




Measurement of RF Emissions from an LRS455-EU-C-MS Transceiver

For FreeWave Technologies, Inc.
1800 S. Flatiron Ct.
Boulder, CO 80301

P.O. Number 35038
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Test Personnel Daniel Crowder
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REVISION HISTORY

Revision	Date	Description
—	27 July 2011	Initial release

Measurement of RF Emissions from a Model No. LRS455-EU-C-MS Transceiver

1. INTRODUCTION

1.1. Scope of Tests

This report presents the results of the RF emissions measurements performed on a Transceiver, Model No. LRS455-EU-C-MS, serial number 455-7378 (hereinafter referred to as the Equipment Under Test (EUT)). The EUT is designed to transmit and receive in the frequency range 435MHz to 470MHz. The receiver contained one local oscillator at 45.0MHz below the tuned frequency. The EUT was manufactured and submitted for testing by FreeWave Technologies, Inc. located in Boulder, CO.

1.2. Purpose

The test series was performed to determine if the EUT meets FCC and Industry Canada (IC) technical requirements for receivers and transmitter. The EUT shall comply with the technical requirements of FCC Part 15 and 90; and IC RSS-119. The testing includes the conducted and radiated RF emission requirements for receivers, and the RF power output, emissions mask, spurious emissions at antenna terminal, field strength of spurious emissions, transient frequency behavior and frequency stability requirements for the transmitters. Testing was performed in accordance with ANSI C63.4-2003 and TIA-603-C-2004.

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 22.4°C and the relative humidity was 23%.

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 2010
- 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"
- Industry Canada Radio Standards Specification, RSS-Gen, "General Requirements and Information for the Certification of Radiocommunication Equipment", Issue 2, June 2007
- RSS-119 - Land Mobile and Fixed Radio Transmitters and Receivers Operating in the Frequency Range 27.41- 960 MHz Issue 11 June 2011
- TIA-603-C-2004, "Land Mobile FM or PM – Communications Equipment – Measurement and Performance Standards"

3. EUT SETUP AND OPERATION

3.1. General Description

The EUT is a FreeWave Technologies, Inc., Transceiver, Model No. LRS455-EU-C-MS. A block diagram of the EUT setup is shown as Figure 1.

3.1.1. Power Input

The EUT is typically powered via 12VDC from a vehicle. For test purposes, a Sceptre AC Adaptor, P/N: PS-1230APL05, M/N: SA-036121A-3 was used to provide 12VDC to the EUT via a 1.85 meter long 2 wire power cable. The Sceptre AC Adaptor was powered with 115V, 60Hz via a 1.7 meter long 3 wire power cable.

3.1.2. Peripheral Equipment

The EUT was submitted for testing with the following peripheral equipment:

- Sony Viao Laptop Computer M/N: PCG-8N2L, P/N: 28398098, S/N: 3000596

3.1.3. Signal Input/Output Leads

The EUT was submitted for testing with a 10 wire, 85 cm long cable. Eight (8) of those wires went to the serial port of the Sony laptop computer. The other two (2) wires went to the output of the Sceptre AC Adaptor and were used to provide 12VDC power to the EUT.

3.1.4. Grounding

The EUT was ungrounded during testing.

3.2. Operational Mode

For all tests, the EUT was set to transmit separately at 450MHz, 460.0MHz, and 470.0MHz or receive separately at 435MHz, 450MHz, 460.0MHz, and 470.0MHz.

3.3. EUT Modifications

No modifications to the EUT 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 C63.4-2003 for site attenuation.

4.2. Test Instrumentation

The test instrumentation and auxiliary equipment used during the tests are listed in Table 9-1.

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. Receiver

5.1.1. Power line Conducted Emission Measurements

5.1.1.1. Requirements

Since the EUT does not connect to the AC mains no conducted emission measurements on the powerlines are required.

5.1.2. Antenna Conducted Emission Measurements

5.1.2.1. Requirements

This test is performed to determine the EUT configuration during the radiated RF emissions tests. The power at the antenna terminal over the frequency range 30MHz to 2000MHz may be measured. If the emissions at the antenna terminal exceed 2 nanowatts, it is necessary to perform the radiated RF emissions tests with the antenna port terminated with an equivalent antenna. If the EUT does meet the 2 nanowatt requirement, the radiated emissions tests can be performed with the antenna port terminated with a shielded load.

5.1.2.2. Procedures

The EUT was set to receive.

- (a) The antenna port of the EUT was connected to a spectrum analyzer.
- (b) The resolution bandwidth of the spectrum analyzer was set to 100 kHz.
- (c) A sweep was made from 30 MHz to 1 GHz.
- (d) The resolution bandwidth of the spectrum analyzer was set to 1 MHz.
- (e) A sweep was made from 1 GHz to 2 GHz.
- (f) Steps (a) through (e) were repeated with the EUT set to receive at all the frequencies in paragraph 3.2.

5.1.2.3. Results

The results of the antenna conducted measurements are presented on pages 21 through 28. The reference line shown on the data pages represents the 2 nanowatt requirement. As can be seen from the data pages, all emissions from the EUT were below the 2 nanowatt requirement. Since the emissions were below the 2 nanowatt limit, the antenna port was terminated with a shielded load for radiated emissions measurements.

5.1.3. Radiated Measurements

5.1.3.1. Requirements

All emanations from a receiver, per 15.109, shall be below the levels shown on the following table:

RADIATION LIMITS FOR RECEIVERS

Frequency (MHz)	Distance between EUT And Antenna in Meters	Field Strength (uV/m)
30-88	3	100



88-216	3	150
216-960	3	200
Above 960	3	500

Note: The tighter limit shall apply at the edge between the two frequency bands.

5.1.3.2. 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 C63.4-2003 for site attenuation.

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.

Since a quasi-peak detector requires long integration times, it is not practical to automatically sweep through the quasi-peak levels. Therefore, radiated emissions from the EUT were first scanned using a peak detector and automatically plotted. The frequencies where significant emission levels were noted were then remeasured using the quasi-peak detector.

The broadband measuring antenna was positioned at a 3 meter distance from the EUT. The frequency range from 30 MHz to 2000 MHz was investigated using a peak detector function with a bilog antenna. The maximum levels were plotted.

Final radiated emissions were performed on all significant broadband and narrowband emissions found in the preliminary sweeps using the following methods:

- 1) For all frequencies 1GHz and below, measurements were made using a broadband bi-log antenna.
- 2) For all frequencies above 1GHz, measurements were made using a waveguide antenna.
- 3) To ensure that the maximum, or worst case, emission levels were measured, the following steps were taken:
 - (a) The EUT was rotated so that all of its sides were exposed to the receiving antenna.
 - (b) Since the measuring antenna is linearly polarized, both horizontal and vertical field components were measured.
 - (c) The measuring antenna was raised and lowered from 1 to 4 meters for each antenna polarization to maximize the readings

5.1.3.3. Results

The preliminary plots are presented on pages 29 through 36. These plots are presented for a reference only, and are not used to determine compliance. The final radiated levels are presented on pages 37 through 40. As can be seen from the data, all emissions measured from the EUT were within the specification limits. Photographs of the test configuration which yielded the highest or worst case radiated emission levels are shown on Figures 2 and 3.

5.2. Transmitter

5.2.1. RF Power Output

5.2.1.1. Requirements

In accordance with paragraph 90.205(r), the output power shall not exceed by more than 20 percent the manufacturer's rated output power for the particular transmitter specifically listed on the authorization.

5.2.1.2. Procedures

With the EUT transmitting, the antenna port of the EUT was connected to a spectrum analyzer through a 40 dB attenuator. The resolution bandwidth of the spectrum analyzer was set wider than the bandwidth of the EUT. The output power of the item was then measured. This procedure was repeated separately with the EUT transmitting at the frequencies listed in paragraph 3.2.

5.2.1.3. Results

The output power plots are shown on pages 41 through 43. The output power measurements are shown in a tabular form on page 43. As can be seen from the data, the power output at each frequency is below the maximum allowable power of 20% above the manufacturer's rated output power.

5.2.2. Emission Mask

5.2.2.1. Requirements

Per 90.210 or 5.8.4 or RSS-119, for equipment with a 12.5 kHz channel bandwidth, any emissions must be attenuated below the power (P) of the highest emission contained within the authorized bandwidth as follows:

- (1) On any frequency from the center of the authorized bandwidth f_0 to 5.625 kHz removed from f_0 : Zero dB.
- (2) On any frequency removed from the center of the authorized bandwidth by a displacement frequency (f_d in kHz) of more than 5.625 kHz but no more than 12.5 kHz: At least $7.27(f_d - 2.88)$ kHz) dB.
- (3) On any frequency removed from the center of the authorized bandwidth by more than 12.5 kHz: At least $50 + 10 \log (P)$ or 70 dB, whichever is the lesser attenuation.

5.2.2.2. Procedures

The EUT was set to transmit.

- (a) The antenna port of the EUT was connected to a spectrum analyzer through a 40 dB attenuator.
- (b) The following spectrum analyzer settings were employed:
 - trace 1 = on
 - center frequency = transmit frequency of the EUT
 - resolution bandwidth = 1 MHz
 - video bandwidth > resolution bandwidth
 - frequency span = 50 kHz
 - sweep = Auto
 - detector function = peak
 - trace = max hold
- (c) Several sweeps were made with the settings listed above.
- (d) Trace 1 was changed from max hold to view
- (e) The following spectrum analyzer settings were employed:
 - trace 2 = on
 - resolution bandwidth = 100 Hz
 - video bandwidth = 1000 Hz
 - sweep = Auto
 - detector function = peak
 - trace = max hold
- (f) Several sweeps were made with the settings listed above.
- (g) Steps (a) through (f) were repeated with the EUT set to transmit all the frequencies in paragraph 3.2.

5.2.2.3. Results

The spectrum analyzer plots of the emissions of the EUT are shown on pages 45 through 50. The limits,

shown on the plots, are referenced to the power measured with a 1MHz resolution bandwidth. As can be seen from the data, the EUT did not produce spurious emissions in excess of the limit. The 99% bandwidth was measured to be 9.68kHz.

5.2.3. Spurious Emissions at the Antenna Terminals

5.2.3.1. Requirements

Per 90.210 or 5.8.4 or RSS-119, on any frequency removed from the center of the authorized bandwidth by a displacement frequency (f_d in kHz) of more than 12.5 kHz the emissions must be attenuated by at least $50 + 10\log(P)$ dB or 70dB whichever is the lesser attenuation.

5.2.3.2. Procedures

The EUT was set to transmit.

- (a) The antenna port of the EUT was connected to a spectrum analyzer through a 40dB attenuator.
- (b) The resolution bandwidth of the spectrum analyzer was set to 100 kHz.
- (c) A sweep was made from 30 MHz to 1 GHz.
- (d) The resolution bandwidth of the spectrum analyzer was set to 1 MHz.
- (e) A sweep was made from 1 GHz to 5 GHz.
- (f) Steps (a) through (e) were repeated with the EUT set to transmit all the frequencies in paragraph 3.2.

5.2.3.3. Results

The plots of the antenna conducted output measurements are presented on pages 51 through 56. The limits, shown on the plots, are referenced to the RF power output measurements made on the EUT. As can be seen from the data, the EUT did not produce spurious emissions in excess of the limit.

5.2.4. Field Strength of Spurious Emissions

5.2.4.1. Requirements

Per 90.210 or 5.8.4 or RSS-119, on any frequency removed from the center of the authorized bandwidth by a displacement frequency (f_d in kHz) of more than 12.5 kHz the emissions must be attenuated by at least $50 + 10\log(P)$ dB or 70dB whichever is the lesser attenuation.

5.2.4.2. Procedures

All tests were performed in a 32 ft. x 20 ft. x 18 ft. 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 2003 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.

1. Preliminary radiated emissions measurements were first performed using a peak detector and automatically plotted. The broadband measuring antenna was positioned at a 3 meter distance from the EUT. The entire frequency range from 30 MHz to 5 GHz was investigated using a peak detector function. All preliminary tests were performed separately with the EUT transmitting at the frequencies listed in paragraph 3.2.
2. All significant broadband and narrowband signals found in the preliminary sweeps were then measured using a peak detector at a test distance of 3 meters. The measurements were made with a tuned dipole or double ridged waveguide antenna over the frequency range of 30 MHz to 5 GHz.
3. To ensure that maximum emission levels were measured, the following steps were

taken:

- a. The EUT was rotated so that all of its sides were exposed to the receiving antenna.
 - b. Since the measuring antennas are linearly polarized, both horizontal and vertical field components were measured.
 - c. The measuring antenna was raised and lowered from 1 to 4 meters for each antenna polarization to maximize the readings.
4. The equivalent power was determined from the field intensity levels measured at 3 meters using the substitution method. To determine the emission power a tuned dipole or double ridged waveguide antenna was set in place of the EUT and connected to a calibrated signal generator. The output of the signal generator was adjusted to match the received level at the spectrum analyzer. The signal level was recorded. The reading was corrected to compensate for cable loss, as required, and when the double ridged waveguide antenna was used, increased by the difference in gain between the dipole and the waveguide antenna.

5.2.4.3. Results

The preliminary radiated emissions plots are presented on pages 57 through 62. This data is only presented for a reference, and is not used as official data. The final radiated levels are presented on pages 63 through 65. The radiated emissions were measured through the 10th harmonic. As can be seen from the data, all emissions measured from the EUT were within the specification limits. Photographs of the test configuration are shown on Figures 2 and 3.

5.2.5. Frequency Stability

5.2.5.1. Requirements

In accordance with paragraph 90.213(a) and 5.3 or RSS-119, mobile stations operating at 2 watts or less with a 12.5 kHz channel bandwidth must have a frequency stability of 1.5 ppm.

5.2.5.2. Procedures

The antenna port of the EUT was connected to a frequency counter through a 20 dB attenuator. The EUT was then placed in a humidity temperature chamber.

- (a) The EUT was set to transmit at 460MHz. The transmit frequency was measured and recorded at ambient temperature.
- (b) The temperature chamber was then set to -30°C.
- (c) Once the temperature chamber had reached -30°C, the EUT was allowed to soak for 30 minutes.
- (d) After soaking at -30°C for thirty minutes, the EUT was turned on and set to transmit and the transmit frequency was measured and recorded.
- (e) Steps (b) through (d) were repeated at -20°C.
- (f) Steps (b) through (d) were repeated at -10°C.
- (g) Steps (b) through (d) were repeated at 0°C.
- (h) Steps (b) through (d) were repeated at +10°C.
- (i) Steps (b) through (d) were repeated at +20°C.
- (j) Steps (b) through (d) were repeated at +30°C.
- (k) Steps (b) through (d) were repeated at +40°C.
- (l) Steps (b) through (d) were repeated at +50°C.
- (m) The EUT was then removed from the temperature chamber and allowed to adjust to nominal room temperature.
- (n) The supply voltage was checked and adjusted to the nominal level (12.0 VDC). The EUT was turned on and set to transmit. The transmit frequency was measured and recorded at ambient temperature.

- (o) The supply voltage was then varied to 85% of its nominal level (10.2 VDC). The EUT was turned on and set to transmit. The transmit frequency was measured and recorded at ambient temperature.
- (p) The supply voltage was then varied to 115% of its nominal level (13.8 VDC). The EUT was turned on and set to transmit. The transmit frequency was measured and recorded at ambient temperature.
- (q) Steps (o) through (p) were repeated with the EUT set to transmit at 470 MHz.

5.2.5.3. Results

The frequency stability measurements are presented on pages 66 and 67. As can be seen from the data, all frequency deviations were within the 2.5 ppm limit. A photograph of the test setup is shown on Figure 4.

5.2.6. Transient Frequency Behavior

5.2.6.1. Requirements

Per 90.214 and 5.9 or RSS-119, transmitters with 12.5 kHz channel spacing must maintain transient frequencies within the maximum frequency difference limits during the time intervals indicated:

Time intervals	Maximum Frequency Difference	Time (ms)
t_1	+/-12.5 kHz	10.0
t_2	+/-6.25 kHz	25.0
t_3	+/-12.5 kHz	10.0

Where:

t_1 is the time period immediately following t_{on}

t_2 is the time period immediately following t_1

t_3 is the time period from the instant when the transmitter is turned off until t_{off}

5.2.6.2. Procedures

Two test signals were connected to the test discriminator via a combining network. The transmitter was connected to a 50 ohm power attenuator. The output of the power attenuator was connected to the test discriminator via one input of the combining network. A test signal was connected to the second input of the combining network.

- (a) The test signal was adjusted to the nominal frequency of the transmitter.
- (b) The test signal was modulated by a 1 kHz signal with a deviation equal to the value of the relevant channel separation (12.5 kHz).
- (c) The test signal was adjusted to correspond to 0.5% of the power of the transmitter under test measured at the input of the test discriminator. This level was maintained throughout the measurement.
- (d) The amplitude difference (a_d) and the frequency difference (f_d) output of the test discriminator were connected to a storage oscilloscope.
- (e) The storage oscilloscope was set to display the channel corresponding to the (f_d) input up to ± 1 channel frequency difference, corresponding to the relevant channel separation, from the nominal frequency.
- (f) The storage oscilloscope was set to a rate of 10 ms/div and set so that the triggering occurs at 1 div from the left edge of the display.

- (g) The 1 kHz test signal was shown continuously. The storage oscilloscope was set to trigger on the channel corresponding to the amplitude difference (ad) input at a low input level, rising.
- (h) The transmitter was then switched on, without modulation, to produce the trigger pulse and a picture on the display. The result of the change in the ratio of power between the test signal and the transmitter output produced two separate sides, one showing the 1 kHz test signal, the other the frequency difference of the transmitter versus time.
- (i) The transmit signal suppresses the 1 kHz test signal and produces the start of the test or t_{on} . During this test time the frequency difference was measured and recorded versus time.
- (j) The transmitter was then switched off to produce the trigger pulse and a picture of the display. The result of the change in the ratio of power between the test signal and the transmitter output produced two separate sides, one showing the frequency difference of the transmitter versus time and the other showing the 1 kHz test signal.
- (k) The transmitter signal no longer suppresses the 1 kHz test signal and produces t_3

5.2.6.3. Results

The plots of the transient frequency behavior are shown on pages 68 and 69. As can be seen from the data, all transient frequencies were within the maximum frequency difference limits. A photograph of the test setup is shown on Figure 5.

6. OTHER TEST CONDITIONS

6.1. Test Personnel and Witnesses

All tests were performed by qualified personnel from Elite Electronic Engineering Incorporated.

6.2. Disposition of the EUT

The EUT and all associated equipment were returned to FreeWave Technologies, Inc. upon completion of the tests.

7. CONCLUSIONS

It was determined that the FreeWave Technologies, Inc., Model No. LRS455-EU-C-MS, Transceiver, did fully meet the conducted and radiated emission requirements of the FCC "Code of Federal Regulations" Title 47, Part 15, Subpart B, Sections 15.107 and 15.109 for receivers when tested per ANSI C63.4-2003.

It was determined that the FreeWave Technologies, Inc., Model No. LRS455-EU-C-MS, Transceiver did fully meet the RF power output, emissions mask, spurious emissions at antenna terminal, field strength of spurious emissions, frequency stability, and transient frequency behavior, requirements of the FCC "Code of Federal Regulations" Title 47, Part 90, Subpart I, when tested per TIA-603-C-2004.

It was determined that the FreeWave Technologies, Inc., Model No. LRS455-EU-C-MS, Transceiver did fully meet the RF power output, emissions mask, spurious emissions at antenna terminal, field strength of spurious emissions, frequency stability, and transient frequency behavior, requirements of the RSS-119 - Land Mobile and Fixed Radio Transmitters and Receivers Operating in the Frequency Range 27.41- 960 MHz Issue 10 April 2010.



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. 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
CDW3	COMPUTER			004		N/A	
CLT3	LAPTOP COMPUTER	SONY	PCG-GRT390ZP	3001143	---	NOTE 1	
CMA1	Controllers	EMCO	2090	9701-1213	---	N/A	
ETH2	TEMPERATURE/HUMIDITY CHAMBER	THERMOTRON	SE-600-10-10	36821	---	12/14/2010	12/14/2011
ETHA	2 CHANNEL CHART RECORDER	HONEYWELL	DR45AT-1100	0623Y670793000001	-70 to 180 C	12/14/2010	12/14/2011
GCR0	SIGNAL GENERATOR	HEWLETT PACKARD	8647A	3414U00454	0.25-1000MHZ	8/24/2010	8/24/2011
MFC0	MICROWAVE FREQ. COUNTER	HEWLETT PACKARD	5343A	2133A00591	10HZ-26GHZ	8/19/2010	8/19/2011
MSP4	8 CHANNEL DIGITAL OSCILLOSCOPE	YOKOGAWA	DL708	27VJ0035	---	3/8/2011	3/8/2012
MSTE	HIGH SPEED ISOLATION MODULE	YOKOGAWA	701850	7018FA144	---	3/8/2011	3/8/2012
NTA0	BILOG ANTENNA	CHASE EMC LTD.	BILOG CBL6112	2057	0.03-2GHZ	6/16/2011	6/16/2012
NWH0	RIDGED WAVE GUIDE	SENSOR	4105	2081	1-12.4GHZ	8/31/2010	8/31/2011
RBA1	EMI TEST RECEIVER	ROHDE & SCHWARZ	ESIB26	100146	20HZ-26.5GHZ	9/8/2010	9/8/2011
RBB0	EMI TEST RECEIVER 20HZ TO 40 GHZ.	ROHDE & SCHWARZ	ESIB40	100250	20 HZ TO 40GHZ	3/24/2011	3/24/2012
RYE0	MODULATION ANALYZER	HEWLETT PACKARD	8901B	3104A03410	0.15-1300MHZ	7/9/2010	8/9/2011
T2DS	20DB, 25W ATTENUATOR	WEINSCHTEL	46-20-34	BS0916	DC-18GHZ	8/9/2010	8/9/2011
T2S3	20DB 25W ATTENUATOR	WEINSCHTEL	46-20-34	BV3544	DC-18GHZ	1/3/2011	1/3/2012

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.

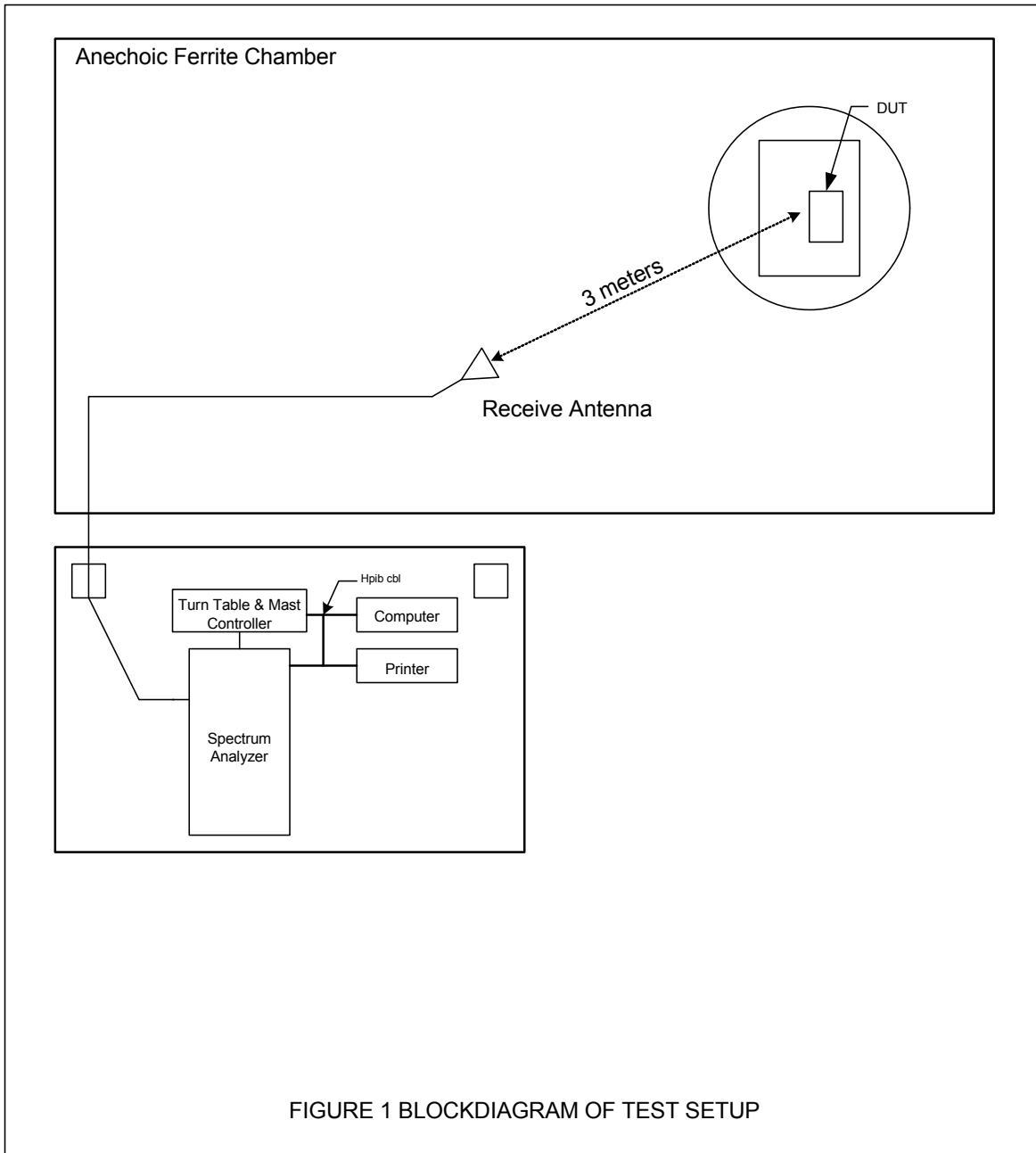
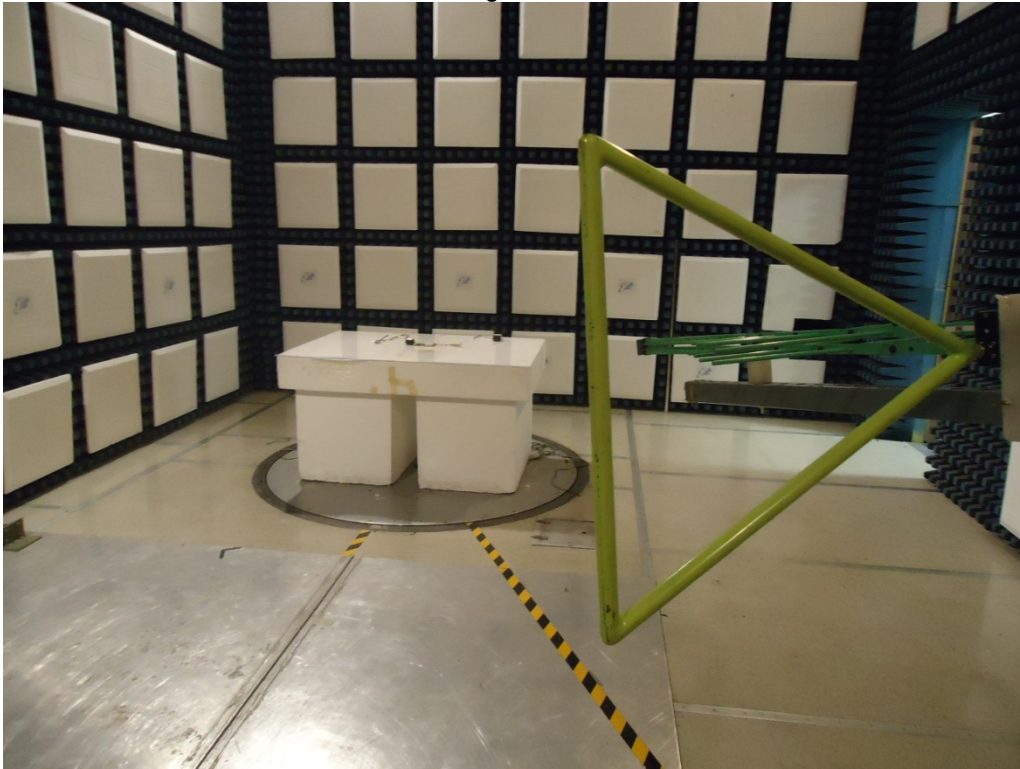
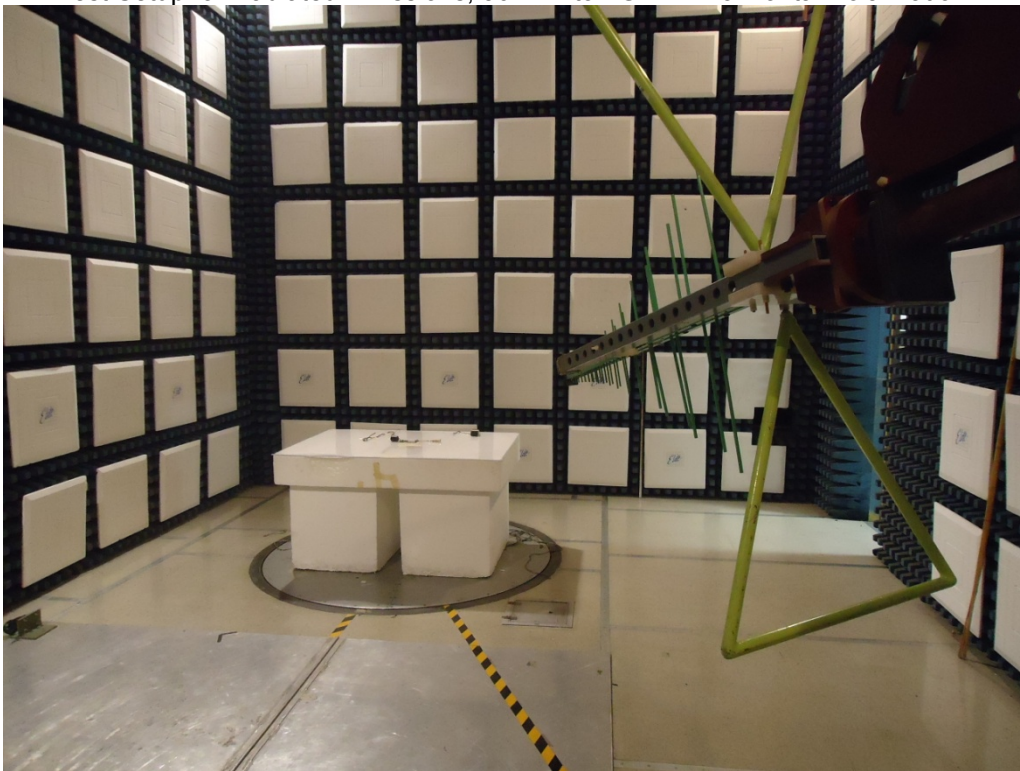


