



Measurement of RF Interference from a Model Absolute Digital Encoder (ADE) Transmitter

For : Badger Meter Inc.
Milwaukee, WI

P.O. No. : 529064
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Test Personnel : Richard E. King
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Part 15, Subpart C

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Measurement of RF Emissions from an Absolute Digital Encoder (ADE) transmitter

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 Absolute Digital Encoder (ADE) transmitter, (hereinafter referred to as the test item). The test item was designed to transmit at approximately 57.1kHz using an internal 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 radiated RF emission requirements of the FCC "Code of Federal Regulations" Title 47, Part 15, Subpart C, Sections for Intentional Radiators. Testing was performed in accordance with ANSI C63.4-2001.

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 2001
- ANSI C63.4-2001, "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°C and the relative humidity was 25%.

2.0 TEST ITEM SETUP AND OPERATION:

The test item is an Absolute Digital Encoder (ADE). A block diagram of the test item setup is shown as Figure 1.

2.1 Power Input - The test item received 20V power via inductive coupling from the support equipment.

2.2 Grounding - Since the test item was powered with 20V 20kHz through inductive coupling, it was ungrounded during the tests.

2.3 Support Equipment - The following support equipment was submitted with the test item:

Item	Description
Function Generator	Leader LG 1301 2MHz Function Generator.
Arbitrary Waveform Generator	Hewlett Packard 33120A 15MHz Function Generator Arbitrary Waveform Generator
Arbitrary Waveform Generator	Agilent 3325A 80MHz Function Generator Arbitrary Waveform Generator

The above support equipment was used to send a signal to a small coil that was used to excite the test item. The support equipment was set in an adjacent shielded enclosure and connected to the coil through 75 feet of Belden 9770 3 wire shielded cable.

2.4 Interconnect Cables - No interconnect cable was submitted with the test item.

2.5 Operational Mode - Under normal operating conditions, when a meter reader probe is placed directly on the test item, the test item will be excited and transmit its data to the meter reader. The meter reader uses an inductive coil to couple power to the test item and receive the data. The test item has a similar coil that couples power from the reader and transmits the data signal. The power signal is a low frequency signal (20-40kHz), 0.5Hz square wave modulated signal. The data signal is transmitted during the off period.

Since the test item's normal operation is too short to measure the emissions, a meter reader simulator was used to cause continuous transmission operation. A 20V, 32kHz, 0.5Hz square wave modulated signal from the support equipment was coupled into the test item. During the off period, the test item transmitted data at 57.1kHz. A time domain plot of the sequence is shown on Data Page 11.

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. The spectrum analyzer peak detected readings were converted to average readings using a duty cycle factor. All measurements were taken with the resolution and video bandwidth of the measuring instrument adjusted to 200Hz below 150kHz and 10kHz above 150kHz.

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).

4.0 REQUIREMENTS, PROCEDURES AND RESULTS:**4.1 Powerline Conducted Emissions**

4.1.1 Requirements – Since the test item was powered by inductive coupling and not connected to the AC network, no conducted emissions tests were performed.

4.2 Radiated Emissions

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 15.209(a) has the following radiated emission limits:

Frequency (MHz)	Field Strength (microvolts/meter)	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

* *- Except as provided in paragraph (g), fundamental emissions from intentional radiators operating under this section shall not be located in the frequency bands 54-72 MHz, 76-88 MHz, 174-216 MHz or 470 MHz-806 MHz. However, operation within these frequency bands is permitted under other sections of this part, e.g., §§ 15.231 and 15.241.

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 -**4.2.2.1 Preliminary Radiated Measurements -**

All preliminary tests were performed in a 32ft. x 20ft. x 14ft. high absorber lined shielded enclosure. All powerlines and signal lines entering the enclosure pass through filters on the enclosure wall.

The loop antenna was positioned at a 1 meter distance from the test item. The entire frequency range from 10kHz to 30MHz was investigated using a peak detector function.

4.2.2.2 Final Radiated Measurements - Measurements were performed at a test distance of 3 meters using a peak detector. The final open field emission tests were performed over the frequency range of 57.1kHz to 571kHz. Between 57.1kHz and 571kHz, a loop antenna was used as the pick-up device. All significant broadband and narrowband signals were measured and recorded. Final measurements

were performed in a 32ft. x 20ft. x 14ft. high absorber lined shielded enclosure.

