



Measurement of RF Interference from a Model MM2-TTL Wireless Digital Transmission Transceiver Using Digital Modulation

For : Freewave Technologies
Boulder, CO

P.O. No. : 31087

Date Received : November 20, 2009

Date Tested : November 20, 2009

Test Personnel : Daniel E. Crowder

Specification : FCC "Code of Federal Regulations" Title 47 Part
15, Subpart C, Section 15.247 for Intentional
Radiators Using Digital Modulation Operating
within the 902MHz to 928MHz band.
RSS 210 Issue 7 June 2007 - Low-power
Licence-exempt Radiocommunication Devices
(All Frequency Bands)

Test Report By : 
Daniel E. Crowder


Approved By : 
Raymond J. Klouda
Registered Professional Engineer
of Illinois - 44894



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REVISION HISTORY

Revision	Date	Description
—	11/25/2009	Initial release

**Measurements of RF Emissions from a
Model MM2-TTL Wireless Digital Transmission Transceiver Using Digital Modulation**

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 MM2-TTL Wireless Digital Transmission Transceiver, (here in after referred to as the test item). No serial number was assigned to the test item. The test item is a wireless data transceiver which uses digital modulation. The MM2-TTL is RF identical to the FGR2 series transmitter as described in Elite Electronic Engineering, Inc Engineering Test Report number 39186-01. It transmits in the 902MHz to 928MHz band and uses an external antenna. The antenna submitted with the test item was an Astron Wireless Technologies, Inc. model ADP91BM 2dBi Omni-directional antenna. The reason for this test is to add the above antenna to the original grant of certification. The test item was manufactured and submitted for testing by Freewave Technologies located in Boulder, CO.

1.2 Purpose - The test series was performed to determine if the test item meets requirements of a Class II Permissive Change requirements of the FCC "Code of Federal Regulations" Title 47, Part 15, Subpart C, Sections 15.247 for Intentional Radiators and RSS 210 Issue 7 June 2007 - Low-power License-exempt Radio communication Devices (All Frequency Bands). The test series was limited to spurious radiated emissions. All other tests were still valid as they were measure at the antenna port. 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 2007
- FCC 558074, New Guidelines on Measurements for Digital Transmission Systems in Section 15.247
- RSS 210 Issue 7 June 2007 - Low-power License-exempt Radio communication Devices (All Frequency Bands)
- 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 and the American Association for Laboratory Accreditation (A2LA): A2LA Lab Code: 1786.01.

1.6 Laboratory Conditions The temperature at the time of the test was 21°C and the relative humidity was 27%.

2.0 TEST ITEM SET-UP AND OPERATION:

The test item is a Wireless Digital Transmission Transceiver, Part No. MM2-TTL. A 2 dBi gain antenna was supplied with the test item. A block diagram of the test item set-up is shown as Figure 1.

2.1 Power Input - The test item obtained 12VDC power through 2 leads from an AC adaptor, Part No. KSAC1200080W1US. The primary of this adaptor received 115V 60Hz power through lowpass powerline filters on the wall of the shielded enclosure. The 12VDC power from the secondary of the transformer was provided to the test item through a 2 wire, 6 foot long unshielded cord.

2.2 Grounding - The test item was ungrounded for all tests.

2.3 Support Equipment - A Sony laptop computer was used to put the test item in different test modes by using HyperTerminal. The laptop computer was connected to the test item via a RS232 cable.

2.4 Interconnect Cables - The test item was connected to the laptop computer via a 2-meter long RS232 cable for initial set up only. It was removed during the tests.

2.5 Operational Mode - For all tests, the test item was transmitting at 902.2464MHz, 914.9184MHz or 927.8208MHz. The output power at the antenna port was 1 watt for all tests.

3.0 TEST EQUIPMENT:

3.1 Test Equipment List - A list of the test equipment used can be found on Table I.

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 Radiated Measurements

4.1.1 Spurious Radiated Emissions

4.1.1.1 Requirement – Radiated emissions which fall in the restricted bands, as defined in 15.205(a), must comply with the radiated emissions limits specified in 15.209(a).

Paragraph 15.209(a) has the following radiated emissions limits:

Frequency (MHz)	Field Strength (microvolts/meter)	Measurement Distance (meters)
0.009 - 0.490	2400/F(kHz)	300
0.490 - 1.705	2400/F(kHz)	30
1.705 - 30	30	3
30.0 - 88.0	100	3
88.0 - 216.0	150	3
216.0 - 960.0	200	3
Above 960	500	3

4.1.1.2 Procedures - Preliminary radiated measurements from 30MHz to 10GHz 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 power lines and signal lines entering the enclosure pass through filters on the enclosure wall. The power line filters prevent extraneous signals from entering the enclosure on these leads.

Final radiated measurements were performed on the following: All significant radiated emissions detected in the preliminary tests which were in the restricted bands listed in 15.205(a). The harmonics of the transmit frequency which fall in the restricted bands of 15.205(a).

All final radiated emissions measurements were manually performed in a 32ft. x 20ft. x 14ft. high shielded enclosure. Measurements below 1GHz were made using a quasi-peak detector and a bilog antenna. Measurements above 1GHz were made using an average detector and a double ridged waveguide antenna. A high-pass filter was used to block the fundamental frequency and avoid saturation.

To ensure that maximum 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 for each antenna polarization to maximize the readings.

4.1.1.3 Results - Photographs of the test item set-up are presented as Figures 2. The preliminary radiated emissions plots from 30MHz to 10GHz with the test item transmitting at 902.2464MHz are presented on data pages 11 and 12. The final radiated emissions data with the test item transmitting at 902.2464MHz are presented on data pages 13 and 14. As can be seen by the data, the test item did meet the emissions limits. The preliminary radiated emissions plots from 30MHz to 10GHz with the test item transmitting at 914.9184MHz are presented on data pages 15 and 16. The final radiated emissions data with the test item transmitting at 914.9184MHz are presented on data pages 17 and 18. As can be seen by the data, the test item did meet the emissions limits. The preliminary radiated emissions plots from 30MHz to 10GHz with the test item transmitting at 927.8208MHz are presented on data pages 19 and 20. The final radiated emissions data with the test item transmitting at 927.8208MHz are presented on data pages 21 and 22. As can be seen by the data, the test item did meet the emissions limits.