Figure 2

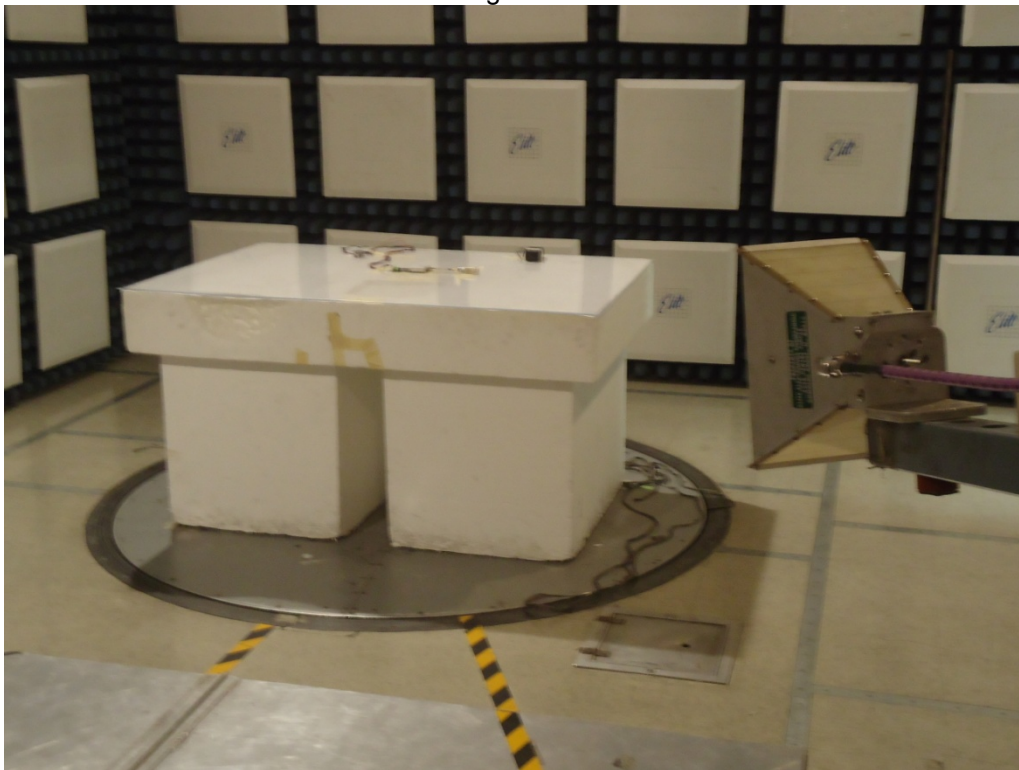


Test Setup for Radiated Emissions, 30MHz to 1GHz – Horizontal Polarization

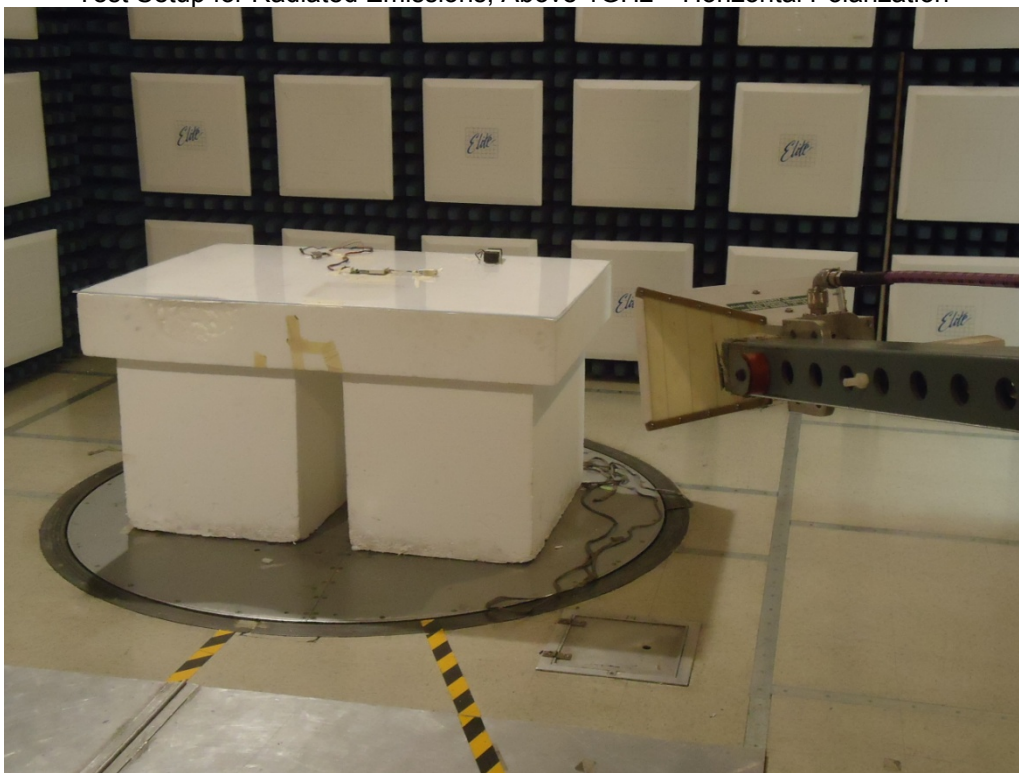


Test Setup for Radiated Emissions, 30MHz to 1GHz – Vertical Polarization

Figure 3

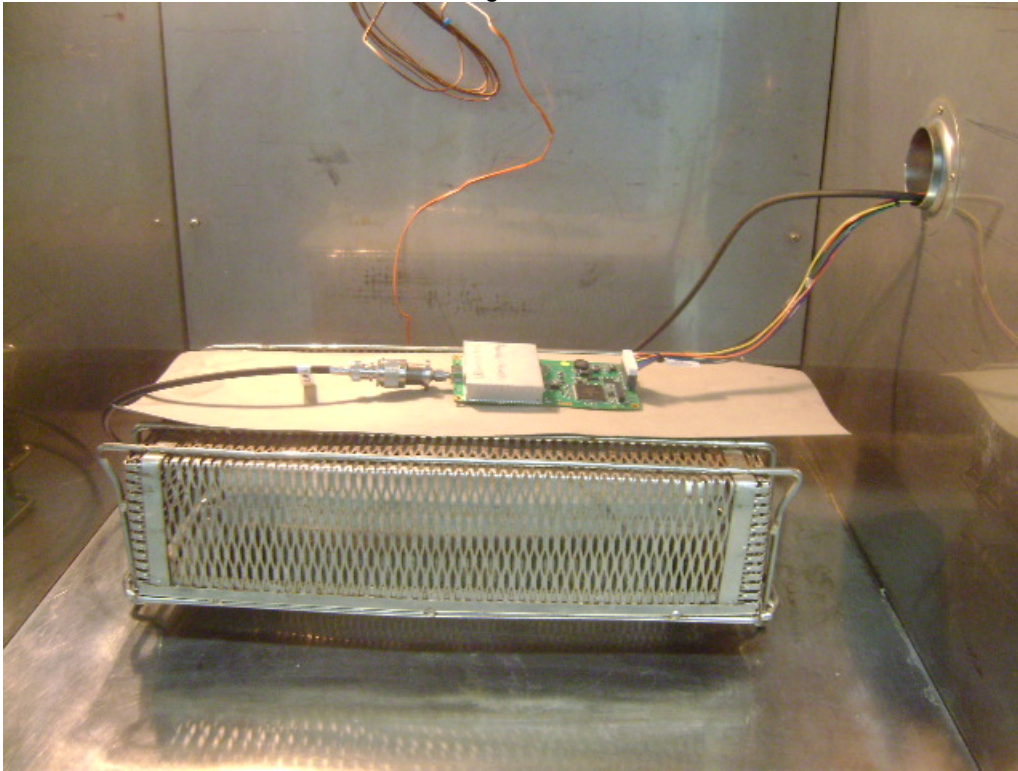


Test Setup for Radiated Emissions, Above 1GHz – Horizontal Polarization



Test Setup for Radiated Emissions, Above 1GHz – Vertical Polarization

Figure 4



Test Setup for Frequency Stability



Test Setup for Frequency Stability

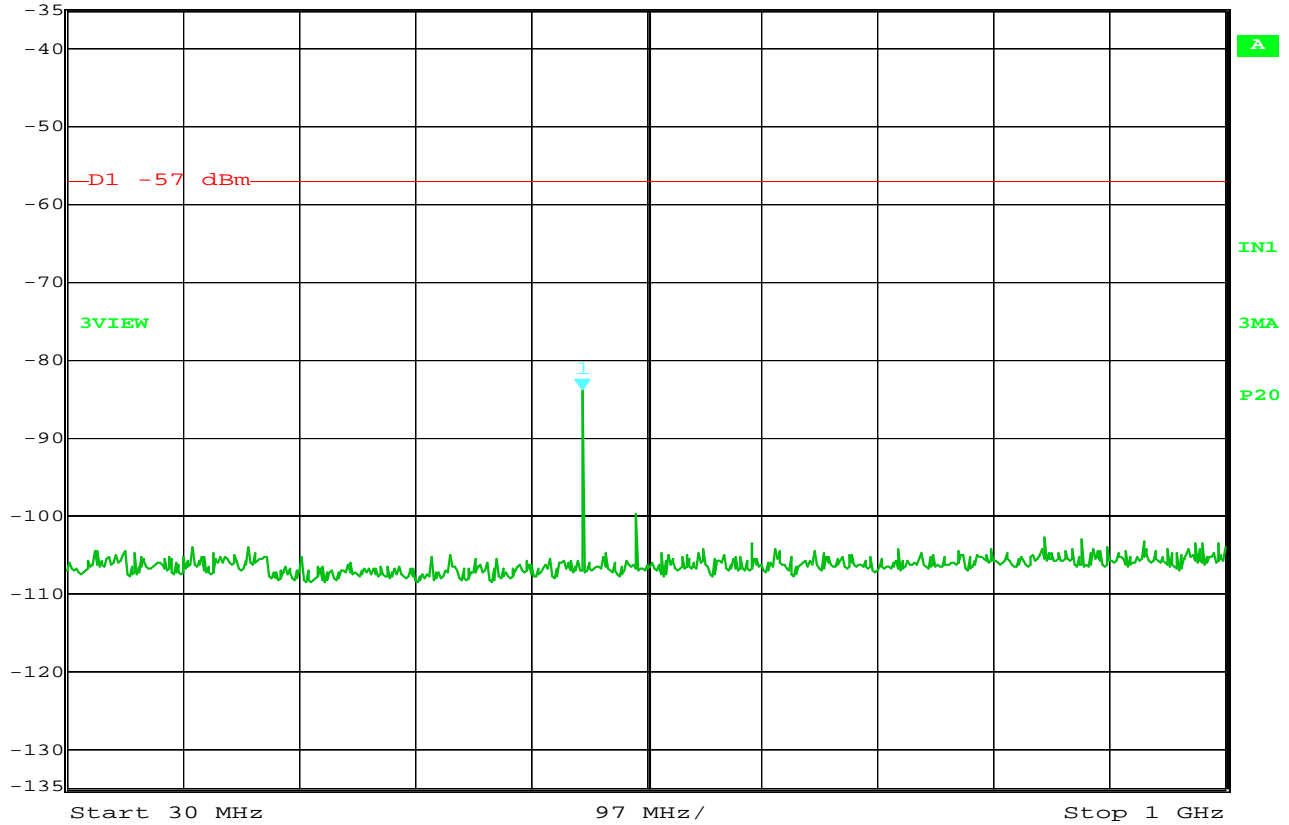
Figure 5



Test Setup for Transient Frequency Behavior



Marker 1 [T3] RBW 100 kHz RF Att 0 dB
Ref Lvl -83.82 dBm VBW 100 kHz
-35 dBm 461.54308617 MHz SWT 300 ms Unit dBm

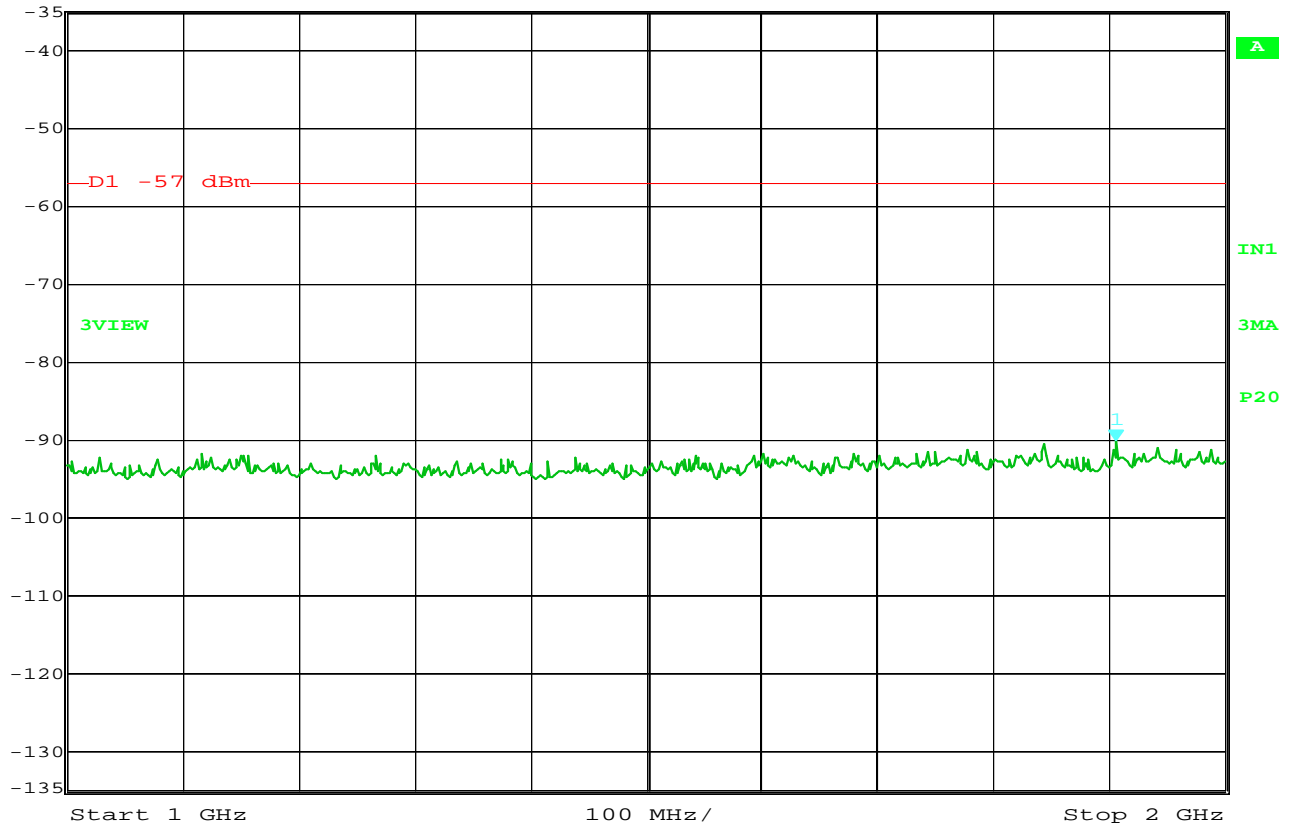


Date: 18.JUL.2011 14:25:48

MANUFACTURER :FreeWave Technologies, Inc.
MODEL NUMBER :LRS455-EU-C-MS
SERIAL NUMBER :455-7378
TEST MODE :Receive at 435MHz
TEST PARAMETERS :Antenna Conducted
NOTES :
EQUIPMENT USED :RBA1



Marker 1 [T3] RBW 1 MHz RF Att 0 dB
 Ref Lvl -90.22 dBm VBW 1 MHz
 -35 dBm 1.90581162 GHz SWT 5 ms Unit dBm

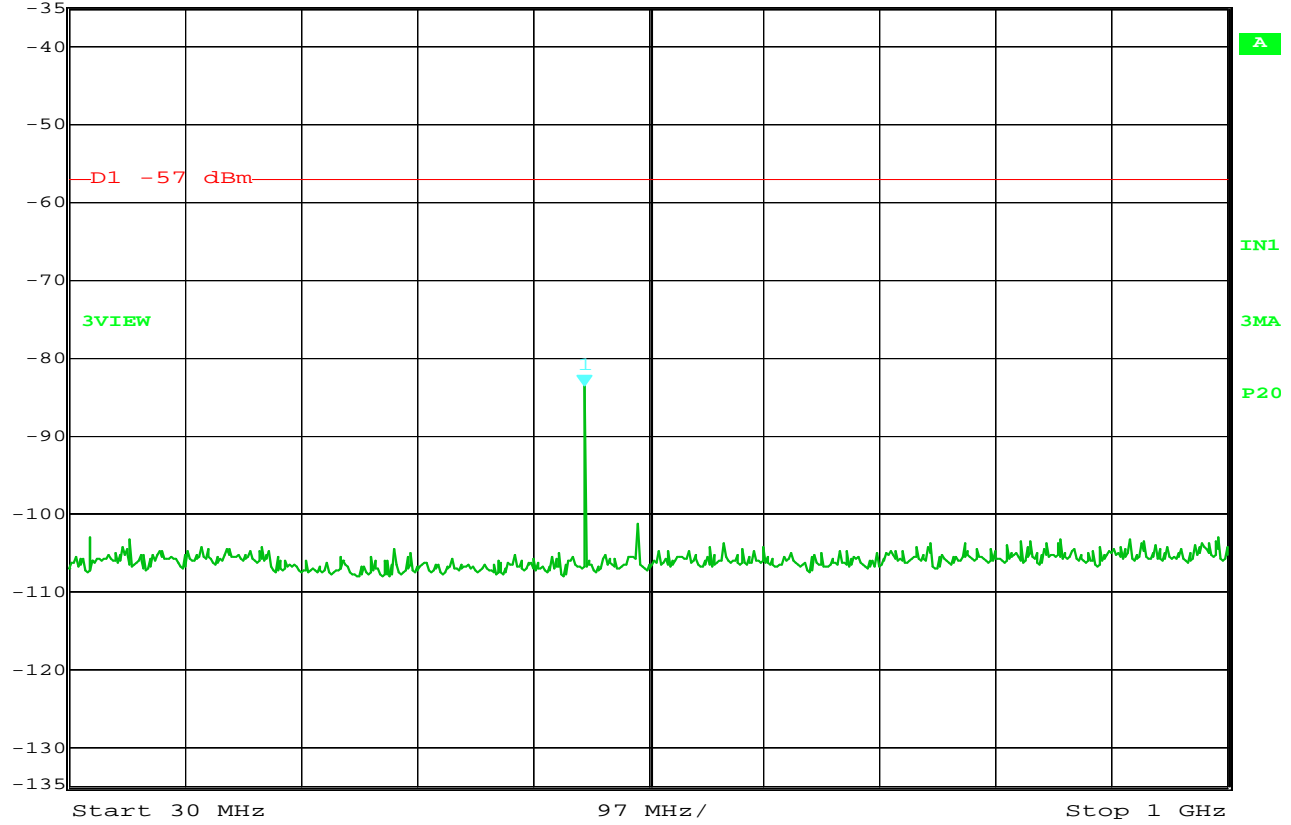


Date: 18.JUL.2011 14:24:47

MANUFACTURER :FreeWave Technologies, Inc.
 MODEL NUMBER :LRS455-EU-C-MS
 SERIAL NUMBER :455-7378
 TEST MODE :Receive at 435MHz
 TEST PARAMETERS :Antenna Conducted
 NOTES :
 EQUIPMENT USED :RBA1



Marker 1 [T3] RBW 100 kHz RF Att 0 dB
 Ref Lvl -83.66 dBm VBW 100 kHz
 -35 dBm 461.54308617 MHz SWT 300 ms Unit dBm

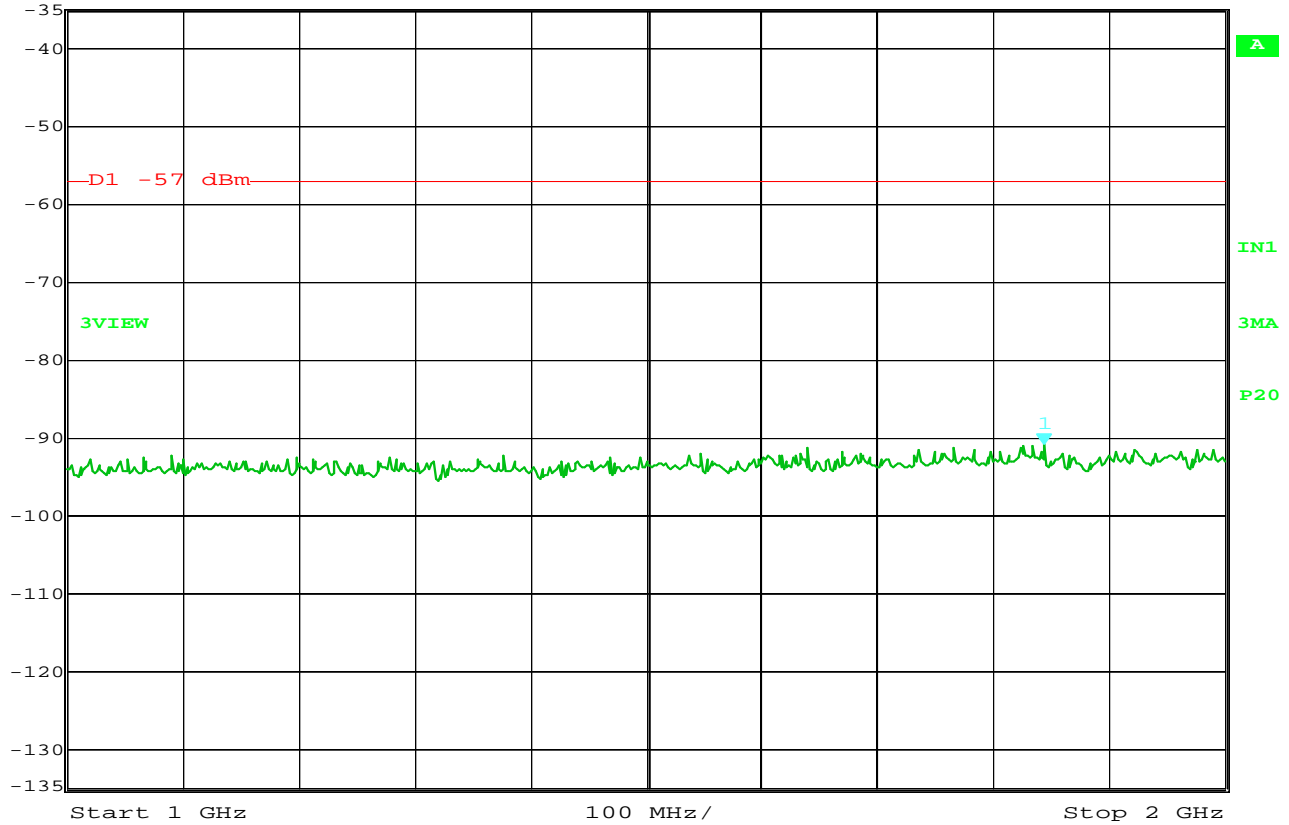


Date: 18.JUL.2011 14:22:20

MANUFACTURER :FreeWave Technologies, Inc.
 MODEL NUMBER :LRS455-EU-C-MS
 SERIAL NUMBER :455-7378
 TEST MODE :Receive at 450MHz
 TEST PARAMETERS :Antenna Conducted
 NOTES :
 EQUIPMENT USED :RBA1



