Measurement of RF Interference from a Model MDG-T1000 Tag Transmitter

For : Matrix Design Group
Newburgh, IN

P.O. No. : 10029
Date Received : November 21, 2006
Date Tested : November 22, 2006
Test Personnel : Mark E. Longinotti
Specification : FCC "Code of Federal Regulations" Title 47 Part 15, Subpart C, Section 15.231

Test Report By : Mark E. Longinotti

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Approved By : Raymond J. Klouda

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REVISION HISTORY

Revision	Date	Description
—	November 27, 2006	Initial release

Measurement of RF Emissions from an MDG-T1000 Tag Transmitter

1.0 INTRODUCTION:

1.1 Description of Test Item - This document represents the results of the series of radio interference measurements performed on an MDG-T1000 Tag transmitter, Serial No. 000108 and 000109 (hereinafter referred to as the test item). Serial No. 000108 was programmed to transmit continuously and was used to perform all radiated emissions tests. Serial No. 000109 was programmed to transmit once approximately ever 2 seconds and was used to calculate the duty cycle correction factor. The test item was designed to transmit at approximately 433.9MHz using an internal antenna. The test item was manufactured and submitted for testing by Matrix Design Group located in Newburgh, IN.

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 15.231 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 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"

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 22C and the relative humidity was 22%.

2.0 TEST ITEM SETUP AND OPERATION:

The test item is an MDG-T1000 Tag transmitter. The test item operates as a location beacon for a tracking system for people in a hazardous industrial location either above ground or underground. The test item is designed to provide real time tracking of people so they can be located in an emergency. A block diagram of the test item setup is shown as Figure 1. A photograph of the test item is shown as Figure 2.

2.1 Power Input - The test item obtained 3VDC via an internal lithium coin cell battery.

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

2.3 Peripheral Equipment - The test item was submitted for testing with no peripheral equipment.

2.4 Interconnect Cables - The test item was submitted for testing with no interconnect cables.

2.5 Operational Mode - For all tests the test item was placed on an 80cm high non-conductive stand. The test item was programmed to continuously transmit at 433.9MHz.

2.6 Test Item Modifications - No modifications were required for compliance to the FCC "Code of Federal Regulations" Title 47, Part 15, Subpart C, Sections 15.231 requirements.

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.

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 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

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 required.

4.2 Duty Cycle Factor Measurements:

4.2.1 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, 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).

4.2.2 Results - A representative plot of the duty cycle is shown on data page 15. The plot shows a word on time of 980usec. The transmitter transmits once every 2 seconds; therefore in any 100msec period there can be at most 1 transmission of 980msec. This yields a duty cycle correction factor of -40.2 (-40.2 = 20* log (0.980msec/100msec). Per Matrix Design Group personnel, the tag operates on an average duty cycle of 928 usec on and 2 seconds off. As such, in any given 100msec interval, there can be at most one transmission yielding a duty cycle correction factor of -40.6 (-40.6 = 20* log (0.928msec/100msec). Per 15.35(b), the limit on peak radio frequency emissions is 20dB above the maximum permitted average emission limit applicable to the equipment under test. The duty cycle correction factor was limited to -20dB to insure that the peak limit is met.

4.3 Radiated Measurements (includes transmission timing issues)

4.3.1 Requirements - The test item was designed to operate under FCC "Code of Federal Regulations Title 47", Part 15, Subpart C, Section 15.231(a)(3) which allows periodic transmission to check the integrity of the test item for safety or security applications as long as the total transmit time per hour is less than 2 seconds. (The test item meets this requirement since it is being used to track and locate people in an industrial environment for the expressed purpose of finding them in an emergency.)

The test item transmits at a variable period of between 1.75 seconds and 2.25 seconds with an average period of 2 seconds resulting in 1800 transmissions per hour typically. Since each word has an average on time of 928 usec, the average transmission time per hour is 1.67 sec ((928usec/word) * (1800words/hour)). This meets the 2 seconds per hour total transmit time per hour requirement of 15.231(a)(3). (A representative plot showing 33 transmissions per minute is shown on data page 16. This would result in 1980 transmissions per hour or a total transmission time per hour of 1.84 sec ((928usec/word) * (33 words/minute)*(60minutes/hour)).) Therefore the limits of 15.231(b) can be used.

Paragraph 15.231(b) has the following radiated emission limits:

Fundamental Frequency MHz	Field Intensity uV/m @ 3 meters	Field Strength Harmonics and Spurious @ 3 meters
260 to 470	3,750 to 12,500*	375 to 1,250*

* - Linear Interpolation

For 433.86MHz, the limit at the fundamental is 10994.2uV/m @ 3m and the limit on the harmonics is 1099.4uV/m @ 3m.

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.

4.3.2 Procedures - Open field 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 5.0GHz was investigated using a peak detector function. The data was then processed by the computer to calculate equivalent field intensity.

The final radiated emission tests were then manually performed over the frequency range of 30MHz to 5000MHz. 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.

4.3.3 Results - The preliminary plots, with the test item transmitting at , are presented on data pages 17 and 18. 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 433.9MHz, are presented on data page 19. 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 433.9MHz. The emissions level at this frequency was 7.6dB within the limit. See data page 19 for details. Photographs of the test configuration which yielded the highest, or worst case, radiated emission levels are shown on Figures 3 and 4.

4.4 Occupied Bandwidth Measurements

4.4.1 Requirement - In accordance with paragraph 15.231(c), all emissions within 20dB of the peak amplitude level of the center frequency are required to be within a band less than 0.25% of the center frequency wide.

