



## Measurement of RF Emissions from a Drum Temperature Sensor Transmitter

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For	Verifi LLC 4992 Rialto Road West Chester, OH 45069
P.O. Number	R002925
Date Tested	February 15, 2011 through December 2, 2011
Test Personnel	Mark E. Longinotti
Test Specification	FCC "Code of Federal Regulations" Title 47 Part15, Subpart C Industry Canada RSS-GEN Industry Canada RSS-210

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**TABLE OF CONTENTS**

PARAGRAPH	DESCRIPTION OF CONTENTS	PAGE NO.
1. Introduction.....		5
1.1. Scope of Tests.....		5
1.2. Purpose .....		5
1.3. Deviations, Additions and Exclusions.....		5
1.4. EMC Laboratory Identification .....		5
1.5. Laboratory Conditions.....		5
2. Applicable Documents.....		5
3. EUT Setup and Operation.....		6
3.1. General Description .....		6
3.1.1. Power Input.....		6
3.1.2. Peripheral Equipment .....		6
3.1.3. Signal Input/Output Leads .....		6
3.1.4. Grounding .....		6
3.2. Operational Mode .....		6
3.3. EUT Modifications.....		6
4. Test Facility and Test Instrumentation .....		6
4.1. Shielded Enclosure.....		6
4.2. Test Instrumentation.....		6
4.3. Calibration Traceability .....		7
4.4. Measurement Uncertainty .....		7
5. Test Procedures .....		7
5.1. Powerline Conducted Emissions .....		7
5.1.1. Requirements.....		7
5.2. Periodic Operation Measurements .....		7
5.2.1. Requirements.....		7
5.2.2. Procedures.....		7
5.2.3. Results .....		8
5.3. Duty Cycle Factor Measurements .....		8
5.3.1. Procedures.....		8
5.3.2. Results .....		8
5.4. Radiated Measurements .....		8
5.4.1. Requirements.....		8
5.4.2. Procedures.....		8
5.4.3. Results .....		9
5.5. Occupied Bandwidth Measurements.....		9
5.5.1. Requirement.....		9
5.5.2. Procedures.....		9
5.5.3. Results .....		10
6. Other Test Conditions .....		10
6.1. Test Personnel and Witnesses.....		10
6.2. Disposition of the EUT .....		10

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WRITTEN APPROVAL OF ELITE ELECTRONIC ENGINEERING INCORPORATED.**

**TABLE OF CONTENTS**

PARAGRAPH	DESCRIPTION OF CONTENTS	PAGE NO.
7. Conclusions.....		10
8. Certification.....		10
9. Equipment List.....		11

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### REVISION HISTORY

Revision	Date	Description
—	December 7, 2011	Initial release
A	January 30, 2012	Updated company name, contact and model number per Verifi LLC. DEC

## Measurement of RF Emissions from a Drum Temperature Sensor Transmitter

### 1. INTRODUCTION

#### 1.1. Scope of Tests

This report presents the results of the RF emissions measurements performed on a Drum Temperature Sensor Transmitter, Serial No. A0619000, (hereinafter referred to as the Equipment Under Test (EUT)). The EUT was designed to transmit at approximately 433.9MHz using an internal wire antenna. The EUT was manufactured and submitted for testing by Verifi LLC located in West Chester, OH.

#### 1.2. Purpose

The test series was performed to determine if the EUT meets the conducted and radiated RF emission requirements of the FCC "Code of Federal Regulations" Title 47, Part 15, Subpart C, Sections 15.207 and 15.231(e) for Intentional Radiators. Testing was performed in accordance with ANSI C63.4-2009.

The test series was also performed to determine if the EUT meets the conducted and radiated RF emission requirements of the Industry Canada Radio Standards Specification RSS-Gen, Section 7.2.4 and RSS-210, Annex 1. Testing was performed in accordance with ANSI C63.4-2009.

#### 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 American Association for Laboratory Accreditation (A2LA). A2LA Certificate Number: 1786.01.

#### 1.5. Laboratory Conditions

The temperature at the time of the test was 21°C and the relative humidity was 22%.

### 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 2011
- ANSI C63.4-2009, "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 Radio Standards Specification, RSS-Gen, "General Requirements and Information for the Certification of Radiocommunication Equipment", Issue 3, December 2010
- Industry Canada Radio Standards Specification, RSS-210, "Low-power Licence-exempt Radiocommunication Devices (All Frequency Bands): Category I Equipment", Issue 8, December 2010

### 3. EUT SETUP AND OPERATION

#### 3.1. General Description

The EUT is a Verifi LLC, Drum Temperature Sensor Transmitter. A block diagram of the EUT setup is shown as Figure 1. A photograph of the EUT is shown as Figure 2.

##### 3.1.1. Power Input

The EUT obtained 3VDC from internal batteries.

##### 3.1.2. Peripheral Equipment

No peripheral equipment was submitted with the EUT:

##### 3.1.3. Signal Input/Output Leads

No interconnect cables were submitted with the EUT:

##### 3.1.4. Grounding

The EUT was ungrounded during the tests.

#### 3.2. Operational Mode

For all tests the EUT was placed on an 80cm high non-conductive stand and the EUT was energized. In normal operation mode, the EUT transmits at a periodic rate. For testing purposes, the EUT was modified so that upon power up, the EUT would transmit continuously.

#### 3.3. EUT Modifications

No modifications were required for compliance.

### 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 C63.4-2009 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 and radiated emission measurements were performed with a spectrum analyzer. This receiver allows measurements with the bandwidths and detector functions specified by the FCC. The receiver bandwidth was 120kHz for the 30MHz to 1000MHz radiated emissions data and 1MHz for the radiated emissions data above 1000MHz.

#### 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 Emissions Measurements		
Combined Standard Uncertainty	1.07	-1.07
Expanded Uncertainty (95% confidence)	2.1	-2.1
Radiated Emissions 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 EUT was powered by internal batteries, no conducted emissions tests are required.

#### 5.2. Periodic Operation Measurements

##### 5.2.1. Requirements

Per FCC "Code of Federal Regulations" Title 47, Part 15, Subpart C, Section 15.231(e) and Industry Canada RSS-210, Annex 1, section A1.1.5, devices operated under these provisions shall be provided with a means for automatically limiting operation so that the duration of each transmission shall not be greater than one second and the silent period between transmissions shall be at least 30 times the duration of the transmission but in no case less than 10 seconds..

##### 5.2.2. Procedures

The spectrum analyzer was setup to display the time domain trace. 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 a sweep rate of 2 sec/div. The amplitude settings are adjusted so that the on/off transitions clear the 6th division from the bottom of the display. The markers are set at the beginning of 2 different transmissions. The time difference between these 2 markers is the silent period between transmissions.

Next the center frequency of the spectrum analyzer was tuned to the transmitter frequency with a zero span and a sweep time of 100msec/div. The amplitude settings are adjusted so that the on/off transitions clear the

6th division from the bottom of the display. The markers are set at the beginning and end of the transmission. The time difference between these 2 markers is the transmission duration.

### 5.2.3. Results

The plots of the silent period between transmissions and the transmission duration are shown on pages 16 and 17. The plots show that the silent time between transmissions is greater than 10 seconds (and greater than 30 times the duration of the transmission) and that the duration of each transmission is less than 1 second.

## 5.3. Duty Cycle Factor Measurements

### 5.3.1. 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 10msec/div. The amplitude settings are adjusted so that the on/off transitions clear the 6th division from the bottom of the display. If the pulse train does not exceed 100msec, then the duty cycle is determined by measuring the on-time of the pulse train in a 100 msec period. The markers are set at the beginning and end of a word period. The on-time is the total time the signal level exceeds the 6th division. The duty cycle is then computed as the (On-time/ 100msec).

### 5.3.2. Results

The plot of the duty cycle is shown on data page 18. The duty cycle factor was computed to be -15.48dB.

## 5.4. Radiated Measurements

### 5.4.1. Requirements

The EUT must comply with the requirements of FCC "Code of Federal Regulations Title 47", Part 15, Subpart C, Section 15.231(e).

