Emissions
Test Report

EUT Name: RFID Reader

Model No.: TR-001-44

CFR 47 Part 15.225:2012 and RSS 210:2010

Prepared for:

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Revisions

Revision No.	Date MM/DD/YYYY	Reason for Change	Author
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Note: Latest revision report will replace all previous reports.

Statement of Compliance

Manufacturer:	Illumina, Inc 5200 Illumina Way. San Diego, CA 92122 (510) 670-9319
Requester / Applicant:	Carol Rogers Escano
Name of Equipment:	RFID Reader
Model No.	TR-001-44
Type of Equipment:	Industrial, Scientific, or Medical (ISM)
Application of Regulations:	CFR 47 Part 15.225:2012 and RSS 210:2010
Test Dates:	February 26, 2013 to May 1, 2013

Guidance Documents:

Emissions: ANSI C63.10: 2009

Test Methods:

Emissions: ANSI C63.10: 2009

The electromagnetic compatibility test and documented data described in this report has been performed and recorded by TUV Rheinland, in accordance with the standards and procedures listed herein. As the responsible authorized agent of the EMC laboratory, I hereby declare that the equipment described above has been shown to be compliant with the EMC requirements of the stated regulations and standards based on these results. If any special accessories and/or modifications were required for compliance, they are listed in the Executive Summary of this report.

This report must not be used to claim product endorsement by A2LA or any agency of the U.S. Government. This report contains data that are not covered by A2LA accreditation. This report shall not be reproduced except in full, without the written authorization of TUV Rheinland of North America.

Suresh Kondapalli	11 June 2013	Conan Boyle	13 June 2013
Test Engineer	Date	A2LA Signatory	Date

Industry Canada

Testing Cert #3331.02 **US5254** **2932M-1**

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1 Executive Summary

1.1 Scope

This report is intended to document the status of conformance with the requirements of the CFR 47 Part 15.225:2012 and RSS 210:2010 based on the results of testing performed on February 26, 2013 through May 1, 2013 on the RFID Reader Model TR-001-44 manufactured by Illumina, Inc. This report only applies to the specific samples tested under the stated test conditions. It is the responsibility of the manufacturer to assure that additional production units of this model are manufactured with identical or EMI equivalent electrical and mechanical components. This report is further intended to document changes and modifications to the EUT throughout its life cycle. All documentation will be included as a supplement.

1.2 Purpose

Testing was performed to evaluate the EMC performance of the EUT in accordance with the applicable requirements, procedures, and criteria defined in the application of regulations and application of standards listed in this report.

1.3 Summary of Test Results

Table 1: Summary of Test Results

Test	Test Method ANSI C63.4	Test Parameters (from Standard)	Result
Receiver Spurious Emissions	CFR47 15.109, RSS-GEN Sect.6	Class B	**Complied**
Transmitter Spurious Emissions	CFR47 15.209, RSS-GEN Sect.7.2.5	Class B	**Complied**
Restricted Bands of Operation	CFR47 15.205, RSS 210 Sect.2.6	Class B	**Complied**
AC Power Conducted Emissions	CFR47 15.207, RSS-GEN Sect.7.2.2	N/A	**Complied**
Occupied Bandwidth	CFR47 15.215 (c), RSS GEN Sect.4.4.1	N/A	**Complied**
Carrier Field Strength	CFR47 15.225 (a), RSS 210 Sect. A 2.6 (a)	124 dBuV/m at 3 meter	**Complied**
Out of Band Emissions	CFR47 15.225 (b), (c) RSS 210 Sect. A 2.6 (b) (c)	Per Standards.	**Complied**
Frequency Stability	CFR47 15.225 (e), RSS 210 Sect. A 2.6 (d)	100ppm / +0.01%	**Complied**
Voltage Variation	CFR47 15.31 (e),	100ppm / +0.01%	**Complied**
RF Exposure	CFR47 Part 1.1310	General Population	**Complied**

1.4 Special Accessories

No special accessories were necessary in order to achieve compliance.

1.5 Equipment Modifications

None.

2 Laboratory Information

2.1 Accreditations & Endorsements

2.1.1 US Federal Communications Commission

TUV Rheinland of North America at 1279 Quarry Lane, Ste. A., Pleasanton, CA 94566, is accredited by the commission for performing testing services for the general public on a fee basis. These laboratory test facilities have been fully described in reports submitted to and accepted by the FCC (FRN # US5254). The laboratory scope of accreditation includes: Title 47 CFR Parts 15, 18, and 90. The accreditation is updated every 3 years.

2.1.2 NIST / A2LA

TUV Rheinland of North America is accredited by the A2LA Accreditation Program, which is administered under the auspices of the National Institute of Standards and Technology. The laboratory has been assessed and accredited in accordance with ISO Guide 17025:2005 and ISO 9002 (Testing Cert #3331.02). The scope of laboratory accreditation includes emission and immunity testing. The accreditation is updated annually.

2.1.3 Canada – Industry Canada

Industry Canada

TUV Rheinland of North America at the 1279 Quarry Ln, Pleasanton, CA 94566 address is accredited by Industry Canada for performing testing services for the general public on a fee basis. This laboratory test facilities have been fully described in reports submitted to and accepted by Industry Canada (File Number 2932M). This reference number is the indication to the Industry Canada Certification Officers that the site meets the requirements of RSS 212, Issue 1 (Provisional). The accreditation is updated every 3 years.

2.1.4 Japan – VCCI

The Voluntary Control Council for Interference by Information Technology Equipment (VCCI) is a group that consists of Information Technology Equipment (ITE) manufacturers and EMC test laboratories. The purpose of the Council is to take voluntary control measures against electromagnetic interference from Information Technology Equipment, and thereby contribute to the development of a socially beneficial and responsible state of affairs in the realm of Information Technology Equipment in Japan. TUV Rheinland of North America at 1279 Quarry Lane, Pleasanton, CA 94566 has been assessed and approved in accordance with the Regulations for Voluntary Control Measures. (Registration Nos. A-0031).

2.2 Test Facilities

All of the test facilities are located at 1279 Quarry Lane, Ste. A, Pleasanton, California 94566, USA. The 2305 Mission College, Santa Clara, 95054, USA location is considered a Pleasanton annex.

2.2.1 Emission Test Facility

The Semi-Anechoic chamber and AC Line Conducted measurement facility used to collect the radiated and conducted data has been constructed in accordance with ANSI C63.7:1992. The site has been measured in accordance with and verified to comply with the theoretical normalized site attenuation requirements of ANSI C63.4:2009, at test distances of 3 and 5 meters. The site is listed with the FCC and accredited by A2LA (Testing Cert #3331.02). The 3/5-meter semi-anechoic chamber used to collect the radiated data has been verified to comply with the theoretical normalized site attenuation requirements of ANSI C63.4:2009, at test distances of 3 meters and 5 meters. A report detailing this site can be obtained from TUV Rheinland of North America.

2.2.2 Immunity Test Facility

ESD, EFT, Surge, PQF: These tests are performed in an environmentally controlled room with a 3.7 m x 4.8 m x 3.175 mm thick aluminum floor connected to PE ground.

For ESD testing, tabletop equipment is placed on an insulated mat with a surface resistivity of 10^9 Ohms/square on a 1.6 m x 0.8 m x 0.8 m high non-conductive table with a 3.175 mm aluminum top (Horizontal Coupling Plane). The HCP is connected to the main ground plane via a low impedance ground strap through two 470-kΩ resistors. The Vertical Coupling Plane consists of an aluminum plate 50 cm x 50 cm x 3.175 mm thick. The VCP is connected to the main ground plane via a low impedance ground strap through two 470-kΩ resistors.

For EFT, Surge, PQF, the HCP and VCP are removed.

RF Field Immunity testing is performed in a 7.3m x 4.3m x 4.1m anechoic chamber.

RF Conducted and Magnetic Field Immunity testing is performed on a 4.8m x 3.7m x 3.175mm thick aluminum ground plane.

All test areas allow a minimum distance of 1 meter from the EUT to walls or conducting objects.

2.3 Measurement Uncertainty

Two types of measurement uncertainty are expressed in this report, per *ISO Guide To The Expression Of Uncertainty In Measurement*, 1st Edition, 1995.

The Combined Standard Uncertainty is the standard uncertainty of the result of a measurement when that result is obtained from the values of a number of other quantities; it is equal to the positive square root of the sum of the variances or co-variances of these other quantities, weighted according to how the measurement result varies with changes in these quantities. The term *standard uncertainty* is the result of a measurement expressed as a standard deviation.

The Expanded Uncertainty defines an interval about the result of a measurement that may be expected to encompass a large fraction of the distribution of values that could reasonably be attributed to the measured. The fraction may be viewed as the coverage probability or level of confidence of the interval.