4.4.2 Procedures - The test item was placed on an 80cm high non-conductive stand. The unit was set to transmit continuously. With an antenna positioned nearby, occupied bandwidth emissions were displayed on the spectrum analyzer. The resolution bandwidth was set to 30 kHz and span was set to 2 MHz. The frequency spectrum near the fundamental was plotted.

4.4.3 Results - The plot of the emissions near the fundamental frequency are 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 957.9kHz.

5.0 CONCLUSIONS:

It was determined that the Matrix Design Group Part No. MDG-T1000 Tag, Serial No. 000108, 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 C63.4-2003.

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. 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: AMPLIFIERS							
APK0	PRE-AMPLIFIER	HEWLETT PACKARD	8449B	3008A00662	1-26.5GHZ	03/06/06	12	03/06/07
	Equipment Type: ANTENNAS							
NDQ1	TUNED DIPOLE ANTENNA	EMCO	3121C-DB4	313	400-1000MHZ	03/10/06	12	03/10/07
NWF0	RIDGED WAVE GUIDE	EMCO	3105	2035	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: 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	02/13/06	12	02/13/07
RACB	RF PRESELECTOR	HEWLETT PACKARD	85685A	3506A01491	20HZ-2GHZ	02/13/06	12	02/13/07
RAF3	QUASIPEAK ADAPTER	HEWLETT PACKARD	85650A	3303A01775	0.01-1000MHZ	02/13/06	12	02/13/07

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.