Paragraph 15.231(e) 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	1,500 to 5,000*	150 to 500*

\* - Linear Interpolation

For 433.92MHz, the limit at the fundamental is 4398.7uV/m @ 3m and the limit on the harmonics is 439.9uV/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.

### 5.4.2. Procedures

All tests were performed in a 32ft. x 20ft. x 18ft. hybrid ferrite-tile/anechoic absorber lined test chamber. The walls and ceiling of the shielded chamber are lined with ferrite tiles. 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 C63.4-2009 for site attenuation.

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 EUT. For the preliminary test, a broadband measuring antenna was positioned at a 3 meter distance from the EUT. The entire frequency range from 30MHz to 4.5GHz 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 4500MHz. Between 30MHz and 1000MHz, a bilog 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 EUT 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 EUT was rotated through three orthogonal axes to determine which orientation produces the highest emission relative to the limit.

#### 5.4.3. Results

The preliminary plots, with the EUT transmitting at 433.9MHz, are presented on data pages 19 through 22. The plots are presented for a reference only, and are not used to determine compliance.

The final radiated levels, with the EUT transmitting at 433.9MHz, are presented on data page 23. As can be seen from the data, all emissions measured from the EUT were within the specification limits. The emissions level closest to the limit (worst case) occurred at 433.92MHz. The emissions level at this frequency was 2.9dB within the limit. See data page 23 for details. Photographs of the test configuration which yielded the highest, or worst case, radiated emission levels are shown on Figure 3 and Figure 4.

### 5.5. Occupied Bandwidth Measurements

#### 5.5.1. 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.

#### 5.5.2. Procedures

The EUT 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 4 MHz. The frequency spectrum near the fundamental was plotted.

### 5.5.3. Results

The plot of the emissions near the fundamental frequency is presented on data page 24. As can be seen from the plot, the transmitter met the occupied bandwidth requirements. The 99% bandwidth was measured to be 737kHz.

## 6. OTHER TEST CONDITIONS

### 6.1. Test Personnel and Witnesses

All tests were performed by qualified personnel from Elite Electronic Engineering Incorporated. The test series was witnessed by Verifi LLC personnel.

### 6.2. Disposition of the EUT

The EUT and all associated equipment were returned to Verifi LLC upon completion of the tests.

## 7. CONCLUSIONS

It was determined that the Verifi LLC Drum Temperature Sensor Transmitter, Serial No. A0619000, did fully meet the conducted and radiated RF emission requirements of the FCC "Code of Federal Regulations" Title 47, Part 15, Subpart C, Sections 15.207 and 15.231(e) for Intentional Radiators, when tested per ANSI C63.4-2009.

It was also determined that the Verifi LLC Drum Temperature Sensor Transmitter, Serial No. A0619000, did fully meet the conducted and radiated RF emission requirements of the Industry Canada Radio Standards Specification RSS-Gen, Section 7.2.4 and RSS-210, Annex 1, when tested per ANSI C63.4-2009.

## 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 EUT at the test date as operated by Verifi LLC personnel. Any electrical or mechanical modification made to the EUT 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**

Eq ID	Equipment Description	Manufacturer	Model No.	Serial No.	Frequency Range	Cal Date	Due Date
APW3	PREAMPLIFIER	PLANAR ELECTRONICS	PE2-35-120-5R0-10-12	PL2924	1GHZ-20GHZ	6/3/2011	6/3/2012
CMA1	Controllers	EMCO	2090	9701-1213	---	N/A	
NTA2	BILOG ANTENNA	TESEQ	6112D	28040	25-1000MHz	6/29/2011	6/29/2012
NWH0	RIDGED WAVE GUIDE	TENSOR	4105	2081	1-12.4GHz	11/3/2011	11/3/2012
PHA0	MAGNETIC FIELD PROBE	ELECTRO-METRICS	EM-6882	134	22-230MHz	NOTE 1	
PLH0	50UH LISN 461A LOW FREQ.	ELITE ELECTRONIC ENG	461-4/70A	---	0.014-10MHz	8/15/2011	8/15/2012
RBB0	EMI TEST RECEIVER 20HZ TO 40 GHZ.	ROHDE & SCHWARZ	ESIB40	100250	20 HZ TO 40GHz	3/24/2011	3/24/2012
SES1	24VDC POWER SUPPLY	P TRANS	FS-32024-1M	002	18-27VDC	NOTE 1	

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.