2.3.1 Sample Calculation – radiated & conducted emissions

The field strength is calculated by subtracting the Amplifier Gain and adding the Cable Loss and Antenna Correction Factor to the measured reading. The basic equation is as follows:

Field Strength (dBμV/m) = RAW **-** AMP + CBL + ACF

Where: RAW = Measured level before correction (dBμV)

AMP = Amplifier Gain (dB)

CBL = Cable Loss (dB)

ACF = Antenna Correction Factor (dB/m)

$$\mu V/m = 10^{\frac{dB\mu V/m}{20}}$$

Sample radiated emissions calculation @ 30 MHz

Measurement +Antenna Factor–Amplifier Gain+Cable loss=Radiated Emissions (dBuV/m)

25 dBuV/m + 17.5 dB – 20 dB + 1.0 dB = 23.5 dBuV/m

2.3.2 Measurement Uncertainties

Table 2: Summary of Uncertainties

	U_{lab}	U_{cispr}
Radiated Disturbance		
30 MHz – 25,000 MHz	3.2 dB	5.2 dB
Conducted Disturbance @ Mains Terminals		
150 kHz – 30 MHz	2.4 dB	3.6 dB
Disturbance Power		
30 MHz – 300 MHz	3.92 dB	4.5 dB

Note: U_{lab} is the calculated Combined Standard Uncertainty
U_{cispr} is the measurement uncertainty requirement per CISPR 16.

Measurement Uncertainty Immunity

The estimated combined standard uncertainty for ESD immunity measurements is ± 4.1%.
The estimated combined standard uncertainty for radiated immunity measurements is ± 2.7dB.
The estimated combined standard uncertainty for conducted immunity measurements is ± 1.4dB.
The estimated combined standard uncertainty for damped oscillatory wave immunity measurements is ± 8.8%.
The estimated combined standard uncertainty for harmonic current and flicker measurements is ± 0.45%.

Measurement Uncertainty – Radio Testing

The estimated combined standard uncertainty for frequency error measurements is ± 3.88 Hz
The estimated combined standard uncertainty for carrier power measurements is ± 1.59 dB.
The estimated combined standard uncertainty for adjacent channel power measurements is ± 1.47 dB.
The estimated combined standard uncertainty for modulation frequency response measurements is ± 0.46 dB.
The estimated combined standard uncertainty for transmitter conducted emission measurements is ± 4.01 dB

The expanded uncertainty at a level of 95% confidence is obtained by multiplying the combined standard uncertainty by a coverage factor of 2. Compliance criteria are not based on measurement uncertainty.

2.4 Calibration Traceability

All measurement instrumentation is traceable to the National Institute of Standards and Technology (NIST). Measurement method complies with ANSI/NCSL Z540-1-1994 and ISO Guide 17025:2005.

3 Product Information

3.1 Product Description

The TR-001-44 RF ID Reader module is an ACK RFID operating at 13.56MHz.

3.2 Equipment Configuration

A description of the equipment configuration is given in Test Plan Section. The EUT was tested as called for in the test standard and was configured and operated in a manner consistent with its intended use. The EUT was connected to rated power and allowed to reach intended operating conditions. The placement of the EUT system components was guided by the test standard and selected to represent typical installation conditions.

In the case of an EUT that can operate in more than one configuration, preliminary testing was performed to determine the configuration that produced maximum radiation.

The final configuration was selected to produce the worst case radiation for emissions testing and to place the EUT in the most susceptible state for immunity testing.

3.3 Operating Mode

A description of the operation mode is given in Test Plan Section. In the case of an EUT that can operate in more than one state, preliminary testing was performed to determine the operating mode that produced maximum radiation.

The final operating mode was selected to produce the worst case radiation for emissions testing and to place the EUT in the most susceptible state for immunity testing.

3.4 Unique Antenna Connector

An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this section. The manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited. This requirement does not apply to carrier current devices or to devices operated under the provisions of CFR47 Parts 15.211, 15.213, 15.217, 15.219, or 15.221.

3.4.1 Results

The TR-001-44 uses the permanently attached antenna.

- PCB antenna integrated in RFID Reader PCB
- Antenna Type: PCB trace loop antenna, 3-turn
- Antenna Size: 40mm diameter

4 Emissions

Testing was performed in accordance with CFR 47 Part 15.225:2010 and RSS 210 Annex 2:2010. These test methods are listed under the laboratory's A2LA Scope of Accreditation. This test measures the levels emanating from the EUT, thus evaluating the potential for the EUT to cause radio frequency interference to other electronic devices. Procedures described in ANSI C63.10: 2009 were used.

4.1 Carrier Field Strength Requirements

The RF fundamental field strength requirement is the power radiated in the direction of the maximum level under specified conditions of measurements in the presence of modulation.

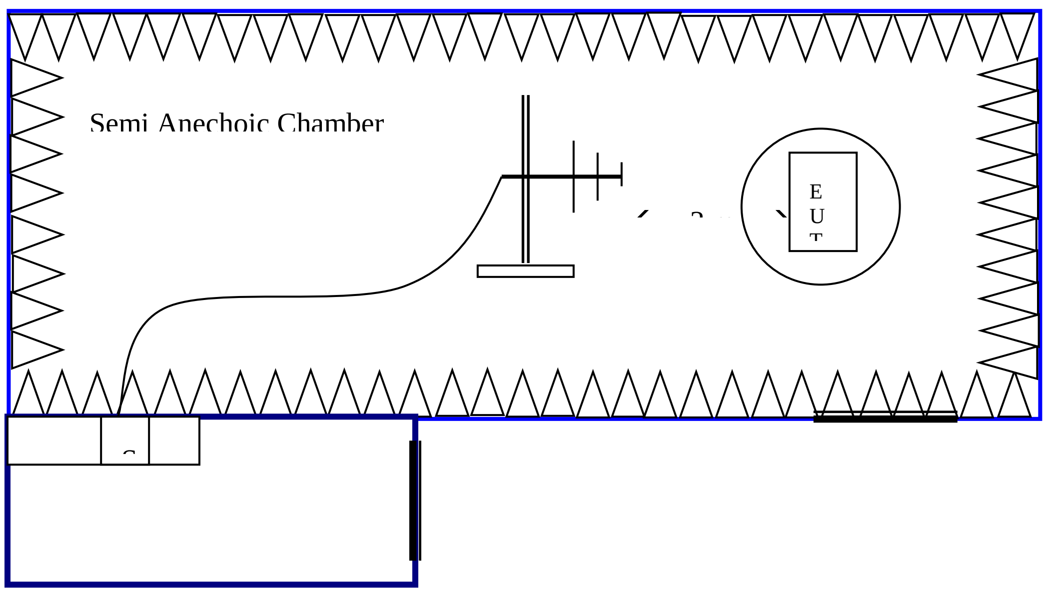
The RF fundamental field strengths shall not exceed CFR47 Part 15.225 (a):2010 and RSS 210 A2.6 (a):2010.

The field strength of any emission in the band of 13.553 and 13.567MHz shall be less than 84 dBuV/m at 30 meter distance; or 124 dBuV/m at 3 meter.

4.1.1 Test Method

The radiated method was used to measure the field strength of the fundamental signal according to ANSI C63.10:2009 Section 6.3. The measurement was performed with modulation. all three RFID boards. The worst result indicated below.

Test Setup:



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4.1.2 Results

As originally tested, the EUT was found to be compliant to the requirements of the test standard(s).

Table 3: RF Fundamental Field Strength – Test Results

Test Conditions: Radiated Measurement, Normal Temperature and Voltage only						
Antenna Type: Integrated				**Power Setting:** 200mW Chipset Output		
Signal State: Modulated				**Duty Cycle:** 100 %		
Ambient Temp.: 22 °C				**Relative Humidity:**31 %		
Operating Frequency:	**Test Results**					
13.56 MHz	**Measured Level [dBuV/m]**	**Loop Position**	**Table [degree]**	**Antenna [cm]**	**Limit [dBuV/m]**	**Margin [dB]**
X-Axis	63.42	90	198	100	124.00	-60.58
Y-Axis	65.98	90	196	100	124.00	-58.02
Z-Axis	66.25	90	240	100	124.00	-57.75
Note: 1. Measurements were taken at 3 meter distance, and the limit was extrapolated accordingly.						

4.2 Occupied Bandwidth

The occupied bandwidth is measured at an amplitude level reduced from the reference level by a specified ratio. The reference level is the level of the highest amplitude signal observed from the transmitter at the fundamental frequency.

The 99% bandwidth is the bandwidth in which 99% of the transmitted power occupied.