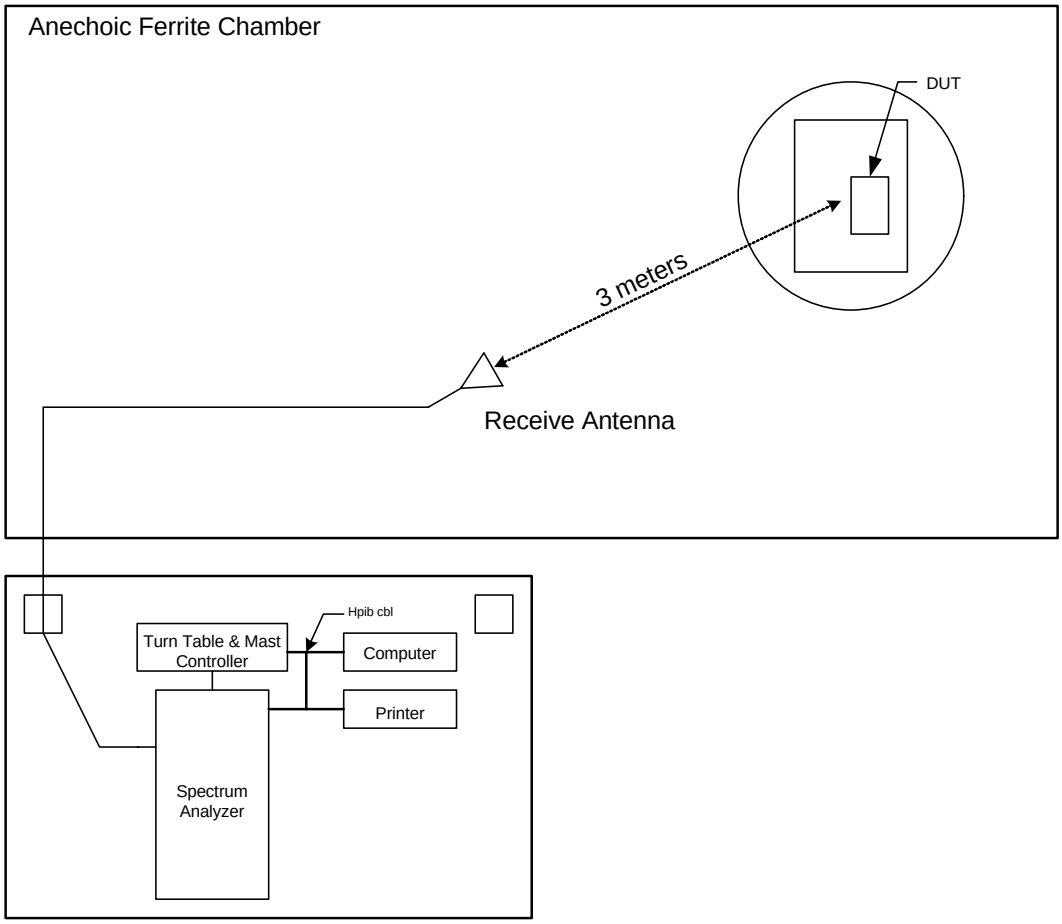


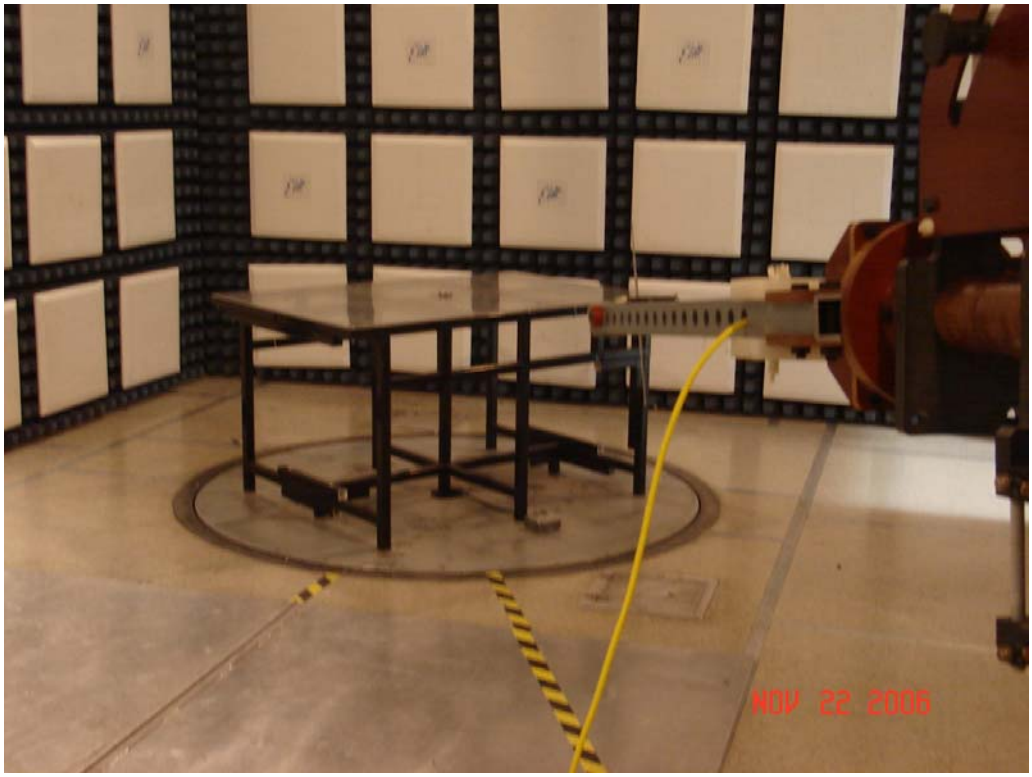
FIGURE 1 BLOCKDIAGRAM OF TEST SETUP

Figure 2

Test Item