Since the signal could not be detected at the 3 meter test distance the antenna was first moved to a 1 meter distance from the test item. The measurement antenna was vertically polarized. The test item was then rotated 360° around its X, Y and Z axis. The worst case position was noted. The measurement antenna was then placed in its horizontal polarization and the procedure was repeated noting the worst case position. The measurement antenna was then moved to a test distance of 3 meters for the final measurements.

4.2.3 Results - A preliminary plot with the test item's support equipment on and the test item removed from the room is presented on data page 12. A preliminary plot with the test item transmitting at 57.1kHz is presented on data page 13. Comparison of data pages 12 and 13 help to show which emissions can be attributed to the support equipment and which emissions can be attributed to the test item. These plots are presented for a reference only, and are not used to determine compliance.

The final open area radiated levels are presented on data page 14. As can be seen from the data, no emissions from the test item could be detected above the ambient level at a 3 meter distance. The ambient level was within the specification limits. The ambient level closet to the limit (worst case) occurred at 513.9kHz. The ambient level at this frequency was 24.4 dB within the limit. See data page 14 for details. Photographs of the test configuration which yielded the highest or worst case, radiated ambient levels are shown on Figure 2.

5.0 CONCLUSIONS:

It was determined that the Badger Meter Inc. Absolute Digital Encoder (ADE), did fully meet the conducted and 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 C63.4-2001.

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. 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								
XZG3	ATTENUATOR/SWITCH DRIVER	HEWLETT PACKARD	11713A	2421A03059	---		N/A	
Equipment Type: AMPLIFIERS								
APK3	PREAMPLIFIER	AGILENT TECHNOL	8449B	3008A01593	1-26.5GHZ	05/09/02	12	05/09/03
Equipment Type: ANTENNAS								
NLS1	24" ACTIVE LOOP ANTENNA	EMCO	6502	8903-2329	0.01-30MHZ	01/23/03	12	01/23/04
Equipment Type: CONTROLLERS								
CDD2	COMPUTER	HEWLETT PACKARD	D4171A#ABA	US61654645	---		N/A	
CMA0	MULTI-DEVICE CONTROLLER	EMCO	2090	9701-1213	---		N/A	
Equipment Type: PRINTERS AND PLOTTERS								
HRE1	LASER JET 5P	HEWLETT PACKARD	C3150A	USHB061052	---		N/A	
Equipment Type: RECEIVERS								
RAC2	SPECTRUM ANALYZER	HEWLETT PACKARD	85660B	3638A08770	100HZ-22GHZ	02/10/03	12	02/10/04
RACD	RF PRESELECTOR	HEWLETT PACKARD	85685A	3010A01205	20HZ-2GHZ	02/10/03	12	02/10/04
RAF4	QUASIPeAK ADAPTER	HEWLETT PACKARD	85650A	2043A00320	0.01-1000MHZ	02/10/03	12	02/10/04

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.