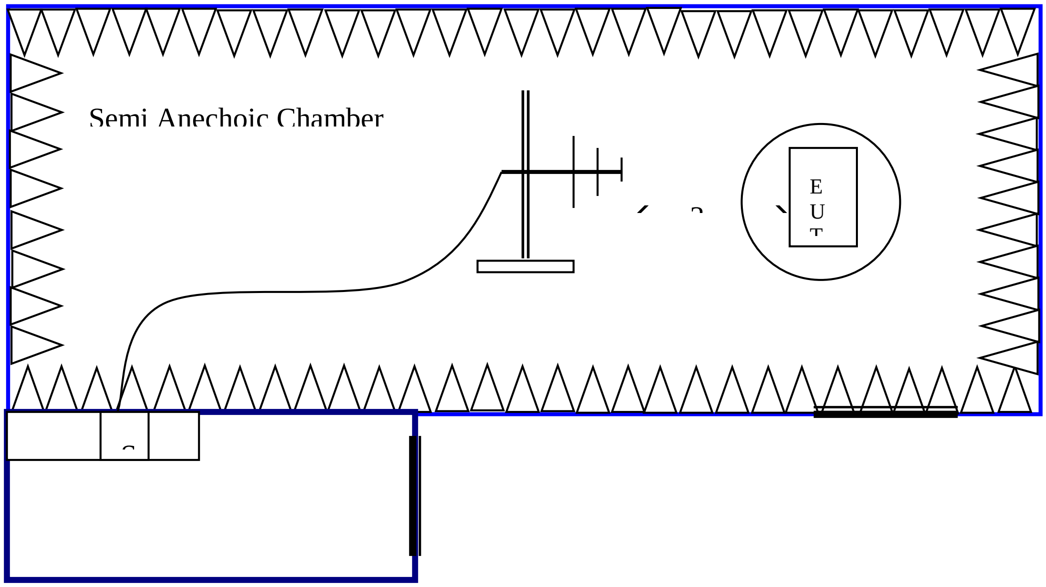
The 20dB bandwidth is defined the bandwidth of 20 dBr from highest transmitted level of the fundamental frequency.

The bandwidth shall be documented per Section CFR47 15.215(c) 2010 and RSS Gen Sect. 4.6: 2010. Intentional radiators operating under the alternative provisions to the general emission limits, must be designed to ensure that the 20 dB bandwidth of the emission, or whatever bandwidth may otherwise be specified in the specific rule section under which the equipment operates, is contained within the frequency band designated in the rule section under which the equipment is operated. The requirement to contain the designated bandwidth of the emission within the specified frequency band includes the effects from frequency sweeping, frequency hopping and other modulation techniques that may be employed as well as the frequency stability of the transmitter over expected variations in temperature and supply voltage. If the frequency stability is not specified in the regulations, it is recommended that the fundamental emission be kept within at least the central 80% of the permitted band in order to minimize the possibility of out-of-band operation.

4.2.1 Test Method

The radiated method was used to measure the occupied bandwidth according to ANSI C63.10:2009. The measurement was performed with modulation. This test was performed on all three RFIDs installed inside MiSeq System; SN 001. The worst sample result indicated below.

Test Setup:



4.2.2 Results

As originally tested, the EUT was found to be compliant to the requirements of the test standard(s).

Table 4: Occupied Bandwidth – Test Results

Test Conditions: Radiated Measurement, Normal Temperature and Voltage only				
Antenna Type: Integrated		**Power Setting:** 200mW Chipset Output		
Signal State: Modulated		**Duty Cycle:** 52.8 %		
Ambient Temp.: 22 °C		**Relative Humidity:**36%		
Occupied Bandwidth for 13.56 MHz RFID				
Sample	**Limit (kHz)**	**99% BW (kHz)**	**20 dB BW (kHz)**	**Results**
RFID Reader	Na	4.776	3.875	Pass
Note: All lower and upper markers of 99% Bandwidth and 20 dB Bandwidth are within the allowable band; 13.553 MHz to 13.567MHz				

Table 5: 20 dB Bandwidth Frequency – Test Results

Test Conditions: Radiated Measurement, Normal Temperature and Voltage only				
Antenna Type: Integrated		**Power Setting:** 200mW Chipset Output		
Signal State: Modulated		**Duty Cycle:** 52.8 %		
Ambient Temp.: 22 °C		**Relative Humidity:**36%		
20 dB Bandwidth Frequencies for 13.56 MHz RFID				
Sample	**Occupied Band Limit (MHz)**	**Lower Freq. (MHz)**	**Upper Freq. (MHz)**	**Results**
RFID Reader	13.553 < X < 13.567	13.559575	13.55995	Pass
Note: All lower and upper markers of 20 dB Bandwidth are within the allowable band; 13.553 MHz to 13.567MHz; where X is the lower frequency and upper frequency.				