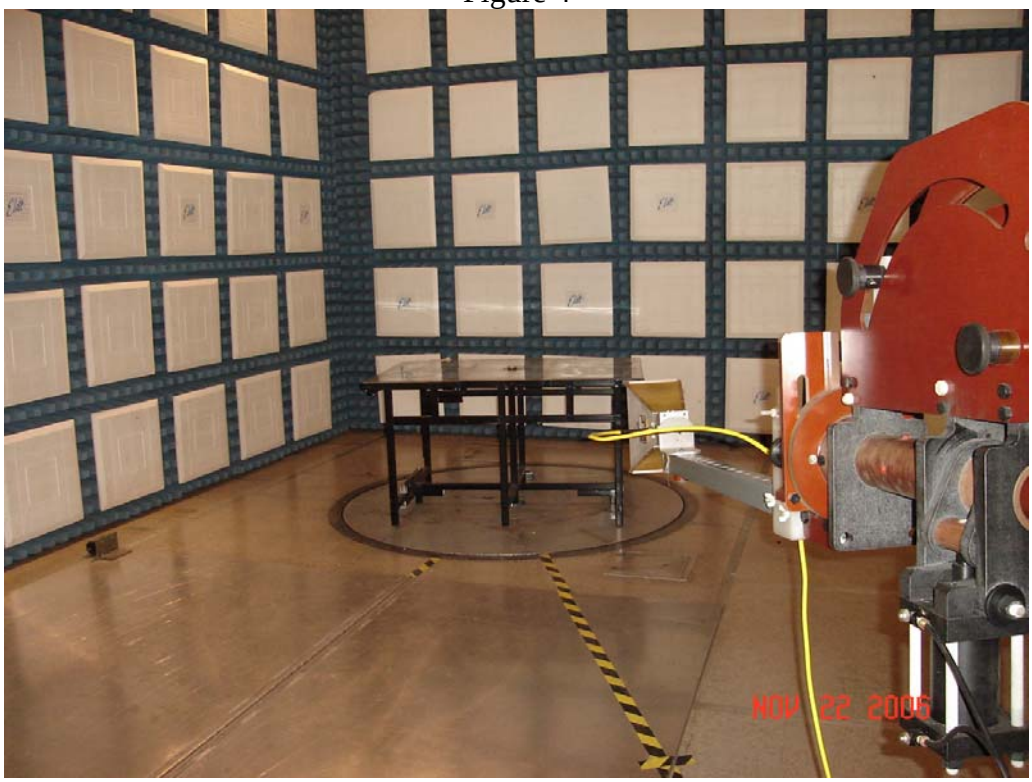
Figure 3

Test Setup for Radiated Emissions, 433.9MHz – Horizontal Polarization

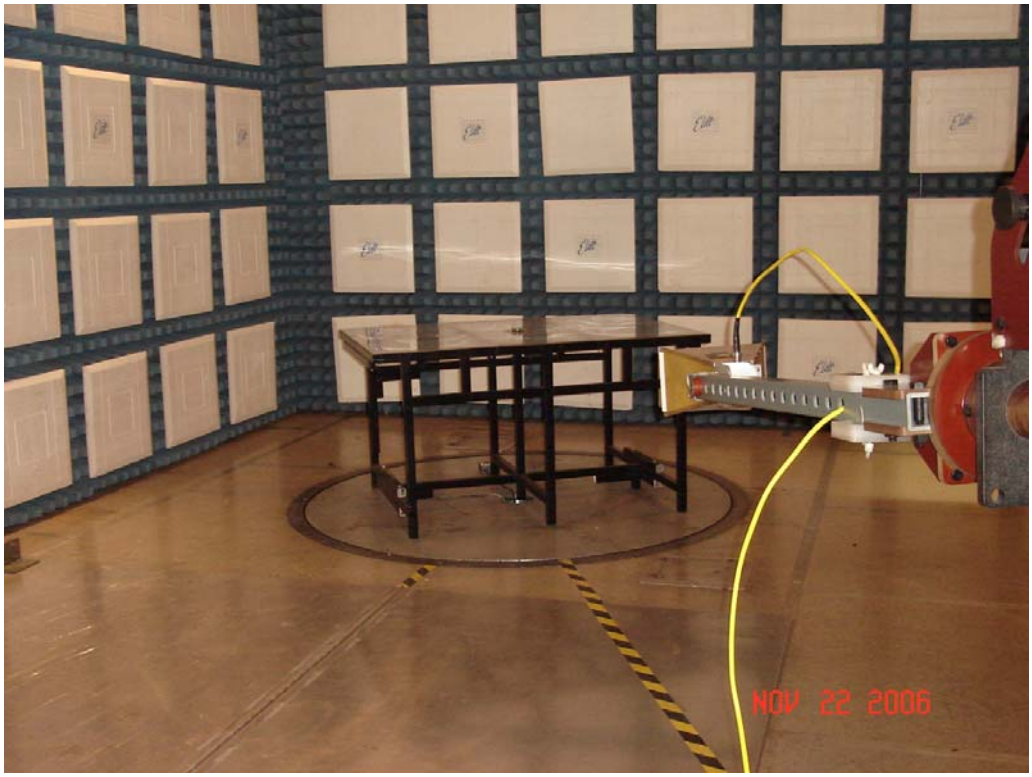