5.0 CONCLUSIONS:

It was determined that the Freewave Technologies Wireless Data Transceiver, Part No. MM2-TTL, did fully meet the requirements of the FCC "Code of Federal Regulations" Title 47, Part 15.247, Subpart C, for Intentional Radiators and RSS 210 Issue 7 June 2007 - Low-power License-exempt Radio communication Devices (All Frequency Bands), 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. 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

Eq ID	Equipment Description	Manufacturer	Model No.	Serial No.	Frequency Range	Cal Date	Due Date
APQ2	PREAMPLIFIER	ROHDE & SCHWARZ	TS-PR40	1000022	26.5GHZ-40GHZ	11/3/2009	11/3/2010
APW2	PREAMPLIFIER	PLANAR ELECTRONICS	PE2-35-120-5R0-10	PL2925	1GHZ-20GHZ	12/16/2008	12/16/2009
CDS2	COMPUTER	GATEWAY	MFATXPNT NMZ 500L	0028483108	1.8GHZ	N/A	
CMA0	MULTI-DEVICE CONTROLLER	EMCO	2090	9701-1213	---	N/A	
NTA0	BILOG ANTENNA	CHASE EMC LTD.	BILOG CBL6112	2057	0.03-2GHZ	11/14/2008	12/14/2009
NWH0	RIDGED WAVE GUIDE	TENSOR	4105	2081	1-12.4GHZ	8/11/2009	8/11/2010

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.

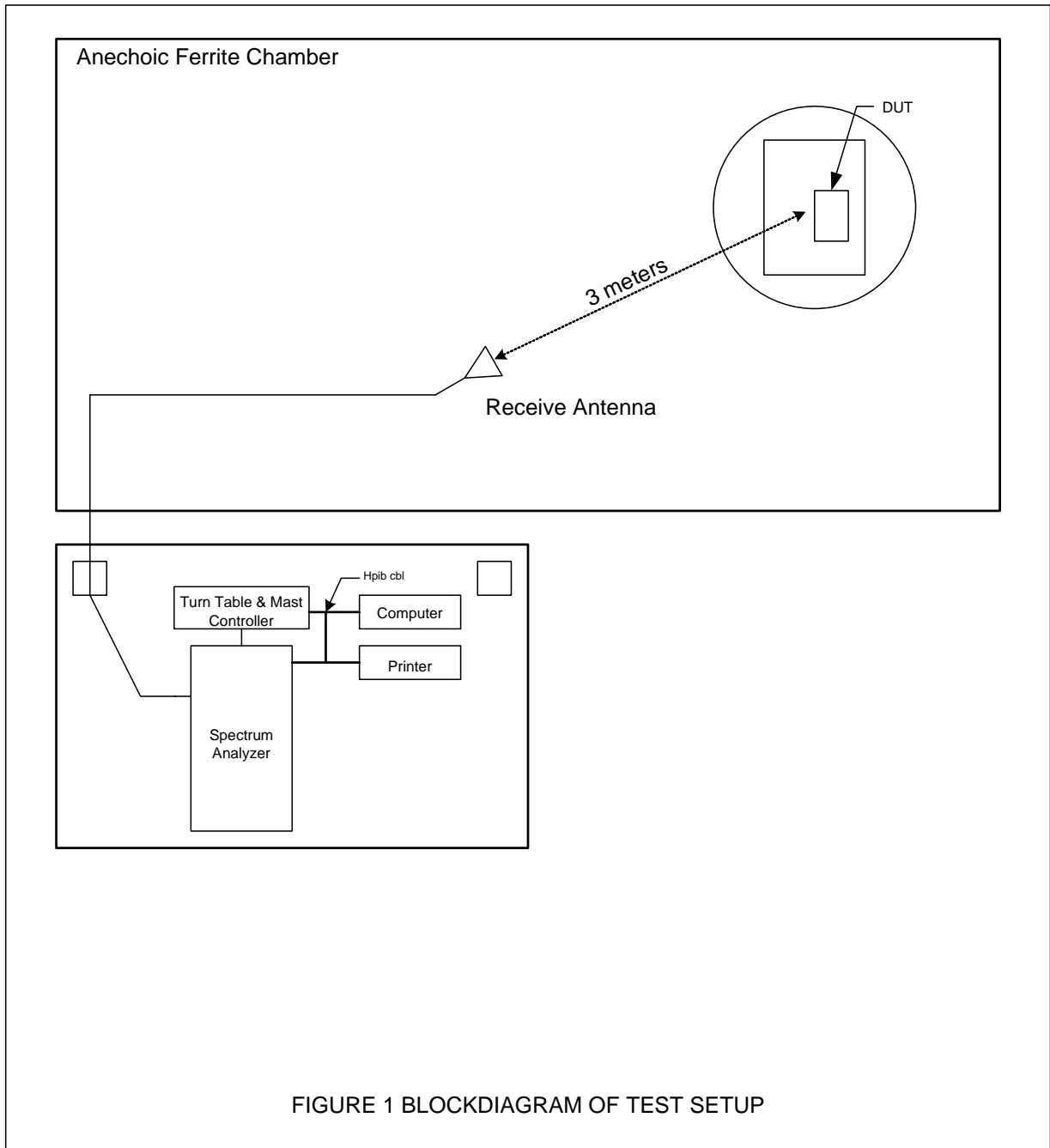
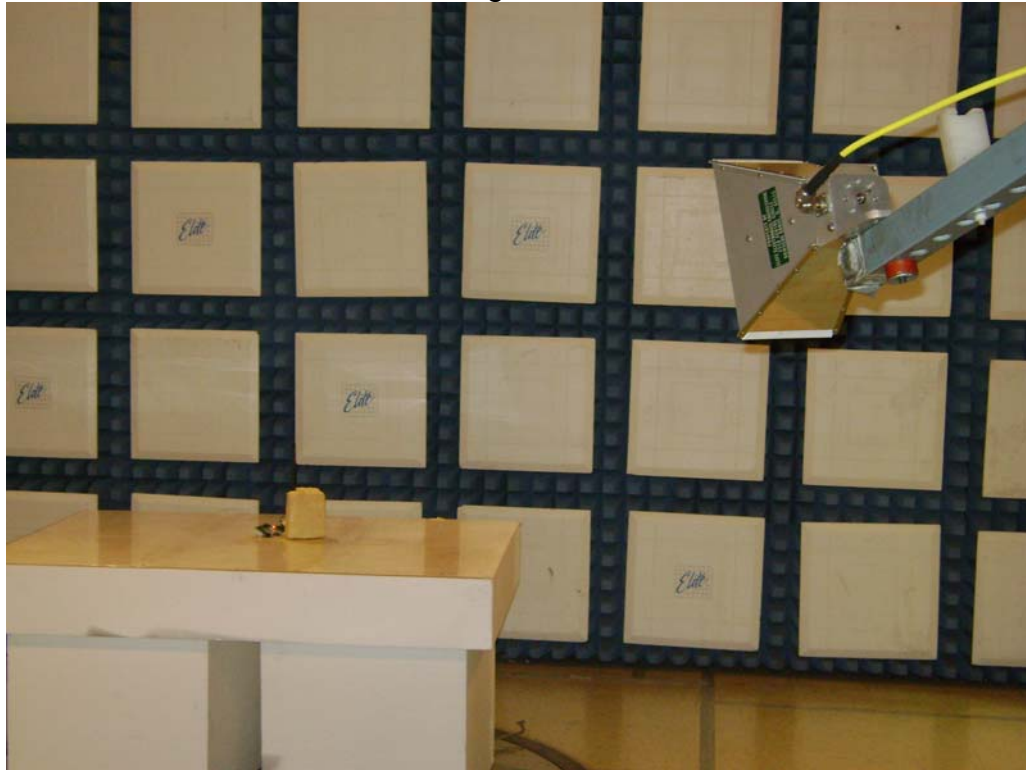