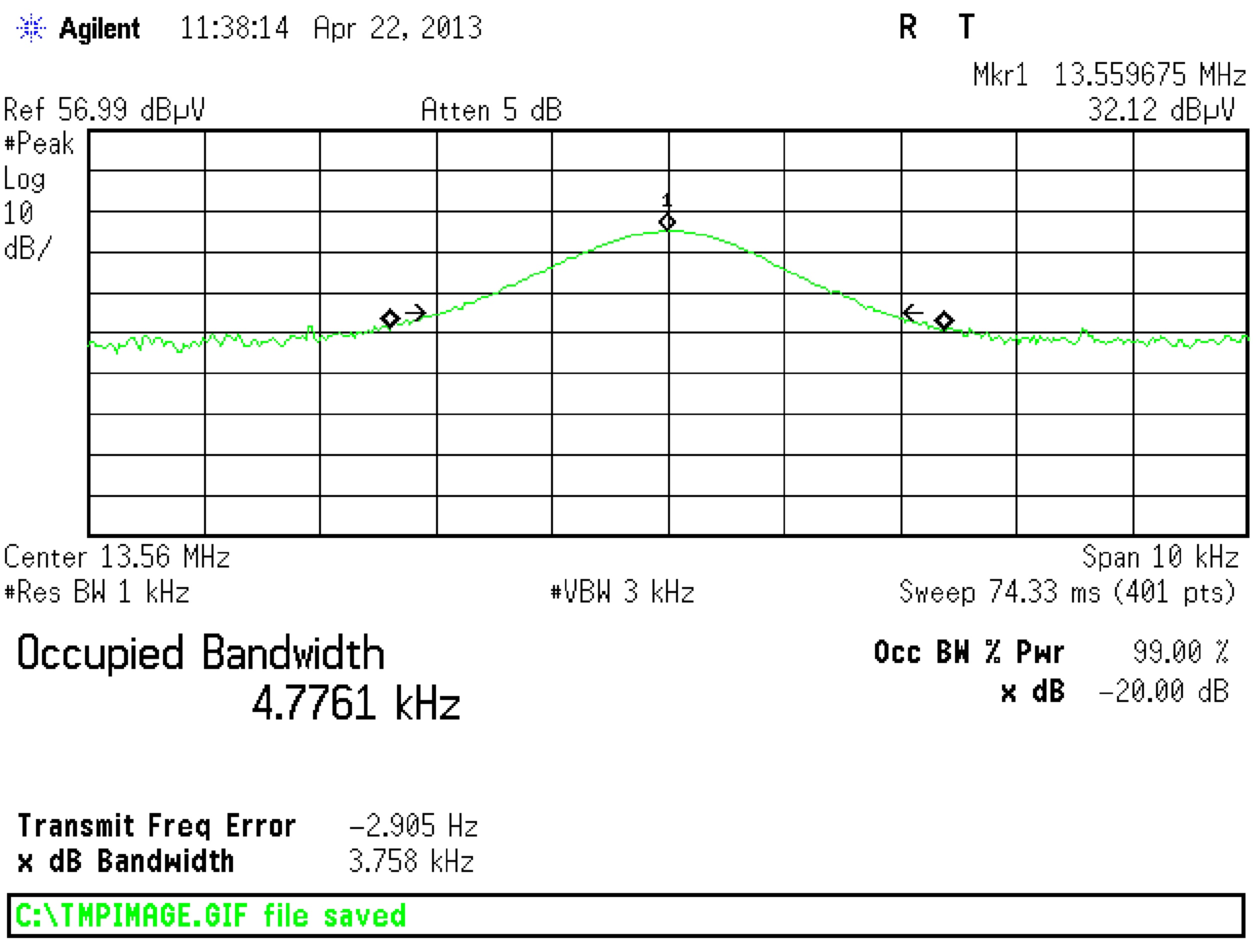


Figure 1: 99% Bandwidth

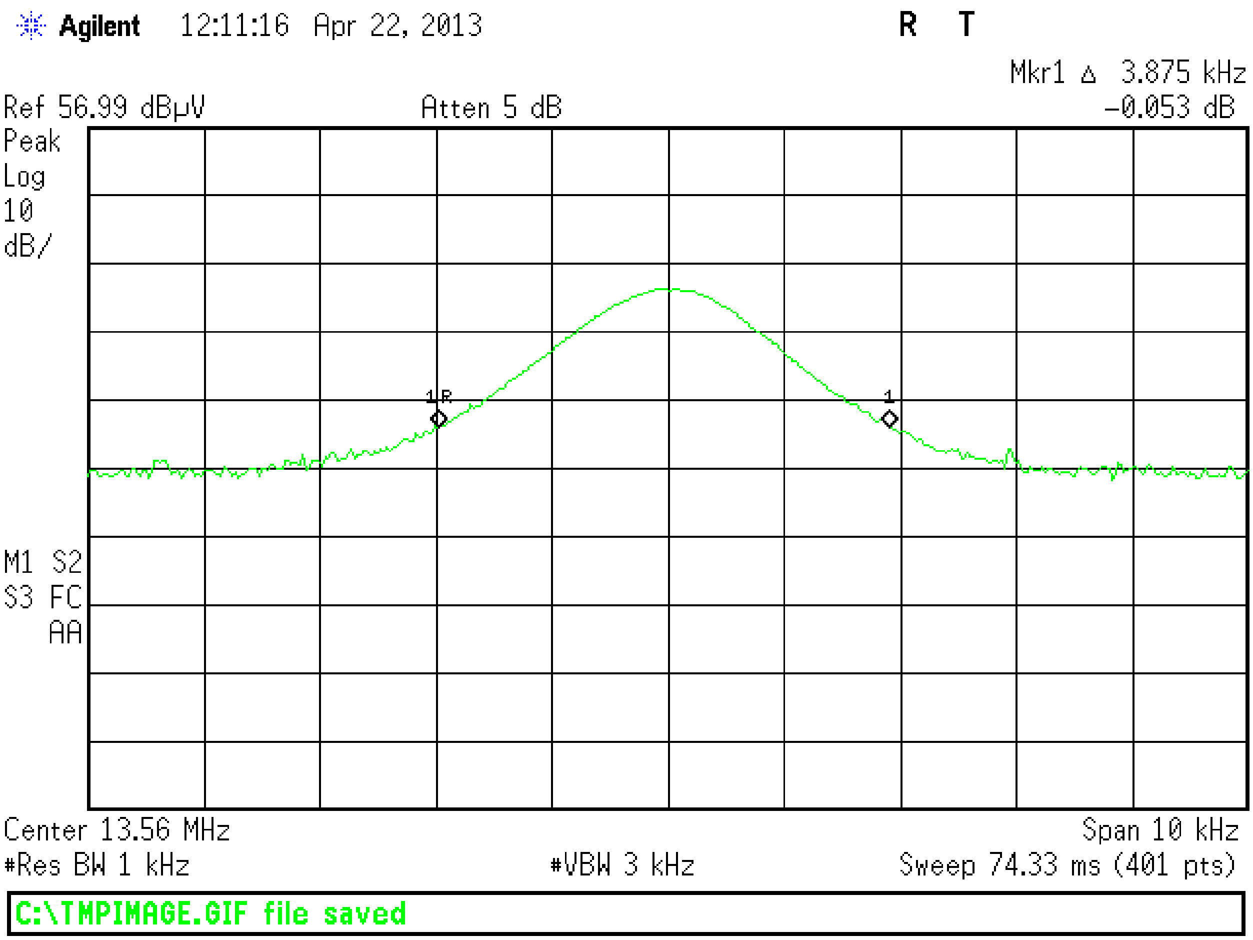


Figure 2: 20 dB Bandwidth

4.3 Out-of-Band Emissions

The out of band emission is leakage measurement of the main carrier outside the allocated operating frequency band; 13.553 MHz to 13.567 MHz.
According to CFR47 Part 15.225: 2010 and RSS210 A2.6: 2010, the out of band emission shall;
-*Within the bands 13.410–13.553 MHz and 13.567–13.710 MHz, the field strength of any emissions shall not exceed 334 microvolts/meter (84 dBuV/m) at 30 meters,*
-*Within the bands 13.110–13.410 MHz and 13.710–14.010 MHz the field strength of any emissions shall not exceed 106 microvolts/meter (40.5 dBuV/m) at 30 meters.*

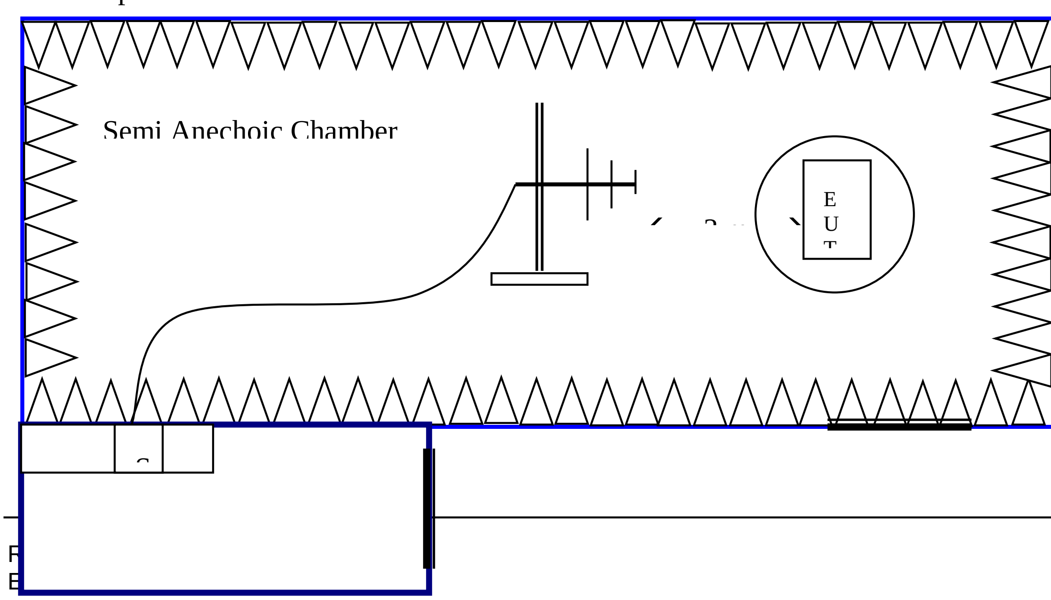
Table 6: Out of Band Emissions Limit

Frequency (MHz)	*Limit at 30m (dBuV/m)*	*Limit at 3m (dBuV/m)*	*Comment*
<13.110	*29.5*	*69.5*	*CFR47 15.225 (d), RSS210 A2.6 (d). Out of Band*
13.110-13.410	*40.5*	*80.5*	*CFR47 15.225 (c), RSS210 A2.6 (c). Out of Band*
13.410-13.533	*50.5*	*90.5*	*CFR47 15.225 (b), RSS210 A2.6 (b). Out of Band*
13.553-13.567	*84.0*	*124.0*	*CFR47 15.225 (a), RSS210 A2.6 (a), Inband (Carrier)*
13.567-13.710	*50.5*	*90.5*	*CFR47 15.225 (b), RSS210 A2.6 (b), Out of Band*
13.710-14.010	*40.5*	*80.5*	*CFR47 15.225 (c), RSS210 A2.6 (c), Out of Band*
>14.010	*29.5*	*69.5*	*CFR47 15.225 (d), RSS210 A2.6 (d), Out of Band*
Note: The limit was extrapolated 40dB/decade per CFR47 Part 15.31 (f)(3).			

4.3.1 Test Method

The radiated method was used to measure the out-of-band emission requirement. The measurement was performed with modulation per CFR47 15.225 (b) (c) 2010 and *RSS 210 A2.6.* (b) (c)*: 2010*. This test was performed on RFID #1. The worst result indicated below.

Test Setup:



4.3.2 Test Result

As originally tested, the EUT was found to be compliant to the requirements of the test standard(s).

Table 7: Out of Band Emissions – Test Results

Test Conditions: Conducted Measurement, Normal Temperature and Voltage only				
Antenna Type: Detachable / Integrated		**Power Setting:** 250mW Chipset Output		
Signal State: Modulated		**Duty Cycle:** 52.8 %		
Ambient Temp.: 21 °C		**Relative Humidity:**34%		
Sample	**Limit**	**Loop Antenna Position**	**Spectrum Mask (13.410 to 14.010MHz)**	**Result**
RFID #1	See Table 6	0	Plot #	Pass
		90	Plot #	Pass
Note: All maximized emissions within 10 MHz to 15 MHz are below the spectrum mask limit per Table 6..				

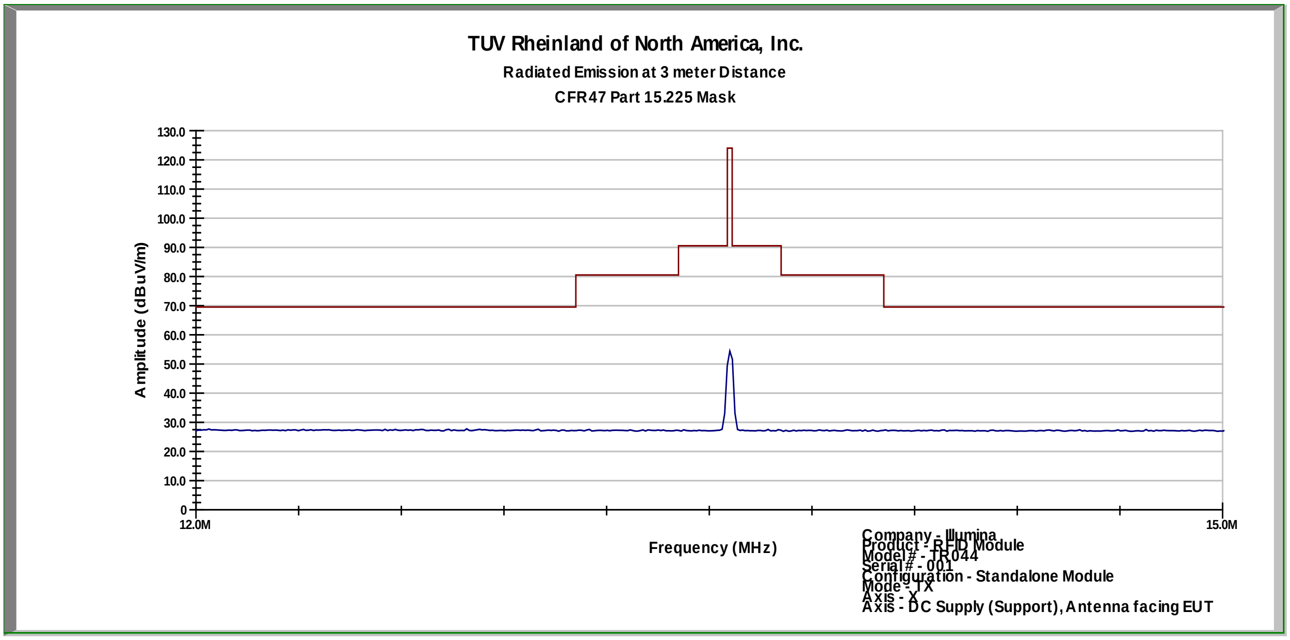


Figure 3: Out of Band Spectrum Mask for RFID Module – 0 Degree Loop Antenna X axis