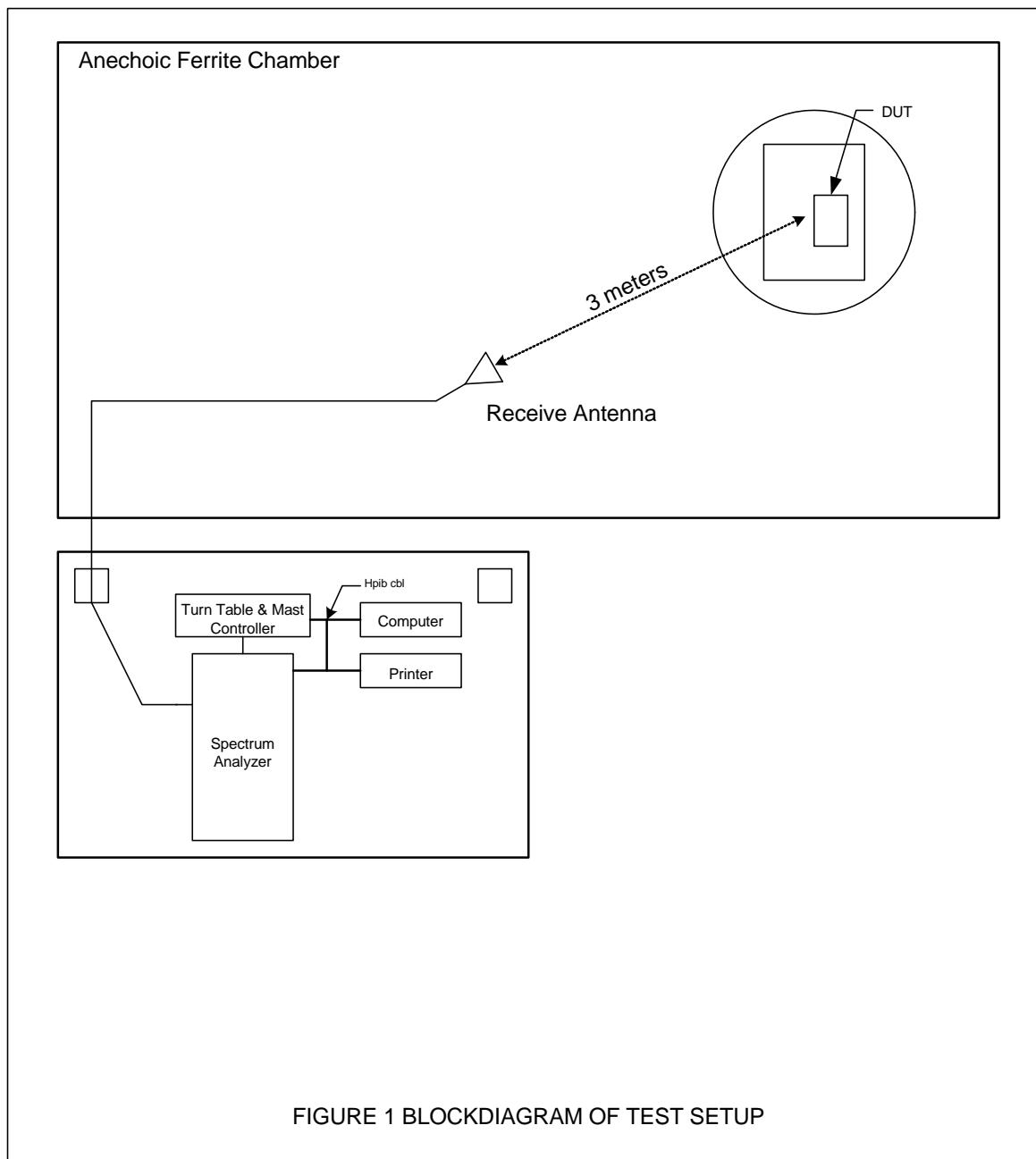
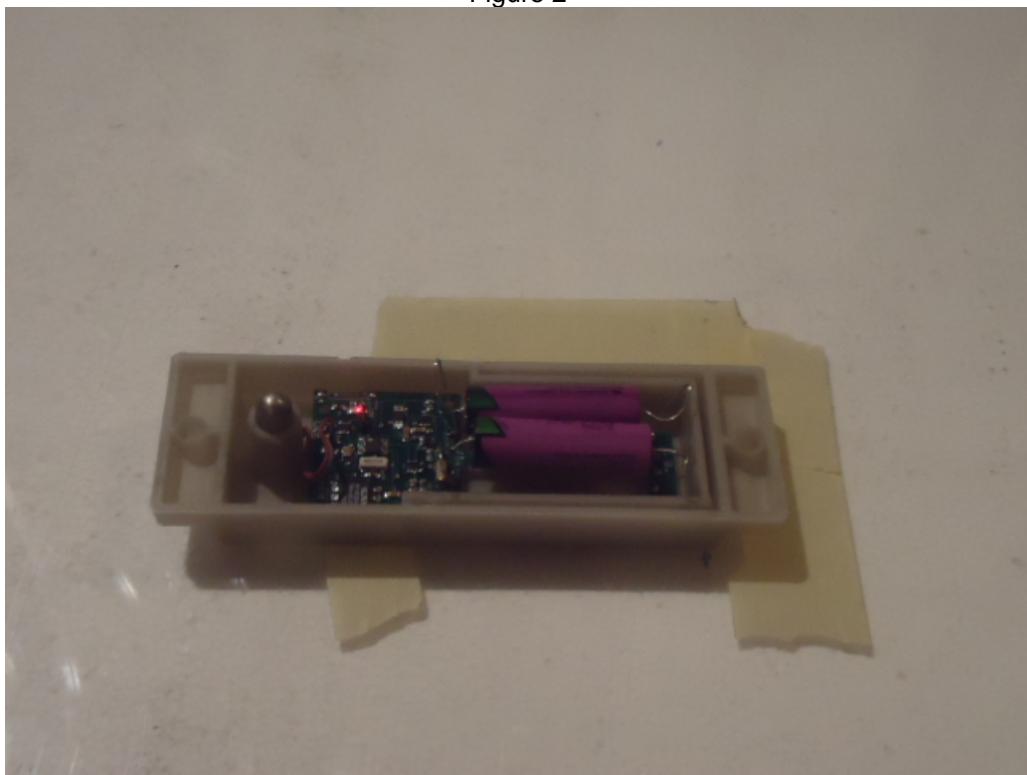
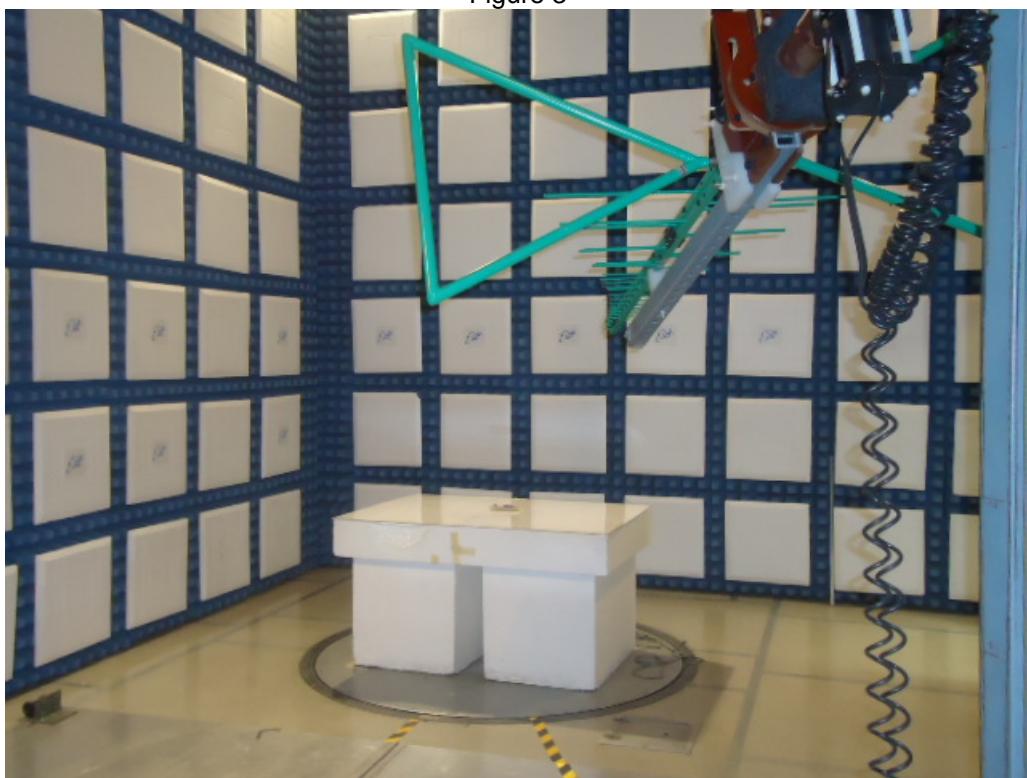