Marker 1 [T3] RBW 1 MHz RF Att 0 dB
 Ref Lvl -90.85 dBm VBW 1 MHz
 -35 dBm 1.84368737 GHz SWT 5 ms Unit dBm

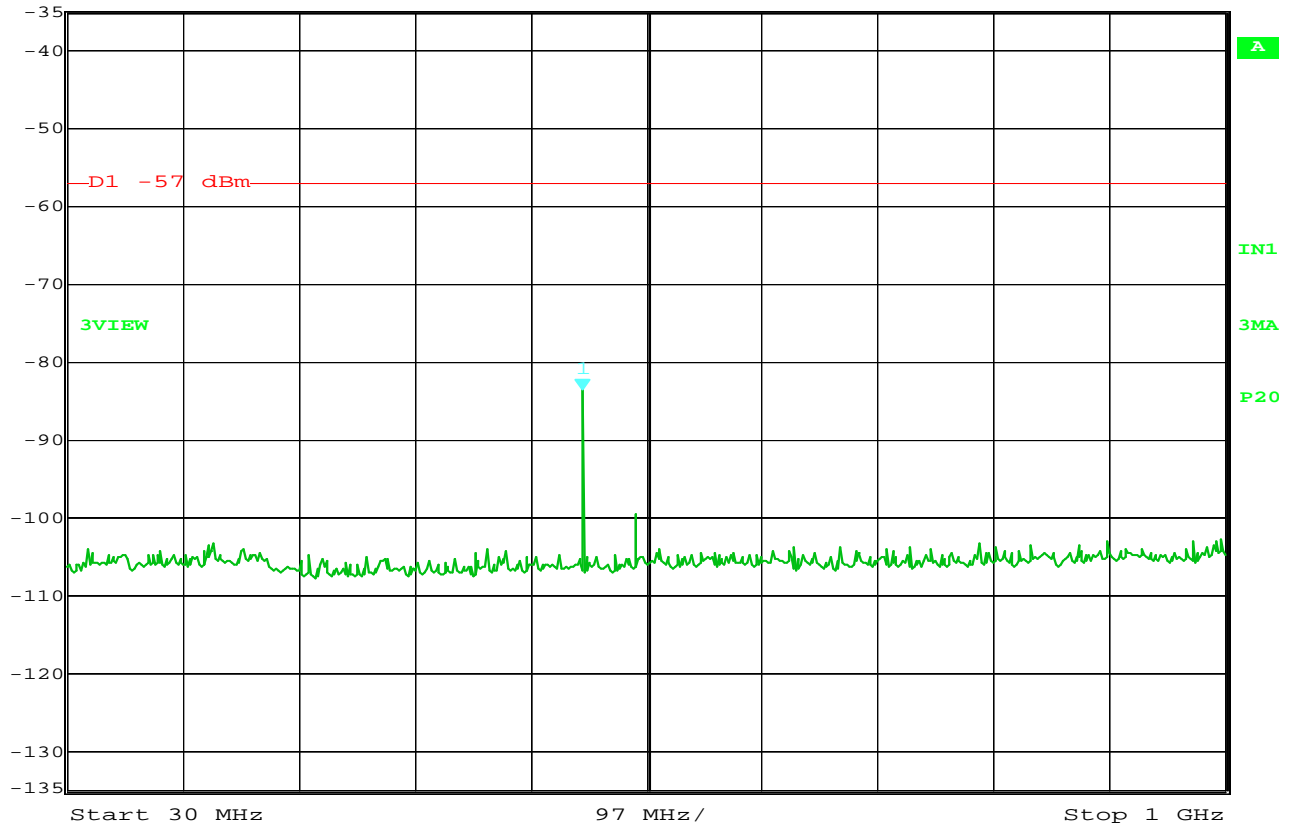


Date: 18.JUL.2011 14:23:17

MANUFACTURER :FreeWave Technologies, Inc.
 MODEL NUMBER :LRS455-EU-C-MS
 SERIAL NUMBER :455-7378
 TEST MODE :Receive at 450MHz
 TEST PARAMETERS :Antenna Conducted
 NOTES :
 EQUIPMENT USED :RBA1



Marker 1 [T3] RBW 100 kHz RF Att 0 dB
Ref Lvl -83.65 dBm VBW 100 kHz
-35 dBm 461.54308617 MHz SWT 300 ms Unit dBm

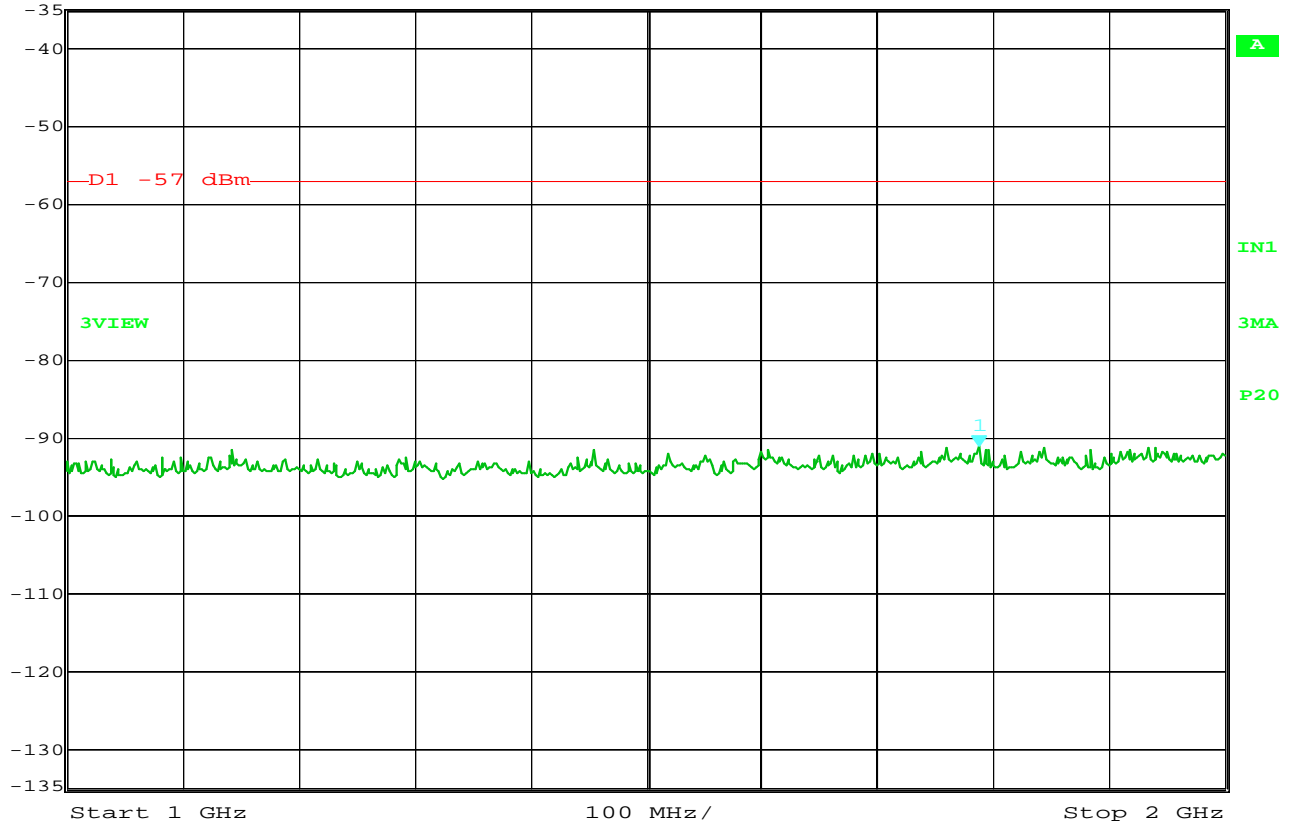


Date: 18.JUL.2011 14:20:56

MANUFACTURER :FreeWave Technologies, Inc.
MODEL NUMBER :LRS455-EU-C-MS
SERIAL NUMBER :455-7378
TEST MODE :Receive at 460MHz
TEST PARAMETERS :Antenna Conducted
NOTES :
EQUIPMENT USED :RBA1



Marker 1 [T3] RBW 1 MHz RF Att 0 dB
Ref Lvl -35 dBm -91.11 dBm VBW 1 MHz
1.78757515 GHz SWT 5 ms Unit dBm

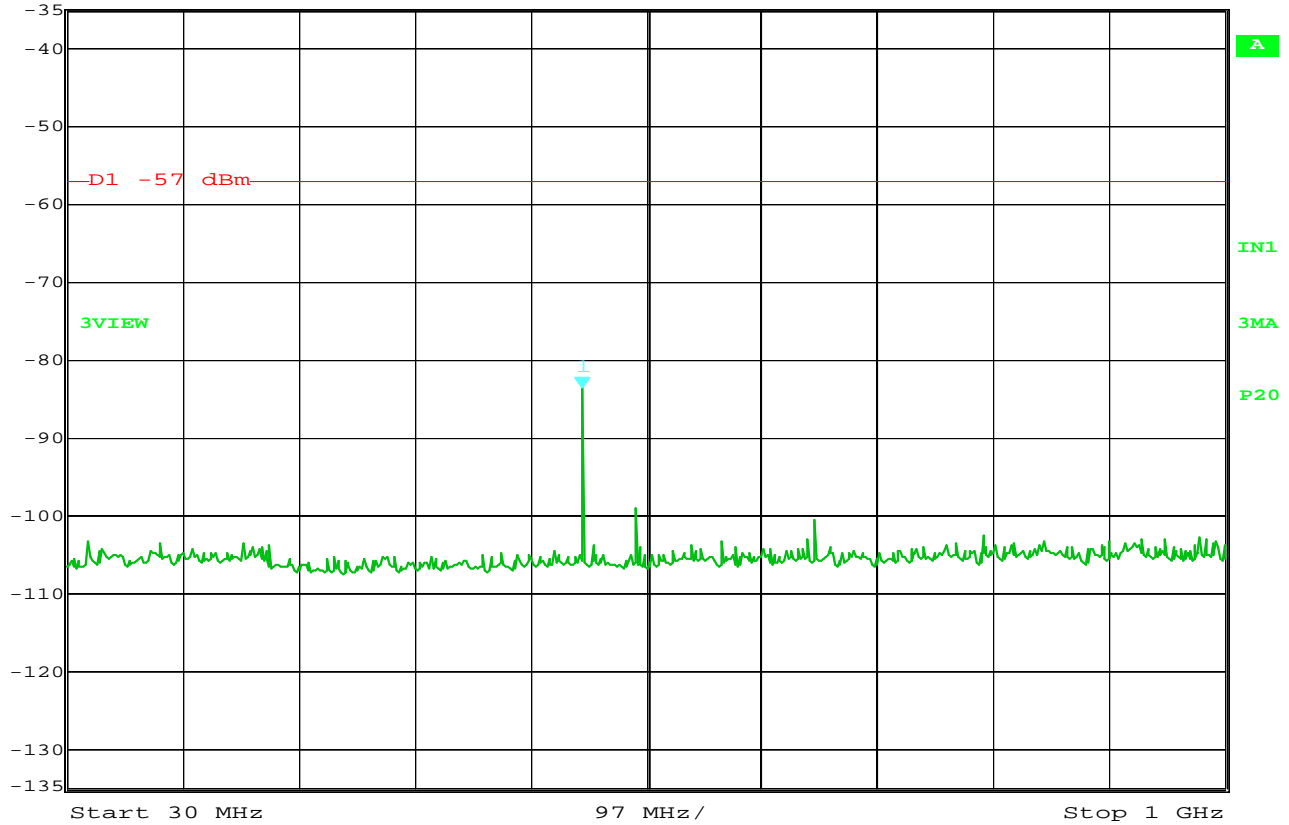


Date: 18.JUL.2011 14:19:31

MANUFACTURER : FreeWave Technologies, Inc.
MODEL NUMBER : LRS455-EU-C-MS
SERIAL NUMBER : 455-7378
TEST MODE : Receive at 460MHz
TEST PARAMETERS : Antenna Conducted
NOTES :
EQUIPMENT USED :RBA1



Marker 1 [T3] RBW 100 kHz RF Att 0 dB
Ref Lvl -83.60 dBm VBW 100 kHz
-35 dBm 461.54308617 MHz SWT 300 ms Unit dBm

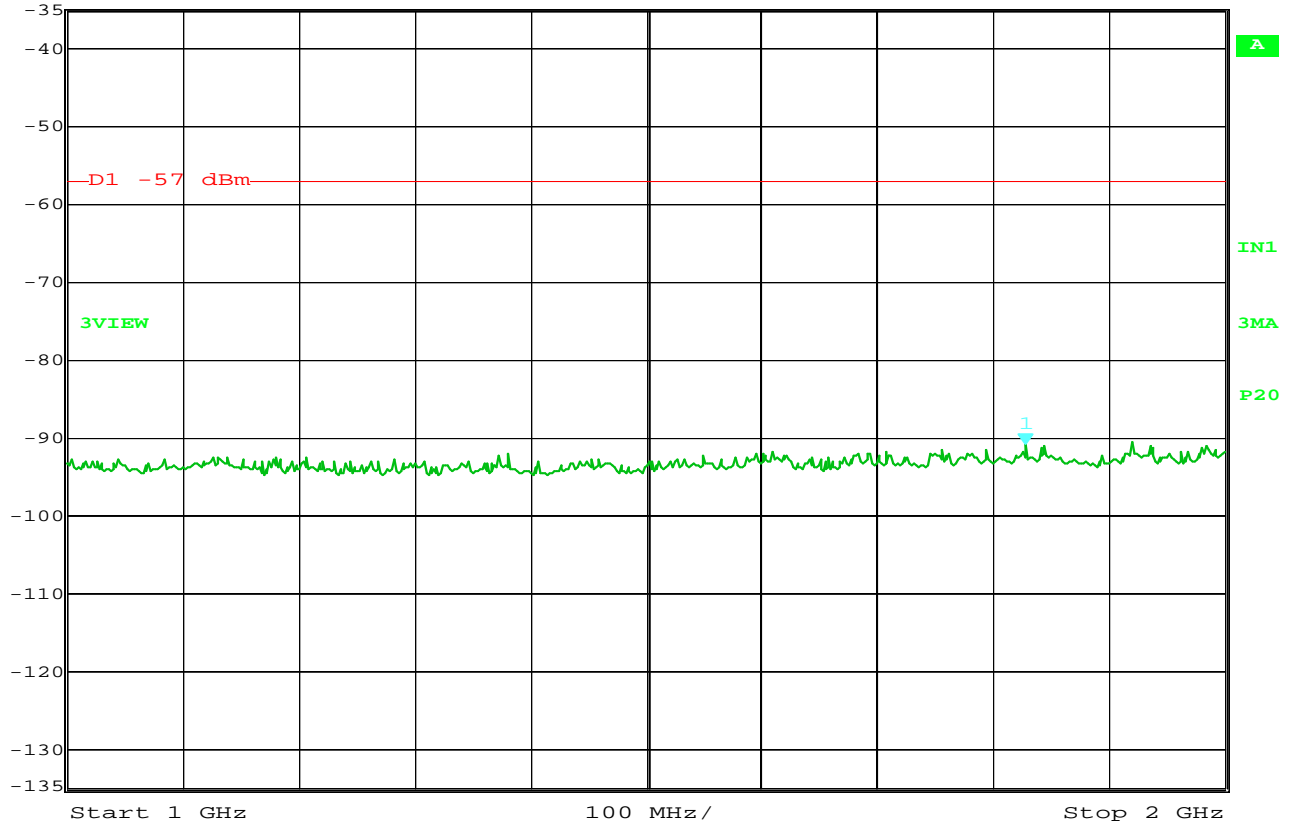


Date: 18.JUL.2011 13:51:56

MANUFACTURER :FreeWave Technologies, Inc.
MODEL NUMBER :LRS455-EU-C-MS
SERIAL NUMBER :455-7378
TEST MODE :Receive at 470MHz
TEST PARAMETERS :Antenna Conducted
NOTES :
EQUIPMENT USED :RBA1



Marker 1 [T3] RBW 1 MHz RF Att 0 dB
Ref Lvl -90.92 dBm VBW 1 MHz
-35 dBm 1.82765531 GHz SWT 5 ms Unit dBm



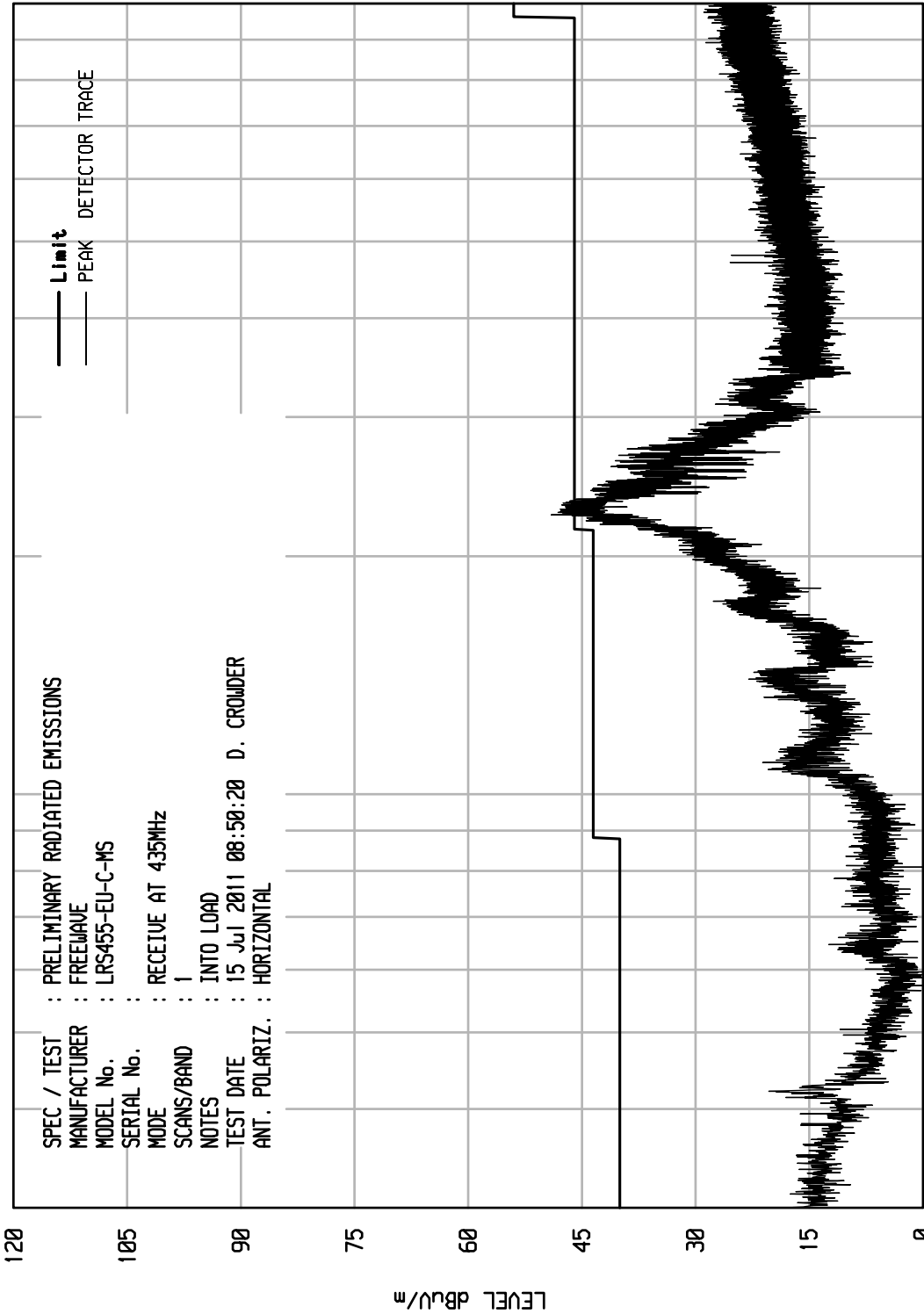
Date: 18.JUL.2011 13:55:42

MANUFACTURER :FreeWave Technologies, Inc.
MODEL NUMBER :LRS455-EU-C-MS
SERIAL NUMBER :455-7378
TEST MODE :Receive at 470MHz
TEST PARAMETERS :Antenna Conducted
NOTES :
EQUIPMENT USED :RBA1

ELITE ELECTRONIC ENGINEERING Inc.
Downers Grove, Ill. 60515

UNIU RCU EMI RUN 12

UKA1 10/20/10



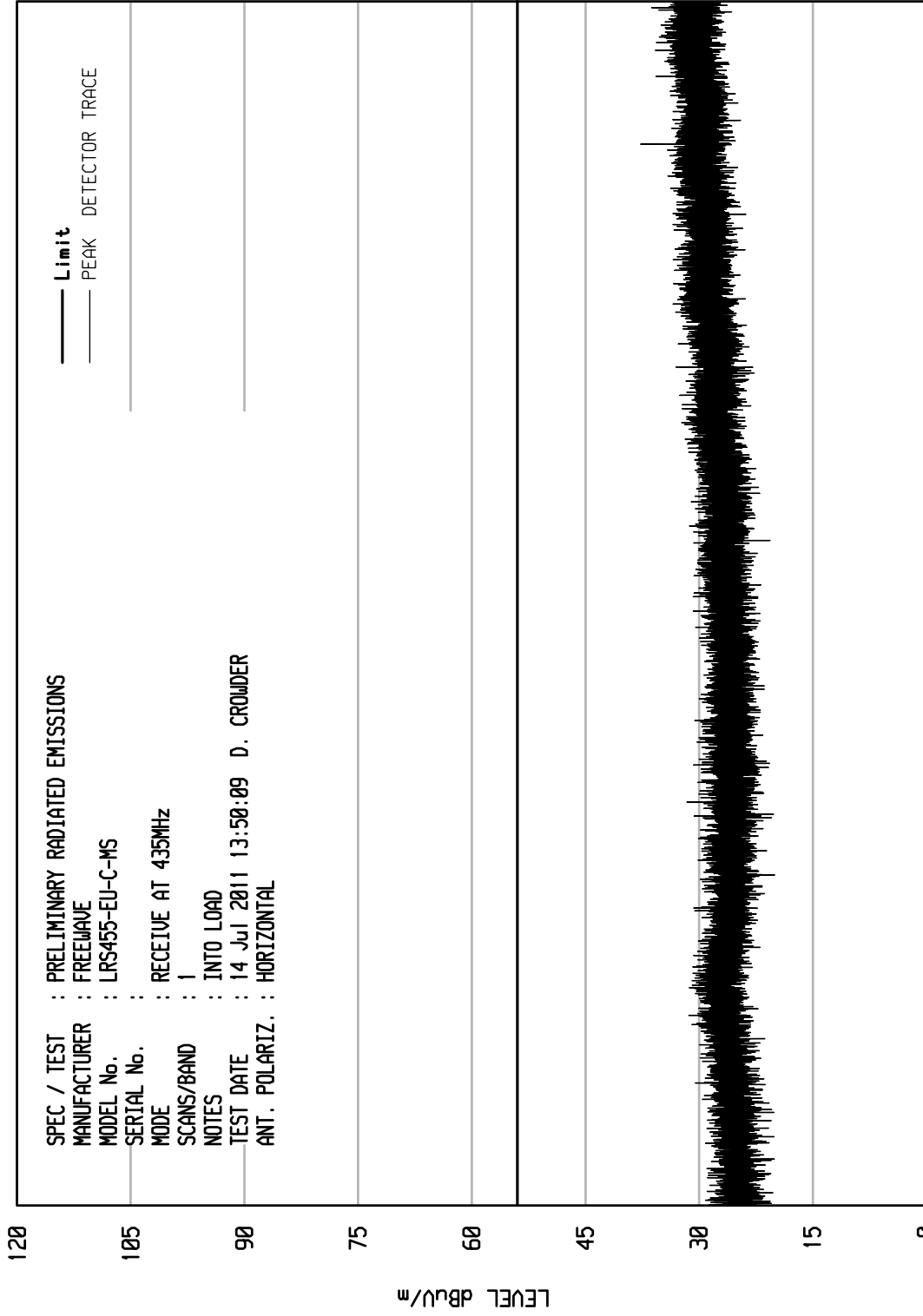
SPEC / TEST : PRELIMINARY RADIATED EMISSIONS
 MANUFACTURER : FREEMOVE
 MODEL No. : LRS455-EU-C-MS
 SERIAL No. :
 MODE : RECEIVE AT 435MHz
 SCANS/BAND : 1
 NOTES : INTO LOAD
 TEST DATE : 15 Jul 2011 08:50:20 D. CROWDER
 ANT. POLARIZ. : HORIZONTAL

START = 30 STOP = 1000 FREQUENCY MHz

ELITE ELECTRONIC ENGINEERING Inc.
Downers Grove, Ill. 60515

UNIU RCU EMI RUN 1

UKA1 10/20/10



SPEC / TEST : PRELIMINARY RADIATED EMISSIONS
 MANUFACTURER : FREEWAVE
 MODEL No. : LRS455-EU-C-MS
 SERIAL No. :
 MODE : RECEIVE AT 435MHz
 SCANS/BAND : 1
 NOTES : INTO LOAD
 TEST DATE : 14 Jul 2011 13:50:09 D. CROWDER
 ANT. POLARIZ. : HORIZONTAL

120
105
90
75
60
45
30
15
0

LEVEL dBu/m

STOP = 2000

FREQUENCY MHz

START = 1000

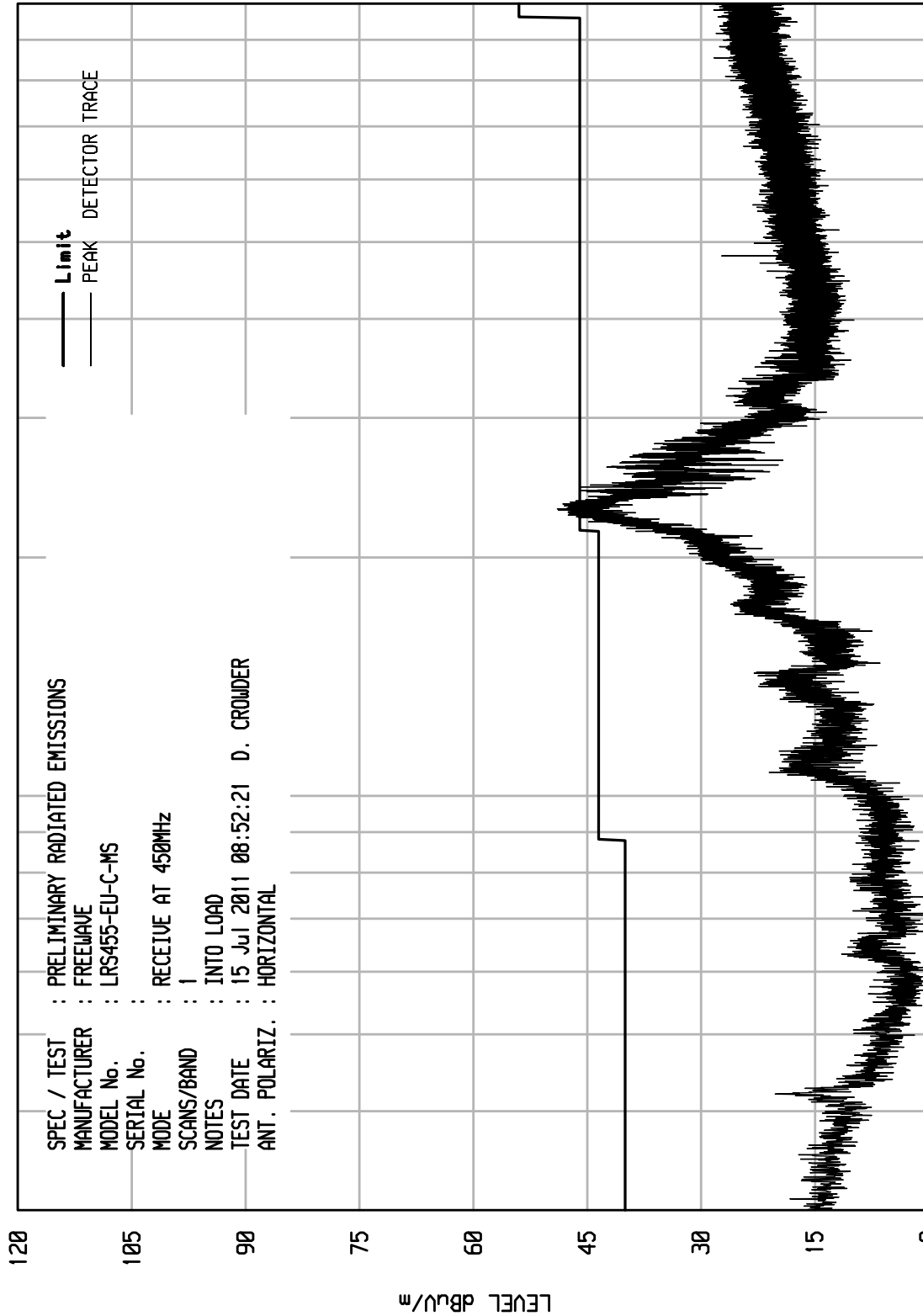
ELITE ELECTRONIC ENGINEERING Inc.

