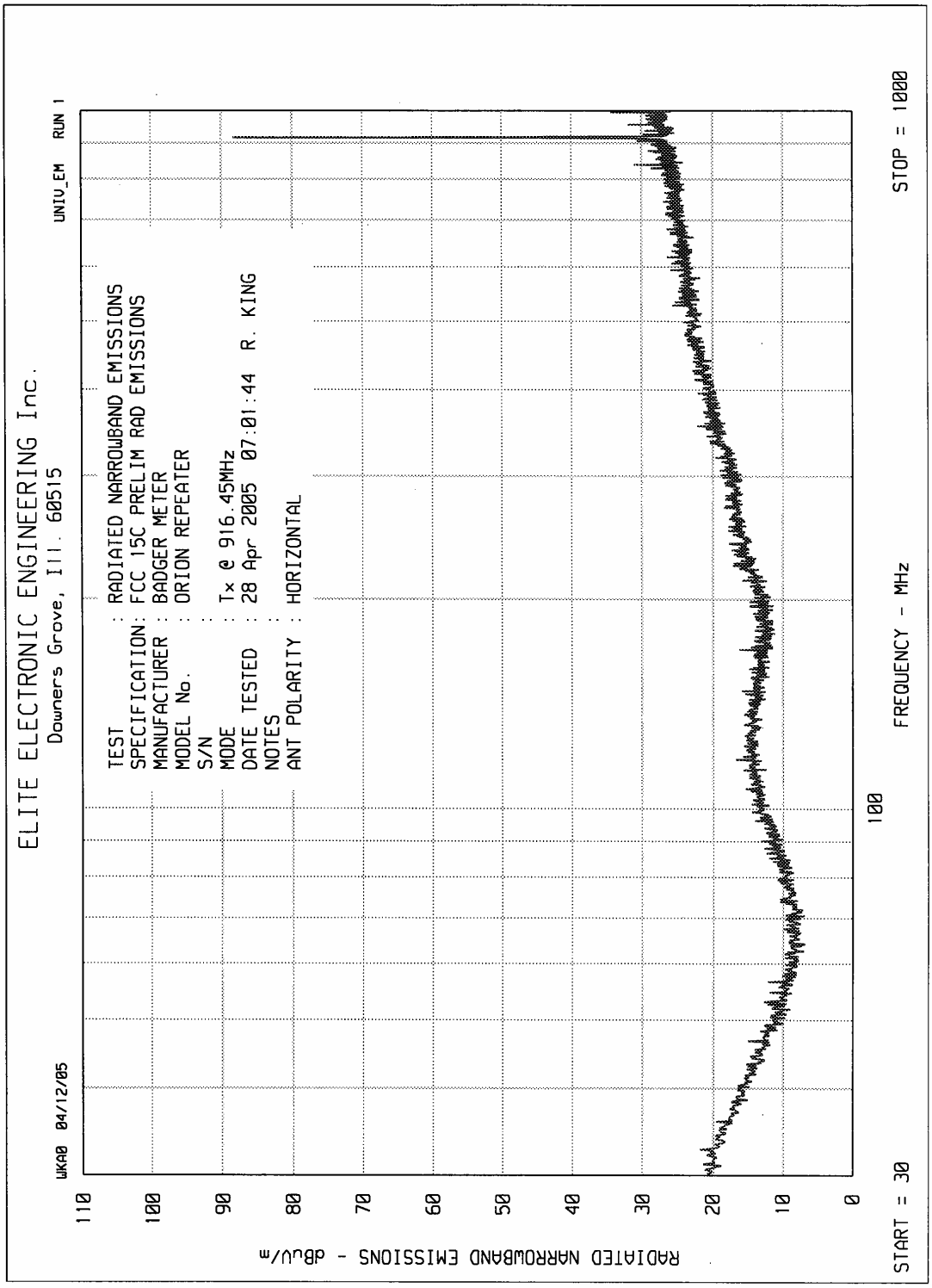