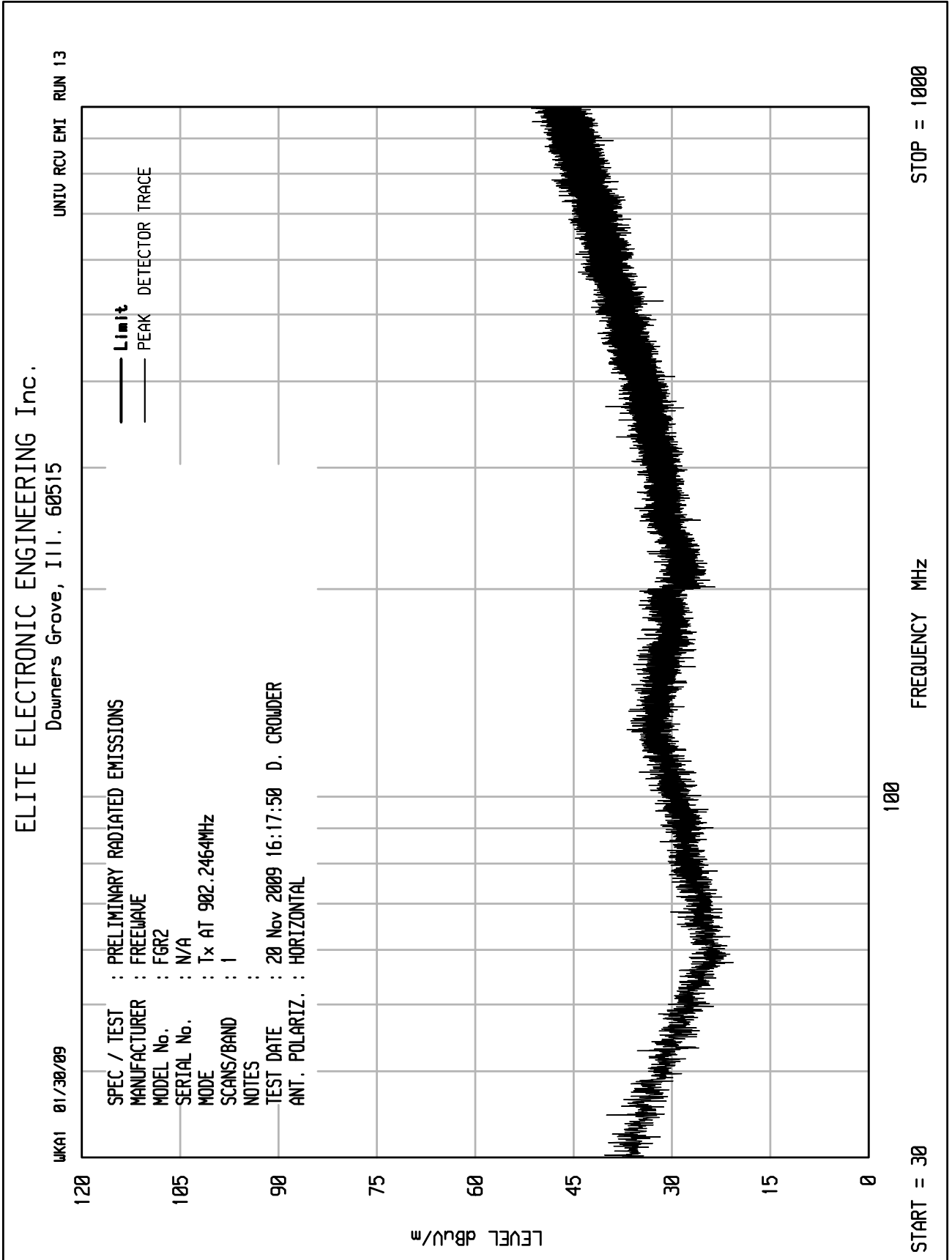
Figure 2

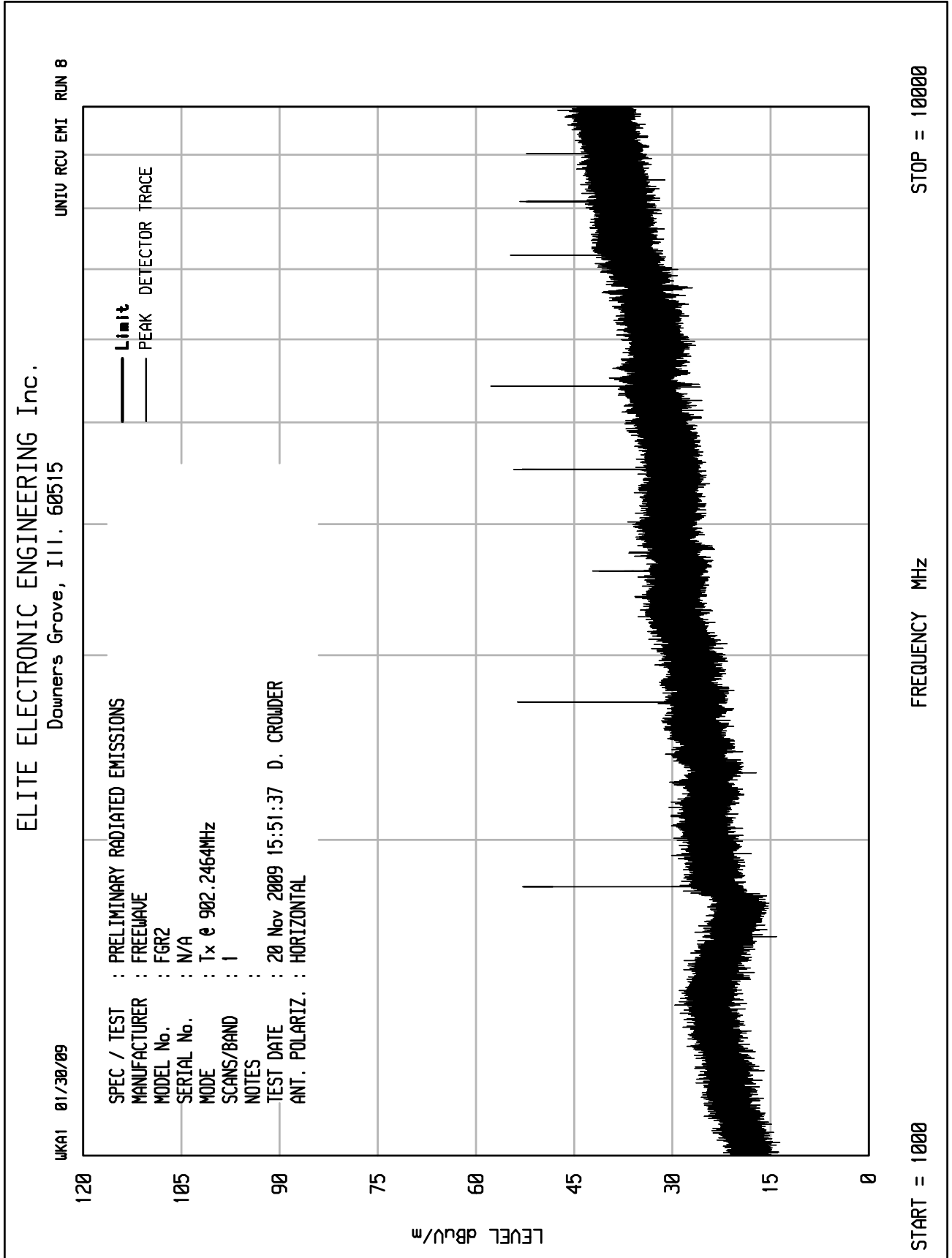


Test Set-up for Radiated Emissions Omni Antenna – Horizontal Polarization



Test Set-up for Radiated Emissions Omni Antenna – Vertical Polarization







DATA PAGE

MANUFACTURER Freewave Technologies
 TEST ITEM Wireless Digital Transmission Transceiver
 SERIAL NO. None Assigned
 SPECIFICATION 15.247 RADIATED SPURIOUS EMISSIONS
 MODE Tx @ 902.2464MHz
 DATE November 20, 2009
 NOTES TEST DISTANCE IS 3 METERS
 ANTENNA Omni Antenna

FREQ. (MHz)	ANT POL	MTR RDG dBuV	AMBIENT	CABLE LOSS dB	ANT FAC dB	PRE AMP dB	DUTY CYCLE dB	PEAK TOTAL dBuV/m	PEAK TOTAL uV/m	PEAK LIMIT uV
2706.74	H	26.7		3.9	29.6	0.0	0.0	60.2	1024.6	5000.0
2706.74	V	31.6		3.9	29.6	0.0	0.0	65.1	1801.1	5000.0
3608.99	H	17.5		4.7	32.0	0.0	0.0	54.2	513.9	5000.0
3608.99	V	17.7		4.7	32.0	0.0	0.0	54.4	525.8	5000.0
4511.23	H	23.0		5.5	32.9	0.0	0.0	61.4	1172.3	5000.0
4511.23	V	24.7		5.5	32.9	0.0	0.0	63.1	1425.7	5000.0
7217.97	H	25.6	Ambient	7.6	37.4	0.0	0.0	70.7	3410.4	5000.0
7217.97	V	26.0	Ambient	7.6	37.4	0.0	0.0	71.1	3571.1	5000.0
8120.22	H	26.0	Ambient	8.0	37.8	0.0	0.0	71.8	3885.3	5000.0
8120.22	V	26.4	Ambient	8.0	37.8	0.0	0.0	72.2	4068.4	5000.0