Figure 2

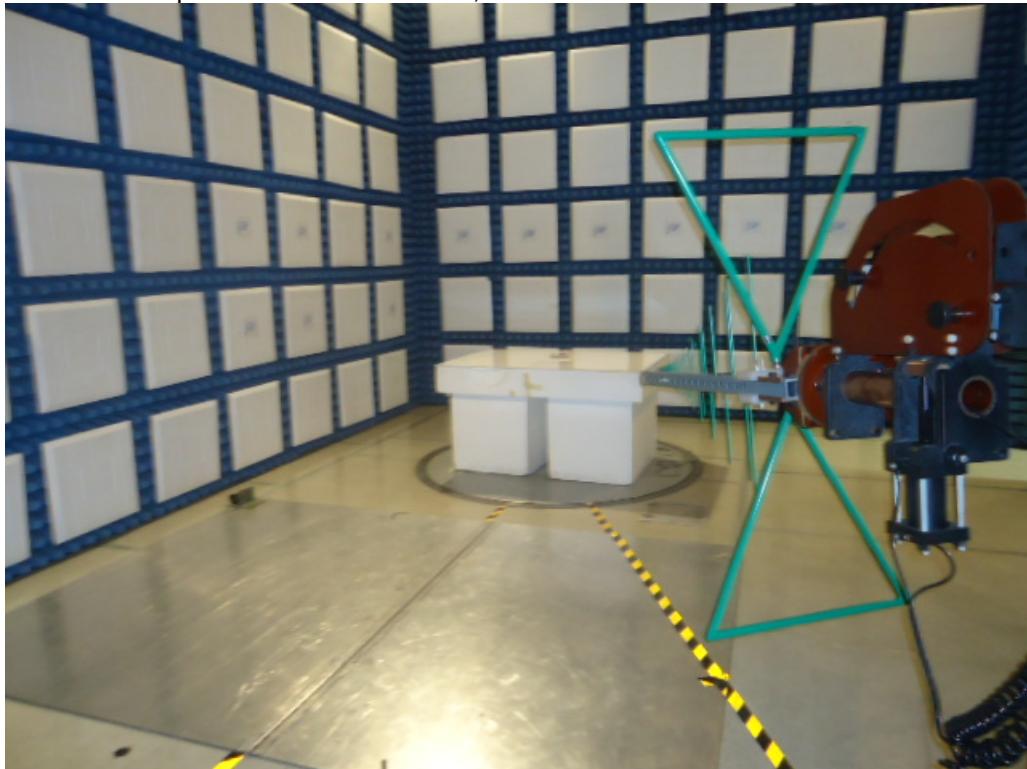


Photograph of EUT

Figure 3



Test Setup for Radiated Emissions, 30MHz to 1GHz – Horizontal Polarization

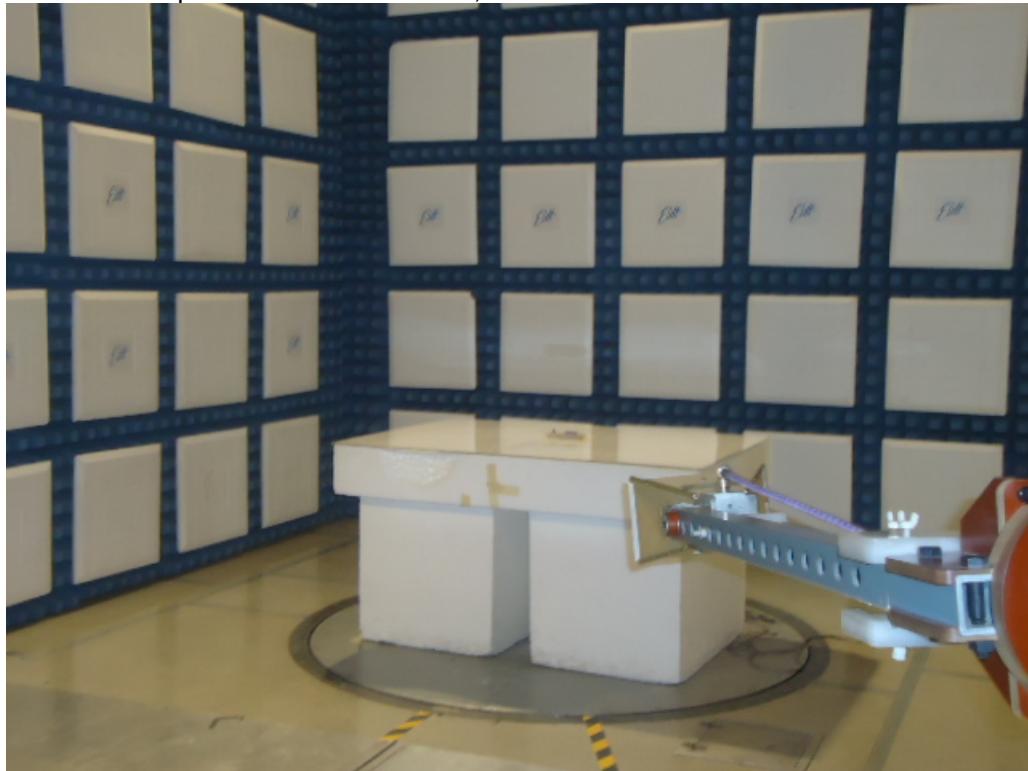


Test Setup for Radiated Emissions, 30MHz to 1GHz – Vertical Polarization

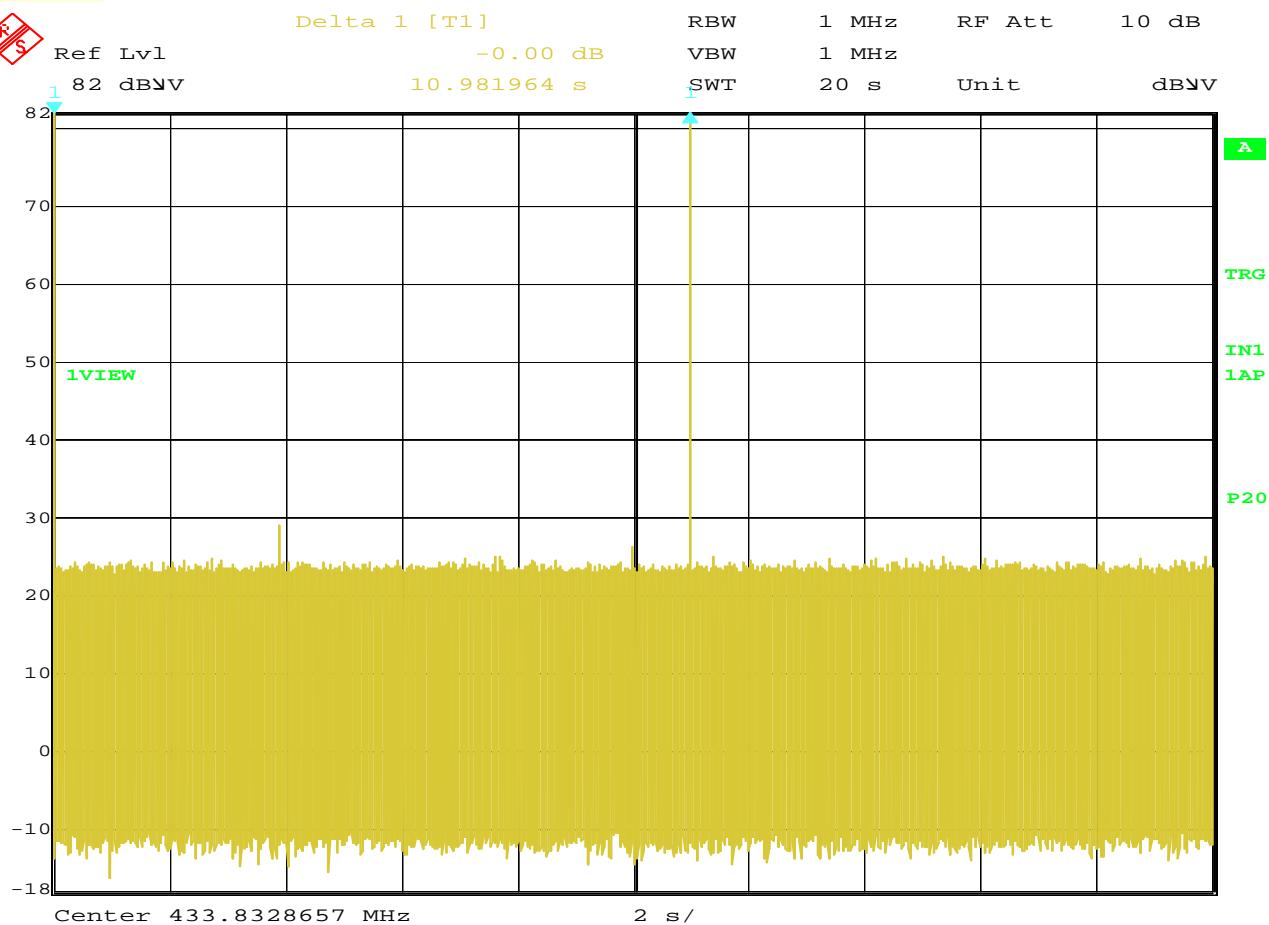
Figure 4



Test Setup for Radiated Emissions, 30MHz to 1GHz – Horizontal Polarization



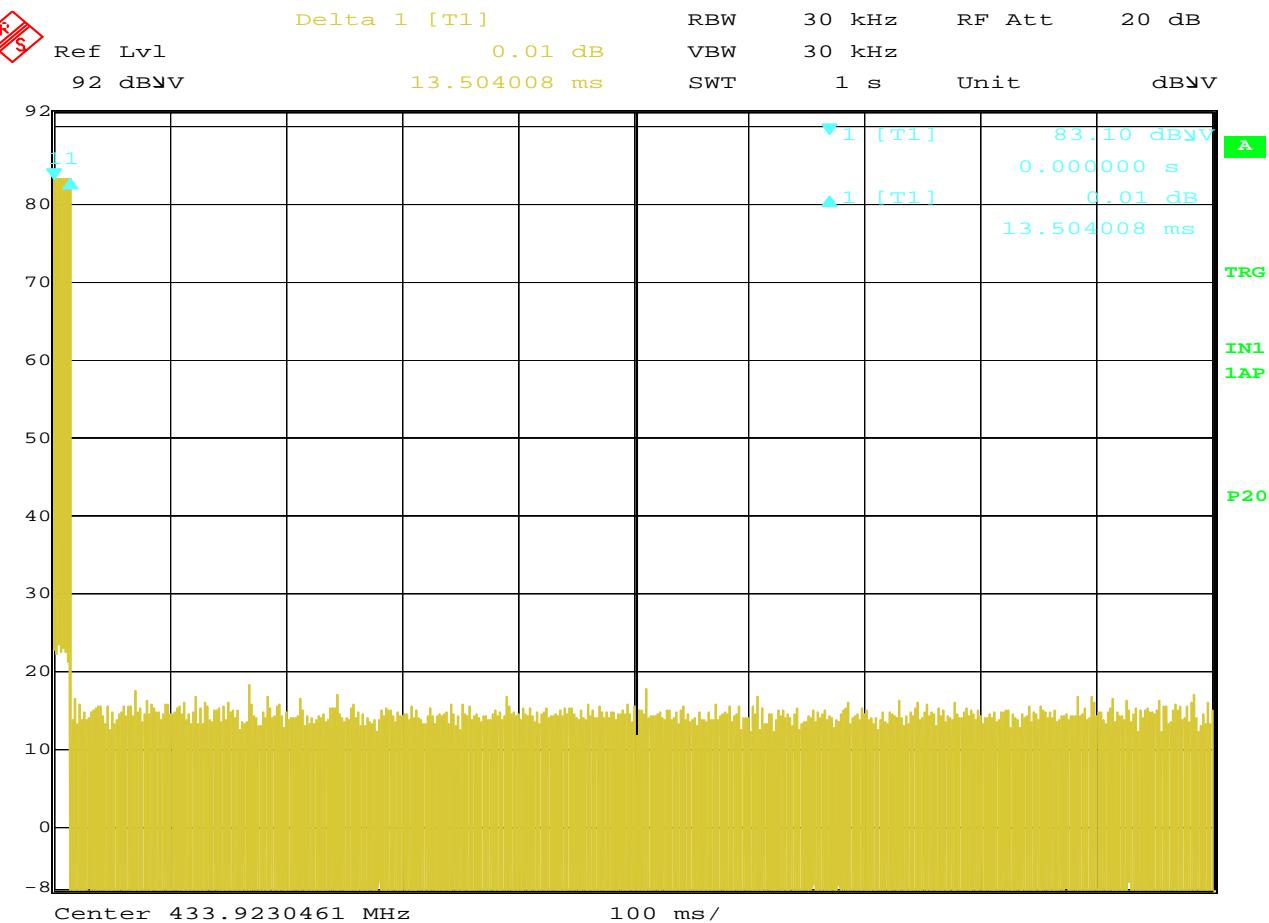
Test Setup for Radiated Emissions, 30MHz to 1GHz – Vertical Polarization



Date: 2.DEC.2011 13:49:02

### 15.231(e) Quiet Time Between Transmissions

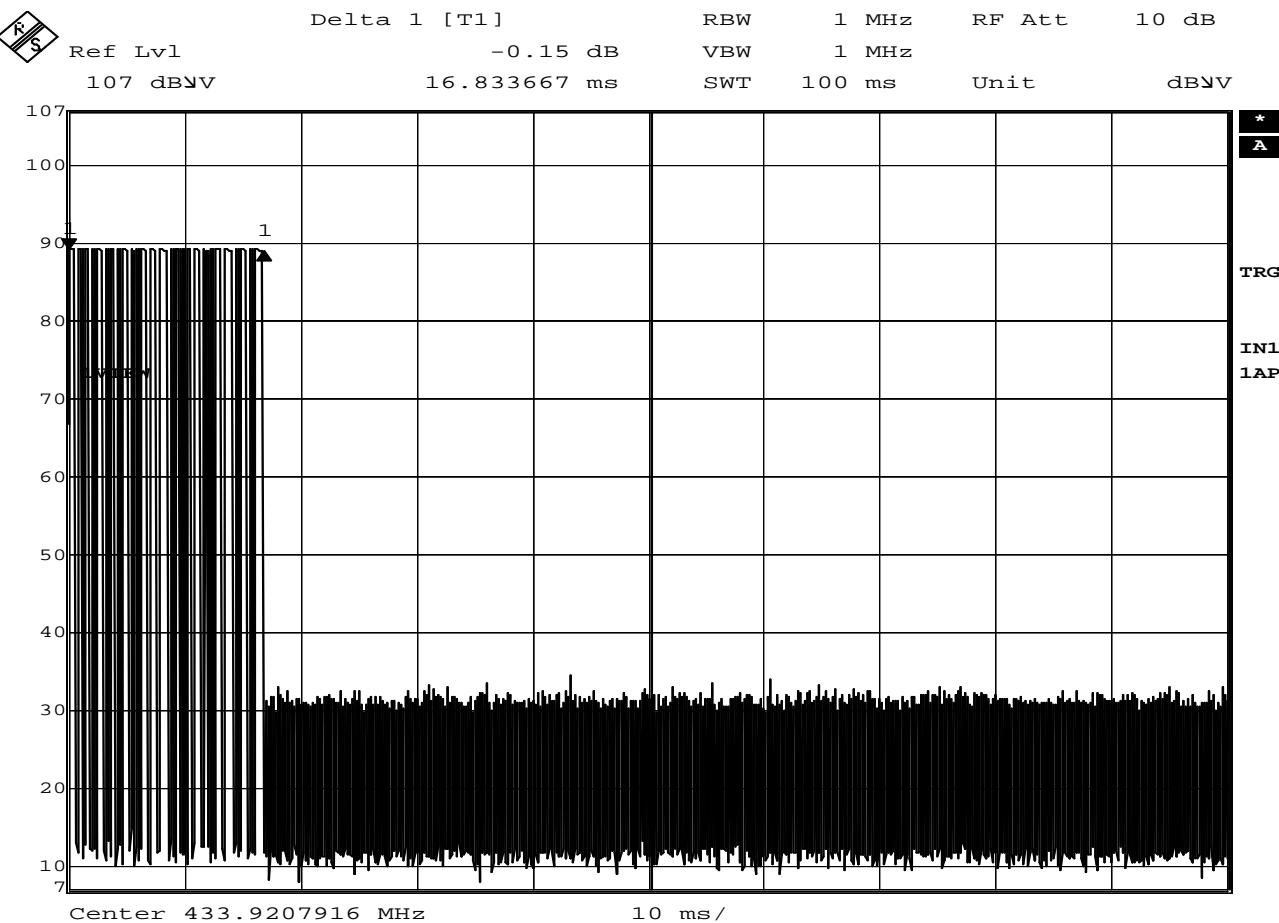
MANUFACTURER	: Verifi LLC
MODEL NUMBER	: RS00995
SERIAL NUMBER	: A0619000
TEST MODE	: Tx @ 433.9MHz
NOTES	:
TEST DATE	: December 2, 2011
TEST PARAMETERS	: Display shows that the quiet time between transmissions is 10.98 seconds
EQUIPMENT USED	: RBB0, PHA0



Date: 2.DEC.2011 14:51:29

### 15.231(e) Transmission Duration

MANUFACTURER	:	Verifi LLC