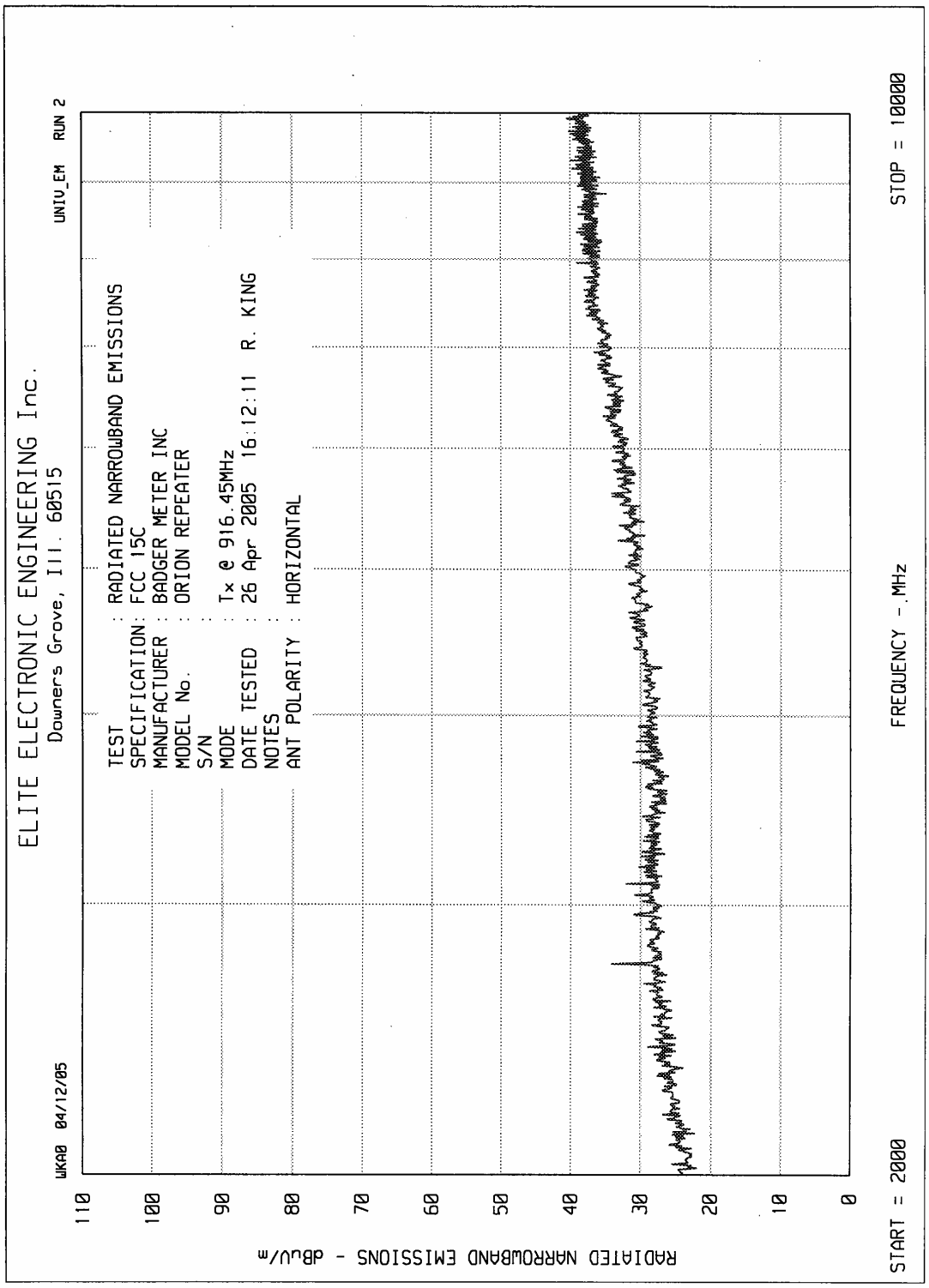