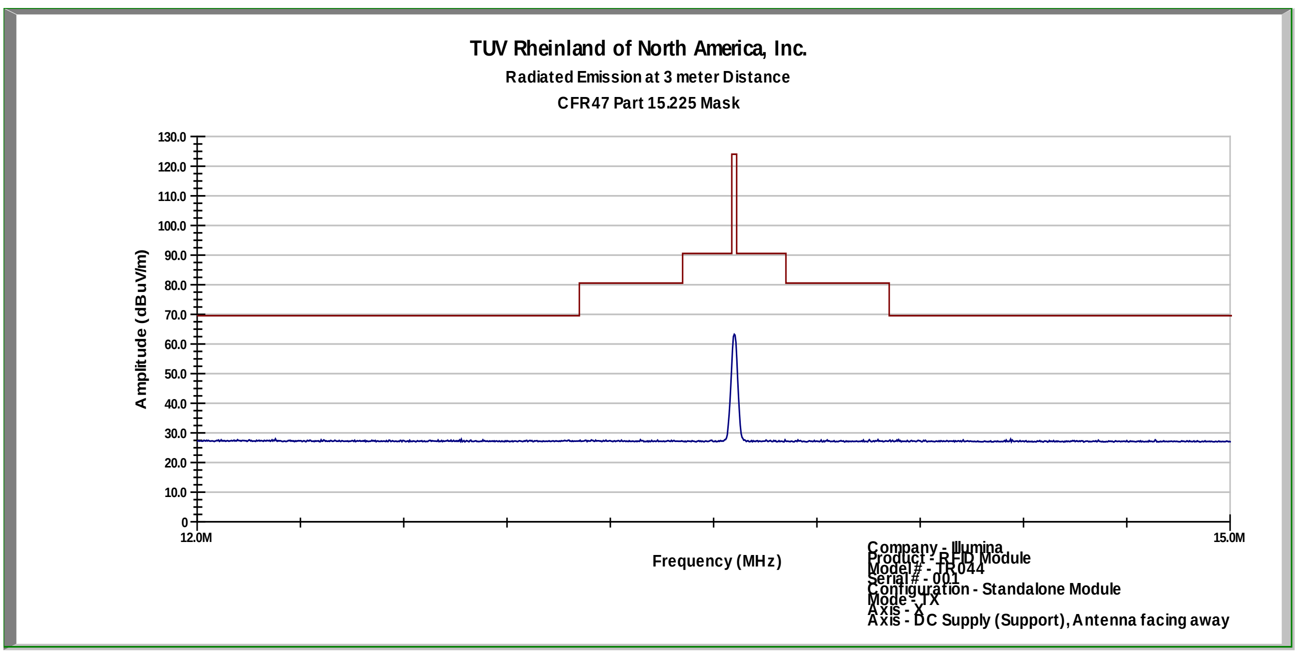


Figure 4: Out of Band Spectrum Mask for RFID Module – 90 Degree Loop Antenna X axis

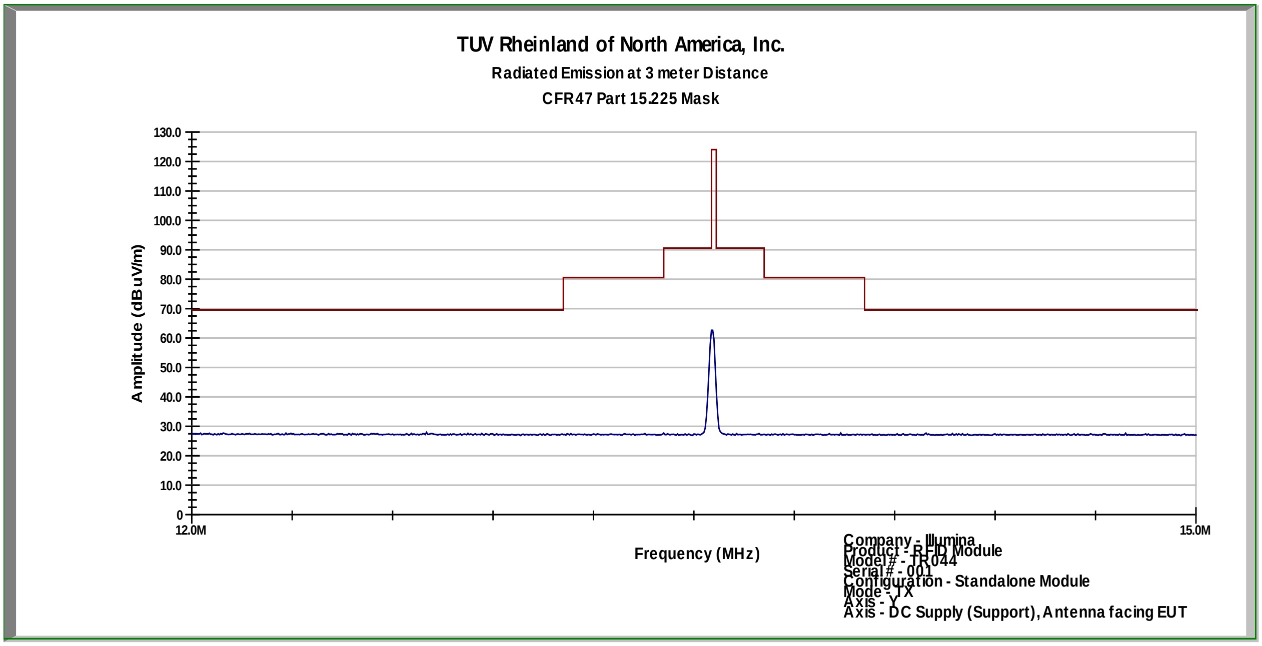


Figure 5: Out of Band Spectrum Mask for RFID Module – 0 Degree Loop Antenna Y axis

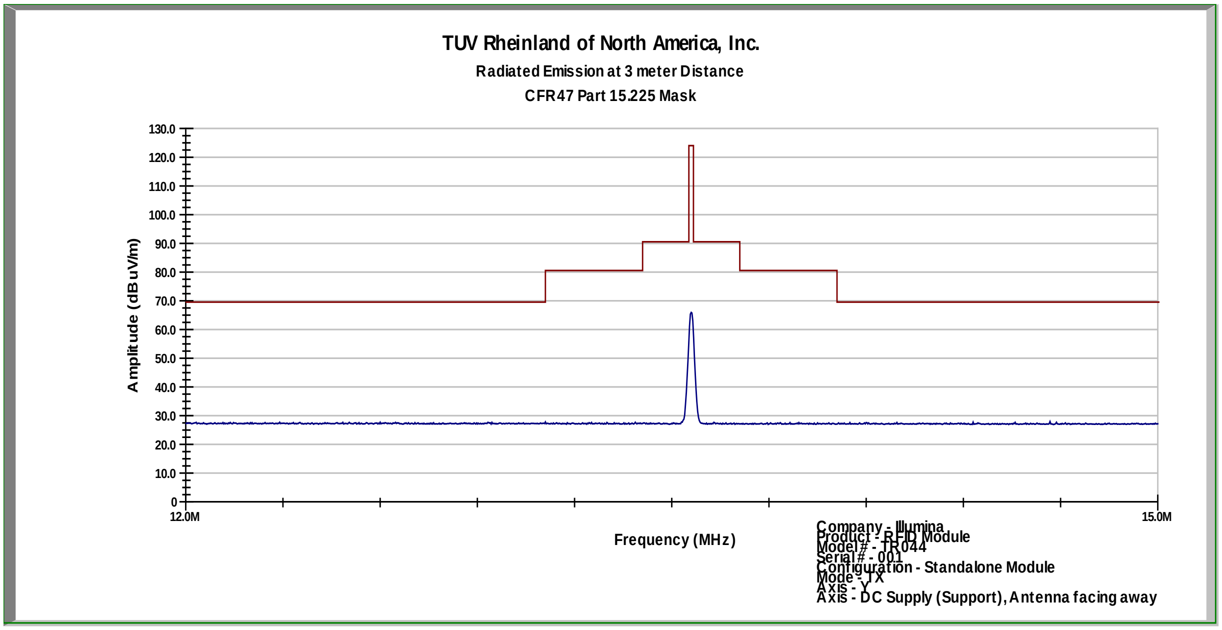


Figure 6: Out of Band Spectrum Mask for RFID Module – 90 Degree Loop Antenna Y axis