MODEL NUMBER	:	RS00995
SERIAL NUMBER	:	A0619000
TEST MODE	:	Tx @ 433.9MHz
NOTES	:	
TEST DATE	:	December 2, 2011
TEST PARAMETERS	:	Display shows that the transmission duration is approximately 13.5msec
EQUIPMENT USED	:	RBB0, PHA0



Date: 15.FEB.2011 10:05:32

#### Duty Cycle Correction Factor

MANUFACTURER : Verifi LLC  
 MODEL NUMBER : RS00995  
 SERIAL NUMBER : A0619000  
 TEST MODE : Transmit at 433.9MHz  
 NOTES : Duty Cycle =  $20 \times \log(\text{on time}/100\text{msec}) = 20 \times \log(16.83\text{msec}/100\text{msec})$   
 : Duty Cycle = -15.48dB  
 EQUIPMENT USED : RBA0, PLH0

ELITE ELECTRONIC ENGINEERING Inc.  
Downers Grove, Ill. 60515

WKA1 10/20/10

120

UNIV RCU EMI RUN 4

SPEC / TEST : FCC 15.231 PRELIM RAD EMISS  
MANUFACTURER : RS SOLUTIONS  
MODEL No. : 433.9MHz TRANSMITTER  
SERIAL No. :  
MODE : Tx @ 433.9MHz  
SCANS/BAND : 2  
NOTES :  
TEST DATE : 15 Feb 2011 14:55:31 M. LONGINOTTI  
ANT. POLARIZ. : VERTICAL