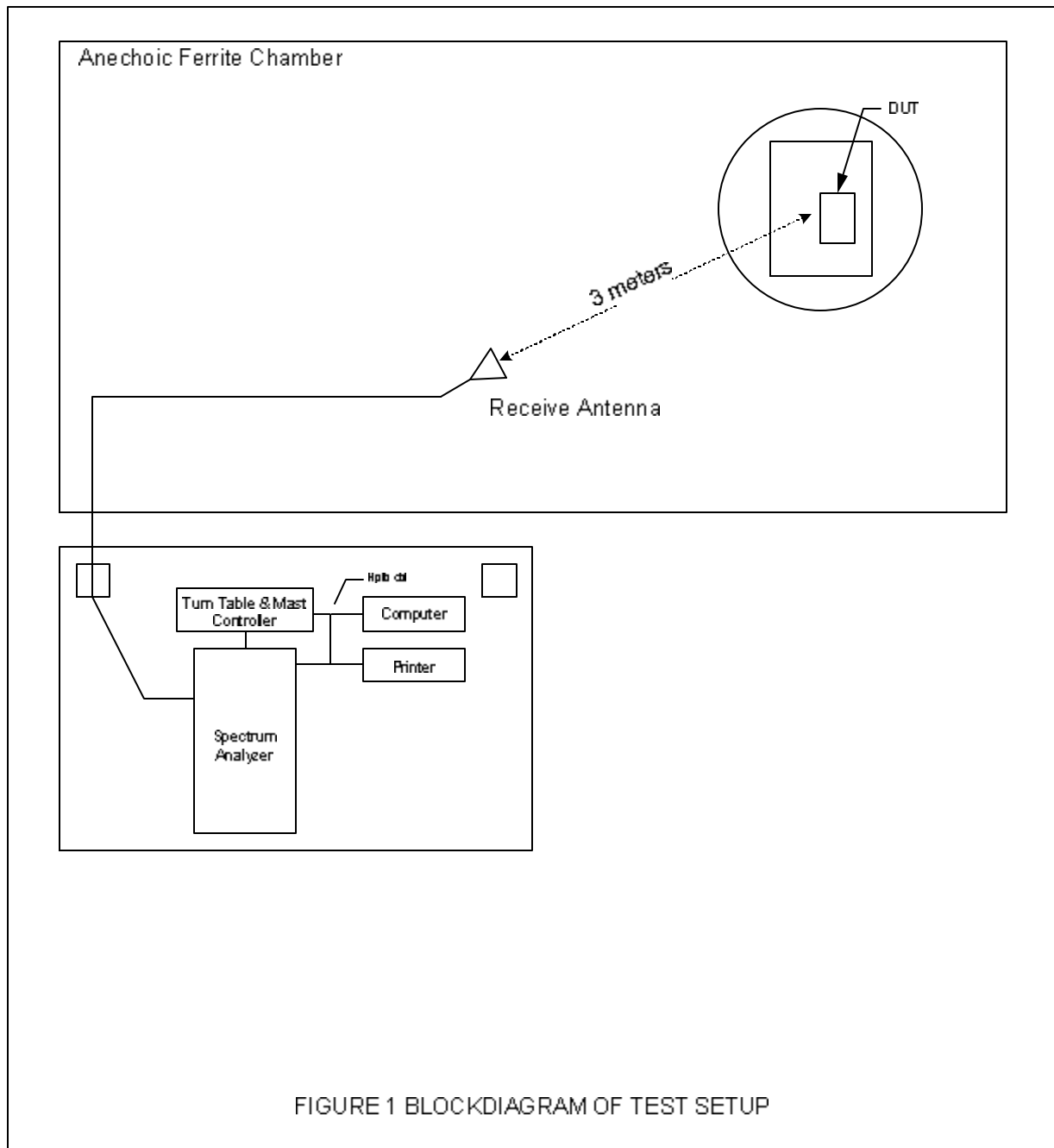


Figure 2