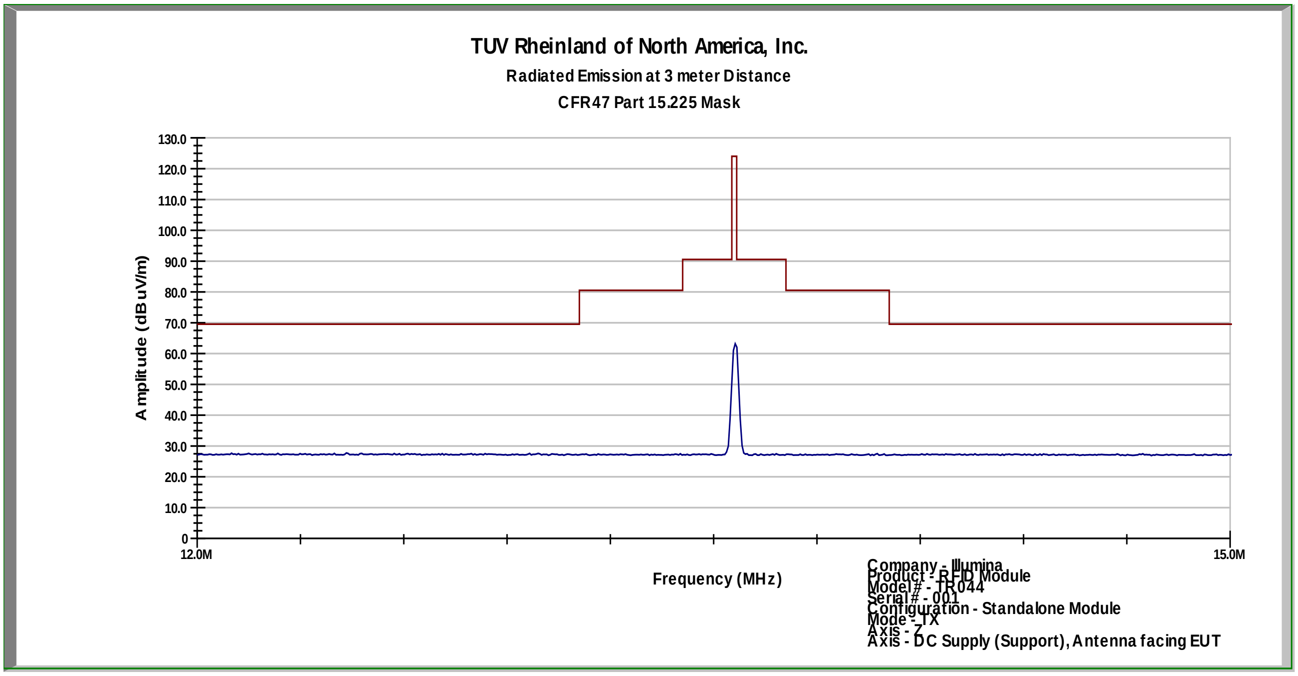


Figure 7: Out of Band Spectrum Mask for RFID –Degree Loop Antenna Z axis

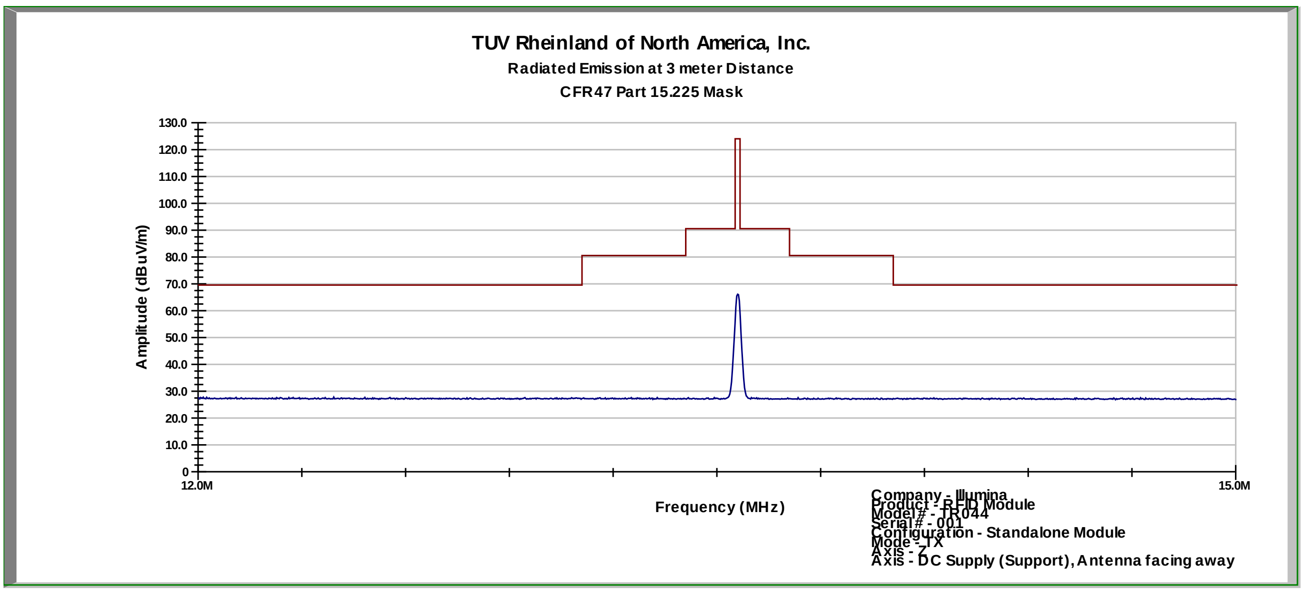


Figure 8: Out of Band Spectrum Mask for RFID Module – 90 Degree Loop Antenna Z axis

4.4 Maximum Permissible Exposure

4.4.1 Test Methodology

In this document, we try to prove the safety of radiation harmfulness to the human body for our product. The limit for Maximum Permissible Exposure (MPE) specified in FCC 1.1310 is followed. The Gain of the antenna used in this product is measured in a Semi-Anechoic Chamber, and also the maximum total power input to the antenna is measured. Through the Friis transmission formula and the maximum gain of the antenna, we can calculate the distance, away from the product, where the limit of MPE is reached.

Although the Friis transmission formula is a far field assumption, the calculated result of that is an over-prediction for near field power density. We will take that as the worst case to specify the safety range.

4.4.2 RF Exposure Limit

According to FCC 1.1310 table 1: The criteria listed in the following table shall be used to evaluate the environmental impact of human exposure to radio-frequency (RF) radiation as specified in 1.1307(b)

LIMITS FOR MAXIMUM PERMISSIBLE EXPOSURE (MPE)

Frequency Range (MHz)	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)	Power Density (mW/cm2)	Average Time (minutes)
(A)Limits For Occupational / Control Exposures				
300 - 1500	…	…	F/300	6
1500 - 100,000	…	…	5	6
(B)Limits For General Population / Uncontrolled Exposure				
300 - 1500	…	…	F/1500	6
1500 - 100,000	…	…	1.0	30

F = Frequency in MHz

4.4.3 EUT Operating Condition

The software provided by Manufacturer enabled the EUT to transmit at the regulated power for RFID; The chipset output power was 200 mW using 9.1.6 FPGA firmware.

4.4.4 Classification

The antenna of the product, under normal use condition, is at least 20cm away from the body of the user. Warning statement to the user for keeping at least 20cm or more separation distance with the antenna should be included in user’s manual. So, this device is classified as a **Mobile Device**.

4.4.5 Test Results

4.4.5.1 Antenna Gain

The transmitting antenna was integrated or attached. Carrier field strength of each RFID was measured.

4.4.5.2 Output Power into Antenna & RF Exposure value at distance 20cm:

Calculations for this report are based on highest carrier field strength measurement.

The highest carrier field strength was +66.25 dBuV/m at 3 meter distance.

The calculated EIRP is -28.98 dBm or 0.0007714mW

Using the Friss transmission formula, the EIRP is Pout*G, and R is 20cm.

Pd = (0.0007714) / (1600π) = 1.534E-7 mW/cm2, which is well below to the limit.

The RFID main carrier is not regulated per FCC 1.1310; furthermore, the calculated power density of RFID Module is less than 1mW.cm2 which meet limit stated above.

As stated, the EUT was found to be compliant to the requirements of the test standard(s).

4.4.6 Sample Calculation

The Friss transmission formula: $Pd = (Pout*G) / (4*\pi*R^2)$

Where;

Pd = power density in mW/cm^2
$Pout$ = output power to antenna in mW
G = gain of antenna in linear scale
$\pi \approx 3.1416$
R = distance between observation point and center of the radiator in cm

Ref. : David K. Cheng, *Field and Wave Electromagnetics*, Second Edition, Page 640, Eq. (11-133).