90

80

70

60

50

40

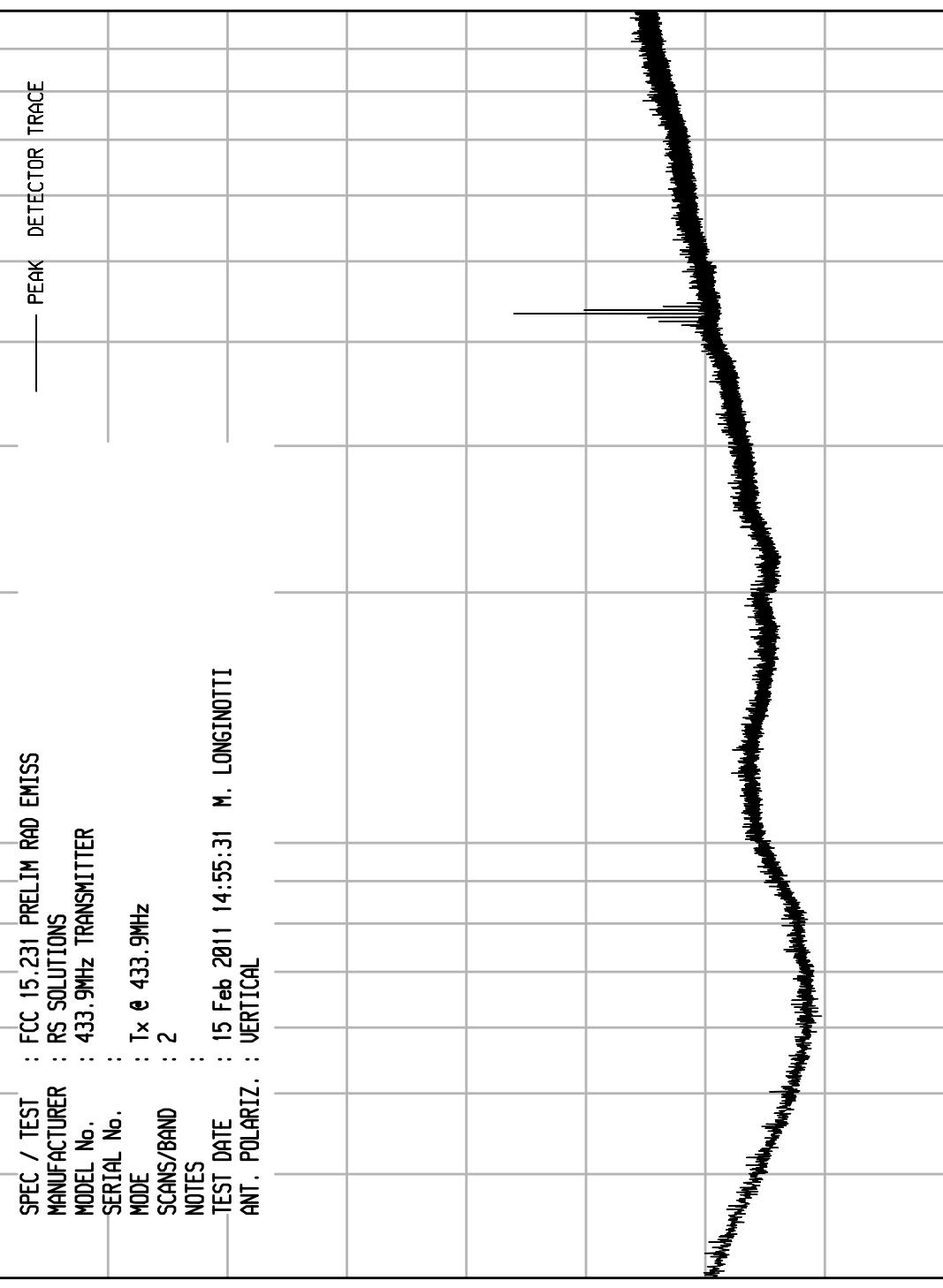
30

20

10

0

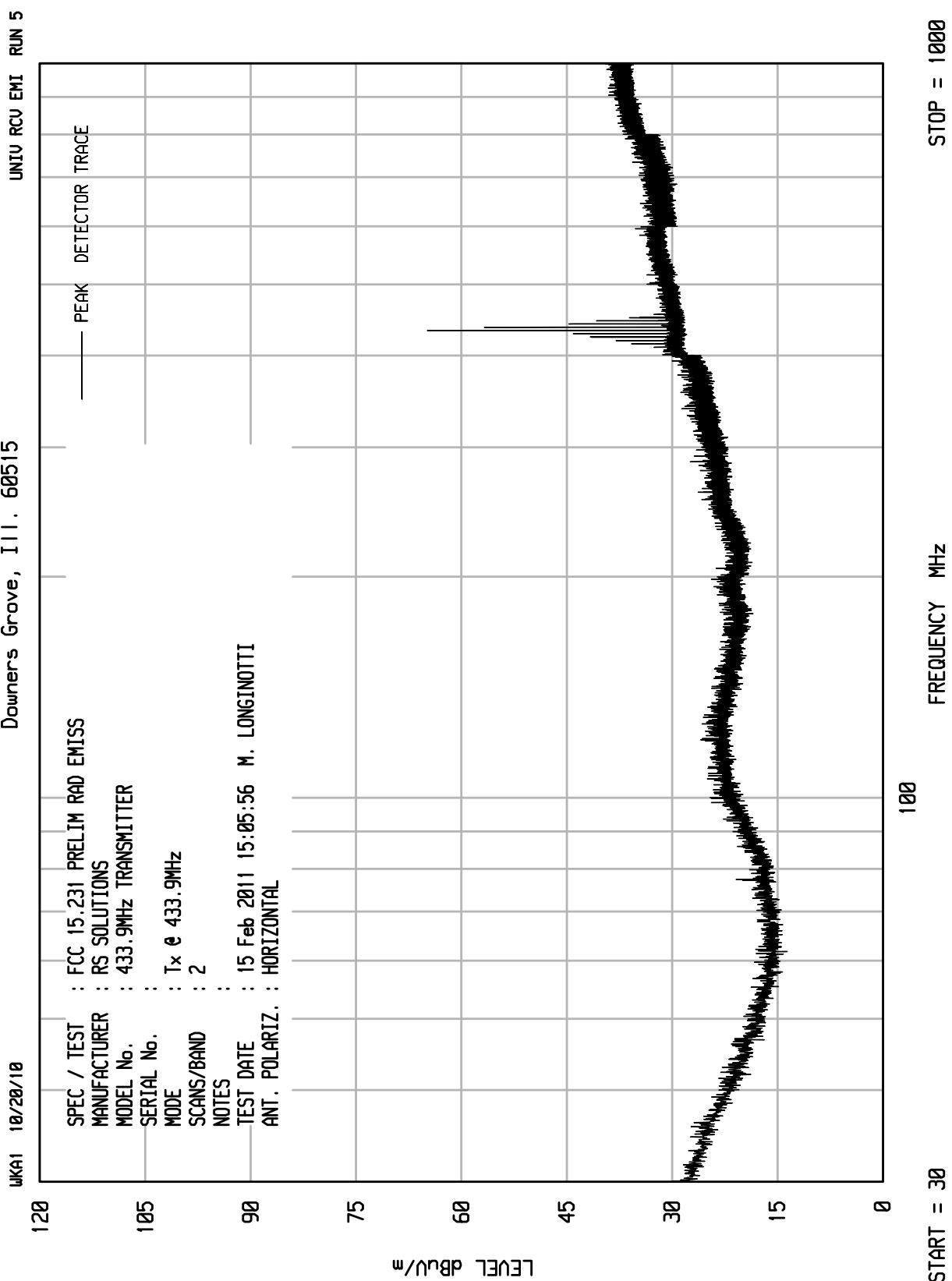
LEVEL dBu/ $\mu$



START = 30

100 FREQUENCY MHz

STOP = 1000



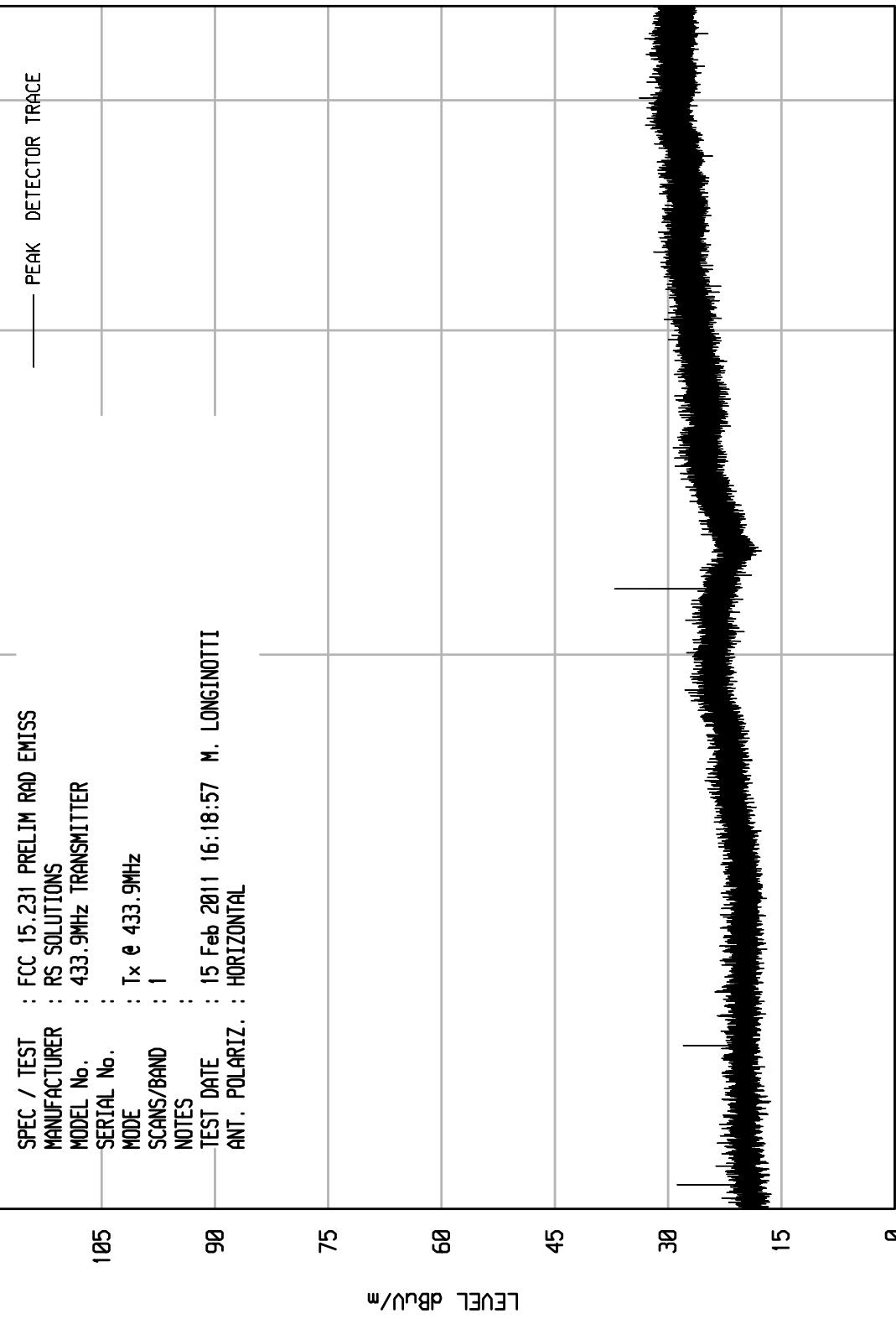
ELITE ELECTRONIC ENGINEERING Inc.  
Downers Grove, Ill. 60515

WKA1 10/20/10

120

UNIV RCU EMI RUN 7