Test Setup for Radiated Emissions, 433.9MHz – Vertical Polarization

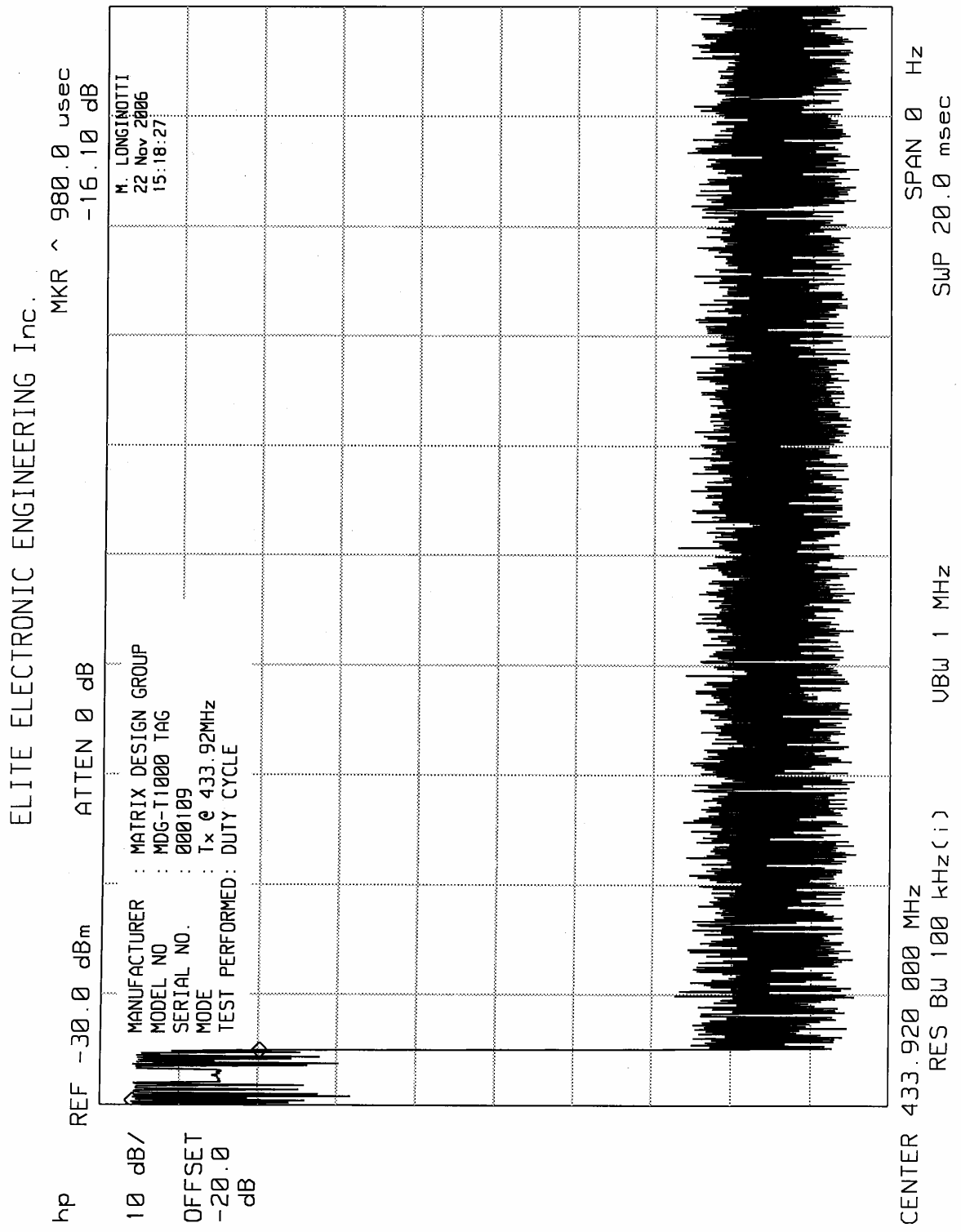
Figure 4