9022.46	H	25.8	Ambient	8.8	37.8	0.0	0.0	72.3	4134.4	5000.0
9022.46	V	24.5	Ambient	8.8	37.8	0.0	0.0	71.0	3559.7	5000.0

Checked By:

Daniel E. Crowder



DATA PAGE

MANUFACTURER Freewave Technologies
 TEST ITEM Wireless Digital Transmission Transceiver
 SERIAL NO. None Assigned
 SPECIFICATION 15.247 RADIATED SPURIOUS EMISSIONS
 MODE Tx @ 902.2464MHz
 DATE November 20, 2009
 NOTES TEST DISTANCE IS 3 METERS
 ANTENNA Omni Antenna

FREQ. (MHz)	ANT POL	MTR RDG dBuV	AMBIENT	CABLE LOSS dB	ANT FAC dB	PRE AMP dB	DUTY CYCLE dB	AVG TOTAL dBuV/m	AVG TOTAL uV/m	AVG LIMIT uV
2706.7	H	25.0		3.9	29.6	0.0	-16.6	41.9	124.6	500.0
2706.7	V	29.9		3.9	29.6	0.0	-16.6	46.8	219.1	500.0
3609.0	H	16.7		4.7	32.0	0.0	-16.6	36.8	69.3	500.0
3609.0	V	16.3		4.7	32.0	0.0	-16.6	36.4	66.2	500.0
4511.2	H	21.1		5.5	32.9	0.0	-16.6	42.9	139.3	500.0
4511.2	V	21.9		5.5	32.9	0.0	-16.6	43.7	152.8	500.0
7218.0	H	15.0	Ambient	7.6	37.4	0.0	-16.6	43.5	148.9	500.0
7218.0	V	15.0	Ambient	7.6	37.4	0.0	-16.6	43.5	148.9	500.0
8120.2	H	15.0	Ambient	8.0	37.8	0.0	-16.6	44.2	162.0	500.0
8120.2	V	15.0	Ambient	8.0	37.8	0.0	-16.6	44.2	162.0	500.0
9022.5	H	15.0	Ambient	8.8	37.8	0.0	-16.6	44.9	176.4	500.0
9022.5	V	15.0	Ambient	8.8	37.8	0.0	-16.6	44.9	176.4	500.0