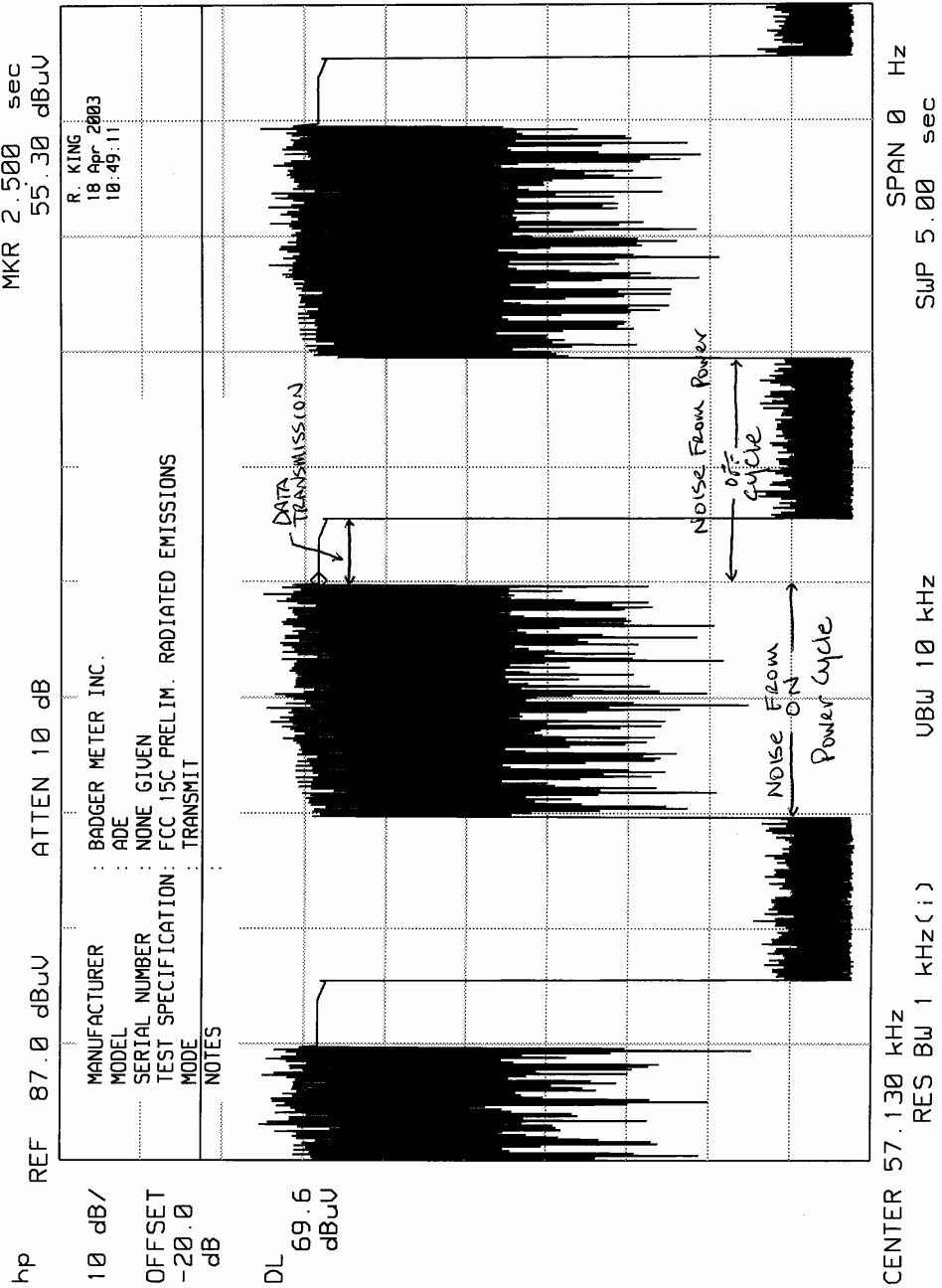


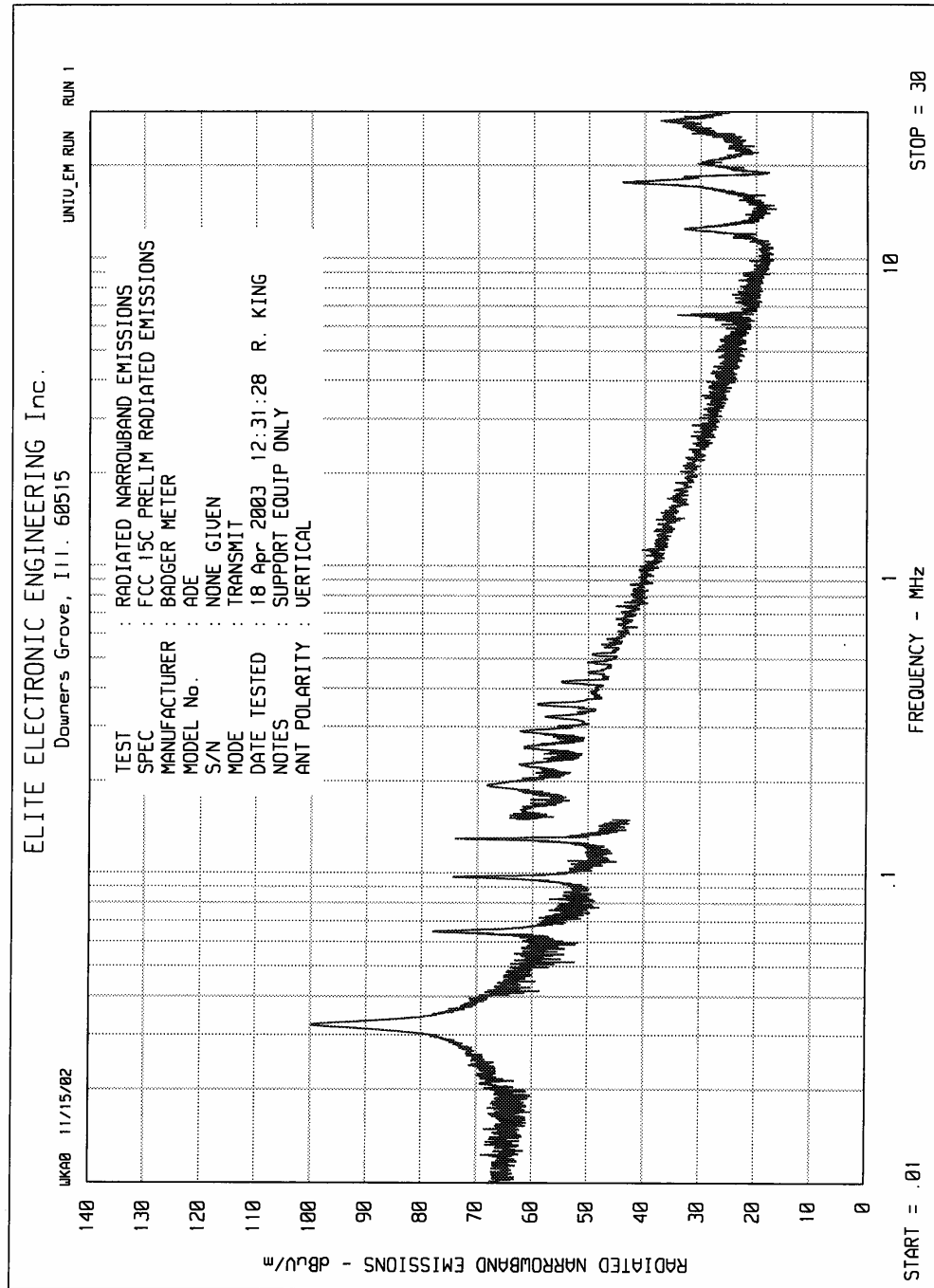
Radiated Emissions Worst Case Horizontal Polarization