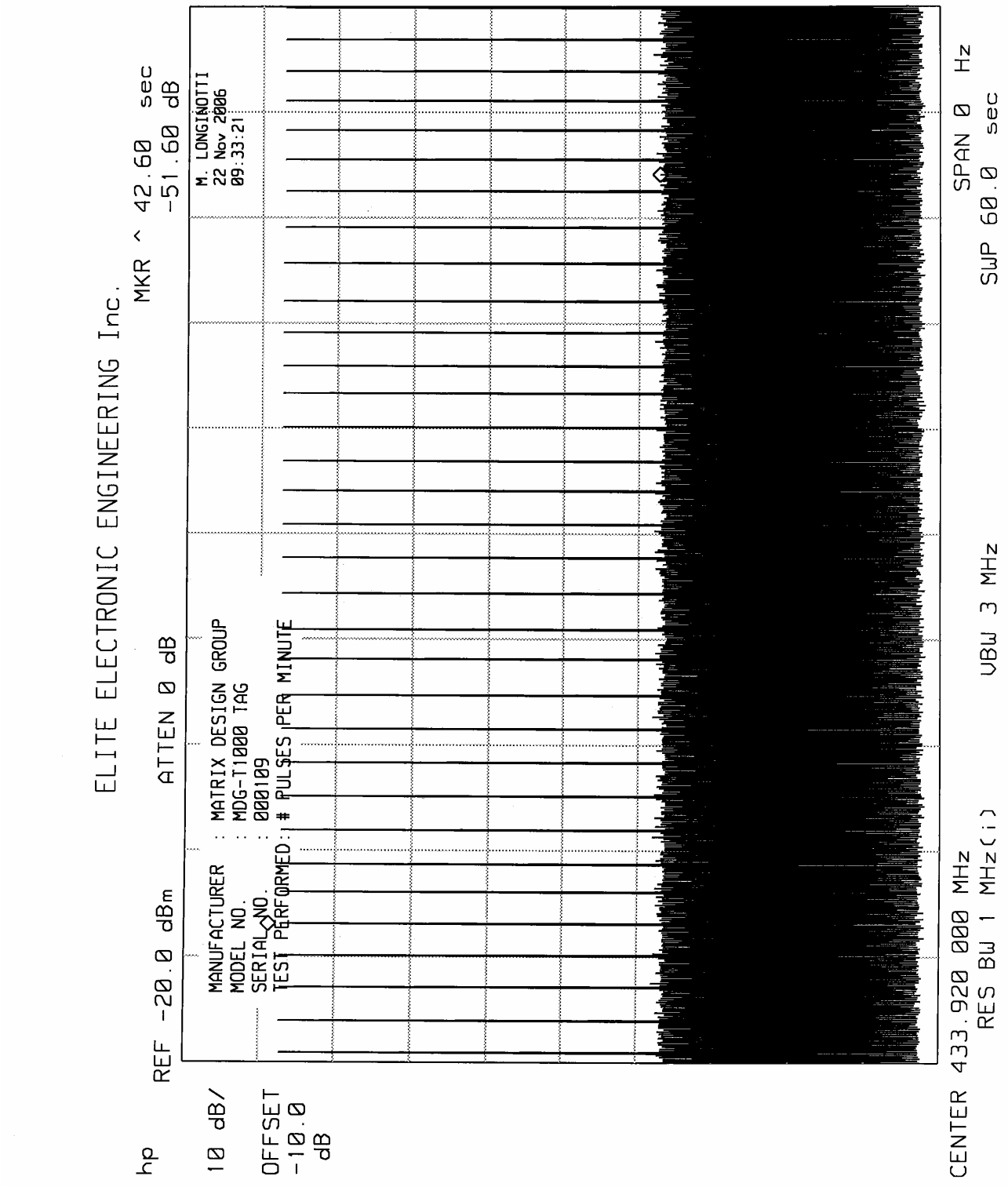


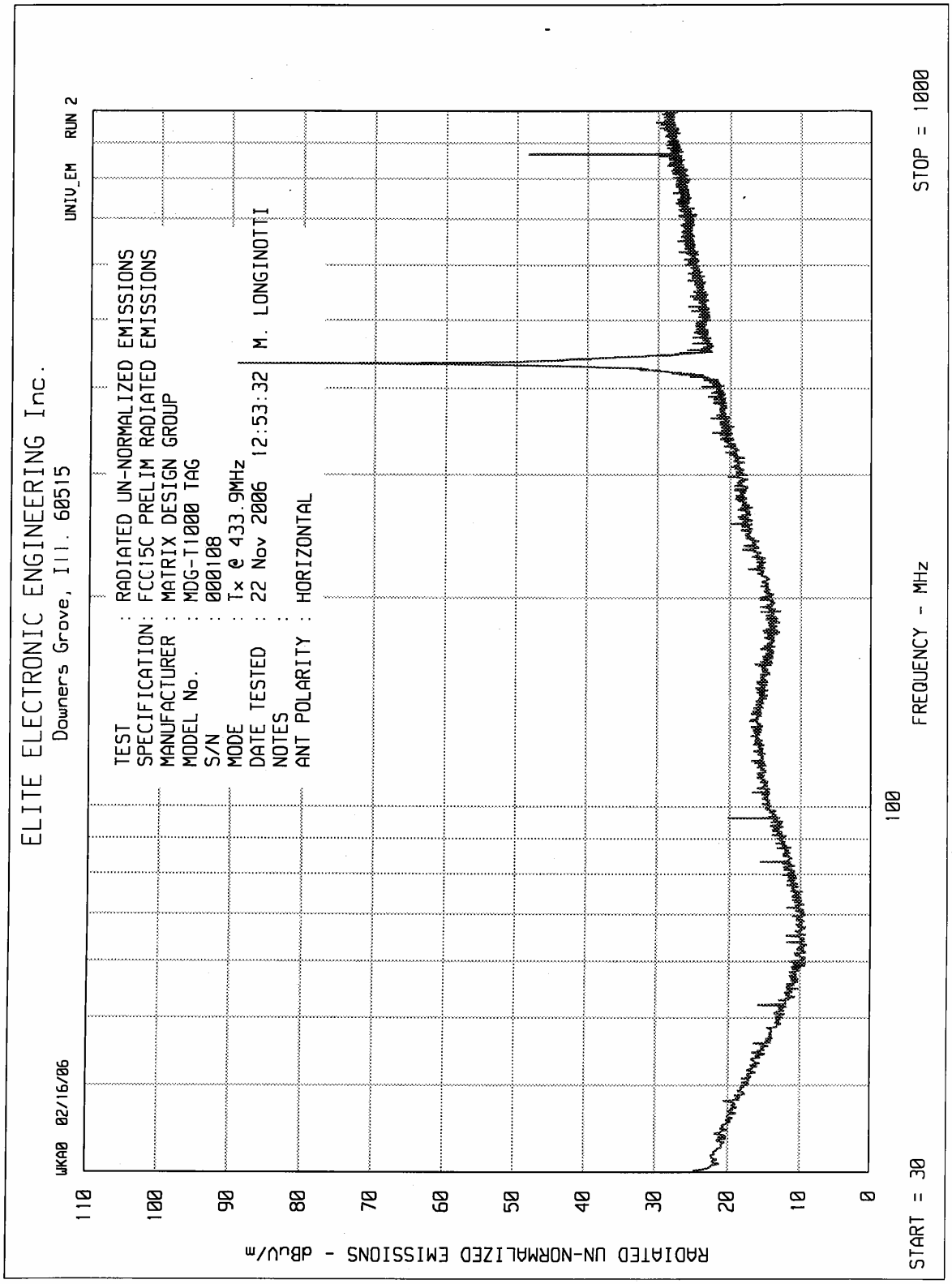
Test Setup for Radiated Emissions, 1GHz to 5GHz – Horizontal Polarization