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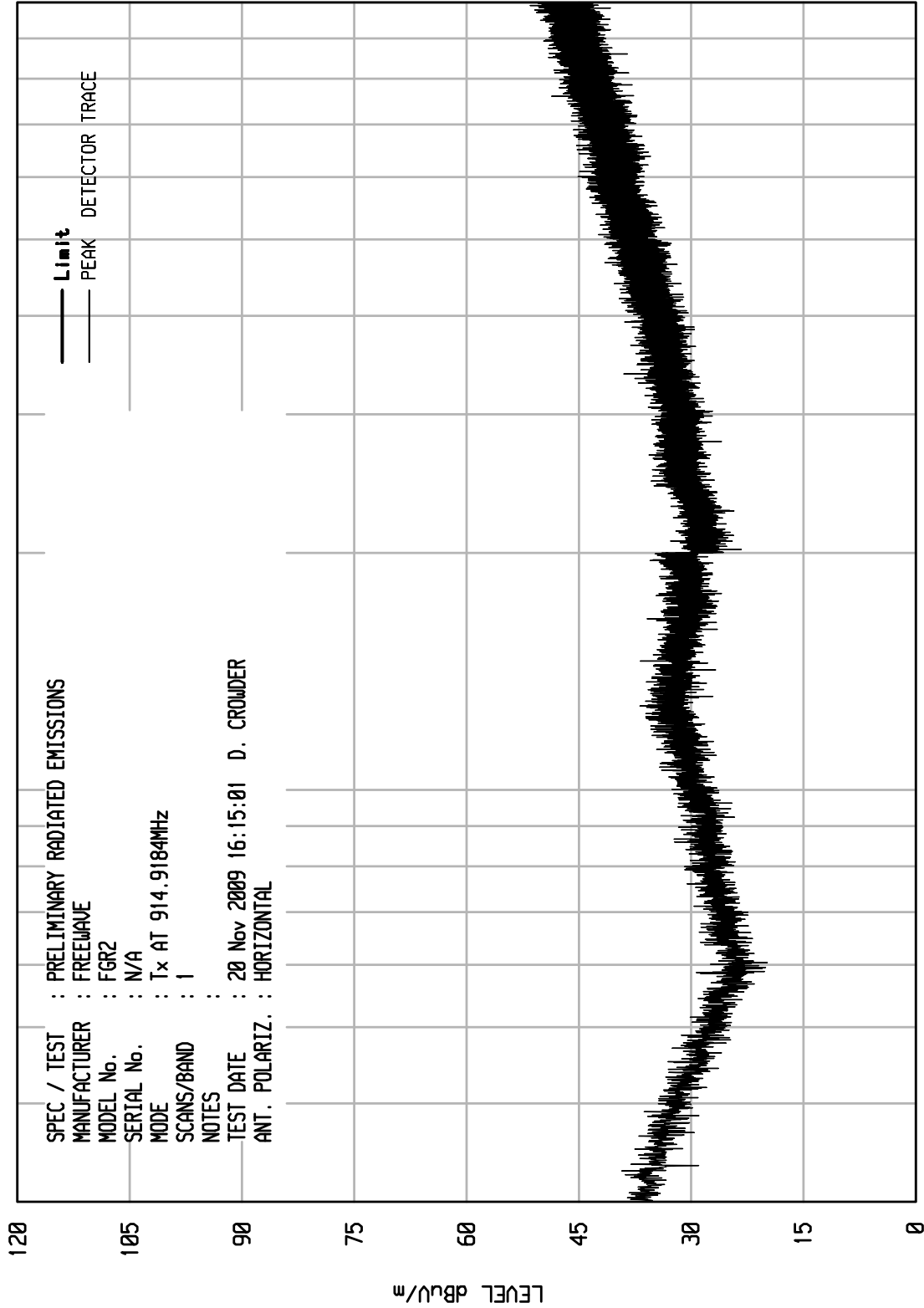
Daniel E. Crowder

ELITE ELECTRONIC ENGINEERING Inc.
Downers Grove, Ill. 60515

UNIU RCU EMI RUN 12

UJKA1 01/30/09

SPEC / TEST : PRELIMINARY RADIATED EMISSIONS
 MANUFACTURER : FREEWAVE
 MODEL No. : FGR2
 SERIAL No. : N/A
 MODE : Tx AT 914.9184MHz
 SCANS/BAND : 1
 NOTES :
 TEST DATE : 20 Nov 2009 16:15:01 D. CROWDER
 ANT. POLARIZ. : HORIZONTAL