Downers Grove, Ill. 60515

UNIU RCU EMI RUN 13

WKA1 10/20/10

SPEC / TEST : PRELIMINARY RADIATED EMISSIONS
 MANUFACTURER : FREEWAVE
 MODEL No. : LRS455-EU-C-MS
 SERIAL No. :
 MODE : RECEIVE AT 450MHz
 SCANS/BAND : 1
 NOTES : INTO LOAD
 TEST DATE : 15 Jul 2011 08:52:21 D. CROWDER
 ANT. POLARIZ. : HORIZONTAL



— Limit
 — PEAK DETECTOR TRACE

STOP = 1000

FREQUENCY MHz

100

START = 30

LEVEL dBu/m

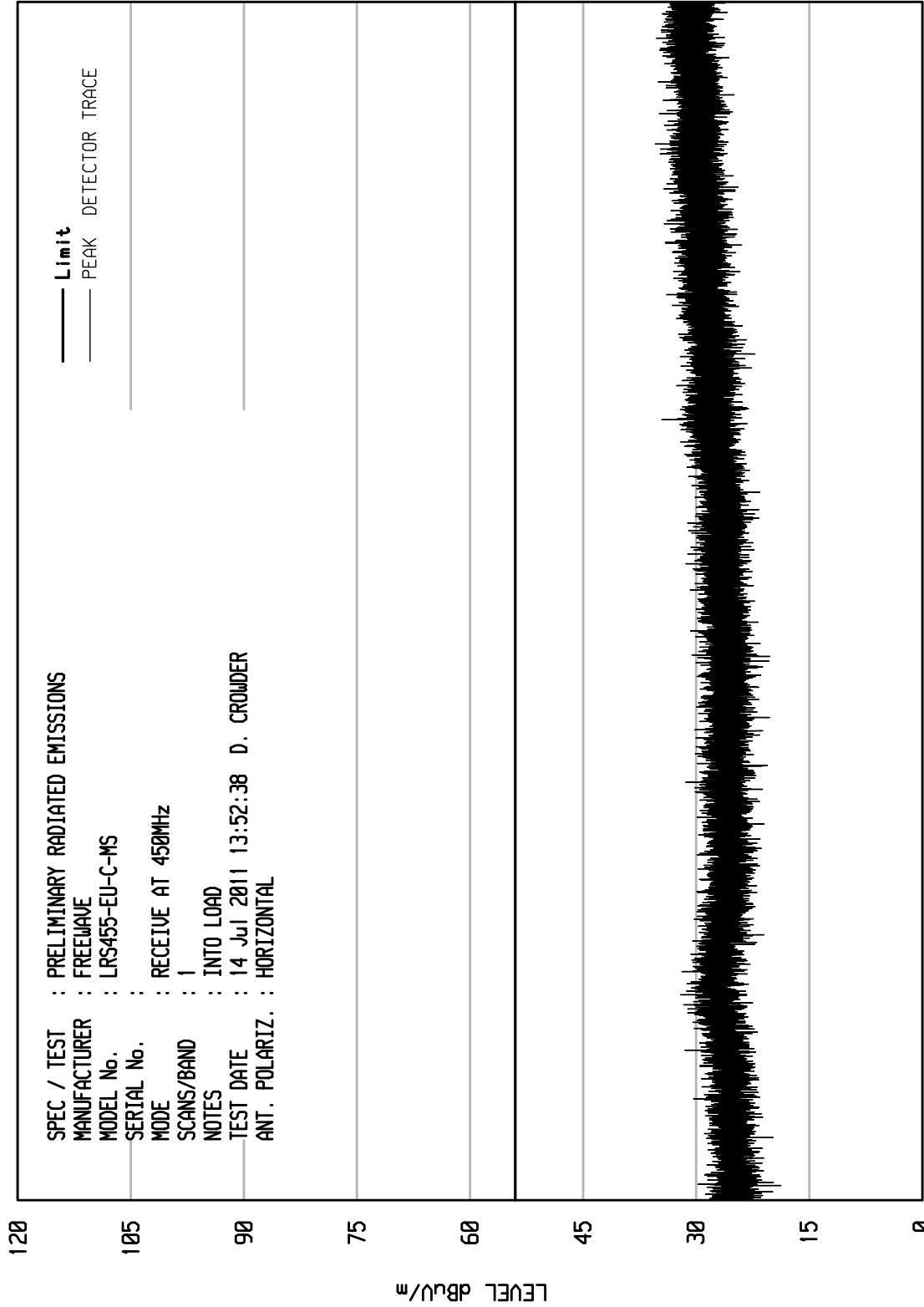
ELITE ELECTRONIC ENGINEERING Inc.
Downers Grove, Ill. 60515

UNIU RCU EMI RUN 2

UJKR1 10/20/10

SPEC / TEST : PRELIMINARY RADIATED EMISSIONS
 MANUFACTURER : FREEWAVE
 MODEL No. : LRS455-EU-C-MS
 SERIAL No. :
 MODE : RECEIVE AT 450MHz
 SCANS/BAND : 1
 NOTES : INTO LOAD
 TEST DATE : 14 Jul 2011 13:52:38 D. CROWDER
 ANT. POLARIZ. : HORIZONTAL

— Limit
 — PEAK DETECTOR TRACE



START = 1000

FREQUENCY MHz

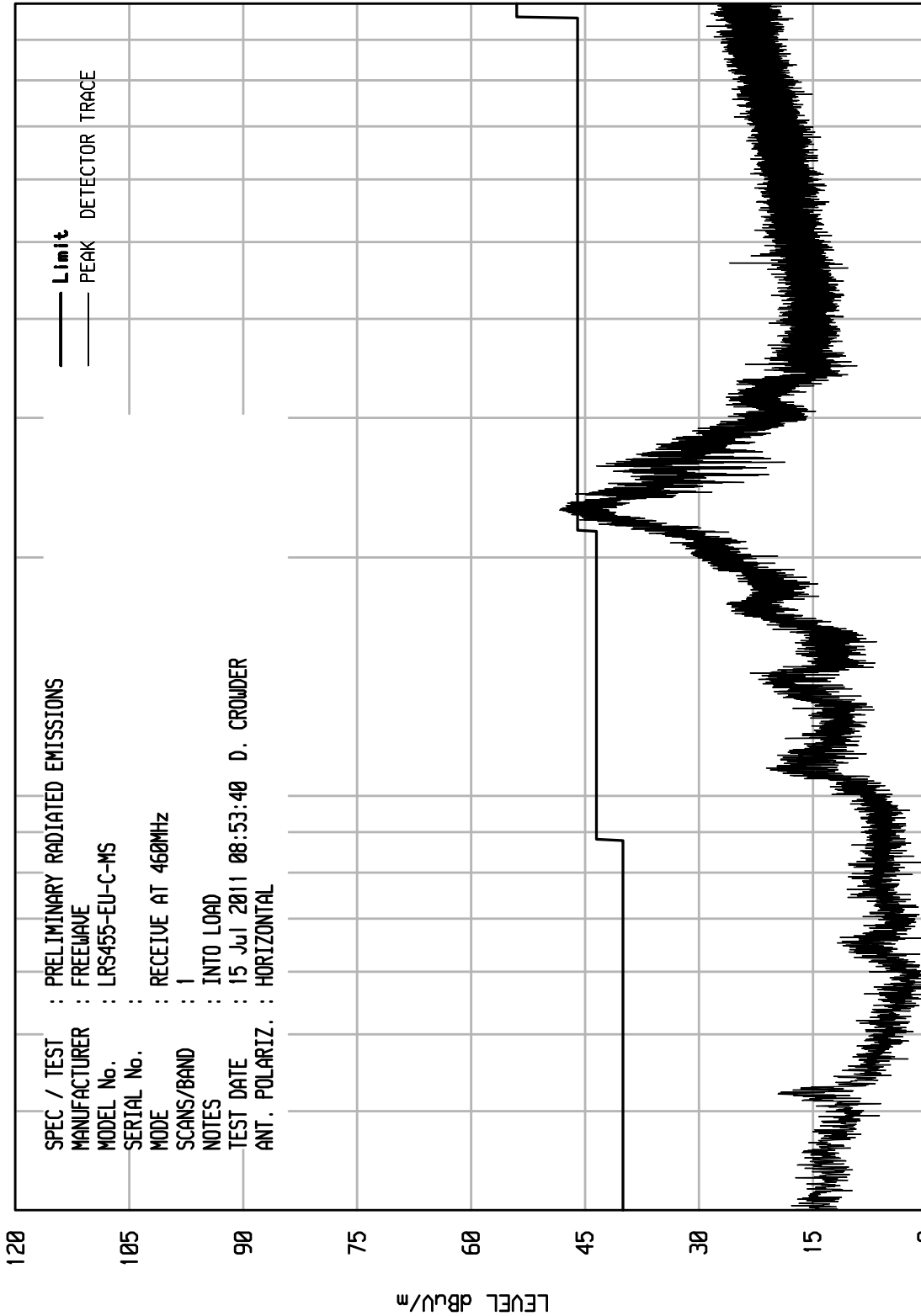
STOP = 2000

ELITE ELECTRONIC ENGINEERING Inc.
Downers Grove, Ill. 60515

UNIU RCU EMI RUN 14

WKA1 10/20/10

SPEC / TEST : PRELIMINARY RADIATED EMISSIONS
 MANUFACTURER : FREEWAVE
 MODEL No. : LRS455-EU-C-MS
 SERIAL No. :
 MODE : RECEIVE AT 460MHz
 SCANS/BAND : 1
 NOTES : INTO LOAD
 TEST DATE : 15 Jul 2011 08:53:40 D. CROWDER
 ANT. POLARIZ. : HORIZONTAL



— Limit
 — PEAK DETECTOR TRACE

STOP = 1000

FREQUENCY MHz

100

START = 30

LEVEL dBu/m

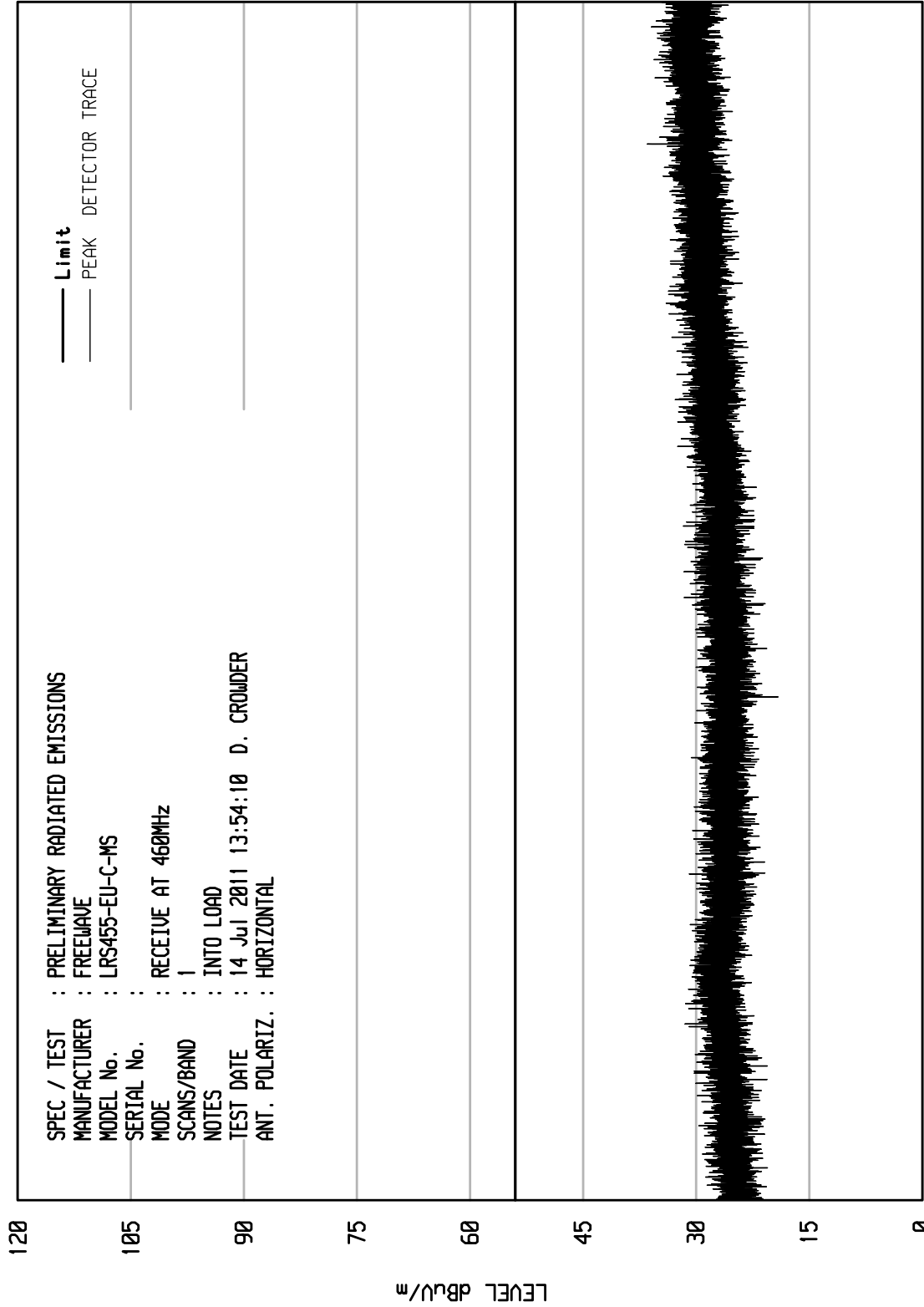
ELITE ELECTRONIC ENGINEERING Inc.
Downers Grove, Ill. 60515

UNIU RCU EMI RUN 3

UJKR1 10/20/10

SPEC / TEST : PRELIMINARY RADIATED EMISSIONS
 MANUFACTURER : FREEWAVE
 MODEL No. : LRS455-EU-C-MS
 SERIAL No. :
 MODE : RECEIVE AT 460MHz
 SCANS/BAND : 1
 NOTES : INTO LOAD
 TEST DATE : 14 Jul 2011 13:54:10 D. CROWDER
 ANT. POLARIZ. : HORIZONTAL

— Limit
 — PEAK DETECTOR TRACE



START = 1000

FREQUENCY MHz

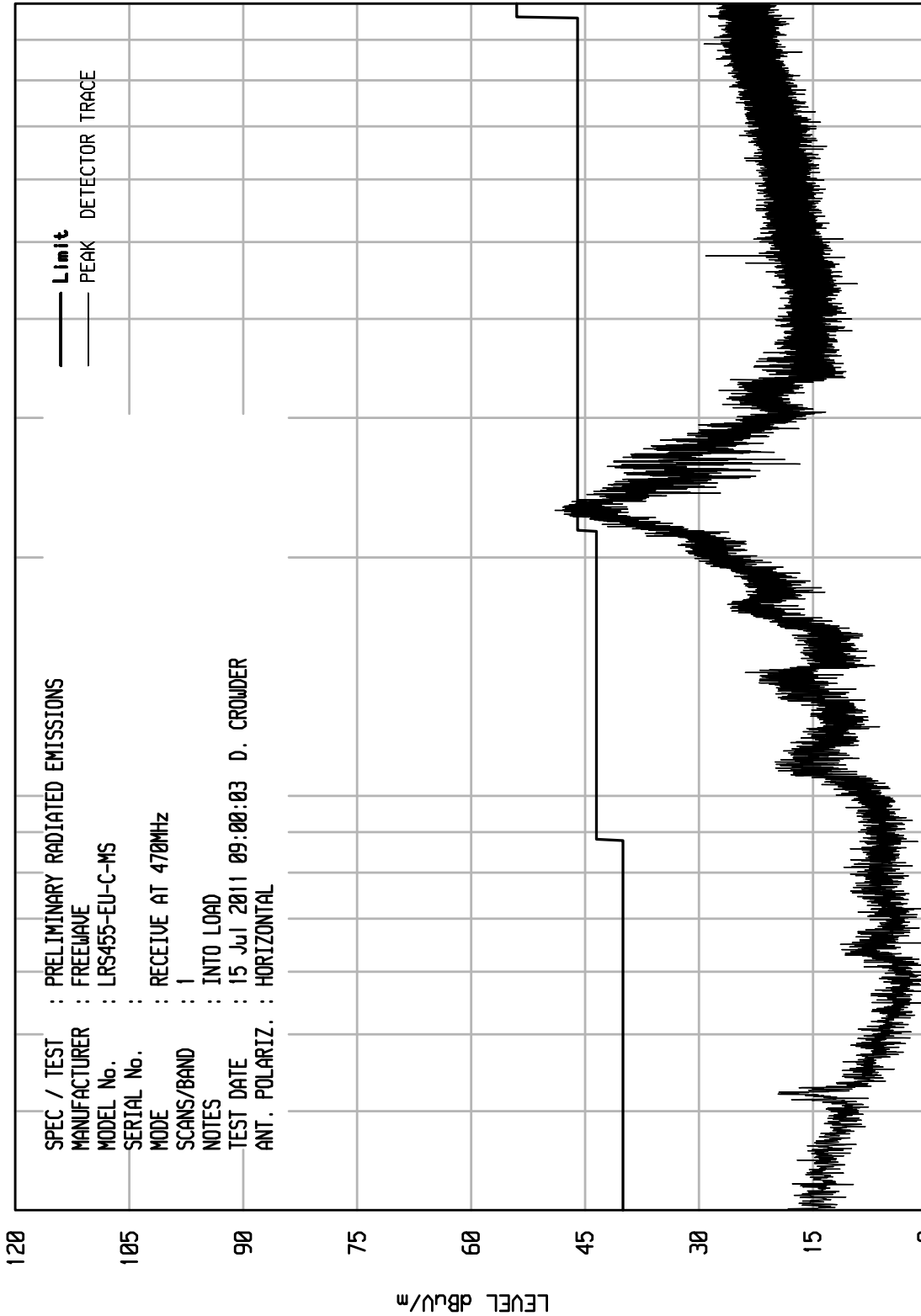
STOP = 2000

ELITE ELECTRONIC ENGINEERING Inc.
Downers Grove, Ill. 60515

UNIU RCU EMI RUN 16

UJKR1 10/20/10

SPEC / TEST : PRELIMINARY RADIATED EMISSIONS
 MANUFACTURER : FREEWAVE
 MODEL No. : LRS455-EU-C-MS
 SERIAL No. :
 MODE : RECEIVE AT 470MHz
 SCANS/BAND : 1
 NOTES : INTO LOAD
 TEST DATE : 15 Jul 2011 09:00:03 D. CROWDER
 ANT. POLARIZ. : HORIZONTAL



— Limit
 — PEAK DETECTOR TRACE

STOP = 1000

FREQUENCY MHz

100

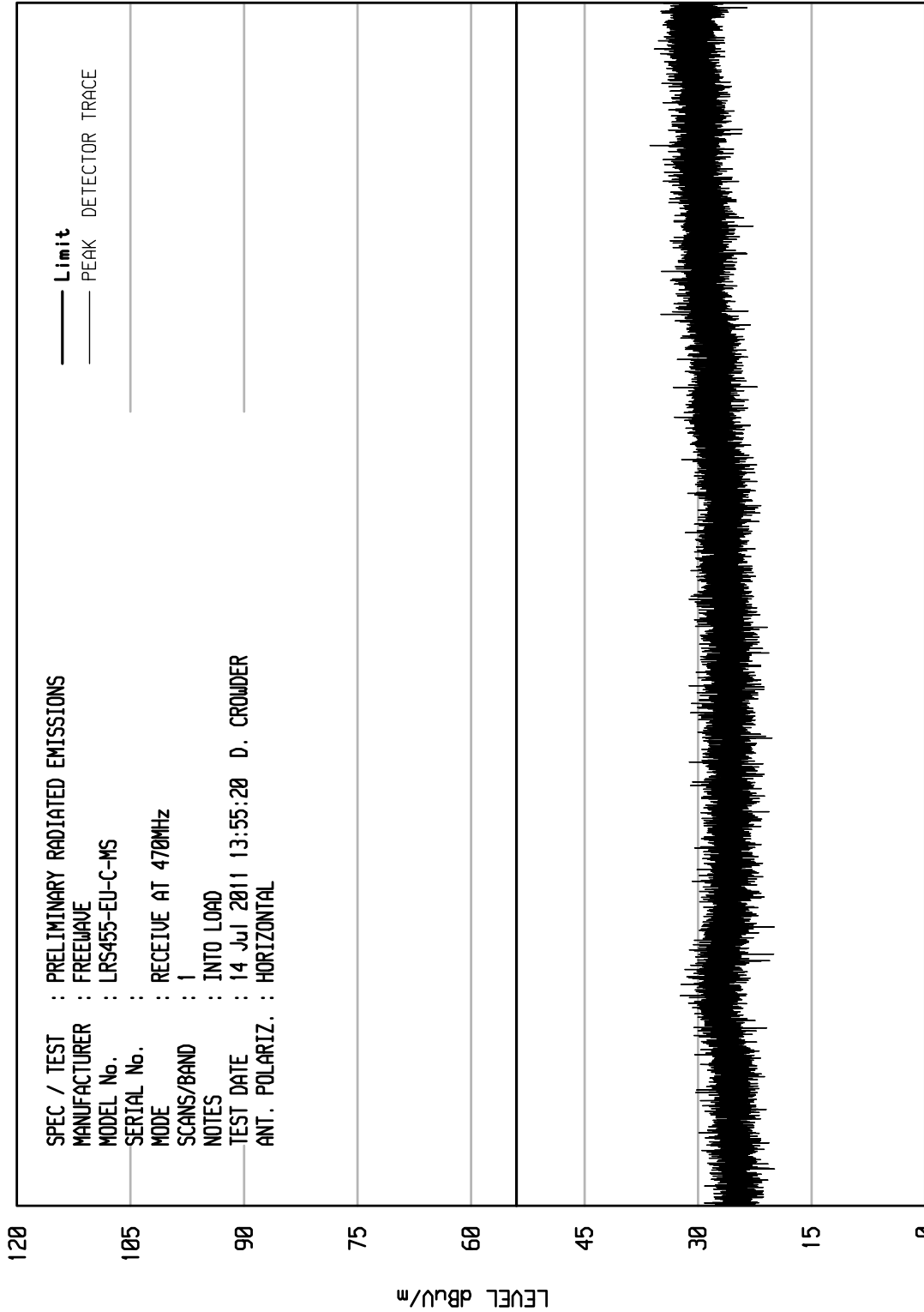
START = 30

LEVEL dBu/m

ELITE ELECTRONIC ENGINEERING Inc.
Downers Grove, Ill. 60515

UNIV RCU EMI RUN 4

UKA1 10/20/10



SPEC / TEST : PRELIMINARY RADIATED EMISSIONS

MANUFACTURER : FREEWAVE

MODEL No. : LRS455-EU-C-MS

SERIAL No. :

MODE : RECEIVE AT 470MHz

SCANS/BAND : 1

NOTES : INTO LOAD

TEST DATE : 14 Jul 2011 13:55:20 D. CROWDER

ANT. POLARIZ. : HORIZONTAL

START = 1000

FREQUENCY MHz

STOP = 2000



MANUFACTURER : FreeWave Technologies, Inc.
 MODEL : LRS455-EU-C-MS
 SPECIFICATION : FCC-15B Spurious Radiated Emissions
 DATE : July 15, 2011
 NOTES : Receive at 435MHz
 : Test Distance is 3 meters

Freq (MHz)	Ant Pol	Meter Reading (dBuV)	Ambient	CBL Fac (dB)	Ant Fac (dB)	Total dBuV/m at 3 M	Total uV/m at 3M	Limit uV/m at 3M	Margin (dB)
219.3	H	29.0	*	1.1	10.5	40.5	106.4	200.0	-5.5
219.3	V	27.4	*	1.1	10.5	38.9	88.5	200.0	-7.1
390.0	H	3.1	*	1.6	16.2	20.9	11.1	200.0	-25.2
390.0	V	2.8	*	1.6	16.2	20.6	10.7	200.0	-25.5
780.0	H	3.5	*	2.2	20.5	26.2	20.5	200.0	-19.8
780.0	V	3.5	*	2.2	20.5	26.2	20.5	200.0	-19.8
1170.0	H	15.6	*	2.7	25.4	43.7	153.3	500.0	-10.3
1170.0	V	14.0	*	2.7	25.4	42.1	127.5	500.0	-11.9
1560.0	H	14.4	*	3.2	26.3	43.9	156.9	500.0	-10.1
1560.0	V	13.8	*	3.2	26.3	43.3	146.4	500.0	-10.7
1950.0	H	15.4	*	3.6	28.0	47.0	222.7	500.0	-7.0
1950.0	V	14.8	*	3.6	28.0	46.4	207.9	500.0	-7.6