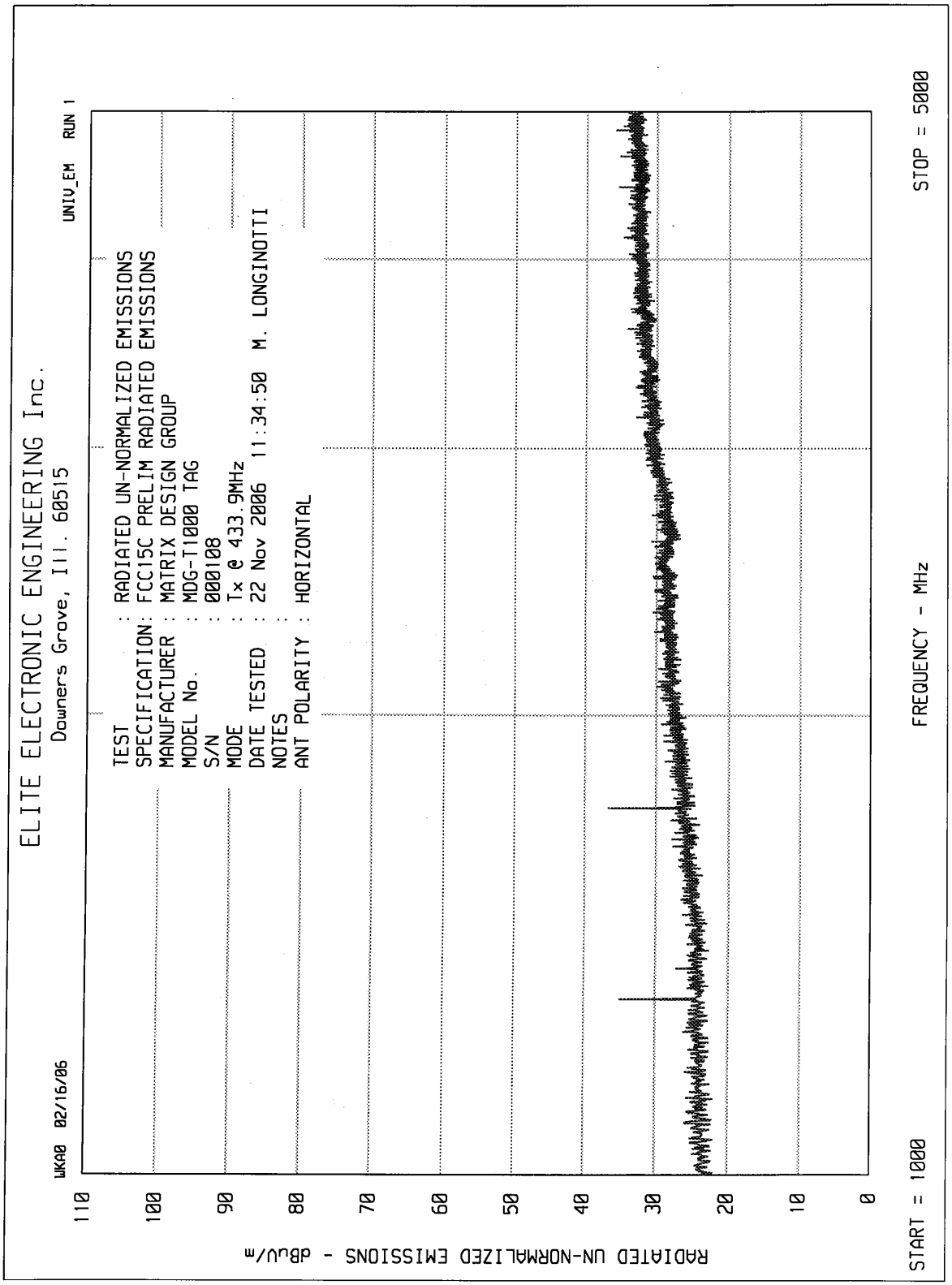


Test Setup for Radiated Emissions, 1GHz to 5GHz – Vertical Polarization


ELITE ELECTRONIC ENGINEERING Inc.
MKR ^ 980.0 usec
-16.10 dB
M. LONGINOTTI
22 Nov 2006
15:18:27
hp
REF -30.0 dBm
ATTEN 0 dB
10 dB/
OFFSET
-20.0
dB
MANUFACTURER : MATRIX DESIGN GROUP
MODEL NO : MDG-T1000 TAG
SERIAL NO. : 000109
MODE : Tx @ 433.92MHz
TEST PERFORMED: DUTY CYCLE
CENTER 433.920 000 MHz
RES BW 100 kHz(i)
VBW 1 MHz
SPAN 0 Hz
SWP 20.0 msec


ELITE ELECTRONIC ENGINEERING Inc.
MKR ^ 42.60 sec
-51.60 dB
M. LONGINOTTI
22 Nov 2006
09:33:21
hp
REF -20.0 dBm
ATTEN 0 dB
10 dB/
OFFSET
-10.0
dB
MANUFACTURER : MATRIX DESIGN GROUP
MODEL NO. : MDG-T1000 TAG
SERIAL NO. : 000109
TEST PERFORMED: # PULSES PER MINUTE
CENTER 433.920 000 MHz
RES BW 1 MHz(i)
VBW 3 MHz
SWP 60.0 sec
SPAN 0 Hz


ELITE ELECTRONIC ENGINEERING Inc.
Downers Grove, Ill. 60515
UNIV_EM RUN 2
WKA0 02/16/06
TEST : RADIATED UN-NORMALIZED EMISSIONS
SPECIFICATION: FCC15C PRELIM RADIATED EMISSIONS
MANUFACTURER : MATRIX DESIGN GROUP
MODEL No. : MDG-T1000 TAG
S/N : 000108
MODE : Tx @ 433.9MHz
DATE TESTED : 22 Nov 2006 12:53:32 M. LONGINOTTI
NOTES :
ANT POLARITY : HORIZONTAL
RADIATED UN-NORMALIZED 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
UNIV_EM RUN 1
WKA0 02/16/06
TEST : RADIATED UN-NORMALIZED EMISSIONS
SPECIFICATION: FCC15C PRELIM RADIATED EMISSIONS
MANUFACTURER : MATRIX DESIGN GROUP
MODEL No. : MDG-T1000 TAG
S/N : 000100
MODE : Tx @ 433.9MHz
DATE TESTED : 22 Nov 2006 11:34:50 M. LONGINOTTI
NOTES :
ANT POLARITY : HORIZONTAL
RADIATED UN-NORMALIZED EMISSIONS - dBuV/m
110
100
90
80
70
60
50
40
30
20
10
0
START = 1000
FREQUENCY - MHz
STOP = 5000