Anechoic Ferrite Chamber

Figure 2

TEST SETUP FOR MEASUREMENT OF RADIATED EMISSIONS, HORIZONTAL POLARIZATION

TEST SETUP FOR MEASUREMENT OF RADIATED EMISSIONS, VERTICAL POLARIZATION


ELITE ELECTRONIC ENGINEERING Inc.
Downers Grove, Ill. 60515
UNIV_EM RUN 1
WKA0 04/12/05
TEST : RADIATED NARROWBAND EMISSIONS
SPECIFICATION: FCC 15C PRELIM RAD EMISSIONS
MANUFACTURER : BADGER METER
MODEL No. : ORION REPEATER
S/N : :
MODE : Tx @ 916.45MHz
DATE TESTED : 28 Apr 2005 07:01:44 R. KING
NOTES : :
ANT POLARITY : HORIZONTAL
RADIATED NARROWBAND EMISSIONS - dBuV/m
110
100
90
80
70
60
50
40
30
20
10
0
START = 30
100
FREQUENCY - MHz
STOP = 1000

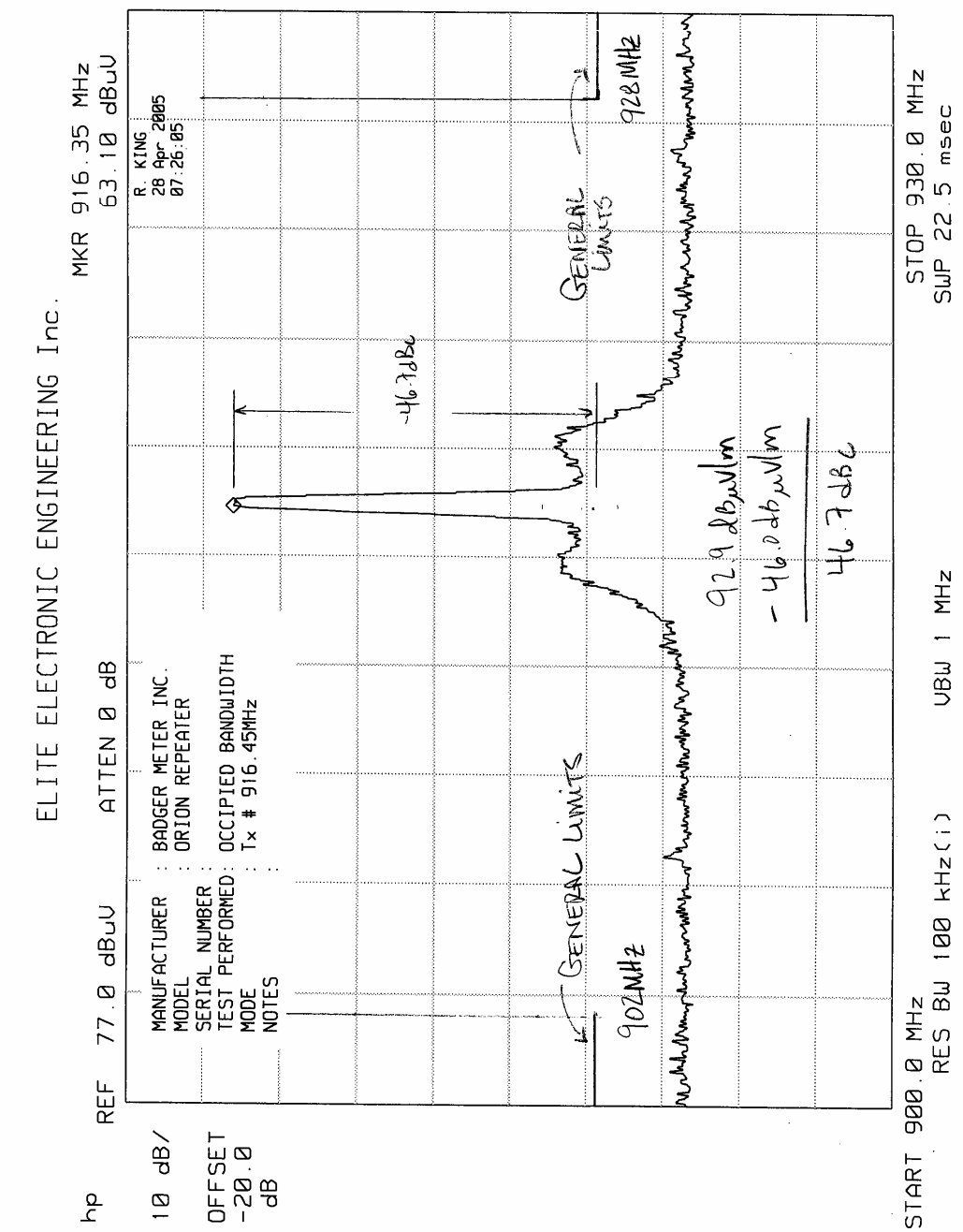

ELITE ELECTRONIC ENGINEERING Inc.
Downers Grove, Ill. 60515
WKA0 04/12/05
UNIV_EM RUN 2
TEST : RADIATED NARROWBAND EMISSIONS
SPECIFICATION: FCC 15C
MANUFACTURER : BADGER METER INC
MODEL No. : ORION REPEATER
S/N :
MODE : Tx @ 916.45MHz
DATE TESTED : 26 Apr 2005 16:12:11 R. KING
NOTES :
ANT POLARITY : HORIZONTAL
RADIATED NARROWBAND EMISSIONS - dBuV/m
110
100
90
80
70
60
50
40
30
20
10
0
START = 2000
FREQUENCY - MHz
STOP = 10000

MANUFACTURER : Badger Meter
MODEL : Orion Repeater
S/N : None assigned
SPECIFICATION : FCC-15C Radiated Emissions
DATE : April 25, 2005
NOTES : Transmitting @ 916.45MHz
: TEST DISTANCE IS 3 METERS

Freq	Ant	Meter Reading	Ambient	CBL Fac	Ant Fac	Pre Amp	Total dBuV/m	Total uV/m	Limit uV/m	Margin
MHz	Pol	dBuV		dB	dB	dB	at 3 M	at 3M	at 3M	dB
916.5	H	63.1		2.0	27.8	0.0	92.9	44157.0	50000.0	-1.1