STOP = 1000

FREQUENCY MHz

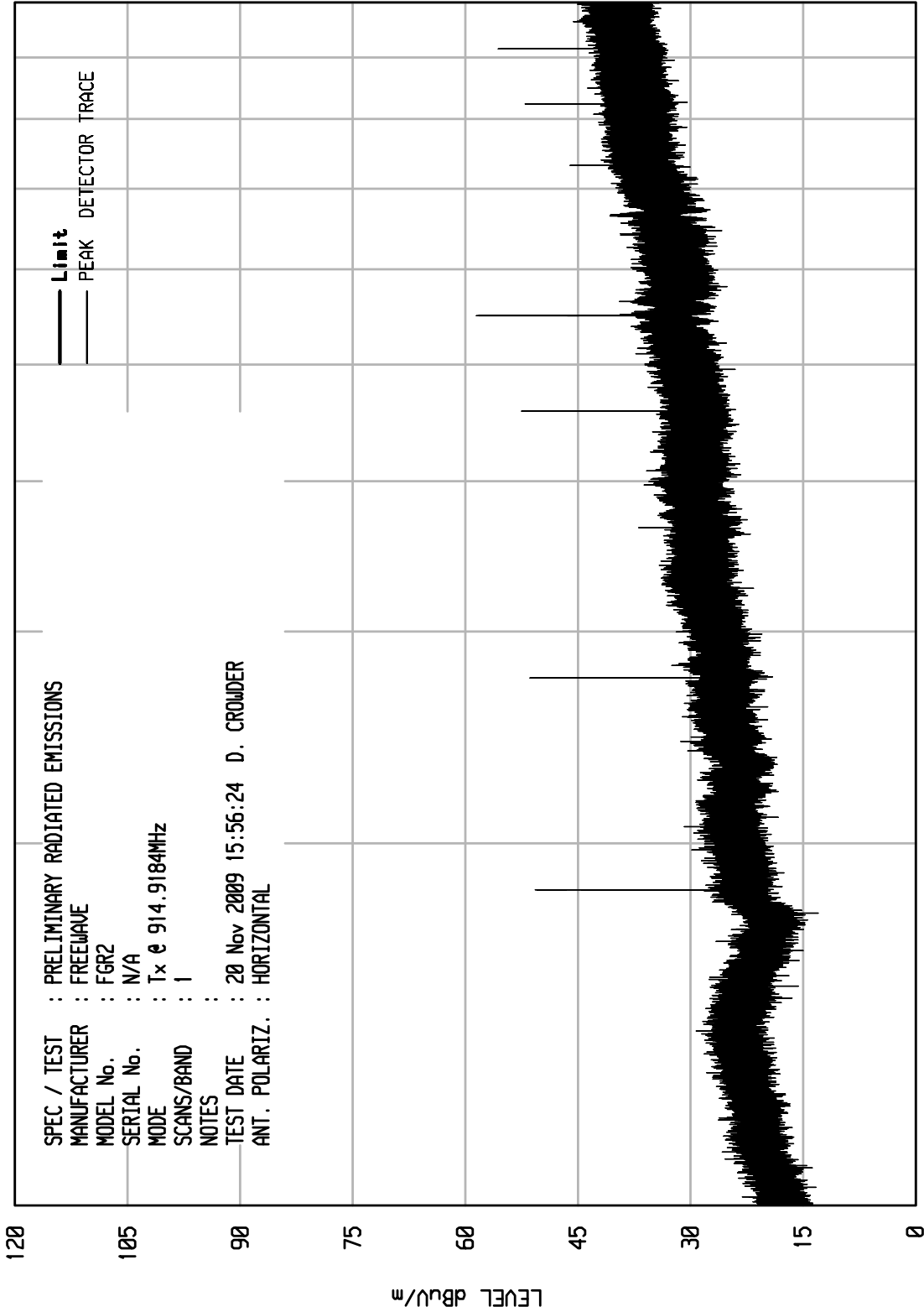
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ELITE ELECTRONIC ENGINEERING Inc.
Downers Grove, Ill. 60515

UNIU RCU EMI RUN 9

UJKA1 01/30/09

SPEC / TEST : PRELIMINARY RADIATED EMISSIONS
 MANUFACTURER : FREEWAVE
 MODEL No. : FGR2
 SERIAL No. : N/A
 MODE : Tx @ 914.9184MHz
 SCANS/BAND : 1
 NOTES :
 TEST DATE : 20 Nov 2009 15:56:24 D. CROWDER
 ANT. POLARIZ. : HORIZONTAL



START = 1000

FREQUENCY MHz

STOP = 10000



DATA PAGE

MANUFACTURER Freewave Technologies
 TEST ITEM Wireless Digital Transmission Transceiver
 SERIAL NO. None Assigned
 SPECIFICATION 15.247 RADIATED SPURIOUS EMISSIONS
 MODE Tx @ 914.9184MHz
 DATE November 20, 2009
 NOTES TEST DISTANCE IS 3 METERS
 ANTENNA Omni Antenna

FREQ. (MHz)	ANT POL	MTR RDG dBuV	AMBIENT	CABLE LOSS dB	ANT FAC dB	PRE AMP dB	DUTY CYCLE dB	PEAK TOTAL dBuV/m	PEAK TOTAL uV/m	PEAK LIMIT uV
2744.76	H	31.5		3.9	29.6	0.0	0.0	65.0	1782.7	5000.0
2744.76	V	33.6		3.9	29.6	0.0	0.0	67.1	2270.3	5000.0
3659.67	H	18.0		4.7	32.2	0.0	0.0	55.0	561.0	5000.0
3659.67	V	18.9		4.7	32.2	0.0	0.0	55.9	622.3	5000.0
4574.59	H	25.5		5.5	33.1	0.0	0.0	64.1	1610.1	5000.0
4574.59	V	27.1		5.5	33.1	0.0	0.0	65.7	1935.7	5000.0
7319.35	H	25.6	Ambient	7.7	37.8	0.0	0.0	71.1	3579.6	5000.0
7319.35	V	26.0	Ambient	7.7	37.8	0.0	0.0	71.5	3748.3	5000.0
8234.27	H	26.0	Ambient	8.1	37.4	0.0	0.0	71.5	3775.9	5000.0
8234.27	V	26.4	Ambient	8.1	37.4	0.0	0.0	71.9	3953.8	5000.0
9149.18	H	25.8	Ambient	8.7	37.8	0.0	0.0	72.3	4144.6	5000.0
9149.18	V	25.8	Ambient	8.7	37.8	0.0	0.0	72.3	4144.6	5000.0

Checked By:

Daniel E. Crowder



DATA PAGE

MANUFACTURER Freewave Technologies
 TEST ITEM Wireless Digital Transmission Transceiver
 SERIAL NO. None Assigned
 SPECIFICATION 15.247 RADIATED SPURIOUS EMISSIONS
 MODE Tx @ 914.9184MHz
 DATE November 20, 2009
 NOTES TEST DISTANCE IS 3 METERS
 ANTENNA Omni Antenna

FREQ. (MHz)	ANT POL	MTR RDG dBuV	AMBIENT	CABLE LOSS dB	ANT FAC dB	PRE AMP dB	DUTY CYCLE dB	AVG TOTAL dBuV/m	AVG TOTAL uV/m	AVG LIMIT uV
2744.8	H	28.8		3.9	29.6	0.0	-16.6	45.7	193.2	500.0
2744.8	V	29.8		3.9	29.6	0.0	-16.6	46.7	216.8	500.0
3659.7	H	16.6		4.7	32.2	0.0	-16.6	37.0	70.6	500.0
3659.7	V	16.7		4.7	32.2	0.0	-16.6	37.1	71.4	500.0
4574.6	H	23.3		5.5	33.1	0.0	-16.6	45.3	184.9	500.0
4574.6	V	22.7		5.5	33.1	0.0	-16.6	44.7	172.5	500.0
7319.3	H	15.0	Ambient	7.7	37.8	0.0	-16.6	43.9	156.3	500.0
7319.3	V	15.0	Ambient	7.7	37.8	0.0	-16.6	43.9	156.3	500.0
8234.3	H	15.0	Ambient	8.1	37.4	0.0	-16.6	43.9	157.4	500.0
8234.3	V	15.0	Ambient	8.1	37.4	0.0	-16.6	43.9	157.4	500.0
9149.2	H	14.8	Ambient	8.7	37.8	0.0	-16.6	44.7	172.8	500.0
9149.2	V	14.8	Ambient	8.7	37.8	0.0	-16.6	44.7	172.8	500.0