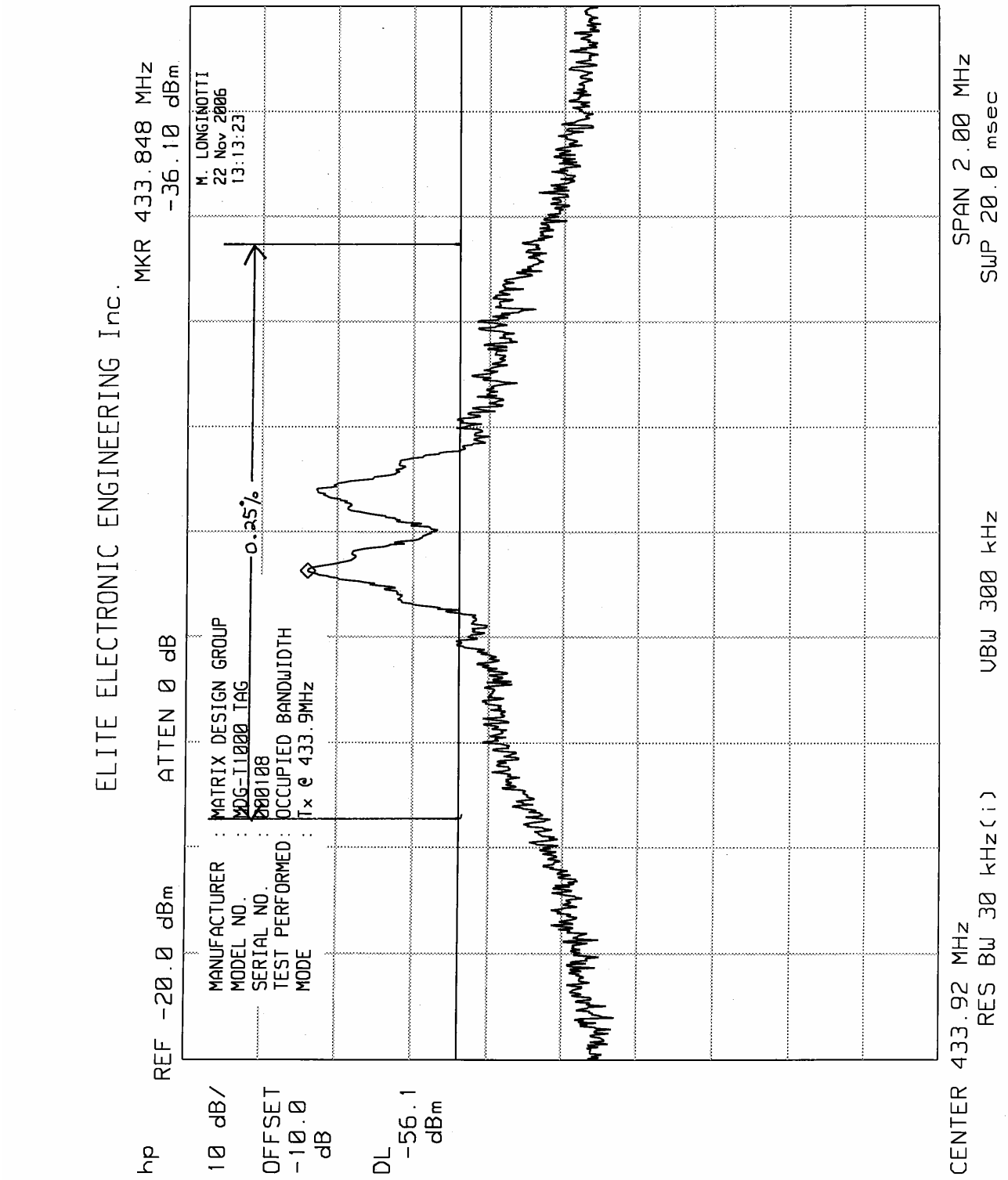
ETR No.
DATA PAGE

SPECIFICATION : FCC PART 15C TRANSMITTER OPEN FIELD DATA
MANUFACTURER : MATRIX DESIGN GROUP
MODEL : MDG-T1000 TAG
S/N : 000108
TEST DATE : 22 Nov 2006
NOTES :
TEST ANTENNA : ROBERTS DIPOLE & DRWG ANTENNAS

FREQUENCY MHz	ANT POL	MTR RDG dBuV	CBL FAC dB	ANT FAC dB	DUTY CYCLE dB	TOTAL dBuV/m @3m	TOTAL uV/m @3m	LIMIT uV/m @3m	NOTES
433.86	H	70.4	1.5	21.3	-20.0	73.2	4584.0	10994.2	
433.86	V	58.8	1.5	21.3	-20.0	61.6	1205.7	10994.2	
867.80	V	18.2	1.9	27.4	-20.0	27.5	23.7	1099.4	
867.80	H	23.0	1.9	27.4	-20.0	32.3	41.2	1099.4	
1301.70	H	25.5	2.4	26.3	-20.0	34.2	51.1	500.0	*
1301.70	V	22.0	2.4	26.3	-20.0	30.7	34.1	500.0	*
1735.60	H	17.6	2.8	27.9	-20.0	28.3	25.9	1099.4	
1735.60	V	14.1	2.8	27.9	-20.0	24.8	17.3	1099.4	
2169.50	H	10.4AMB	3.2	29.4	0.0	43.0	141.3	1099.4	
2169.50	V	7.8AMB	3.2	29.4	0.0	40.4	104.7	1099.4	
2603.40	V	8.3AMB	3.7	30.4	0.0	42.4	131.6	1099.4	
2603.40	H	7.6AMB	3.7	30.4	0.0	41.7	121.4	1099.4	
3037.30	H	7.6AMB	4.0	31.6	0.0	43.3	145.6	1099.4	
3037.30	V	8.2AMB	4.0	31.6	0.0	43.9	156.0	1099.4	
3471.20	V	8.4AMB	4.3	32.1	0.0	44.8	173.0	1099.4	
3471.20	H	8.5AMB	4.3	32.1	0.0	44.9	175.0	1099.4	
3905.10	H	9.1AMB	4.5	33.0	0.0	46.6	214.2	500.0	*
3905.10	V	7.9AMB	4.5	33.0	0.0	45.4	186.6	500.0	*
4338.60	V	8.2AMB	4.7	32.9	0.0	45.8	196.0	500.0	*
4338.60	H	7.8AMB	4.7	32.9	0.0	45.4	187.2	500.0	*

* DENOTES A FREQUENCY CONFLICT WITH RESTRICTED BANDS

checked by: Mark E Longinotti
M. LONGINOTTI


hp
ELITE ELECTRONIC ENGINEERING Inc.
REF -20.0 dBm
ATTEN 0 dB
MKR 433.848 MHz
-36.10 dBm
M. LONGINOTTI
22 Nov 2006
13:13:23
10 dB/
OFFSET
-10.0
dB
DL
-56.1
dBm
MANUFACTURER : MATRIX DESIGN GROUP
MODEL NO. : MDG-I1000 TAG
SERIAL NO. : 000108
TEST PERFORMED: OCCUPIED BANDWIDTH
MODE : Tx @ 433.9MHz
0.25%
CENTER 433.92 MHz
RES BW 30 kHz(i)
VBW 300 kHz
SPAN 2.00 MHz
SWP 20.0 msec