V – Vertical, H - Horizontal

Total (dBuV/m) = Meter Reading + Cable Factor + Antenna Factor



MANUFACTURER : FreeWave Technologies, Inc.
 MODEL : LRS455-EU-C-MS
 SPECIFICATION : FCC-15B Spurious Radiated Emissions
 DATE : July 15, 2011
 NOTES : Receive at 450MHz
 : Test Distance is 3 meters

Freq (MHz)	Ant Pol	Meter Reading (dBuV)	Ambient	CBL Fac (dB)	Ant Fac (dB)	Total dBuV/m at 3 M	Total uV/m at 3M	Limit uV/m at 3M	Margin (dB)
219.3	H	29.0	*	1.1	10.5	40.5	106.4	200.0	-5.5
219.3	V	27.4	*	1.1	10.5	38.9	88.5	200.0	-7.1
405.0	H	3.2	*	1.6	17.0	21.8	12.3	200.0	-24.2
405.0	V	3.5	*	1.6	17.0	22.1	12.7	200.0	-23.9
810.0	H	3.6	*	2.3	20.8	26.7	21.5	200.0	-19.4
810.0	V	4.3	*	2.3	20.8	27.4	23.4	200.0	-18.7
1215.0	H	14.4	*	2.8	25.5	42.7	136.0	500.0	-11.3
1215.0	V	15.2	*	2.8	25.5	43.5	149.1	500.0	-10.5
1620.0	H	14.3	*	3.3	26.6	44.2	161.4	500.0	-9.8
1620.0	V	14.0	*	3.3	26.6	43.9	155.9	500.0	-10.1

V – Vertical, H - Horizontal

Total (dBuV/m) = Meter Reading + Cable Factor + Antenna Factor



MANUFACTURER : FreeWave Technologies, Inc.
 MODEL : LRS455-EU-C-MS
 SPECIFICATION : FCC-15B Spurious Radiated Emissions
 DATE : July 15, 2011
 NOTES : Receive at 460MHz
 : Test Distance is 3 meters

Freq (MHz)	Ant Pol	Meter Reading (dBuV)	CBL Fac (dB)	Ant Fac (dB)	Total dBuV/m at 3 M	Total uV/m at 3M	Limit uV/m at 3M	Margin (dB)	
219.3	H	29.0	*	1.1	10.5	40.5	106.4	200.0	-5.5
219.3	V	27.4	*	1.1	10.5	38.9	88.5	200.0	-7.1
415.0	H	3.0	*	1.6	17.3	21.9	12.5	200.0	-24.1
415.0	V	4.7	*	1.6	17.3	23.6	15.2	200.0	-22.4
830.0	H	4.2	*	2.3	21.2	27.7	24.2	200.0	-18.3
830.0	V	4.0	*	2.3	21.2	27.5	23.7	200.0	-18.5
1245.0	H	13.2	*	2.8	25.5	41.6	119.8	500.0	-12.4
1245.0	V	13.6	*	2.8	25.5	42.0	125.5	500.0	-12.0
1660.0	H	14.6	*	3.3	26.8	44.7	171.4	500.0	-9.3
1660.0	V	14.2	*	3.3	26.8	44.3	163.7	500.0	-9.7

V – Vertical, H - Horizontal

Total (dBuV/m) = Meter Reading + Cable Factor + Antenna Factor



MANUFACTURER : FreeWave Technologies, Inc.
 MODEL : LRS455-EU-C-MS
 SPECIFICATION : FCC-15B Spurious Radiated Emissions
 DATE : July 15, 2011
 NOTES : Receive at 470MHz
 : Test Distance is 3 meters

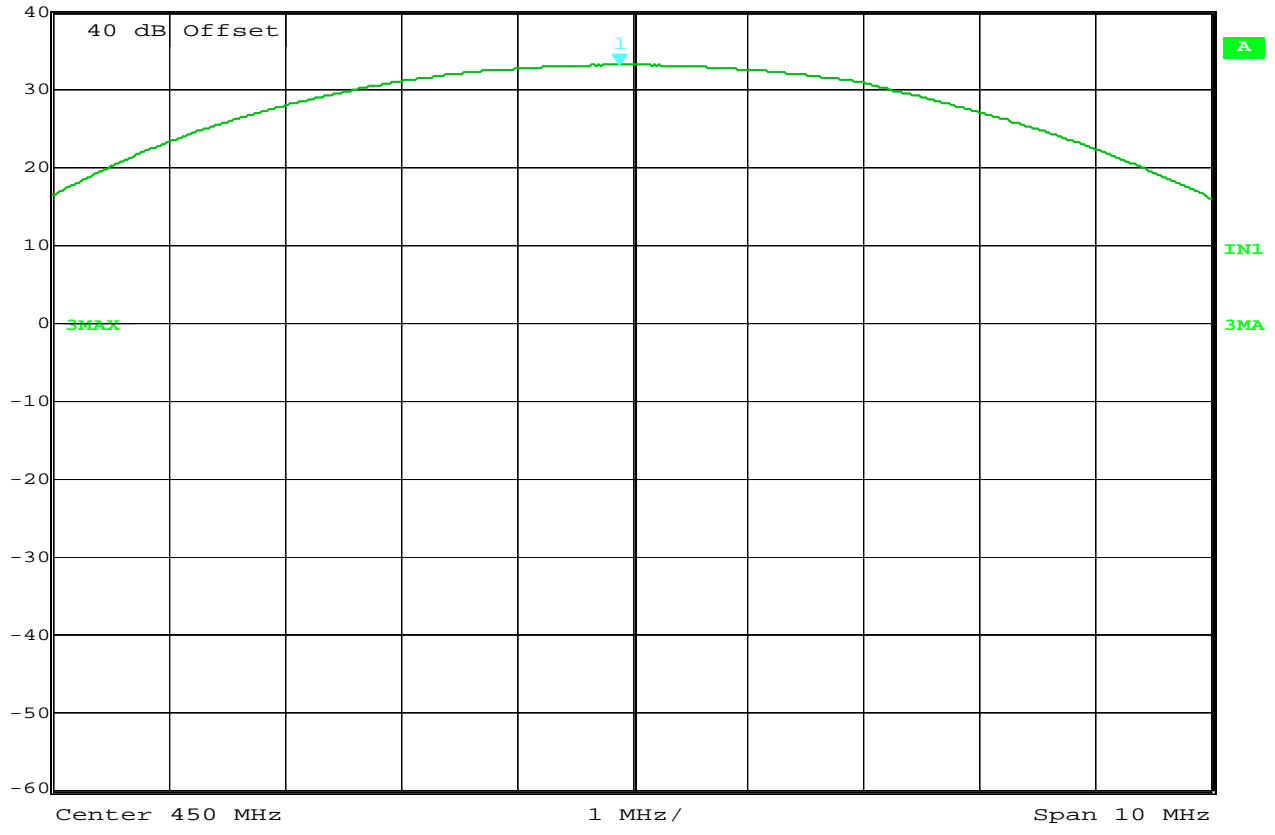
Freq (MHz)	Ant Pol	Meter		CBL Fac (dB)	Ant Fac (dB)	Total dBuV/m at 3 M	Total uV/m at 3M	Limit uV/m at 3M	Margin (dB)
		Reading (dBuV)	Ambient						
219.3	H	29.0	*	1.1	10.5	40.5	106.4	200.0	-5.5
219.3	V	27.4	*	1.1	10.5	38.9	88.5	200.0	-7.1
425.00	H	4.2	*	1.6	17.2	23.0	14.2	200.0	-23.0
425.00	V	5.2	*	1.6	17.2	24.0	15.9	200.0	-22.0
850.00	H	3.9	*	2.3	21.3	27.5	23.8	200.0	-18.5
850.00	V	3.5	*	2.3	21.3	27.1	22.7	200.0	-18.9
1275.00	H	15.3	*	2.9	25.6	43.8	154.4	500.0	-10.2
1275.00	V	14.9	*	2.9	25.6	43.4	147.4	500.0	-10.6
1700.00	H	14.4	*	3.3	27.0	44.7	171.8	500.0	-9.3
1700.00	V	14.6	*	3.3	27.0	44.9	175.8	500.0	-9.1

V – Vertical, H - Horizontal

Total (dBuV/m) = Meter Reading + Cable Factor + Antenna Factor



Marker 1 [T3] RBW 5 MHz RF Att 30 dB
 Ref Lvl 33.12 dBm VBW 5 MHz
 40 dBm 449.88977956 MHz SWT 5 ms Unit dBm

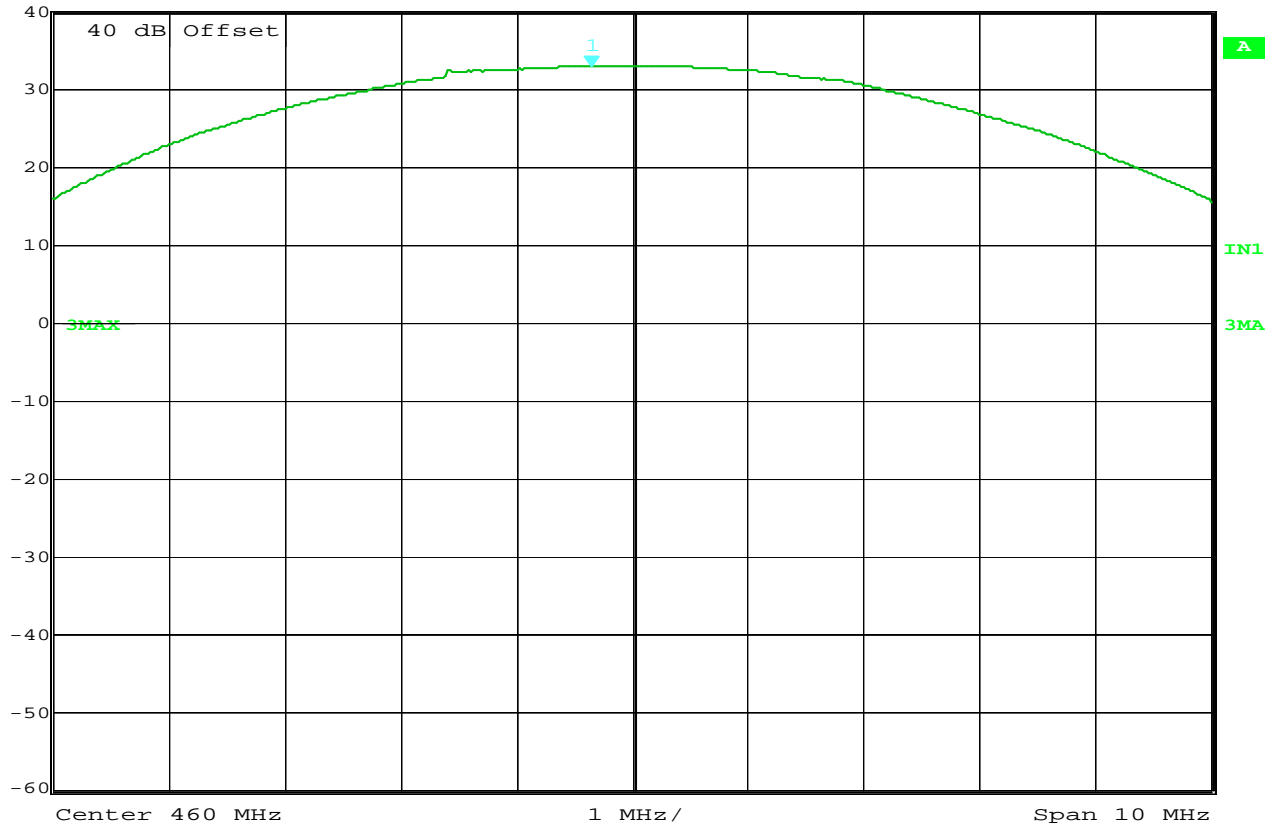


Date: 14.JUL.2011 15:29:05

MANUFACTURER :FreeWave Technologies, Inc.
 MODEL NUMBER :LRS455-EU-C-MS
 TEST MODE :Transmit at 450MHz
 TEST PARAMETERS :Power Output
 NOTES :2 Watt Setting
 EQUIPMENT USED :RBB0, T2S3, T2DS



Marker 1 [T3] RBW 5 MHz RF Att 30 dB
 Ref Lvl 32.99 dBm VBW 5 MHz
 40 dBm 459.64929860 MHz SWT 5 ms Unit dBm

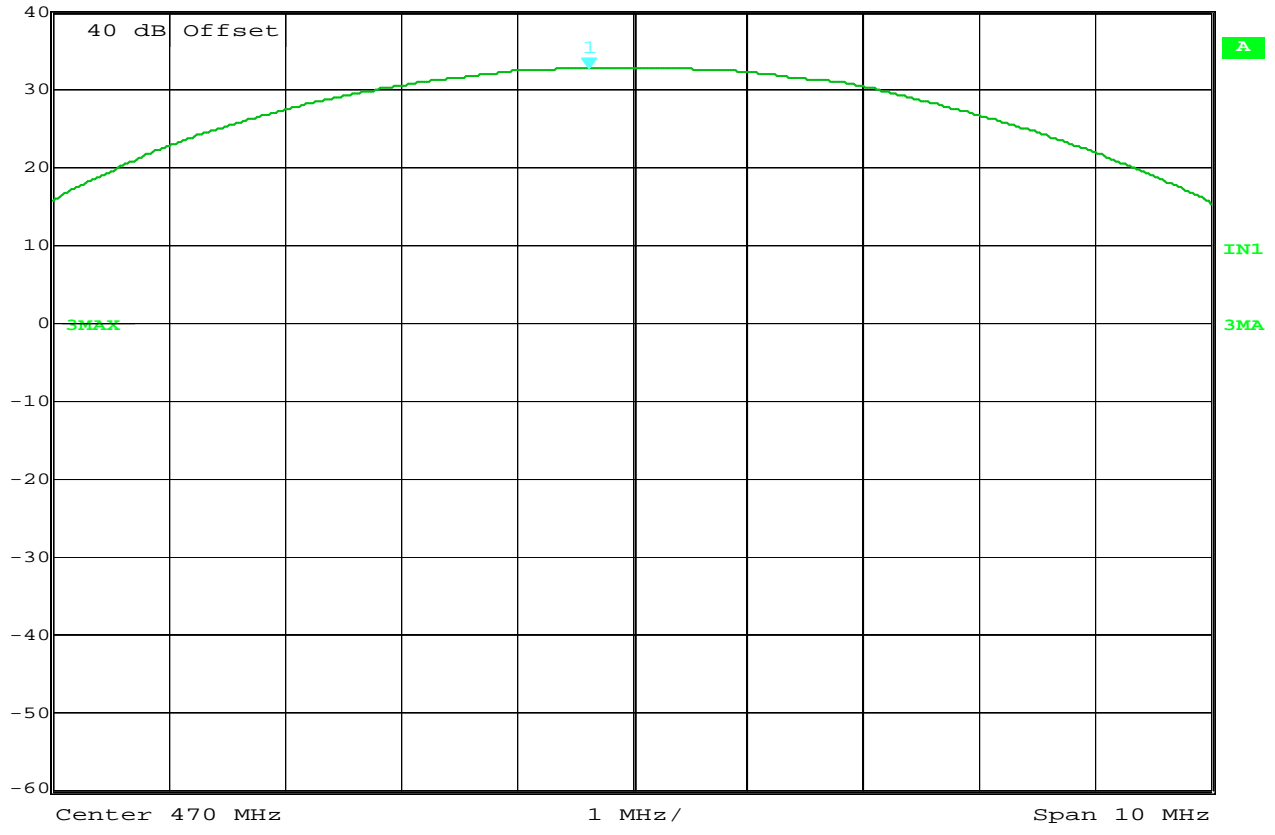


Date: 14.JUL.2011 15:31:36

MANUFACTURER :FreeWave Technologies, Inc.
 MODEL NUMBER :LRS455-EU-C-MS
 TEST MODE :Transmit at 460MHz
 TEST PARAMETERS :Power Output
 NOTES :2 Watt Setting
 EQUIPMENT USED :RBB0, T2S3, T2DS



Marker 1 [T3] RBW 5 MHz RF Att 30 dB
 Ref Lvl 32.75 dBm VBW 5 MHz
 40 dBm 469.62925852 MHz SWT 5 ms Unit dBm



Date: 14.JUL.2011 15:34:07

MANUFACTURER :FreeWave Technologies, Inc.
 MODEL NUMBER :LRS455-EU-C-MS
 TEST MODE :Transmit at 470MHz
 TEST PARAMETERS :Power Output
 NOTES :2 Watt Setting
 EQUIPMENT USED :RBB0, T2S3, T2DS

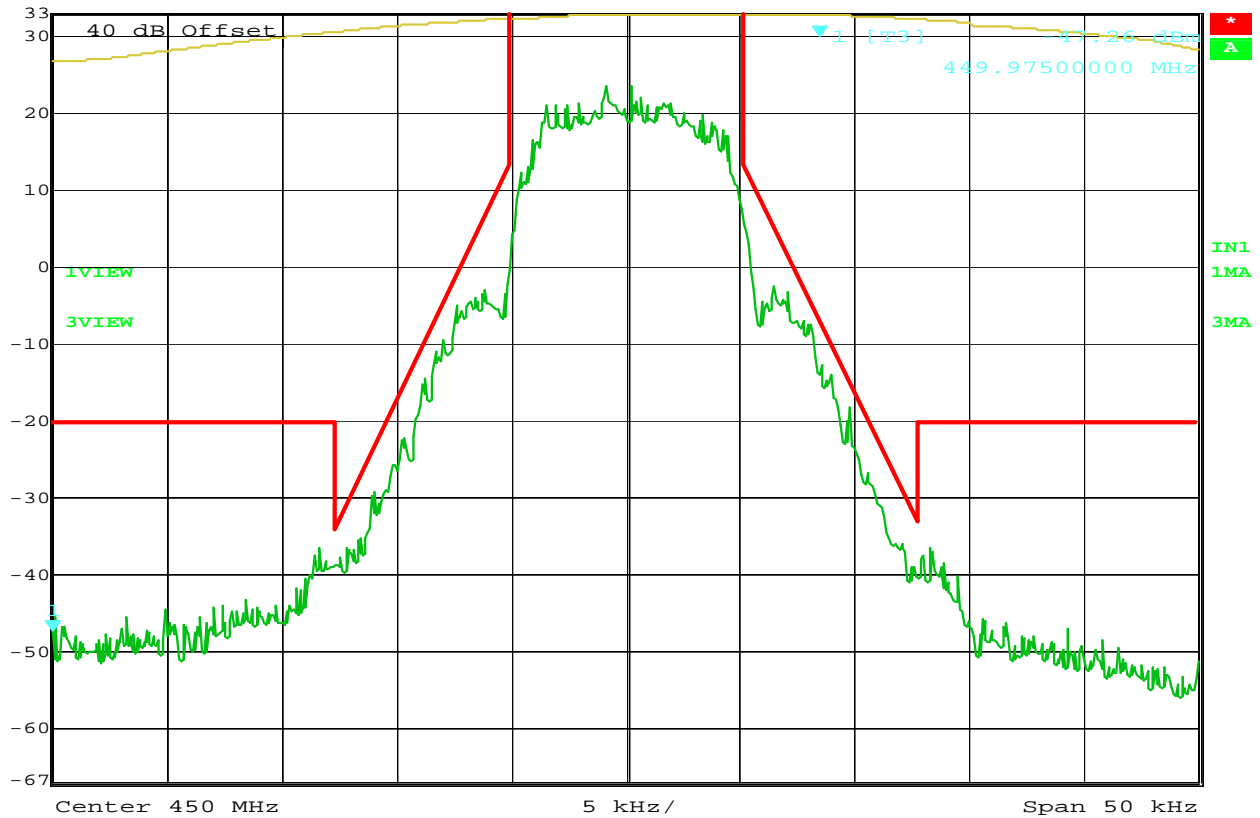


MANUFACTURER : Free Wave Technologies
MODEL : LRS455-EU-C-MS
SPECIFICATION : FCC 90.205 Power Output
DATE : July 14, 2011

Frequency MHz	Measured Output Power dBm	Measured Output Power Watts	Manufacturer's Rated Power Watts	Manufacturer's Rated Power + 20% Watts
450.0	33.1	2.1	2.0	2.4
460.0	33.0	2.0	2.0	2.4
470.0	32.8	1.9	2.0	2.4



Marker 1 [T3] RBW 100 Hz RF Att 20 dB
 -47.26 dBm VBW 1 kHz
 449.97500000 MHz SWT 25 s Unit dBm
 Ref Lvl 33 dBm



Date: 18.JUL.2011 11:06:03

MANUFACTURER :FreeWave Technologies, Inc.
 MODEL NUMBER :LRS455-EU-C-MS
 TEST MODE :Transmit at 450MHz
 TEST PARAMETERS :Occupied Bandwidth
 NOTES :2 WATT SETTING, 2 LEVEL GFSK
 EQUIPMENT USED :RBA1, T2S3, T2DS

NOTES



Marker 1 [T3]

RBW 100 Hz RF Att 20 dB

Ref Lvl

-50.94 dBm

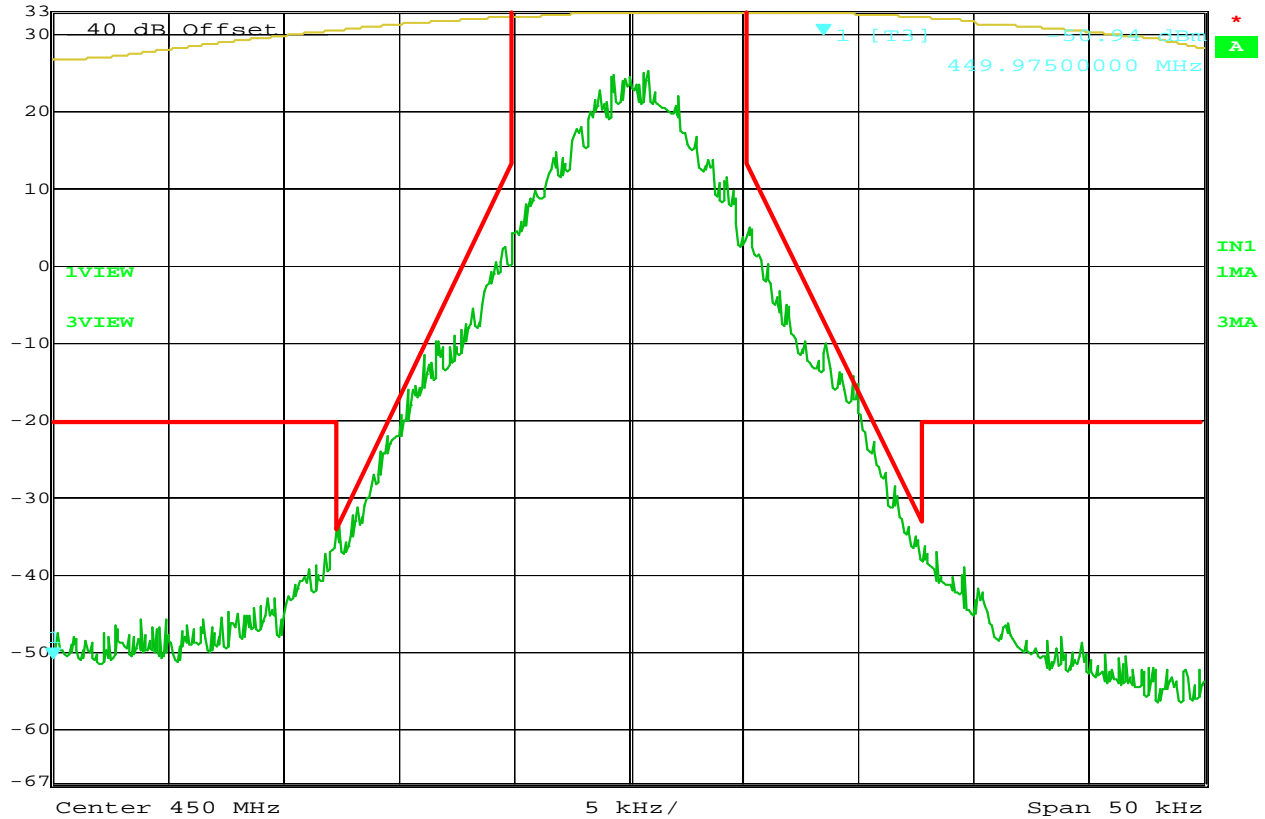
VBW 1 kHz

33 dBm

449.97500000 MHz

SWT 25 s

Unit dBm



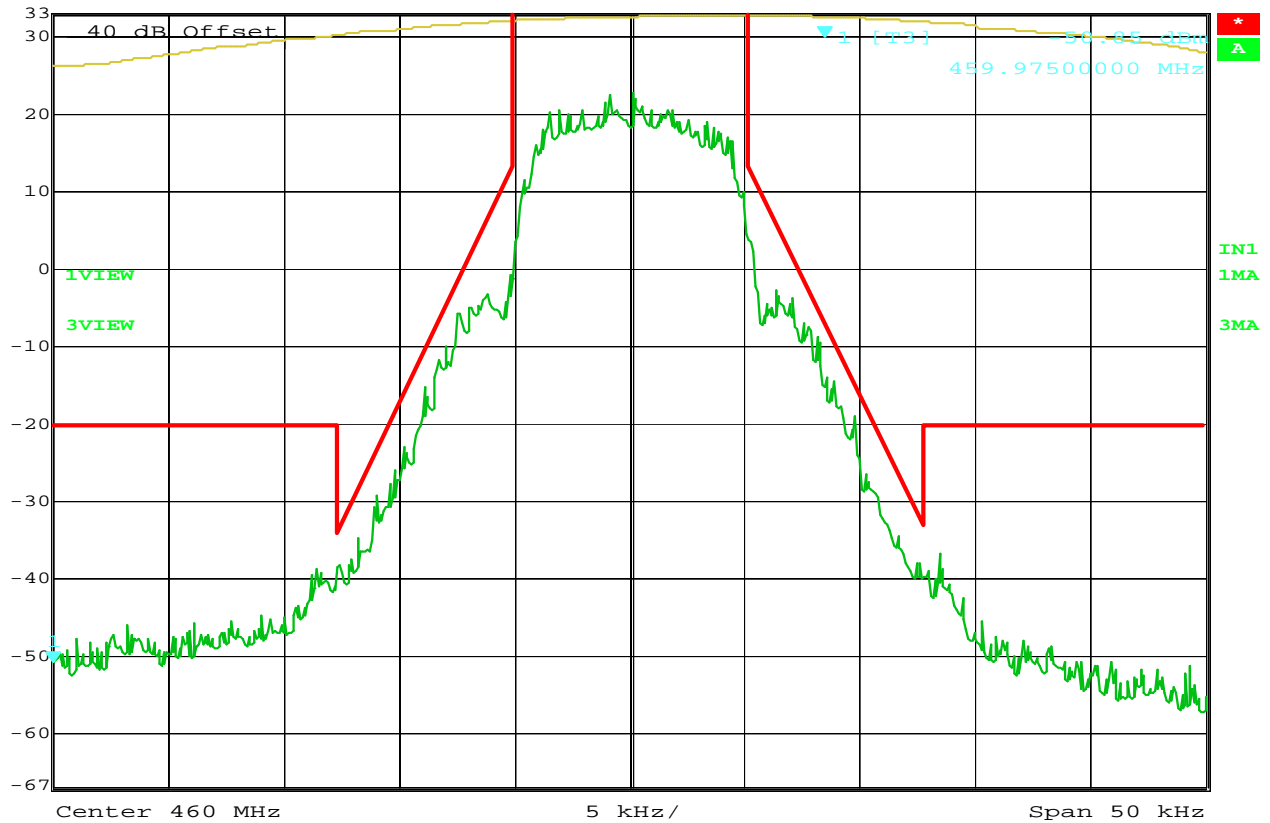
Date: 18.JUL.2011 11:09:54

MANUFACTURER :FreeWave Technologies, Inc.
 MODEL NUMBER :LRS455-EU-C-MS
 TEST MODE :TRANSMIT AT 450MHz
 TEST PARAMETERS :OCCUPIED BANDWIDTH
 NOTES :2 WATT SETTING, 4 LEVEL GFSK
 EQUIPMENT USED :RBA1, T2S3, T2DS