4.5 Transmitter Spurious Emissions

Transmitter spurious emissions are emissions outside the frequency range of the equipment when the equipment is in transmit mode; per requirement of CFR47 15.205, 15.209, 15.225(d), RSS GEN Sect. 6

4.5.1 Test Methodology

4.5.1.1 Preliminary Test

A test program that controls instrumentation and data logging was used to automate the preliminary RF emission test procedure. The frequency range of interest was divided into sub-ranges to yield a frequency resolution of approximately 120 kHz and provide a reading at each frequency for no more than 12° of turntable rotation. For each frequency sub-range the turntable was rotated 360° while peak emission data was recorded and plotted over the frequency range of interest in horizontal and vertical antenna polarization’s.

Preliminary emission profile testing was performed inside the anechoic chamber. The EUT was placed on a 1.0m x 1.5m non-conductive table 80cm above the floor. The EUT was positioned as shown in the setup photographs. The receiving antenna was placed at a distance of 3m at a fixed height of 1m. Measurement equipment was located outside of the chamber. A video camera was placed inside the chamber to view the EUT.

4.5.1.2 Final Test

For each frequency measured, the peak emission was maximized by manipulating the receiving antenna from 1 to 4 meters above the ground plane and placing it at the position that produced the maximum signal strength reading. The turntable was then rotated through 360° while observing the peak signal and placing the EUT at the position that produced maximum radiation. The six highest emissions relative to the limit were measured unless such emissions were more than 20 dB below the limit. If less than six emissions are within 20 dB of the limit, than the noise level of the receiver is measured at frequencies where emissions are expected. Multiples of all oscillator and microprocessor frequencies were also checked.

Final testing was performed on an NSA compliant test site. The EUT was placed on a 1.0m x 1.5m non-conductive table 80cm above the ground plane. The placement of EUT and cables were the same as for preliminary testing and is shown in the setup photographs.

The final spurious emission scans performed on the Z-Axis.

4.5.1.3 Deviations

None.

4.5.2 Transmitter Spurious Emission Limit

The spurious emissions of the transmitter shall not exceed the values in CFR47 Part 15.205, 15.209: 2010 and RSS GEN 6.1: 2010.

Frequency (MHz)	Field strength (microvolts/meter)	Measurement distance (meters)
0.009-0.490	2400/F(kHz)	300
0.490-1.705	24000/F(kHz)	30
1.705-30.0	30	30
30-88	100 **	3
88-216	150 **	3
216-960	200 **	3
Above 960	500	3

4.5.3 Test Results

The final measurement data was taken under the worst case operating modes, configurations, and/or cable positions. It also reflects the results including any modifications and/or special accessories listed in Sections 1.4 and 1.5.

As originally tested, the EUT was found to be compliant to the requirements of the test standard(s).

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EUT Name	RFID Reader	**Date**	February 26, 2013
EUT Model	TR-001-44	**Temp / Hum in**	22°C / 37%rh
EUT Serial	001	**Temp / Hum out**	N/A
EUT Config.	Standalone Module Orientation X axis	**Line AC / Freq**	120 Vac / 60Hz
Standard	CFR47 Part 15 Subpart C	**RBW / VBW**	120 kHz/ 300 kHz
Dist/Ant Used	3m / 6511 & JB3	**Performed by**	Jeremy Luong

Frequency	Peak	QP	Ave.	Limit	Margin (QP)	Margin (Ave)	Turntable	Height	Ant	Note
MHz	dBuV/m	dBuV/m	dBuV/m	dBuV/m	dB	dB	degree	cm		
0.037	52.36	45.18	42.93	126.48	-81.29	-83.54	296	100	0	Spurious
0.178	55.39	52.24	46.22	116.34	-64.10	-70.12	174	100	0	Spurious
1.045	37.85	34.94	29.91	68.85	-33.91	-38.94	174	100	0	Spurious
13.560	63.41	63.29	63.29	124.00	-60.71	-60.71	171	100	0	Fundamental
0.038	51.21	44.77	42.33	126.42	-81.65	-84.09	0	100	90	Spurious
0.322	52.37	47.03	40.94	105.91	-58.88	-64.97	375	100	90	Spurious
13.560	66.25	66.21	66.20	124.00	-57.79	-57.80	240	100	90	Fundamental
27.119	19.83	15.31	9.23	69.50	-54.19	-60.27	189	100	90	Spurious

Spec Margin = E-Field QP – Limit, E-Field QP = FIM QP+ Total CF ± Uncertainty
Total CF= Amp Gain + Cable Loss + ANT Factor

Combined Standard Uncertainty $u_c(y)$ = ± 3.2 dB Expanded Uncertainty $U = ku_c(y)$ k = 2 for 95% confidence

Note: 1. MiSeq System configured with Cool Master PS, Ferrite bead, Rev. B., 9.1.6 FPGA
2. RBW/VBW Setting:
9 kHz to 150 kHz; RBW = 200Hz, VBW = 1kHz
150 kHz to 30 MHz; RBW = 9kHz, VBW = 30kHz
30 MHz to 1000 MHz; RBW = 120kHz, VBW = 300kHz

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EUT Name	RFID Reader	**Date**	February 26, 2013
EUT Model	TR-001-44	**Temp / Hum in**	22°C / 37%rh
EUT Serial	001	**Temp / Hum out**	N/A
EUT Config.	Standalone Module Orientation X axis	**Line AC / Freq**	120 Vac / 60Hz
Standard	CFR47 Part 15 Subpart C	**RBW / VBW**	120 kHz/ 300 kHz
Dist/Ant Used	3m / 6511 & JB3	**Performed by**	Jeremy Luong

Emission Freq (MHz)	ANT Polar (H/V)	ANT Pos (cm)	Table Pos (deg)	FIM (Pk) Pk (dBuV/m)	FIM QP/Ave (dBuV/m)	Total CF dBuV	E-Field QP/Ave (dBuV/m)	Spec Limit (dBuV/m)	Spec Margin (dB)	Type
30MHz to 1000MHz										
338.99	H	106	67	42.52	43.42	-9.72	33.70	46.02	-12.32	Spurious
840.70	H	106	257	37.34	37.15	-1.32	35.83	46.02	-10.19	Spurious
867.82	H	262	130	36.56	35.92	-1.01	34.91	46.02	-11.11	Spurious
949.17	H	103	305	32.67	31.91	0.42	32.33	46.02	-13.69	Spurious
867.82	V	115	168	35.74	35.03	-1.61	33.42	46.02	-12.60	Spurious
949.16	V	109	192	36.88	36.89	-0.20	36.69	46.02	-9.33	Spurious
338.99	H	106	67	42.52	43.42	-9.72	33.70	46.02	-12.32	Spurious
840.70	H	106	257	37.34	37.15	-1.32	35.83	46.02	-10.19	Spurious

Spec Margin = E-Field QP – Limit, E-Field QP = FIM QP+ Total CF ± Uncertainty
Total CF= Amp Gain + Cable Loss + ANT Factor

Combined Standard Uncertainty $u_c(y)$ = ± 3.2 dB Expanded Uncertainty $U = ku_c(y)$ k = 2 for 95% confidence

Note: 1. MiSeq System configured with Cool Master PS, Ferrite bead, Rev. B., 9.1.6 FPGA
2. RBW/VBW Setting:
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150 kHz to 30 MHz; RBW = 9kHz, VBW = 30kHz
30 MHz to 1000 MHz; RBW = 120kHz, VBW = 300kHz