Checked By:

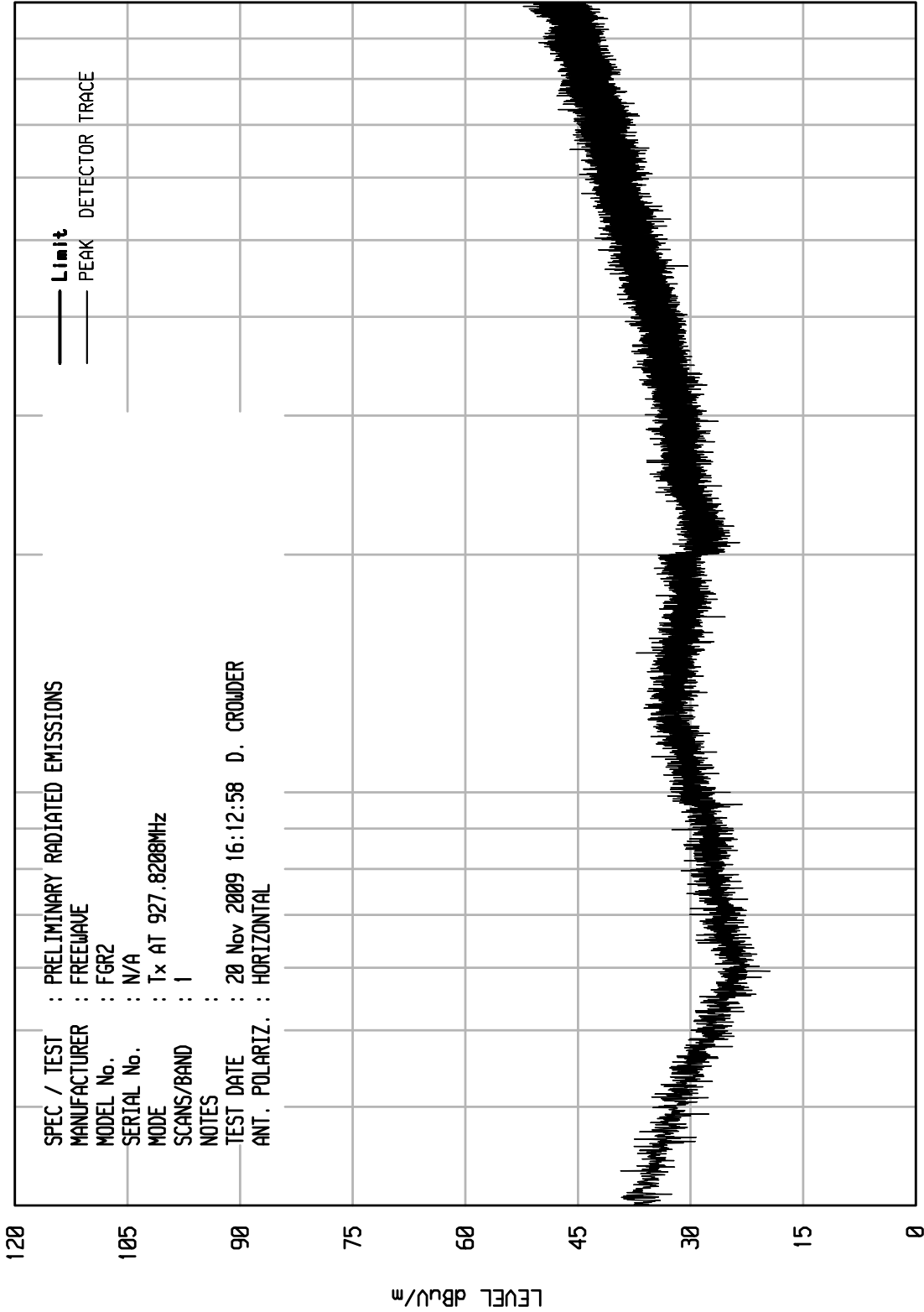
Daniel E. Crowder

ELITE ELECTRONIC ENGINEERING Inc.
Downers Grove, Ill. 60515

UNIU RCU EMI RUN 11

UJKA1 01/30/09

SPEC / TEST : PRELIMINARY RADIATED EMISSIONS
 MANUFACTURER : FREEWAVE
 MODEL No. : FGR2
 SERIAL No. : N/A
 MODE : Tx AT 927.8208MHz
 SCANS/BAND : 1
 NOTES :
 TEST DATE : 20 Nov 2009 16:12:58 D. CROWDER
 ANT. POLARIZ. : HORIZONTAL