NOTES



Marker 1 [T3] RBW 100 Hz RF Att 20 dB
 Ref Lvl -50.85 dBm VBW 1 kHz
 33 dBm 459.9750000 MHz SWT 25 s Unit dBm



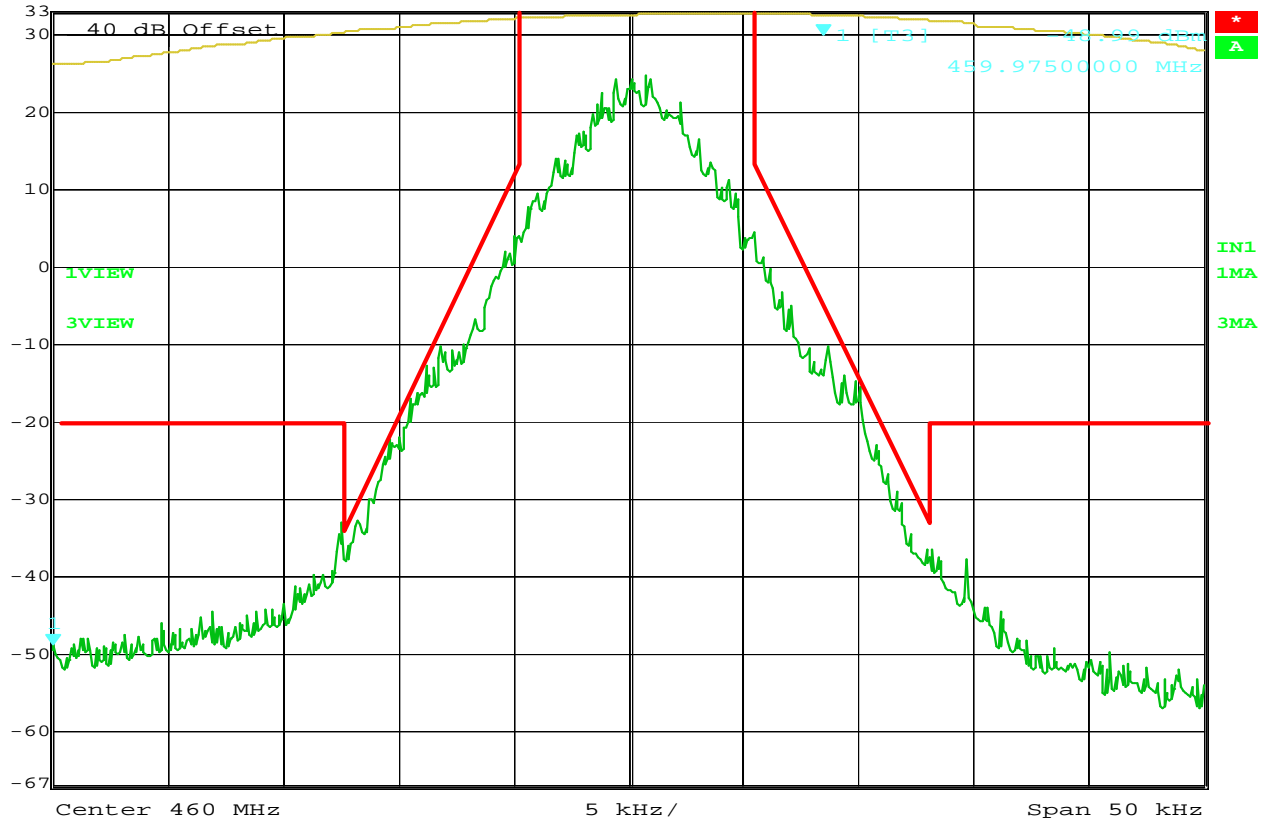
Date: 18.JUL.2011 11:27:07

MANUFACTURER :FreeWave Technologies, Inc.
 MODEL NUMBER :LRS455-EU-C-MS
 TEST MODE :TRANSMIT AT 460MHz
 TEST PARAMETERS :OCCUPIED BANDWIDTH
 NOTES :2 WATT SETTING, 2 LEVEL GFSK
 EQUIPMENT USED :RBA1, T2S3, T2DS

NOTES



Marker 1 [T3] RBW 100 Hz RF Att 20 dB
 Ref Lvl -48.99 dBm VBW 1 kHz
 33 dBm 459.9750000 MHz SWT 25 s Unit dBm



Date: 18.JUL.2011 11:24:42
 MANUFACTURER :FreeWave Technologies, Inc.
 MODEL NUMBER :LRS455-EU-C-MS
 TEST MODE :TRANSMIT AT 460MHz
 TEST PARAMETERS :OCCUPIED BANDWIDTH
 NOTES :2 WATT SETTING, 4 LEVEL GFSK
 EQUIPMENT USED :RBA1, T2S3, T2DS

NOTES



Marker 1 [T3]

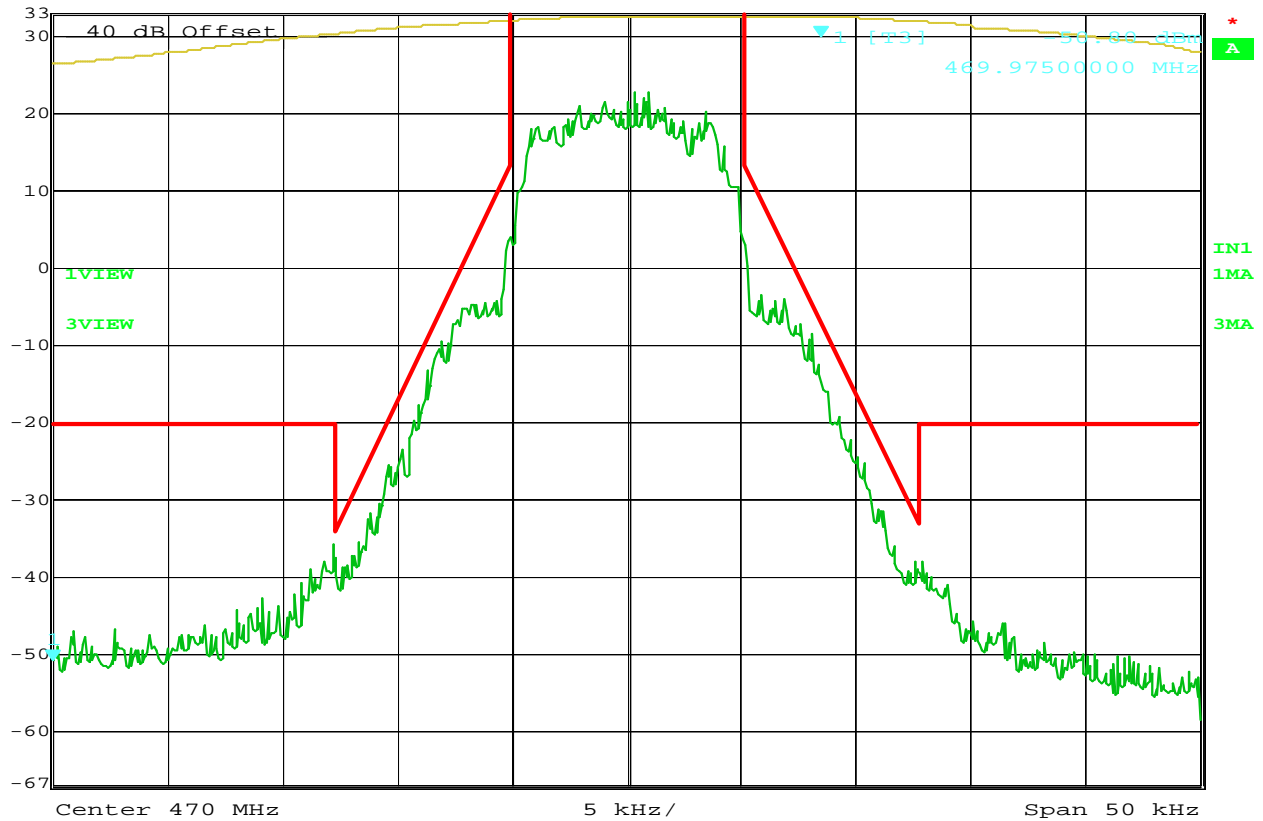
RBW 100 Hz RF Att 20 dB

Ref Lvl 33 dBm

-50.80 dBm
469.9750000 MHz

VBW 1 kHz
SWT 25 s

Unit dBm



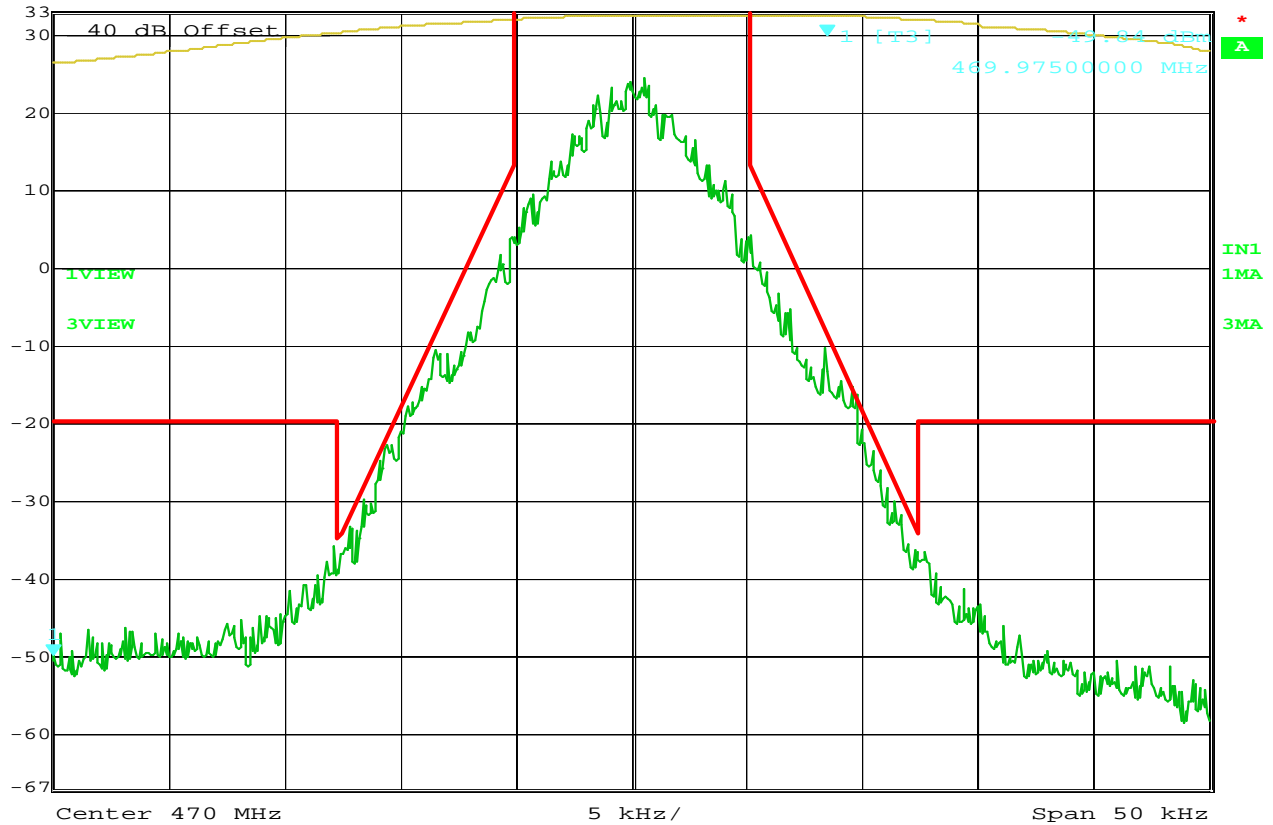
Date: 18.JUL.2011 11:30:48

MANUFACTURER :FreeWave Technologies, Inc.
 MODEL NUMBER :LRS455-EU-C-MS
 TEST MODE :TRANSMIT AT 470MHz
 TEST PARAMETERS :OCCUPIED BANDWIDTH
 NOTES :2 WATT SETTING, 2 LEVEL GFSK
 EQUIPMENT USED :RBA1, T2S3, T2DS

NOTES



Marker 1 [T3] RBW 100 Hz RF Att 20 dB
 Ref Lvl -49.84 dBm VBW 1 kHz
 33 dBm 469.9750000 MHz SWT 25 s Unit dBm



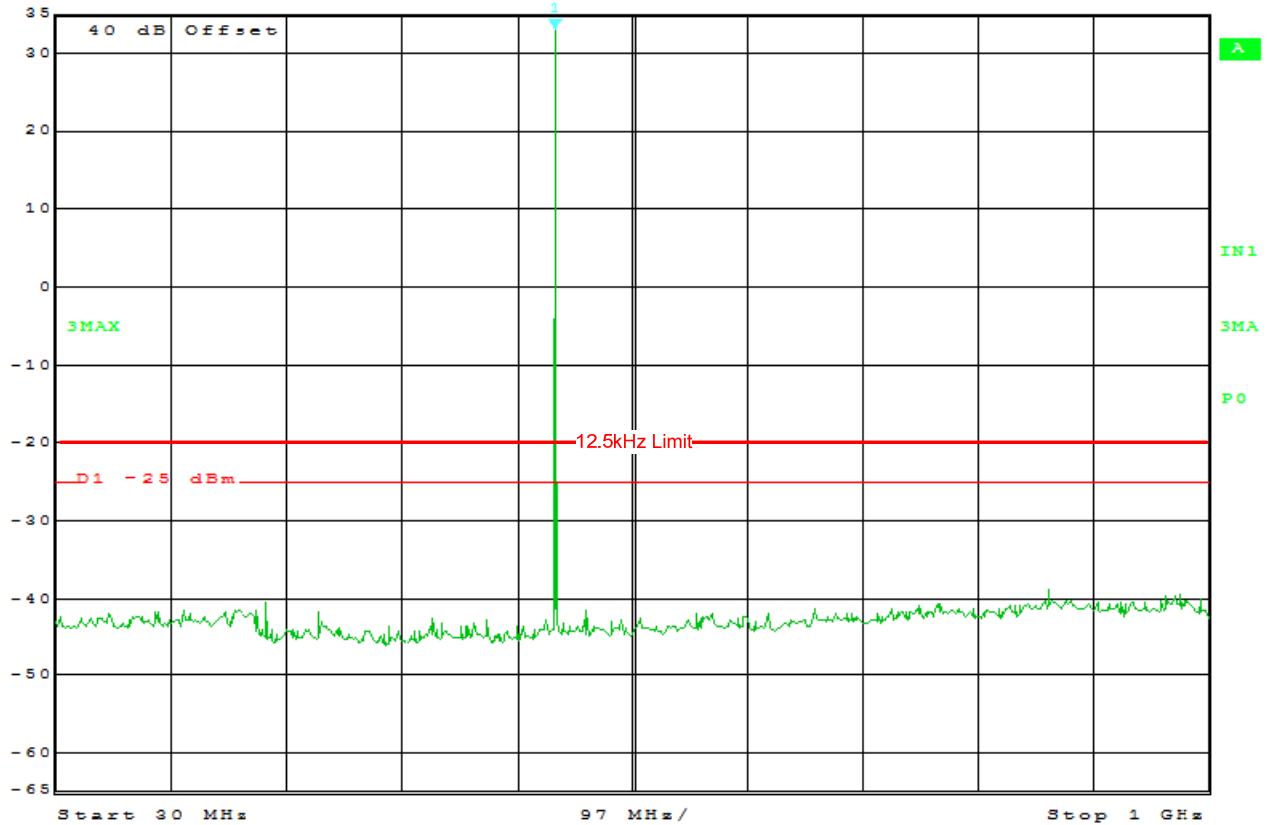
Date: 18.JUL.2011 11:32:49

MANUFACTURER :FreeWave Technologies, Inc.
 MODEL NUMBER :LRS455-EU-C-MS
 TEST MODE :TRANSMIT AT 470MHz
 TEST PARAMETERS :OCCUPIED BANDWIDTH
 NOTES :2 WATT SETTING, 4 LEVEL GFSK
 EQUIPMENT USED :RBA1, T2S3, T2DS

NOTES



Marker 1 [T3] RBW 100 kHz RF Att 10 dB
 Ref Lvl 32.97 dBm VBW 100 kHz
 35 dBm 449.87975952 MHz SWT 300 ms Unit dBm



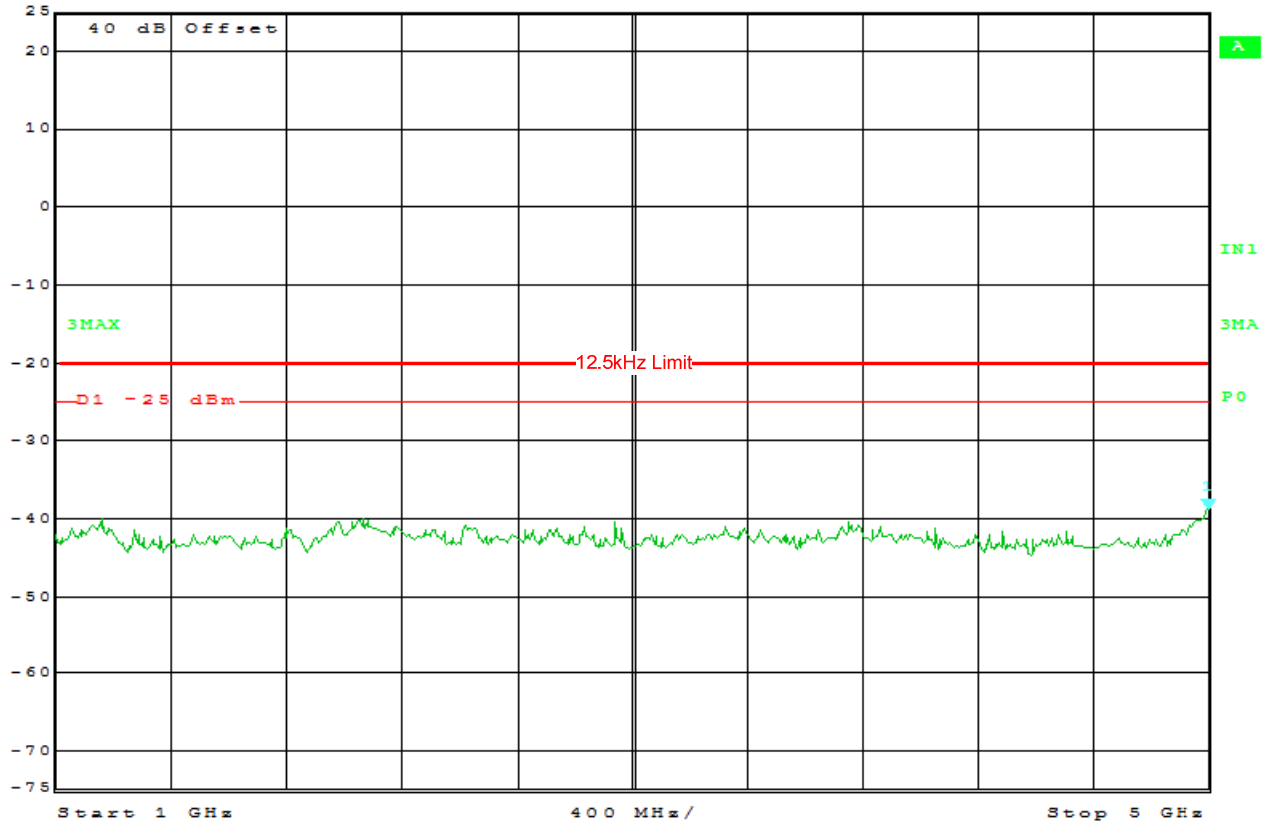
Date: 14.JUL.2011 16:05:20

MANUFACTURER :FreeWave Technologies, Inc.
 MODEL NUMBER :LRS455-EU-C-MS
 TEST MODE :TRANSMIT AT 450.0MHz
 TEST PARAMETERS :ANTENNA CONDUCTED
 NOTES :2 WATT SETTING
 EQUIPMENT USED :RBB0, T2S3, T2DS

NOTES



Marker 1 [T3] RBW 1 MHz RF Att 0 dB
 Ref Lvl -38.96 dBm VBW 1 MHz
 25 dBm 5.00000000 GHz SWT 10 ms Unit dBm



Date: 14.JUL.2011 16:16:26

MANUFACTURER :FreeWave Technologies, Inc.
 MODEL NUMBER :LRS455-EU-C-MS
 TEST MODE :TRANSMIT AT 450.0MHz
 TEST PARAMETERS :ANTENNA CONDUCTED
 NOTES :2 WATT SETTING
 EQUIPMENT USED :RBB0, T2S3, T2DS

NOTES



Marker 1 [T3]

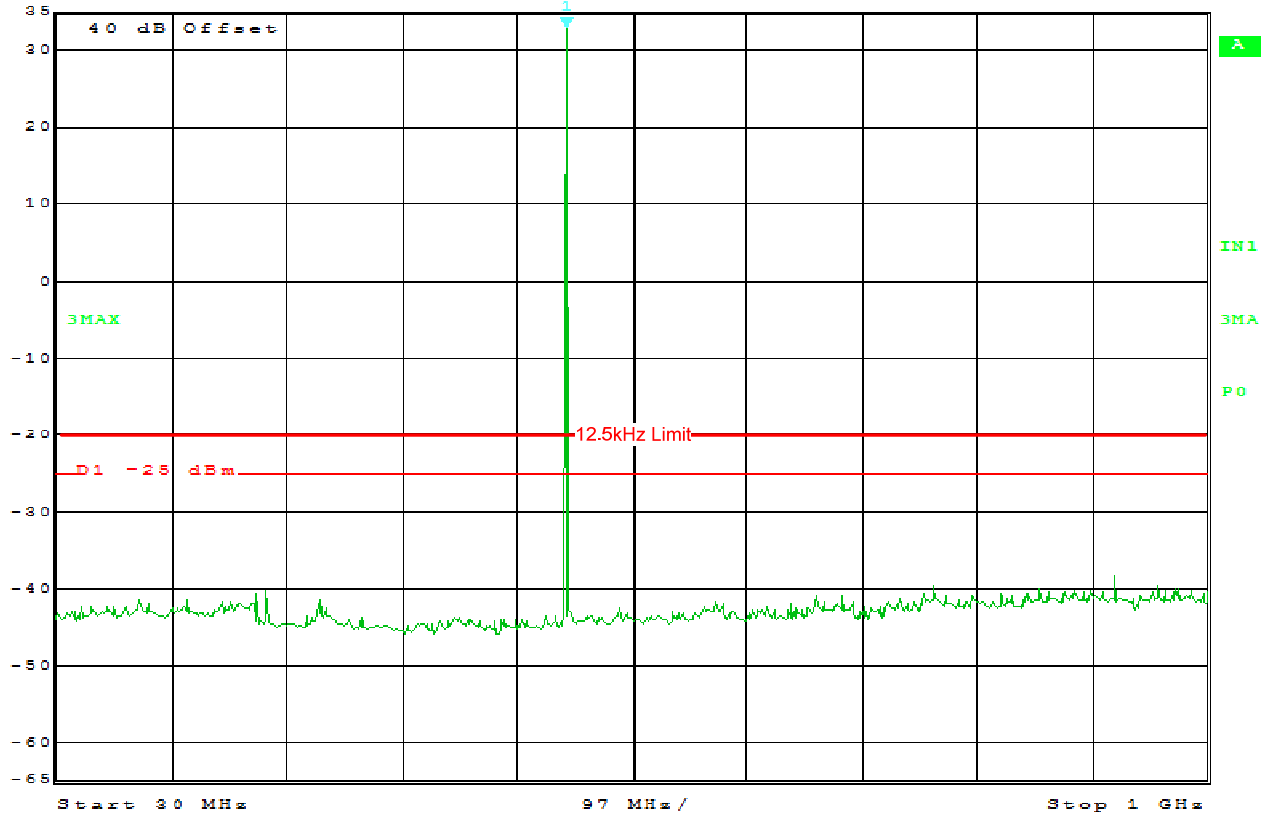
RBW 100 kHz RF Att 10 dB

Ref Lvl 32.94 dBm

VBW 100 kHz

35 dBm 459.59919840 MHz

SWT 300 ms Unit dBm



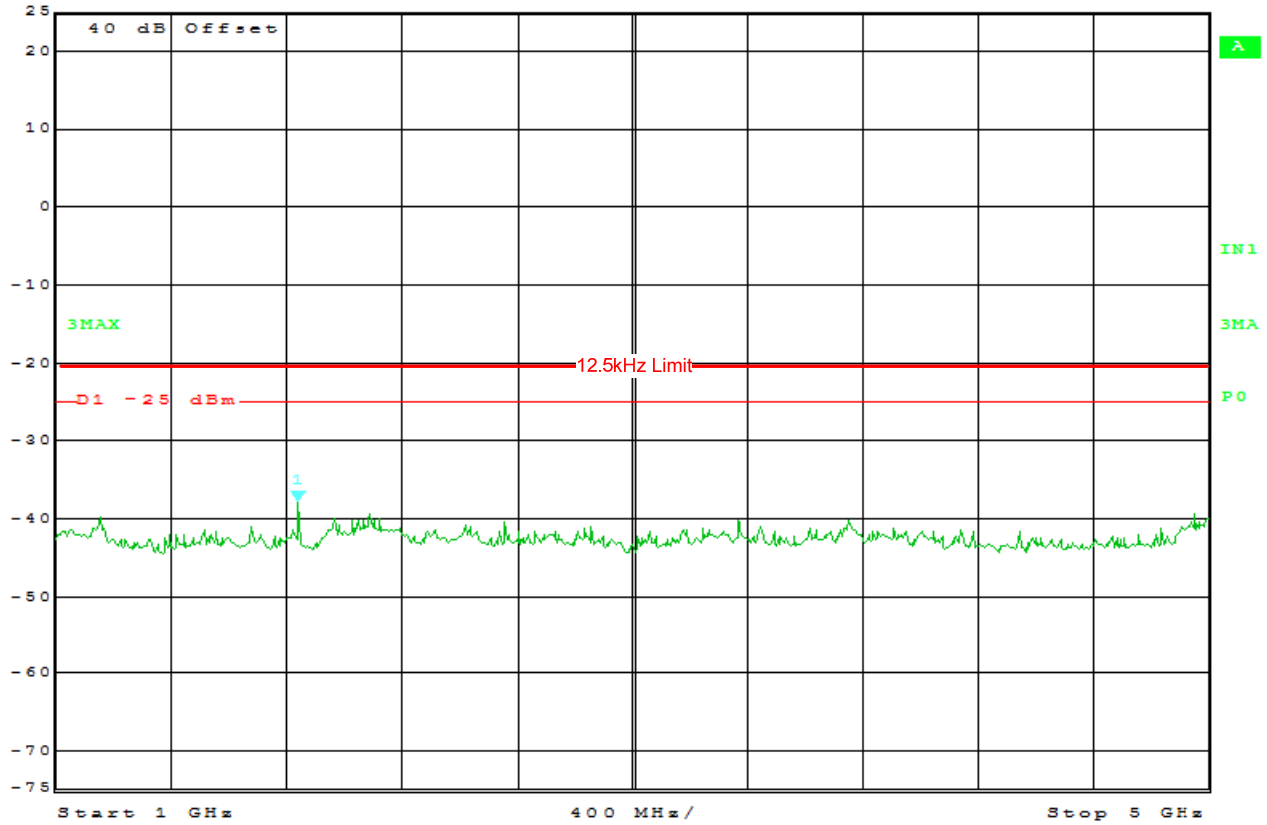
Date: 14.JUL.2011 16:06:51

MANUFACTURER :FreeWave Technologies, Inc.
 MODEL NUMBER :LRS455-EU-C-MS
 TEST MODE :TRANSMIT AT 460.0MHz
 TEST PARAMETERS :ANTENNA CONDUCTED
 NOTES :2 WATT SETTING
 EQUIPMENT USED :RBB0, T2S3, T2DS