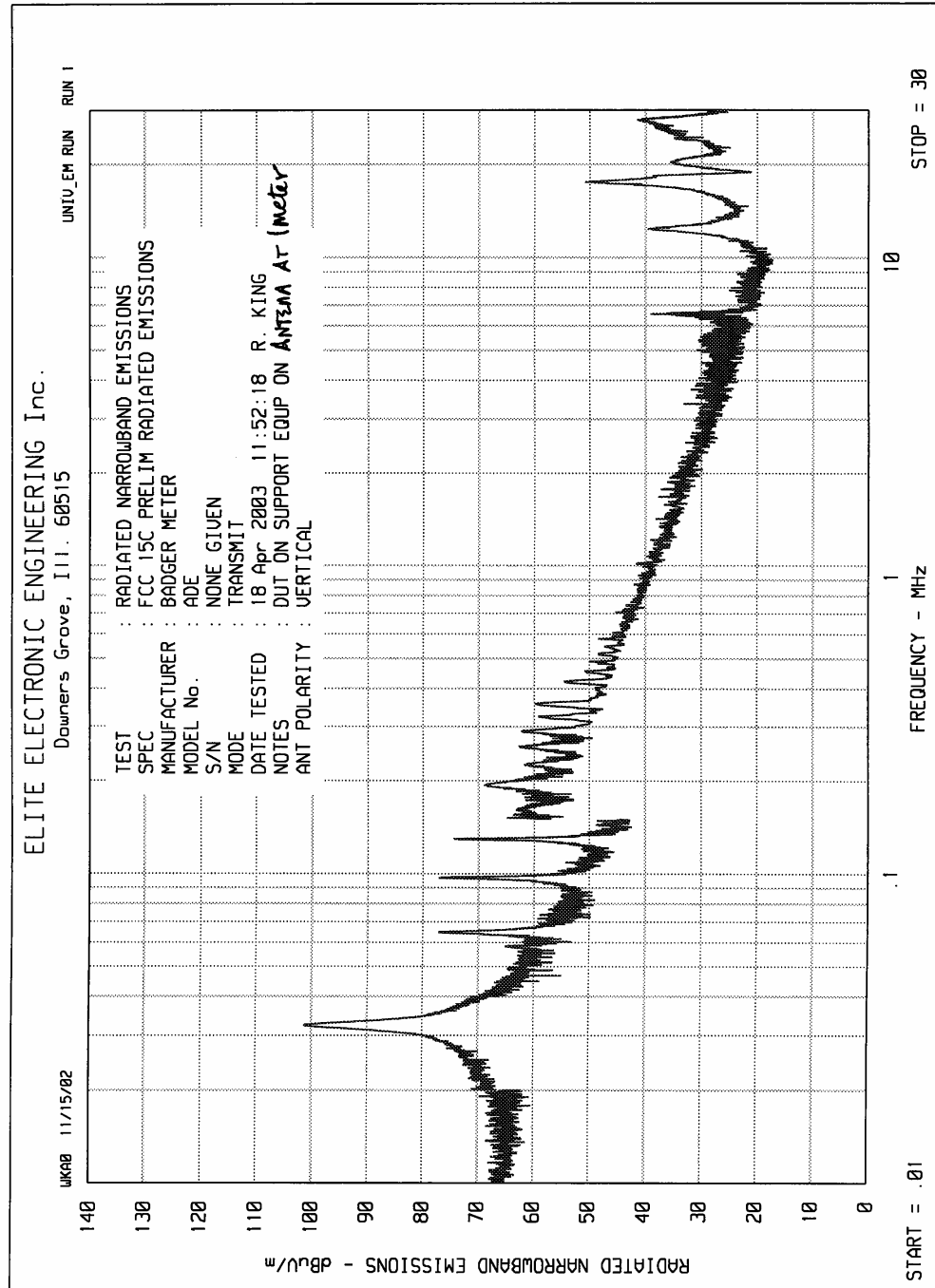


Radiated Emissions Worst Case Vertical Polarization

ELITE ELECTRONIC ENGINEERING Inc.







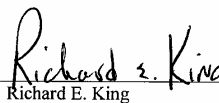


MANUFACTURER : Badger Meter Inc.
MODEL : Absolute Digital Encoder (ADE)
S/N : None Given
SPECIFICATION : FCC-15C Radiated Emissions
DATE : April 18, 2003
NOTES : See below.
:

FREQ. (kHz)	BW	DET.	ANT. POL.	METER READING		ANT. FAC.	CBL. FAC.	DIST. CORR. FAC.	TOTAL dBuV/m	LIMIT 300M dBuV/m	LIMIT 30M dBuV/m
				dBuV	AMB						
57.1	1KHz	Peak	V	45.1	*	11.0	0	-80	-23.9	32.5	
57.1	1KHz	Peak	H	44.6	*	11.0	0	-80	-24.4	32.5	
114.3	1KHz	Peak	V	39.4	*	10.8	0	-80	-29.8	26.4	
114.3	1KHz	Peak	H	38.7	*	10.8	0	-80	-30.5	26.4	
171.3	10kHz	Peak	V	49.7	*	10.7	0	-80	-19.6	22.9	
171.3	10kHz	Peak	H	47.4	*	10.7	0	-80	-21.9	22.9	
228.4	10kHz	Peak	V	49.3	*	10.3	0	-80	-20.4	20.4	
228.4	10kHz	Peak	H	45.7	*	10.3	0	-80	-24.0	20.4	
285.5	10kHz	Peak	V	44.6	*	10.4	0	-80	-25.0	18.5	
285.5	10kHz	Peak	H	44.2	*	10.4	0	-80	-25.4	18.5	
342.6	10kHz	Peak	V	42.4	*	10.4	0	-80	-27.2	16.9	
342.6	10kHz	Peak	H	42.0	*	10.4	0	-80	-27.6	16.9	
399.7	10kHz	Peak	V	41.6	*	10.4	0	-80	-28.0	15.6	
399.7	10kHz	Peak	H	41.2	*	10.4	0	-80	-28.4	15.6	
456.8	10kHz	Peak	V	39.3	*	10.4	0	-80	-30.3	14.4	
456.8	10kHz	Peak	H	38.8	*	10.4	0	-80	-30.8	14.4	
513.9	10kHz	Peak	V	38.4	*	10.4	0	-40	8.8		33.4
513.9	10kHz	Peak	H	38.6	*	10.4	0	-40	9.0		33.4
571.0	10kHz	Peak	V	37.4	*	10.3	0	-40	7.7		32.5
571.0	10kHz	Peak	H	37.5	*	10.3	0	-40	7.8		32.5

Test Distance = 3 Meters
Site = 3M Anechoic Chamber

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)

CHECKED BY: 
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