	SPEC / TEST	: FCC 15.231 PRELIM RAD EMISS
105	MANUFACTURER	: RS SOLUTIONS
	MODEL No.	: 433.9MHz TRANSMITTER
	SERIAL No.	
	MODE	: Tx @ 433.9MHz
	SCANS/BAND	: 1
90	NOTES	
	TEST DATE	: 15 Feb 2011 16:18:57
	ANT. POLARIZ.	: HORIZONTAL



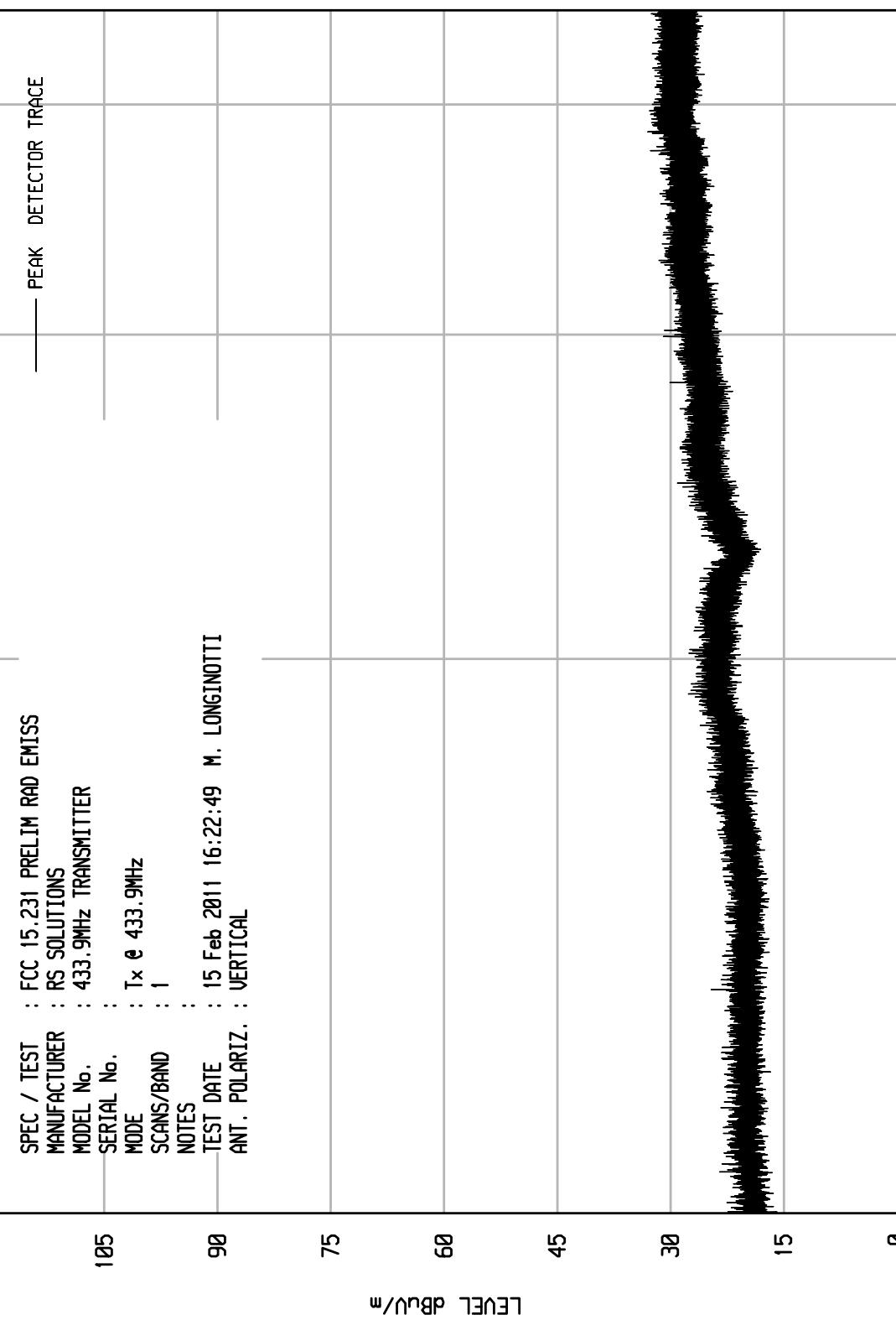
ELITE ELECTRONIC ENGINEERING Inc.  
Downers Grove, Ill. 60515