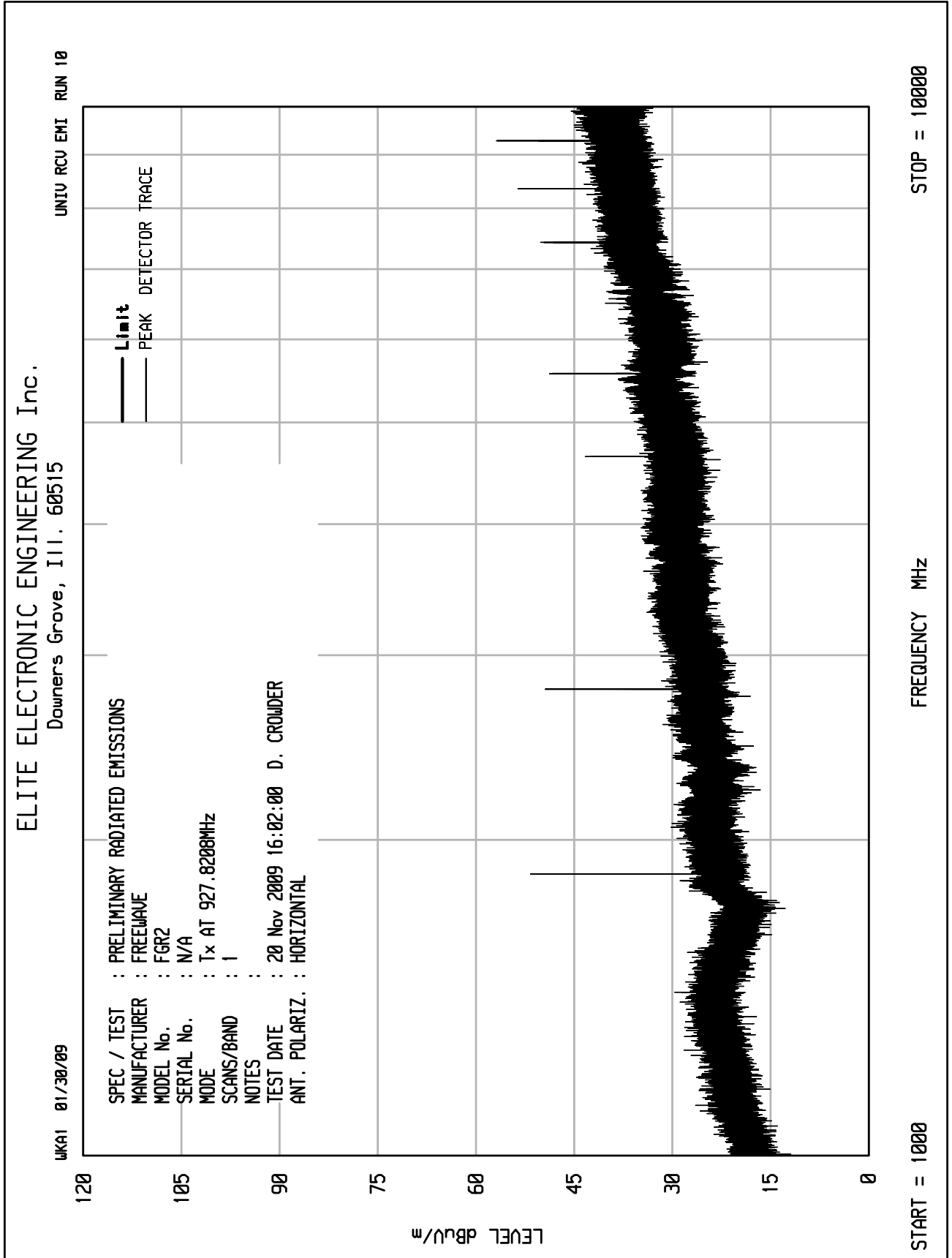


STOP = 1000

FREQUENCY MHz

100

START = 30





DATA PAGE

MANUFACTURER Freewave Technologies
 TEST ITEM Wireless Digital Transmission Transceiver
 SERIAL NO. None Assigned
 SPECIFICATION 15.247 RADIATED SPURIOUS EMISSIONS
 MODE Tx @ 927.8208MHz
 DATE November 20, 2009
 NOTES TEST DISTANCE IS 3 METERS
 ANTENNA Omni Antenna

FREQ. (MHz)	ANT POL	MTR RDG dBuV	AMBIENT	CABLE LOSS dB	ANT FAC dB	PRE AMP dB	DUTY CYCLE dB	PEAK TOTAL dBuV/m	PEAK TOTAL uV/m	PEAK LIMIT uV
2783.46	H	30.1		4.0	29.6	0.0	0.0	63.6	1519.2	5000.0
2783.46	V	35.3		4.0	29.6	0.0	0.0	68.8	2764.6	5000.0
3711.28	H	22.3		4.8	32.4	0.0	0.0	59.5	947.4	5000.0
3711.28	V	22.9		4.8	32.4	0.0	0.0	60.1	1015.1	5000.0
4639.10	H	28.4		5.6	33.3	0.0	0.0	67.3	2315.9	5000.0
4639.10	V	29.8		5.6	33.3	0.0	0.0	68.7	2721.0	5000.0
7422.57	H	25.6	Ambient	7.7	37.8	0.0	0.0	71.1	3587.4	5000.0
7422.57	V	26.0	Ambient	7.7	37.8	0.0	0.0	71.5	3756.5	5000.0
8350.39	H	26.0	Ambient	8.2	37.3	0.0	0.0	71.5	3744.5	5000.0
8350.39	V	26.4	Ambient	8.2	37.3	0.0	0.0	71.9	3920.9	5000.0

Checked By:

Daniel E. Crowder



DATA PAGE

MANUFACTURER Freewave Technologies
 TEST ITEM Wireless Digital Transmission Transceiver
 SERIAL NO. None Assigned
 SPECIFICATION 15.247 RADIATED SPURIOUS EMISSIONS
 MODE Tx @ 927.8208MHz
 DATE November 20, 2009
 NOTES TEST DISTANCE IS 3 METERS
 ANTENNA Omni Antenna

FREQ. (MHz)	ANT POL	MTR RDG dBuV	AMBIENT	CABLE LOSS dB	ANT FAC dB	PRE AMP dB	DUTY CYCLE dB	AVG TOTAL dBuV/m	AVG TOTAL uV/m	AVG LIMIT uV
2783.5	H	26.7		4.0	29.6	0.0	-16.6	43.6	151.9	500.0
2783.5	V	31.6		4.0	29.6	0.0	-16.6	48.5	267.1	500.0
3711.3	H	17.5		4.8	32.4	0.0	-16.6	38.1	80.6	500.0
3711.3	V	17.7		4.8	32.4	0.0	-16.6	38.3	82.5	500.0
4639.1	H	23.0		5.6	33.3	0.0	-16.6	45.3	184.0	500.0
4639.1	V	24.7		5.6	33.3	0.0	-16.6	47.0	223.7	500.0
7422.6	H	15.0	Ambient	7.7	37.8	0.0	-16.6	43.9	156.6	500.0
7422.6	V	15.0	Ambient	7.7	37.8	0.0	-16.6	43.9	156.6	500.0
8350.4	H	15.0	Ambient	8.2	37.3	0.0	-16.6	43.9	156.1	500.0
8350.4	V	15.0	Ambient	8.2	37.3	0.0	-16.6	43.9	156.1	500.0

Checked By:

Daniel E. Crowder