NOTES



Marker 1 [T3] RBW 1 MHz RF Att 0 dB
 Ref Lvl -37.85 dBm VBW 1 MHz
 25 dBm 1.84168337 GHz SWT 10 ms Unit dBm



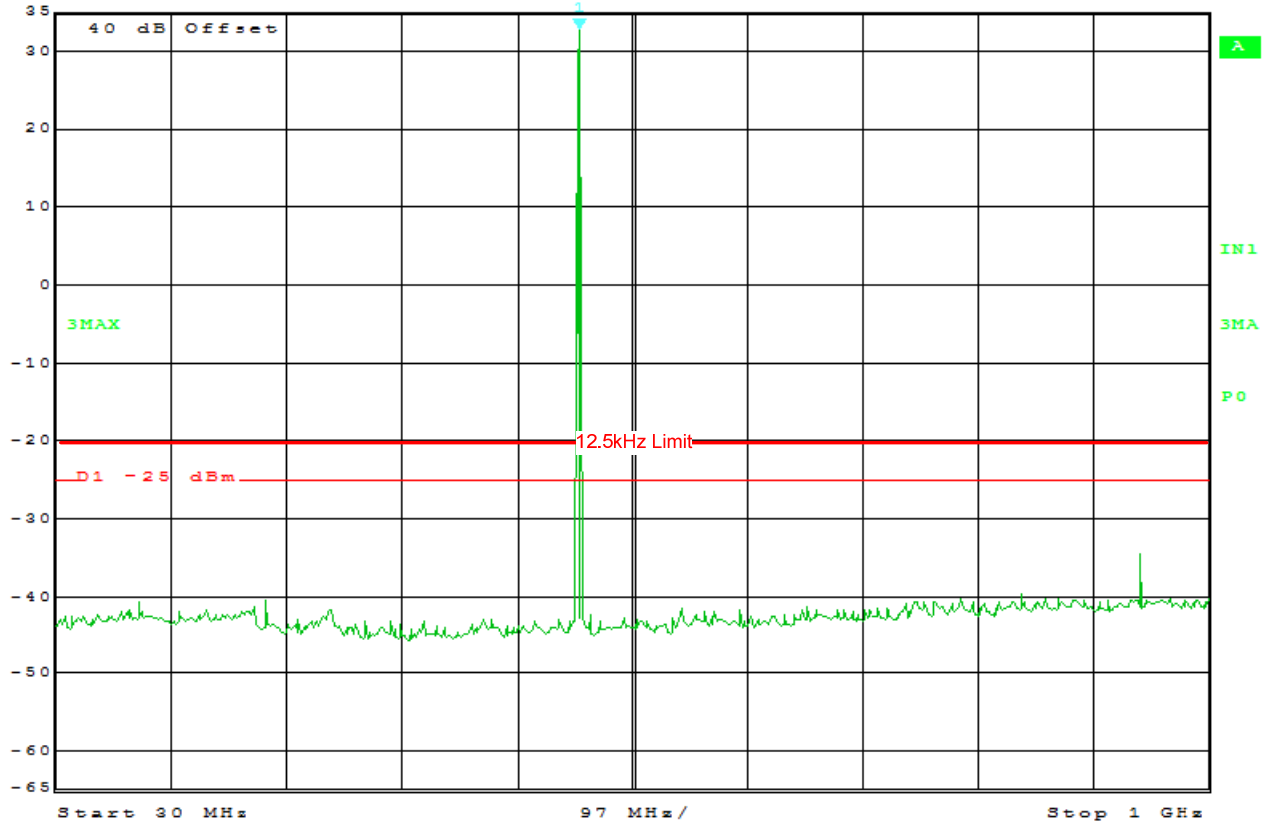
Date: 14.JUL.2011 16:14:59

MANUFACTURER :FreeWave Technologies, Inc.
 MODEL NUMBER :LRS455-EU-C-MS
 TEST MODE :TRANSMIT AT 460.0MHz
 TEST PARAMETERS :ANTENNA CONDUCTED
 NOTES :2 WATT SETTING
 EQUIPMENT USED :RBB0, T2S3, T2DS

NOTES



Marker 1 [T3] RBW 100 kHz RF Att 10 dB
 Ref Lvl 32.58 dBm VBW 100 kHz
 35 dBm 471.26252505 MHz SWT 300 ms Unit dBm



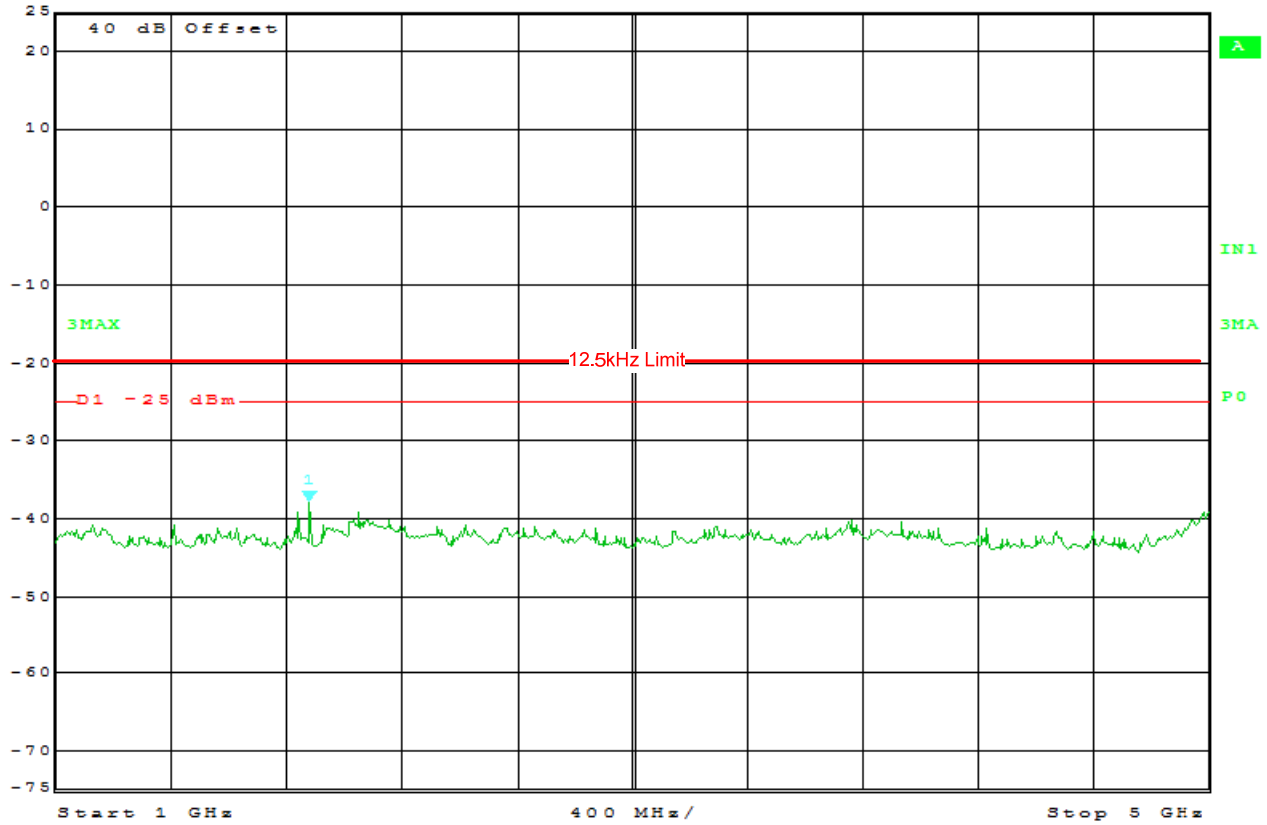
Date: 14.JUL.2011 16:08:44

MANUFACTURER :FreeWave Technologies, Inc.
 MODEL NUMBER :LRS455-EU-C-MS
 TEST MODE :TRANSMIT AT 470.0MHz
 TEST PARAMETERS :ANTENNA CONDUCTED
 NOTES :2 WATT SETTING
 EQUIPMENT USED :RBB0, T2S3, T2DS

NOTES



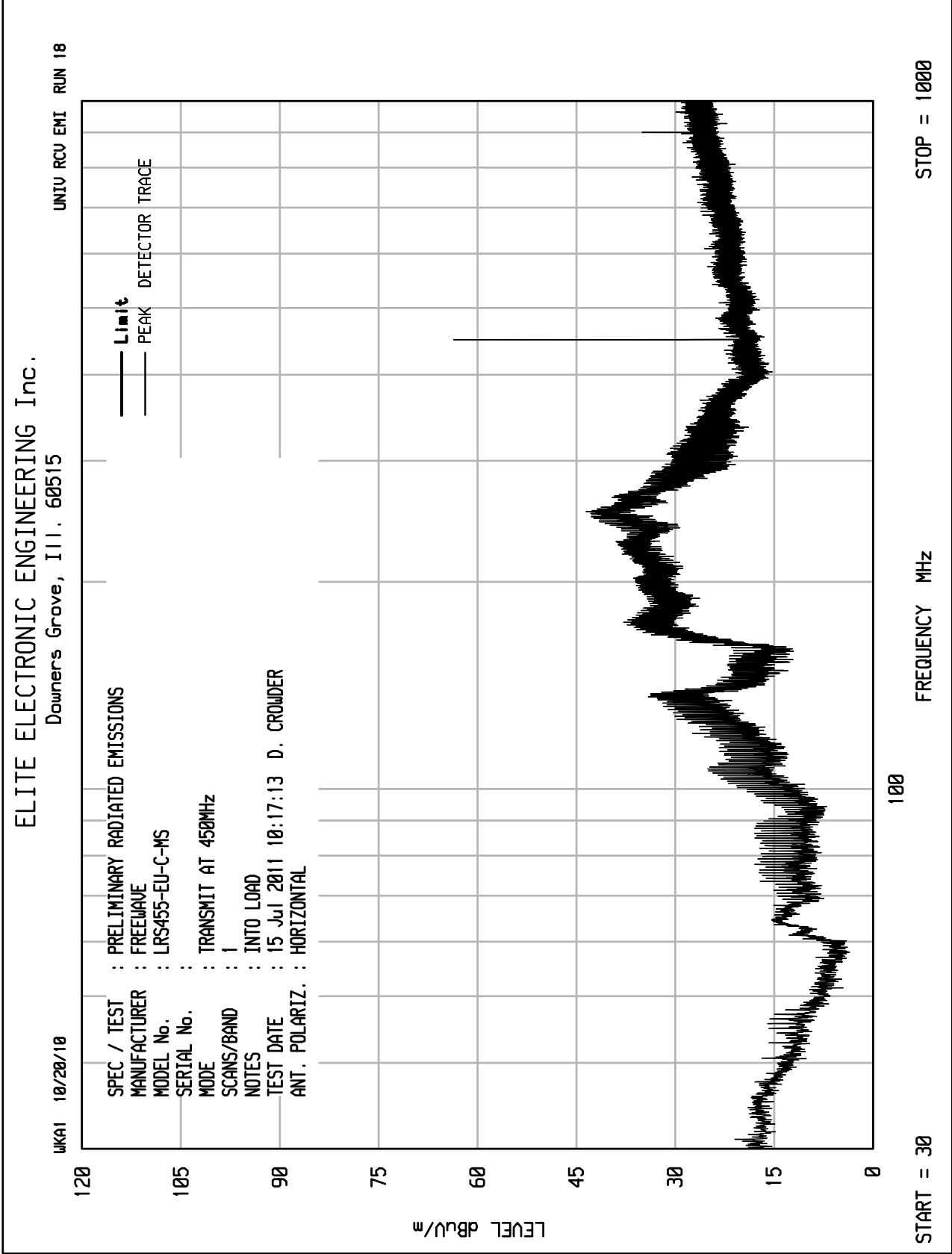
Marker 1 [T3] RBW 1 MHz RF Att 0 dB
 Ref Lvl -37.78 dBm VBW 1 MHz
 25 dBm 1.88176353 GHz SWT 10 ms Unit dBm



Date: 14.JUL.2011 16:13:28

MANUFACTURER :FreeWave Technologies, Inc.
 MODEL NUMBER :LRS455-EU-C-MS
 TEST MODE :TRANSMIT AT 470.0MHz
 TEST PARAMETERS :ANTENNA CONDUCTED
 NOTES :2 WATT SETTING
 EQUIPMENT USED :RBB0, T2S3, T2DS

NOTES

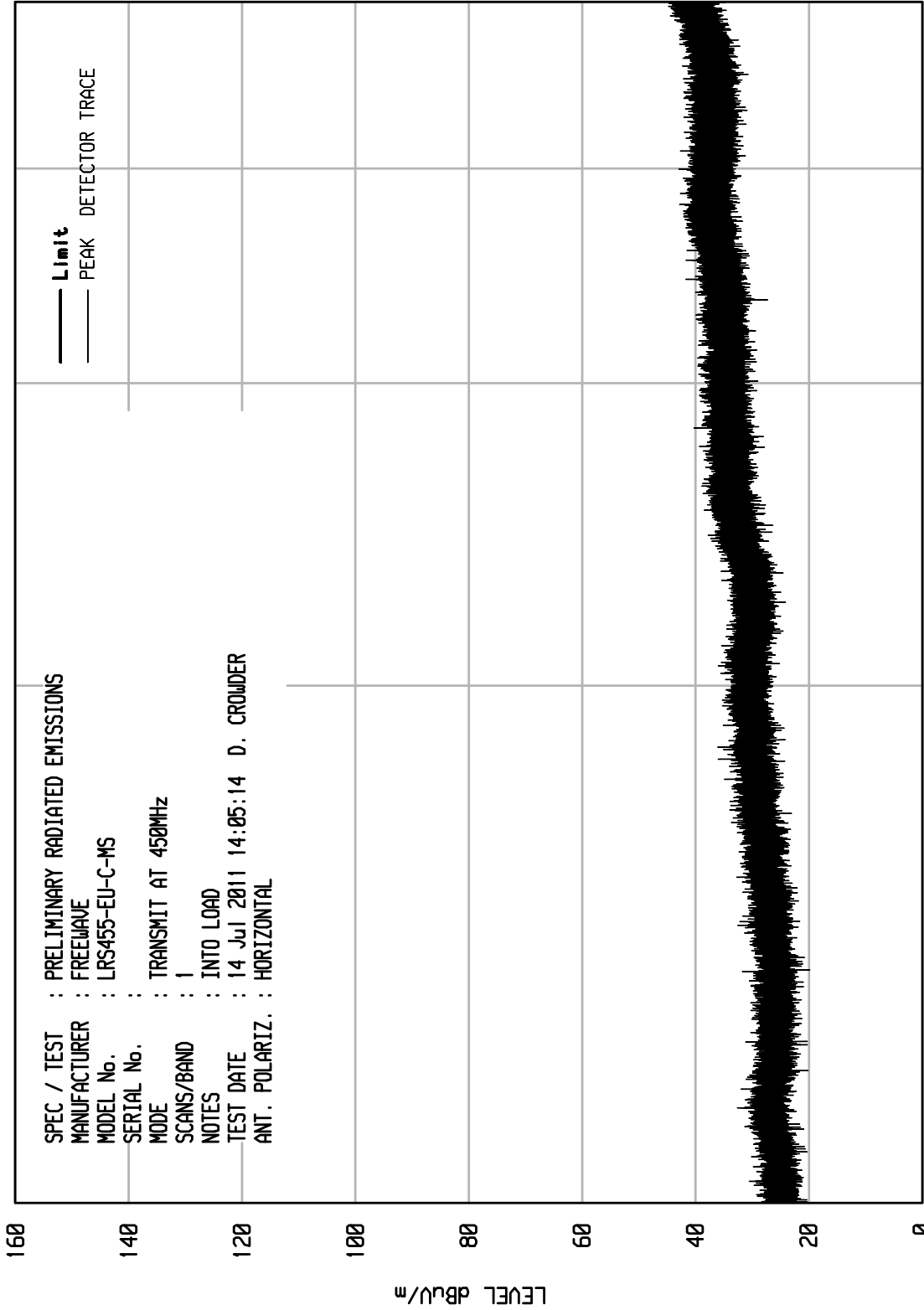


ELITE ELECTRONIC ENGINEERING Inc.
Downers Grove, Ill. 60515

UNIU RCU EMI RUN 8

UJKR1 10/20/10

SPEC / TEST : PRELIMINARY RADIATED EMISSIONS
 MANUFACTURER : FREEWAVE
 MODEL No. : LRS455-EU-C-MS
 SERIAL No. :
 MODE : TRANSMIT AT 450MHz
 SCANS/BAND : 1
 NOTES : INTO LOAD
 TEST DATE : 14 Jul 2011 14:05:14 D. CROWDER
 ANT. POLARIZ. : HORIZONTAL



STOP = 5000

FREQUENCY MHz

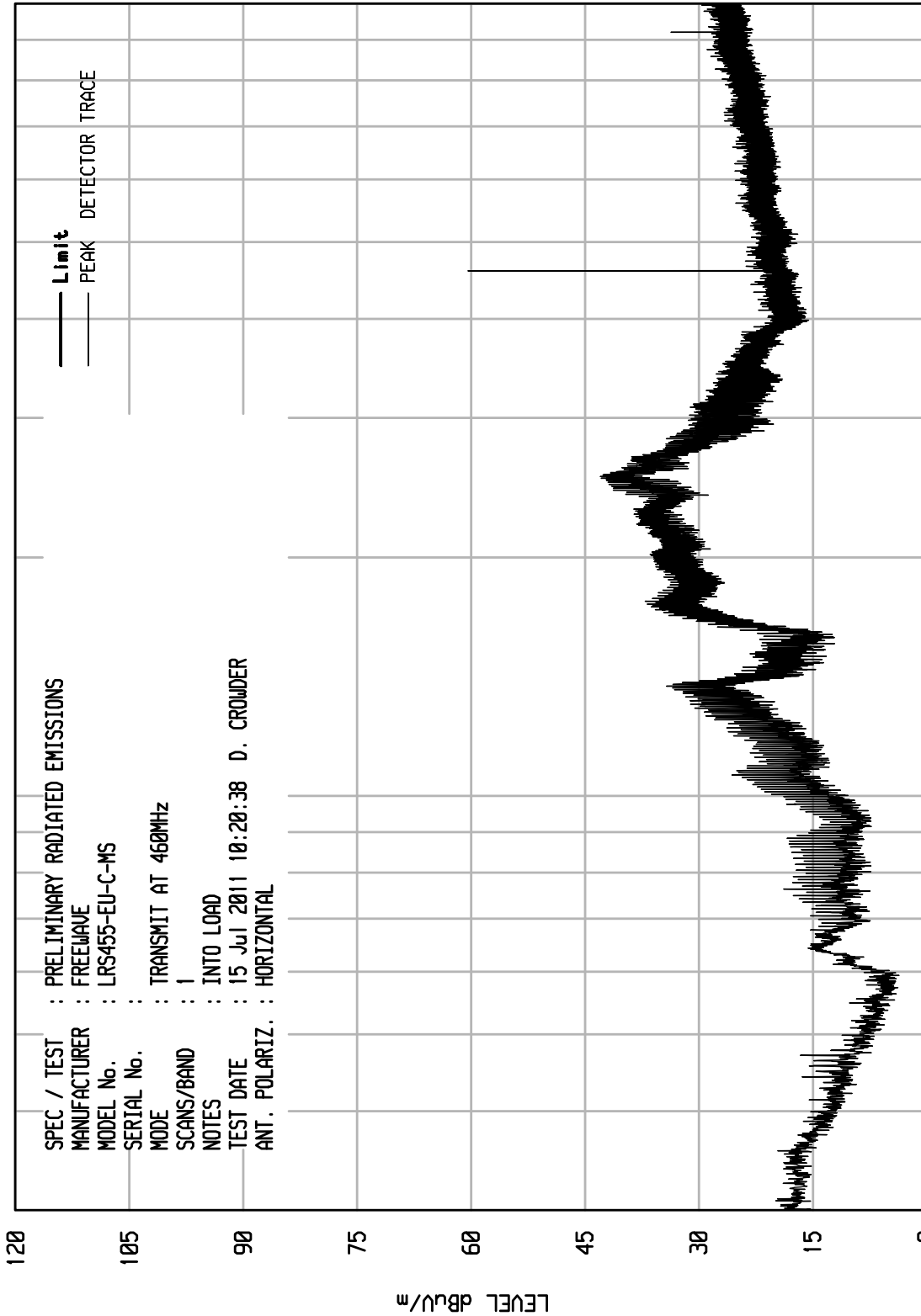
START = 1000

ELITE ELECTRONIC ENGINEERING Inc.
Downers Grove, Ill. 60515

UNIU RCU EMI RUN 19

UJKR1 10/20/10

SPEC / TEST : PRELIMINARY RADIATED EMISSIONS
 MANUFACTURER : FREEWAVE
 MODEL No. : LRS455-EU-C-MS
 SERIAL No. :
 MODE : TRANSMIT AT 460MHz
 SCANS/BAND : 1
 NOTES : INTO LOAD
 TEST DATE : 15 Jul 2011 10:20:38 D. CROWDER
 ANT. POLARIZ. : HORIZONTAL



STOP = 1000

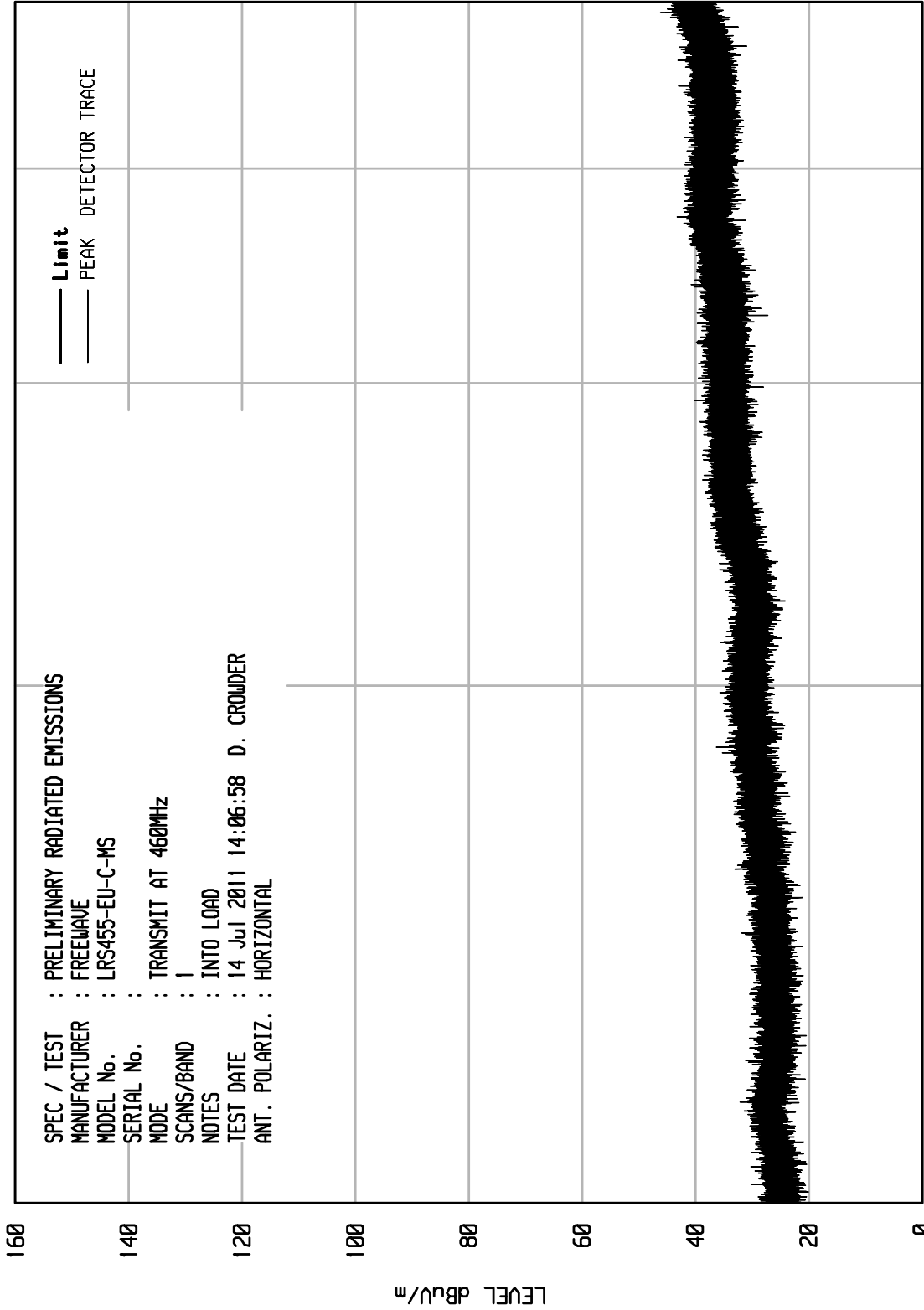
START = 30

ELITE ELECTRONIC ENGINEERING Inc.
Downers Grove, Ill. 60515

UNIU RCU EMI RUN 9

UJKAI 10/20/10

SPEC / TEST : PRELIMINARY RADIATED EMISSIONS
 MANUFACTURER : FREEWAVE
 MODEL No. : LRS455-EU-C-MS
 SERIAL No. :
 MODE : TRANSMIT AT 460MHz
 SCANS/BAND : 1
 NOTES : INTO LOAD
 TEST DATE : 14 Jul 2011 14:06:58 D. CROWDER
 ANT. POLARIZ. : HORIZONTAL