WKA1 10/20/10

120

UNIV RCU EMI RUN 8

SPEC / TEST : FCC 15.231 PRELIM RAD EMISS  
MANUFACTURER : RS SOLUTIONS  
MODEL No. : 433.9MHz TRANSMITTER  
SERIAL No. :  
MODE : Tx @ 433.9MHz  
SCANS/BAND : 1  
NOTES :  
TEST DATE : 15 Feb 2011 16:22:49 M. LONGINOTTI  
ANT. POLARIZ. : VERTICAL



START = 1000

FREQUENCY MHz

STOP = 4500

Manufacturer : Verifi LLC  
 EUT : Drum Temperature Sensor  
 Model No. : RS00995  
 Serial No. : A0619000  
 Specification : FCC-15.231(e) Spurious Radiated Emissions  
 Date : February 16, 2011  
 Mode : Tx @ 433.9MHz  
 Equipment Used : RBB0, NTA2, CMA1, NWH0, APW3, SES1  
 Notes : Test Distance is 3 meters  
 Notes :

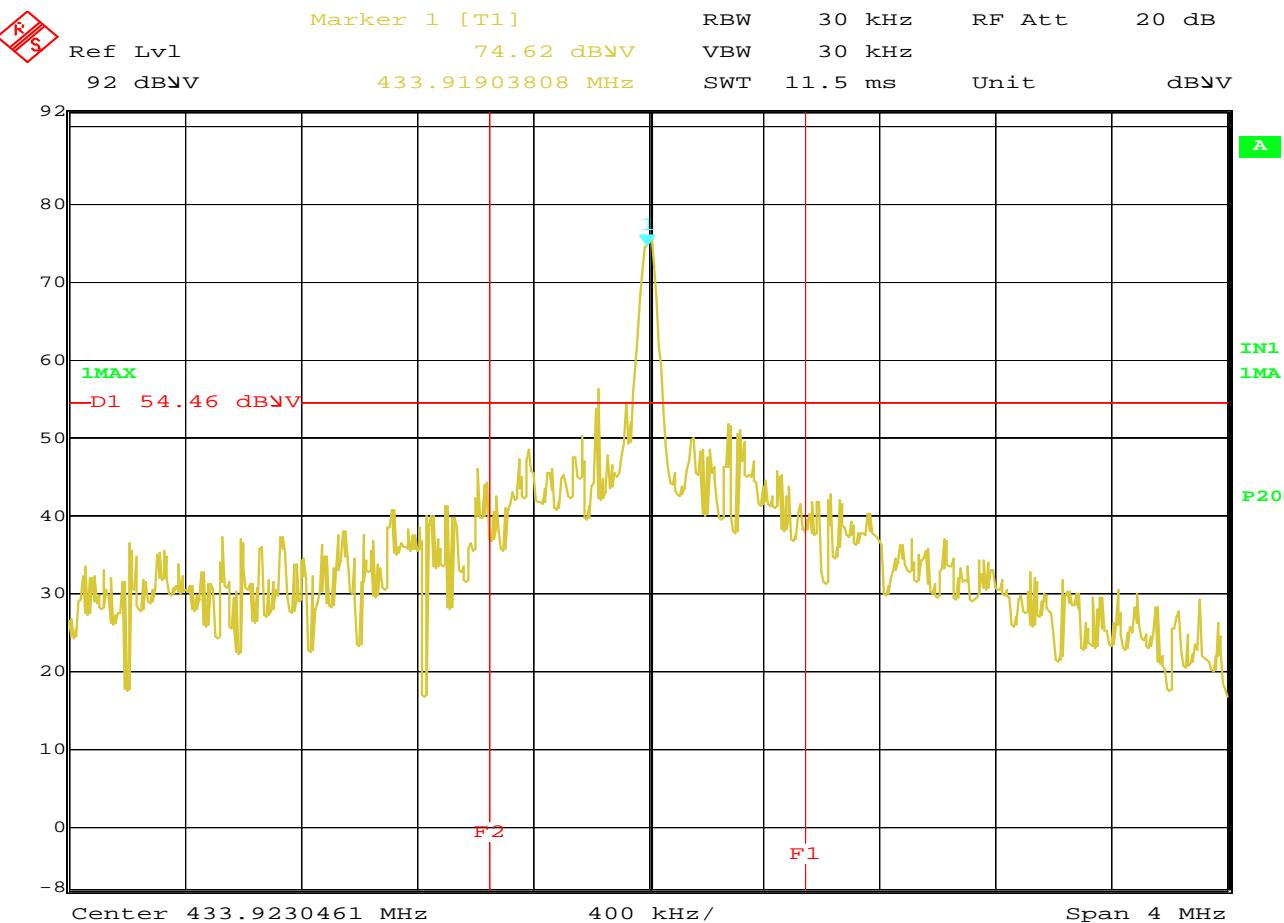
Freq (MHz)	Ant Pol	Meter Reading (dBuV)	CBL Fac (dB)	Ant Fac (dB)	Pre Amp (dB)	D.C. Corr dB	Total dBuV/m at 3 M	Total uV/m at 3M	Limit uV/m at 3M	Margin (dB)
433.920	H	66.9	1.5	17.0	0.0	-15.5	69.9	3133.3	4398.7	-2.9
433.920	V	59.9	1.5	17.0	0.0	-15.5	62.9	1399.6	4398.7	-9.9
867.840	H	33.3	2.0	21.4	0.0	-15.5	41.2	115.3	439.9	-11.6
867.840	V	31.4	2.0	21.4	0.0	-15.5	39.3	92.7	439.9	-13.5
1301.760	H	55.9	2.4	24.9	-41.3	-15.5	26.4	20.9	500.0	-27.6
1301.760	V	54.6	2.4	24.9	-41.3	-15.5	25.1	18.0	500.0	-28.9
1735.680	H	59.4	2.8	26.4	-40.8	-15.5	32.3	41.2	500.0	-21.7
1735.680	V	56.5	2.8	26.4	-40.8	-15.5	29.4	29.5	500.0	-24.6
2169.600	H	66.3	3.2	27.6	-40.2	-15.5	41.4	117.5	500.0	-12.6
2169.600	V	59.9	3.2	27.6	-40.2	-15.5	35.0	56.3	500.0	-19.0
2603.520	H	50.9	3.6	29.7	-40.3	-15.5	28.3	26.1	500.0	-25.7
2603.520	V	50.6	3.6	29.7	-40.3	-15.5	28.0	25.2	500.0	-26.0
3037.440	H	54.7	3.9	30.8	-40.4	-15.5	33.6	47.6	500.0	-20.4
3037.440	V	56.8	3.9	30.8	-40.4	-15.5	35.7	60.6	500.0	-18.3
3471.360	H	53.5	4.2	31.9	-40.2	-15.5	33.9	49.3	500.0	-20.1
3471.360	V	51.9	4.2	31.9	-40.2	-15.5	32.3	41.0	500.0	-21.7
3905.280	H	55.7	4.5	33.1	-39.1	-15.5	38.7	85.9	500.0	-15.3
3905.280	V	50.4	4.5	33.1	-39.1	-15.5	33.4	46.6	500.0	-20.6
4339.200	H	53.2	4.7	32.9	-39.6	-15.5	35.7	60.6	500.0	-18.3
4339.200	V	48.1	4.7	32.9	-39.6	-15.5	30.6	33.7	500.0	-23.4

D.C. Corr = Duty Cycle Correction Factor

H – Horizontal

V – Vertical

Total (dBuV/m) = Meter Reading (dBuV) + Cable Factor (dB) + Antenna Factor (dB) + Pre Amp (dB) + D.C. Corr. (dB)



Date: 2.DEC.2011 14:05:46

#### FCC 15.231(c) 20dB Band Width

**MANUFACTURER** : Verifi LLC  
**MODEL NUMBER** : RS00995  
**SERIAL NUMBER** : A0619000  
**TEST MODE** : Transmit at 433.9MHz  
**NOTES** : Display Line (D1) represents the 20dB down level from the carrier.  
 : Display Lines (F1) and (F2) represent the bandwidth of 0.25% of the center frequency.  
**EQUIPMENT USED** : RBB0, PLH0