916.5	V	53.0		2.0	27.8	0.0	82.8	13803.8	50000.0	-11.2
1832.9	H	48.1		2.9	28.2	-36.4	42.8	138.0	500.0	-11.2
1832.9	V	39.7		2.9	28.2	-36.4	34.4	52.5	500.0	-19.6
2749.4	V	29.4		3.8	31.5	-35.8	28.9	27.9	500.0	-25.1
2749.4	H	27.9		3.8	31.5	-35.8	27.4	23.4	500.0	-26.6
3665.8	H	23.5		4.4	32.5	-35.5	24.9	17.6	500.0	-29.1
3665.8	V	21.2		4.4	32.5	-35.5	22.6	13.5	500.0	-31.4
4582.3	V	41.0	*	4.8	33.0	-35.4	43.4	147.9	500.0	-10.6
4582.3	H	41.0	*	4.8	33.0	-35.4	43.4	147.9	500.0	-10.6
5498.7	H	39.0	*	5.7	35.5	-35.4	44.8	173.8	500.0	-9.2
5498.7	V	39.0	*	5.7	35.5	-35.4	44.8	173.8	500.0	-9.2
6415.2	V	41.9	*	6.5	36.2	-35.5	49.1	285.1	500.0	-4.9
6415.2	H	42.2	*	6.5	36.2	-35.5	49.4	295.1	500.0	-4.6
7331.6	V	42.4	*	7.0	37.1	-35.6	50.9	350.8	500.0	-3.1
7331.6	H	42.0	*	7.0	37.1	-35.6	50.5	335.0	500.0	-3.5
8248.1	V	41.8	*	8.0	37.7	-36.1	51.4	371.5	500.0	-2.6
8248.1	H	41.8	*	8.0	37.7	-36.1	51.4	371.5	500.0	-2.6
9164.5	H	41.0	*	8.0	38.1	-36.5	50.6	338.8	500.0	-3.4
9164.5	V	41.8	*	8.0	38.1	-36.5	51.4	371.5	500.0	-2.6

Checked BY : Richard E. King

Richard E. King


ELITE ELECTRONIC ENGINEERING Inc.
hp
REF 77.0 dBuV
ATTEN 0 dB
MKR 916.35 MHz
63.10 dBuV
10 dB/
OFFSET
-20.0
dB
MANUFACTURER : BADGER METER INC.
MODEL : ORION REPEATER
SERIAL NUMBER :
TEST PERFORMED: OCCUPIED BANDWIDTH
MODE : Tx # 916.45MHz
NOTES :
R. KING
28 Apr 2005
07:26:05
-46.7dBc
GENERAL LIMITS
902MHz
928MHz
92.9 dBuV/m
-46.0 dBuV/m
46.7 dBc
START 900.0 MHz
RES BW 100 kHz(i)
VBW 1 MHz
STOP 930.0 MHz
SWP 22.5 msec