START = 1000

FREQUENCY MHz

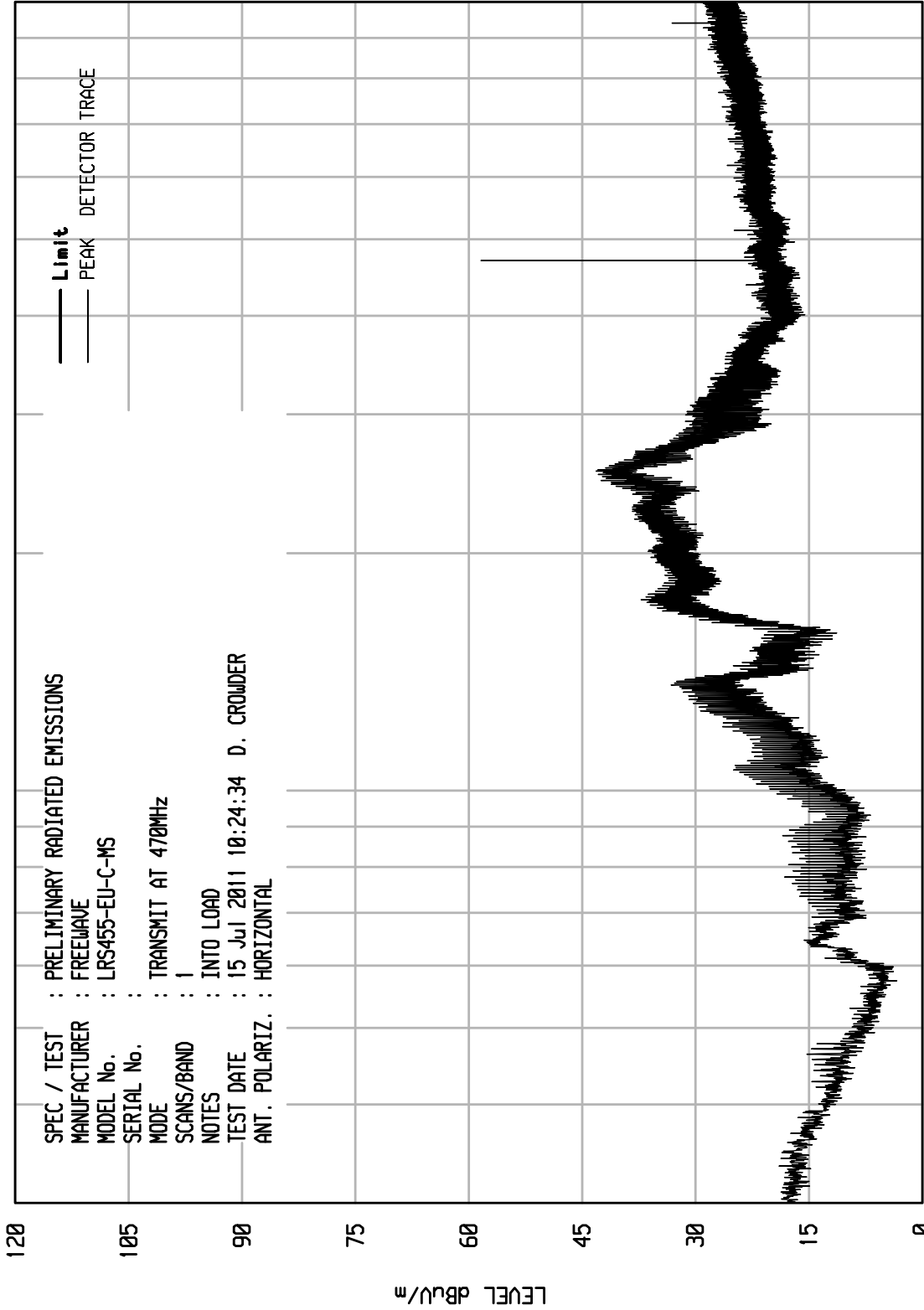
STOP = 5000

ELITE ELECTRONIC ENGINEERING Inc.
Downers Grove, Ill. 60515

UNIU RCU EMI RUN 20

UJK1 10/20/10

SPEC / TEST : PRELIMINARY RADIATED EMISSIONS
 MANUFACTURER : FREEWAVE
 MODEL No. : LRS455-EU-C-MS
 SERIAL No. :
 MODE : TRANSMIT AT 470MHz
 SCANS/BAND : 1
 NOTES : INTO LOAD
 TEST DATE : 15 Jul 2011 10:24:34 D. CROWDER
 ANT. POLARIZ. : HORIZONTAL



— Limit
 — PEAK
 — DETECTOR TRACE

STOP = 1000

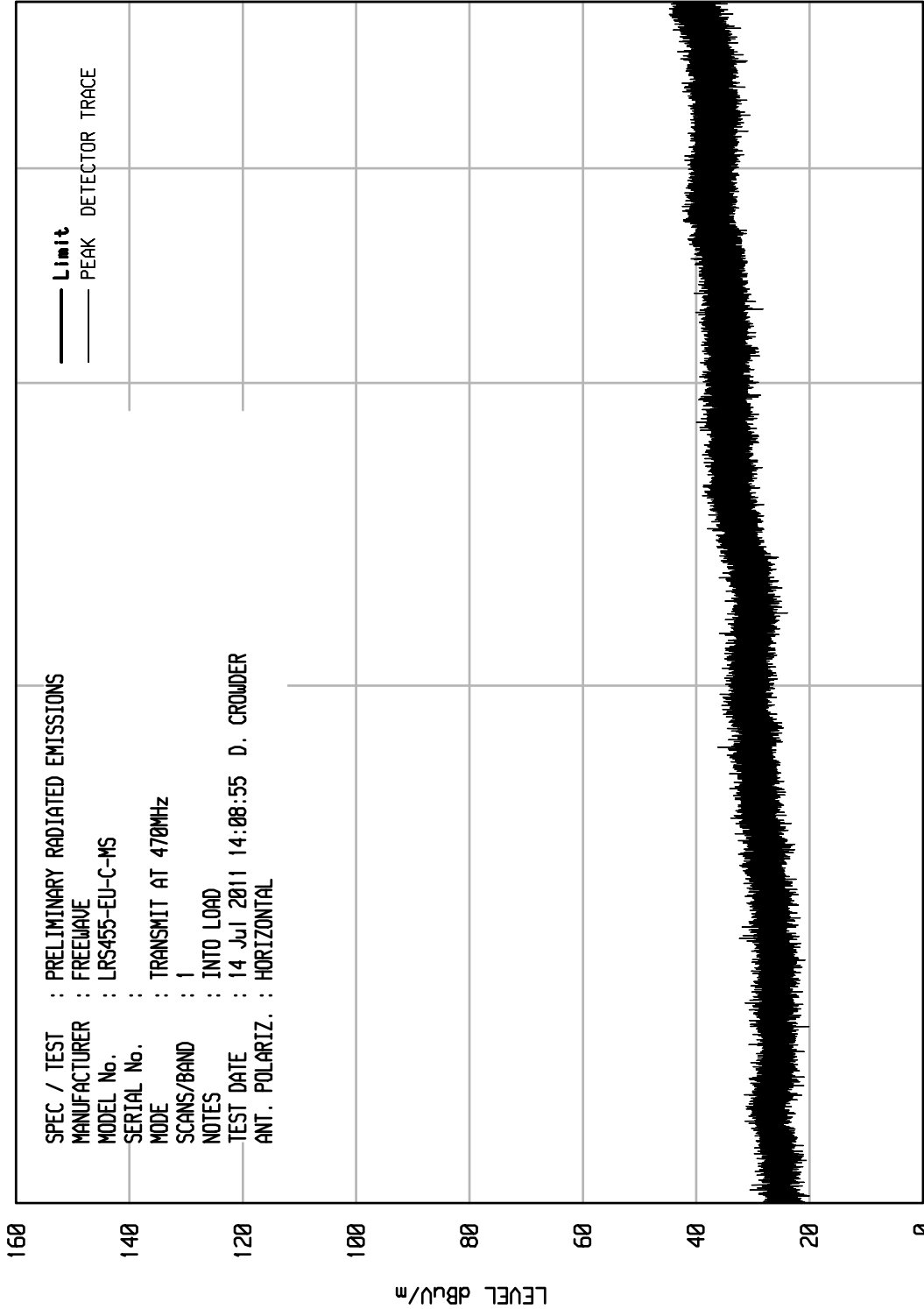
FREQUENCY MHz

START = 30

ELITE ELECTRONIC ENGINEERING Inc.
Downers Grove, Ill. 60515

UNIU RCU EMI RUN 10

UKA1 10/20/10



SPEC / TEST : PRELIMINARY RADIATED EMISSIONS
 MANUFACTURER : FREEMOVE
 MODEL No. : LRS455-EU-C-MS
 SERIAL No. :
 MODE : TRANSMIT AT 470MHz
 SCANS/BAND : 1
 NOTES : INTO LOAD
 TEST DATE : 14 Jul 2011 14:08:55 D. CROWDER
 ANT. POLARIZ. : HORIZONTAL

START = 1000

FREQUENCY MHz

STOP = 5000



MANUFACTURER : FreeWave Technologies, Inc.
 MODEL : LRS455-EU-C-MS
 SPECIFICATION : FCC Part 90/RSS-119 Spurious Radiated Emissions
 DATE : July 15, 2011
 NOTES : Transmit at 450MHz
 : Test Distance is 3 meters

Freq (MHz)	Ant Pol	Meter Reading (dBuV)	Ambient	Matched	Equivalent	CBL (dB)	Total (dBm)	MIN ATTEN	FCC Minimum Attenuation
				SIG. GEN. (dB)	Ant Gain (dB)				
910.00	H	17.7		-57.2	0.0	1.9	-59.1	92.1	53
910.00	V	14.4		-59.0	0.0	1.9	-60.9	93.9	53
1365.00	H	14.1	*	-62.6	4.4	2.4	-60.5	93.6	53
1365.00	V	14.8	*	-61.6	4.4	2.4	-59.6	92.6	53
1820.00	H	17.2		-57.4	5.2	2.8	-55.0	88.0	53
1820.00	V	17.8		-56.1	5.2	2.8	-53.7	86.7	53
2275.00	H	14.5	*	-58.5	5.6	3.0	-55.9	88.9	53
2275.00	V	14.9	*	-56.4	5.6	3.0	-53.8	86.8	53
2730.00	H	14.7	*	-56.8	5.8	3.2	-54.2	87.2	53
2730.00	V	15.0	*	-54.1	5.8	3.2	-51.5	84.5	53
3185.00	H	15.3	*	-54.8	6.1	3.4	-52.0	85.0	53
3185.00	V	15.2	*	-52.8	6.1	3.4	-50.1	83.1	53
3640.00	H	16.3	*	-51.9	6.8	3.8	-48.9	81.9	53
3640.00	V	15.8	*	-51.1	6.8	3.8	-48.1	81.1	53
4095.00	H	15.5	*	-50.1	7.2	4.1	-47.0	80.0	53
4095.00	V	15.3	*	-50.0	7.2	4.1	-46.8	79.8	53
4550.00	H	16.2	*	-48.9	8.2	4.4	-45.1	78.1	53
4550.00	V	15.5	*	-50.1	8.2	4.4	-46.2	79.2	53

MIN ATTEN = (matched signal + antenna gain - cable loss) – power in dBm
 FCC minimum attenuation = 50+ 10*log(Power in watts) = 50 + 10*log(2W) = 53



MANUFACTURER : FreeWave Technologies, Inc.
 MODEL : LRS455-EU-C-MS
 SPECIFICATION : FCC Part 90/RSS-119 Spurious Radiated Emissions
 DATE : July 15, 2011
 NOTES : Transmit at 460MHz
 : Test Distance is 3 meters

Freq (MHz)	Ant Pol	Meter		Matched	Equivalent		Total (dBm)	MIN ATTEN	FCC Minimum Attenuation
		Reading (dBuV)	Ambient	SIG. GEN. (dB)	Ant Gain (dB)	CBL (dB)			
920.00	H	16.1		-58.5	0.0	1.9	-60.4	93.4	53
920.00	V	12.8		-60.0	0.0	1.9	-61.9	94.9	53
1380.00	H	14.4	*	-62.3	4.5	2.4	-60.2	93.2	53
1380.00	V	14.9	*	-61.5	4.5	2.4	-59.4	92.5	53
1840.00	H	16.7		-57.8	5.2	2.8	-55.4	88.4	53
1840.00	V	16.6		-57.2	5.2	2.8	-54.8	87.8	53
2300.00	H	14.5	*	-58.5	5.6	3.0	-55.8	88.9	53
2300.00	V	14.9	*	-56.2	5.6	3.0	-53.6	86.6	53
2760.00	H	15.2	*	-56.2	5.8	3.2	-53.6	86.6	53
2760.00	V	16.2	*	-52.8	5.8	3.2	-50.2	83.2	53
3220.00	H	15.2	*	-54.8	6.2	3.4	-52.0	85.0	53
3220.00	V	15.6	*	-52.4	6.2	3.4	-49.6	82.6	53
3680.00	H	15.5	*	-52.4	6.8	3.8	-49.4	82.4	53
3680.00	V	17.1	*	-49.6	6.8	3.8	-46.6	79.6	53
4140.00	H	15.7	*	-49.9	7.4	4.1	-46.7	79.7	53
4140.00	V	15.4	*	-49.9	7.4	4.1	-46.7	79.7	53
4600.00	H	17.0	*	-47.8	8.2	4.4	-44.0	77.0	53
4600.00	V	15.1	*	-50.1	8.2	4.4	-46.4	79.4	53

MIN ATTEN = (matched signal + antenna gain - cable loss) – power in dBm
 FCC minimum attenuation = $50 + 10 \cdot \log(\text{Power in watts}) = 50 + 10 \cdot \log(2W) = 53$



MANUFACTURER : FreeWave Technologies, Inc.
 MODEL : LRS455-EU-C-MS
 SPECIFICATION : FCC Part 90/RSS-119 Spurious Radiated Emissions
 DATE : July 15, 2011
 NOTES : Transmit at 470MHz
 : Test Distance is 3 meters

Freq (MHz)	Ant Pol	Meter Reading (dBuV)	Ambient	Matched Equivalent		CBL (dB)	Total (dBm)	MIN ATTEN	FCC Minimum Attenuation
				SIG. GEN. (dB)	Ant Gain (dB)				
940.00	H	15.2		-58.7	0.0	1.9	-60.6	93.6	53
940.00	V	13.7		-58.0	0.0	1.9	-59.9	92.9	53
1410.00	H	14.8	*	-61.9	4.6	2.4	-59.7	92.7	53
1410.00	V	13.7	*	-62.8	4.6	2.4	-60.6	93.6	53
1880.00	H	16.6	*	-57.8	5.2	2.8	-55.3	88.4	53
1880.00	V	14.3	*	-59.3	5.2	2.8	-56.9	89.9	53
2350.00	H	14.5	*	-58.3	5.7	3.0	-55.7	88.7	53
2350.00	V	13.9	*	-56.9	5.7	3.0	-54.3	87.3	53
2820.00	H	15.5	*	-55.7	5.8	3.2	-53.1	86.1	53
2820.00	V	15.9	*	-52.9	5.8	3.2	-50.3	83.3	53
3290.00	H	14.9	*	-54.9	6.3	3.5	-52.0	85.0	53
3290.00	V	14.8	*	-53.1	6.3	3.5	-50.3	83.3	53
3760.00	H	15.2	*	-52.1	6.8	3.9	-49.1	82.2	53
3760.00	V	15.9	*	-50.4	6.8	3.9	-47.4	80.4	53
4230.00	H	15.3	*	-50.3	7.6	4.2	-46.9	79.9	53
4230.00	V	14.9	*	-50.6	7.6	4.2	-47.2	80.2	53
4700.00	H	15.0	*	-49.2	8.1	4.5	-45.6	78.6	53
4700.00	V	15.7	*	-48.8	8.1	4.5	-45.2	78.2	53

MIN ATTEN = (matched signal + antenna gain - cable loss) – power in dBm
 FCC minimum attenuation = 50+ 10*log(Power in watts) = 50 + 10*log(2W) = 53



MANUFACTURER : FreeWave Technologies, Inc.
MODEL : LRS455-EU-C-MS
SPECIFICATION : FCC Part 90/RSS-119 Frequency Stability vs. Temperature
DATE : July 21, 2011
EQUIPMENT USED : MFC0, ETH2, ETHA
NOTES : Transmit at 460MHz

Temperature °C	Measured Frequency Hz	Frequency Error Hz	Limit Hz
+23	460000880		
-30	459999874	1006	1150
-20	459999788	1092	1150
-10	459999779	1101	1150
0	459999806	1074	1150
+10	459999806	1074	1150
+20	460000397	483	1150
+30	460001106	-226	1150
+40	460001236	-356	1150
+50	460001254	-374	1150

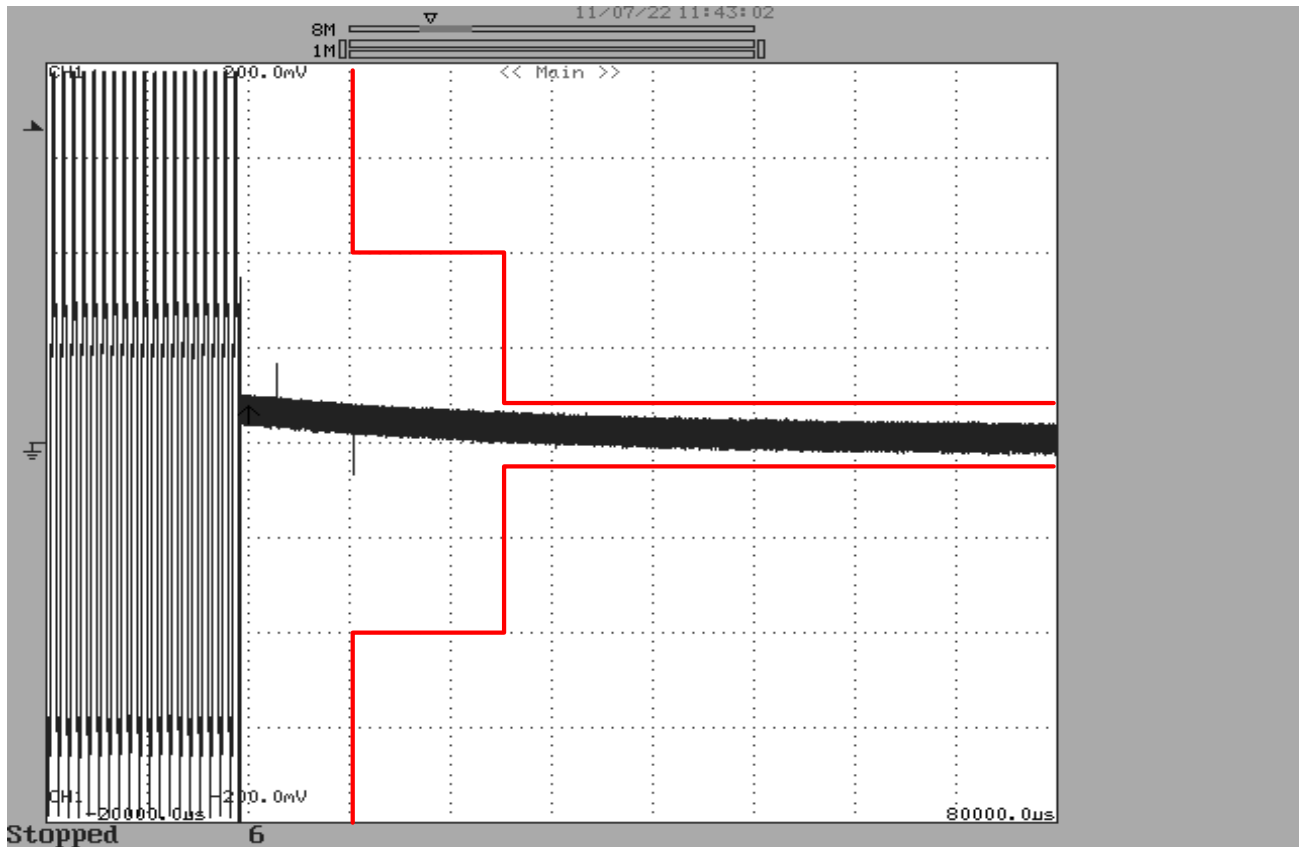
Limit = 2.5ppm = 460,000,880* 2.5ppm = 1150Hz



MANUFACTURER : FreeWave Technologies, Inc.
MODEL : LRS455-EU-C-MS
SPECIFICATION : FCC Part 90/RSS-119 Frequency Stability vs. Temperature
DATE : July 21, 2011
EQUIPMENT USED : MFC0, ETH2, ETHA
NOTES : Transmit at 460MHz

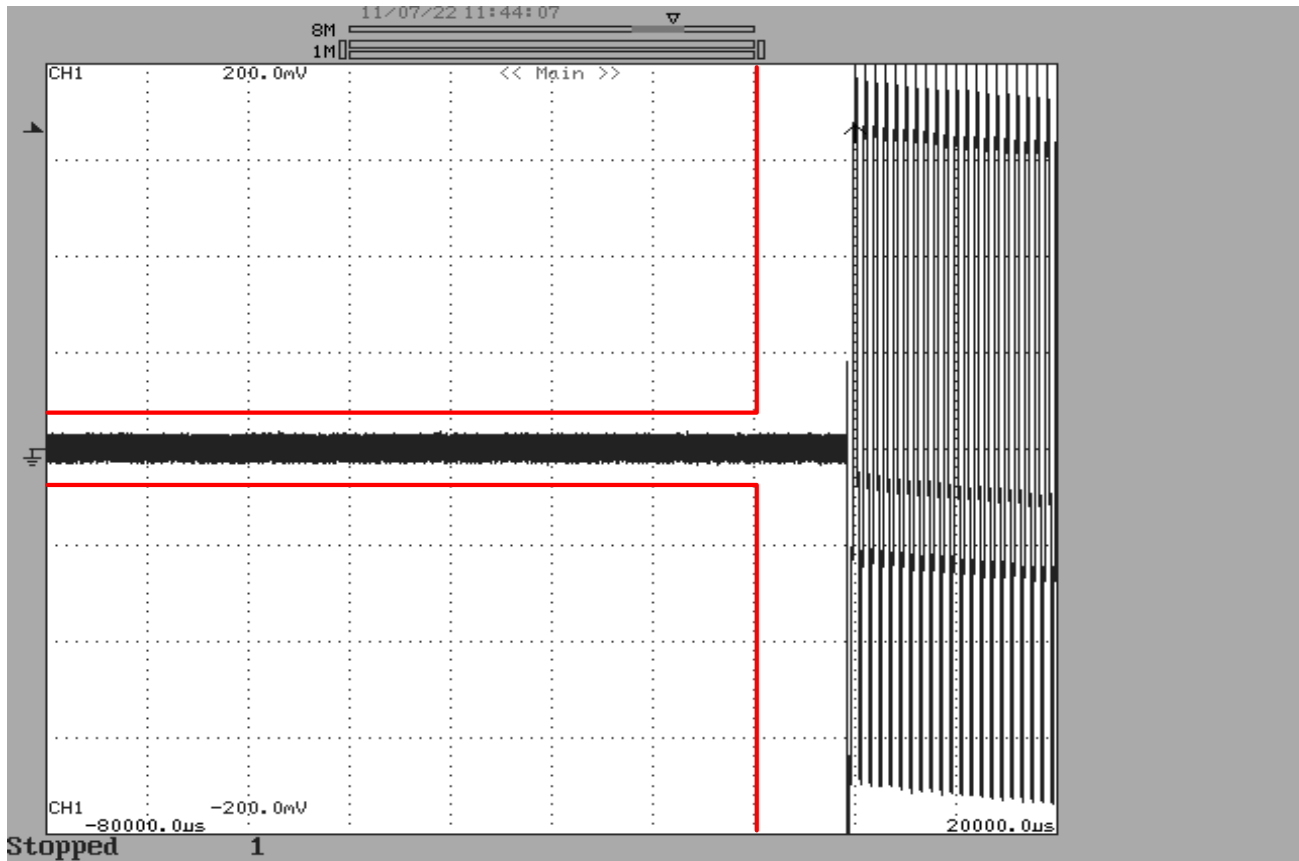
Supply Voltage VDC	Measured Frequency Hz	Frequency Error Hz	Limit Hz
10.2 (85%)	460000569	311	1150
12.0	460000880		
13.8 (115%)	460000777	103	1150

Limit = 2.5ppm = 460,000,880* 2.5ppm = 1150Hz



PART 90/RSS-119 - TRANSIENT FREQUENCY BEHAVIOR, ON TIME

MANUFACTURER	: FreeWave Technologies, Inc.
MODEL NUMBER	: LRS455-EU-C-MS
TEST	: Transient Frequency Behavior, On-time
TEST MODE	: Tx @ 460MHz, 12.5kHz channel spacing
TEST	: Transmit on Time, t1= 10ms, t2=25ms
EQUIPMENT USED	: MSP4, GBQ0, RYE0, T1D2



PART 90/RSS-119 - TRANSIENT FREQUENCY BEHAVIOR, OFF TIME

MANUFACTURER	: FreeWave Technologies, Inc.
MODEL NUMBER	: LRS455-EU-C-MS
TEST	: Transient Frequency Behavior, OFF-time
TEST MODE	: Tx @ 460MHz, 12.5kHz channel spacing
TEST	: Transmit off Time, t3=10msec
EQUIPMENT USED	: MSP4, GBQ0, RYE0, T1D2