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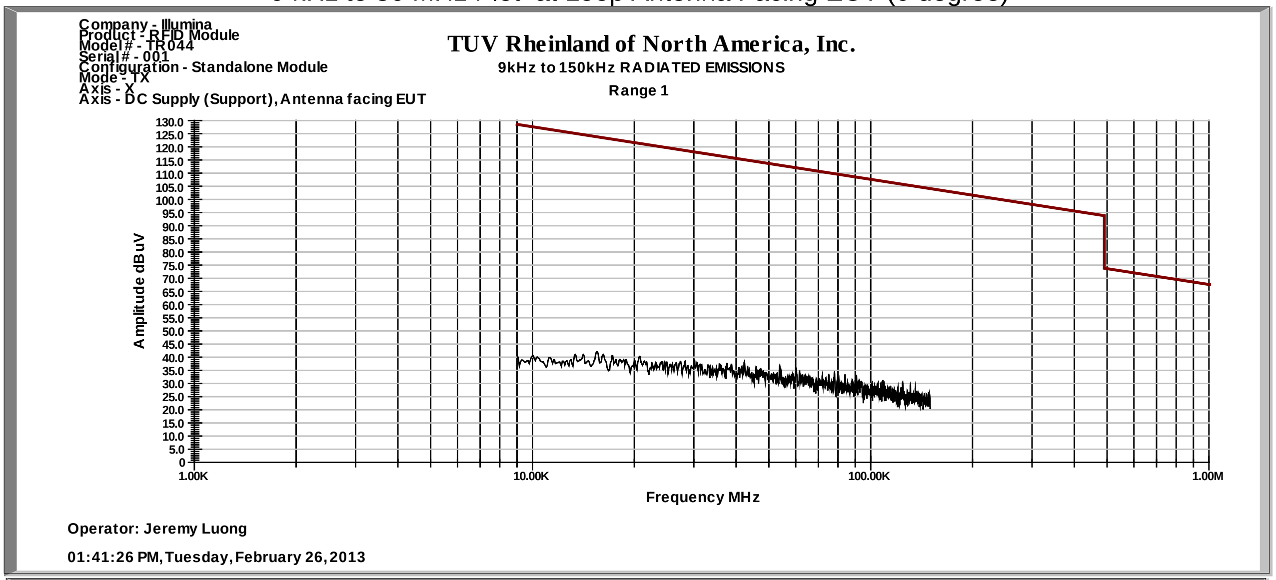
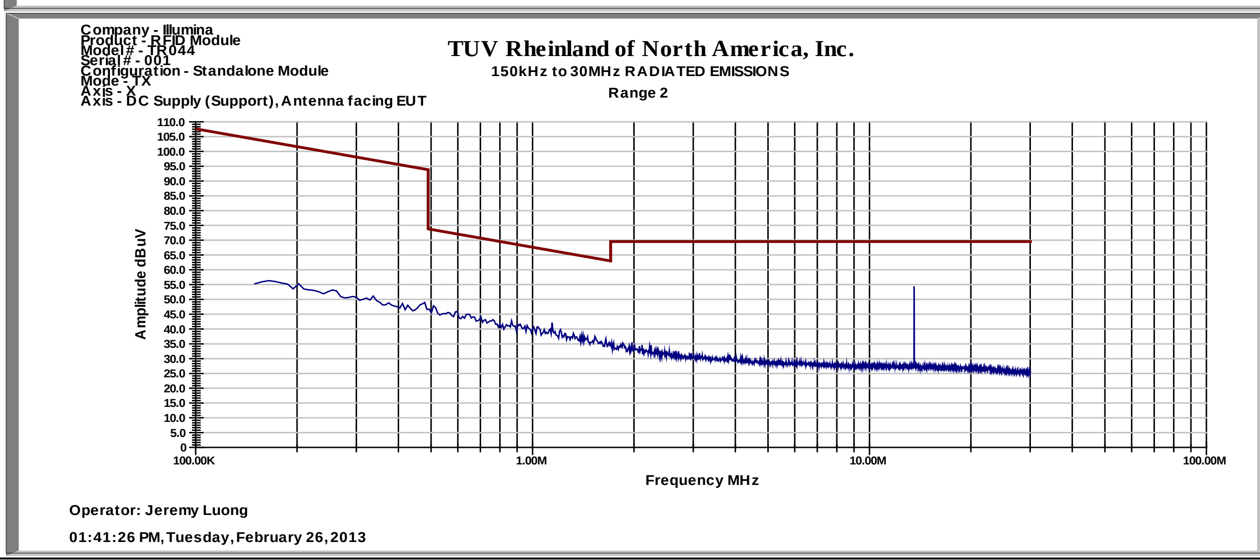
EUT Name	RFID Reader	**Date**	Feb26, 2013
EUT Model	TR-001-44	**Temp / Hum in**	22°C / 37%rh
EUT Serial	001	**Temp / Hum out**	N/A
EUT Config.	Standalone Module X axis	**Line AC**	120V/60Hz
Standard	CFR47 Part 15 Subpart C	**RBW / VBW**	See below
Dist/Ant Used	3m / 6511	**Performed by**	Jeremy Luong

9 kHz to 30 MHz Plot at Loop Antenna Facing EUT (0 degree)





Notes: 9 kHz to 150 kHz; RBW = 200Hz, VBW = 1kHz
150 kHz to 30 MHz; RBW = 9kHz, VBW = 30kHz

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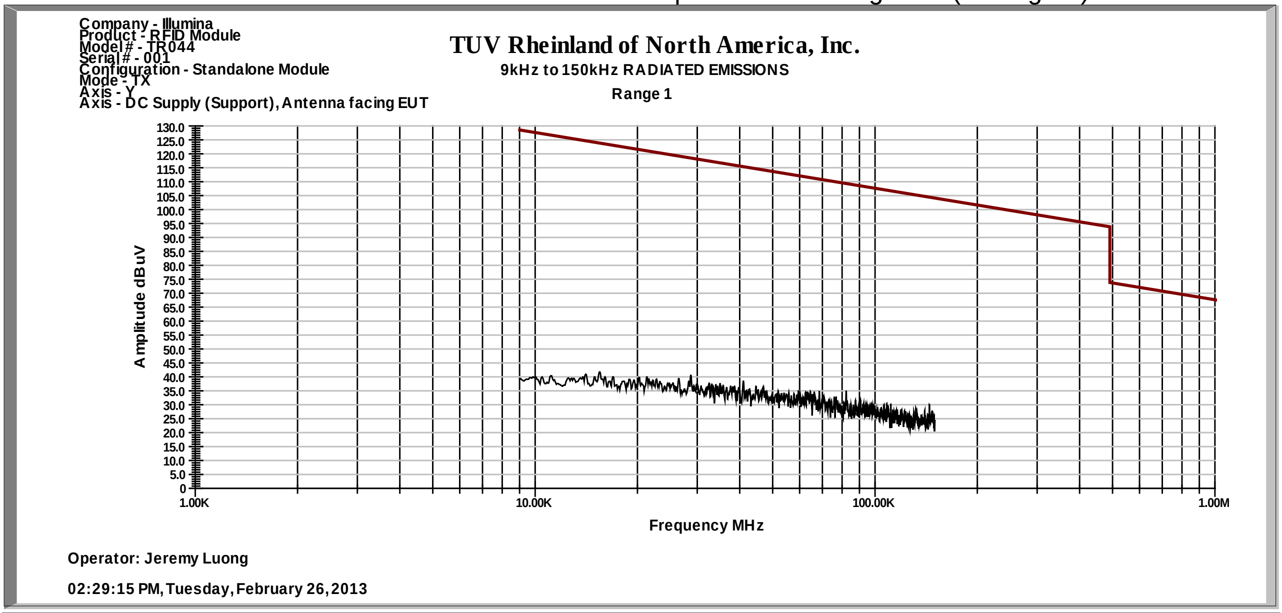
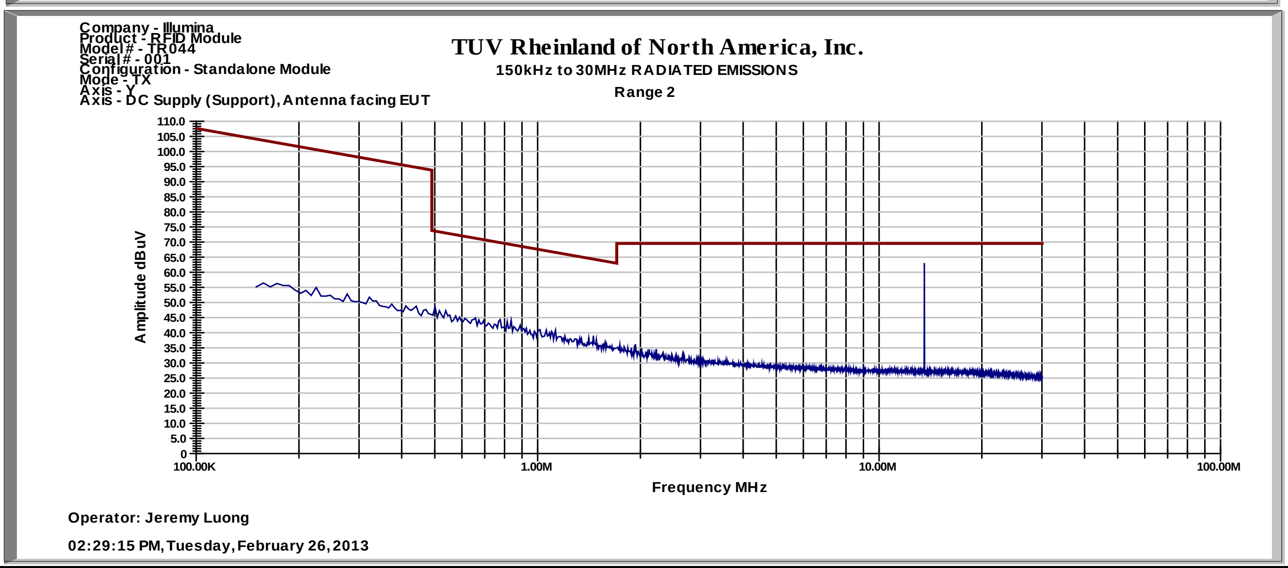
EUT Name	RFID Reader	**Date**	Feb 28, 2013
EUT Model	TR-001-44	**Temp / Hum in**	22°C / 37%rh
EUT Serial	001	**Temp / Hum out**	N/A
EUT Config.	Standalone Module orientation X axis	**Line AC**	120V/60Hz
Standard	CFR47 Part 15 Subpart C	**RBW / VBW**	See below
Dist/Ant Used	3m / 6511	**Performed by**	Jeremy Luong

9 kHz to 30 MHz Plot for RFID #1 at Loop Antenna Facing EUT (90 degree)





Notes: 9 kHz to 150 kHz; RBW = 200Hz, VBW = 1kHz
150 kHz to 30 MHz; RBW = 9kHz, VBW = 30kHz

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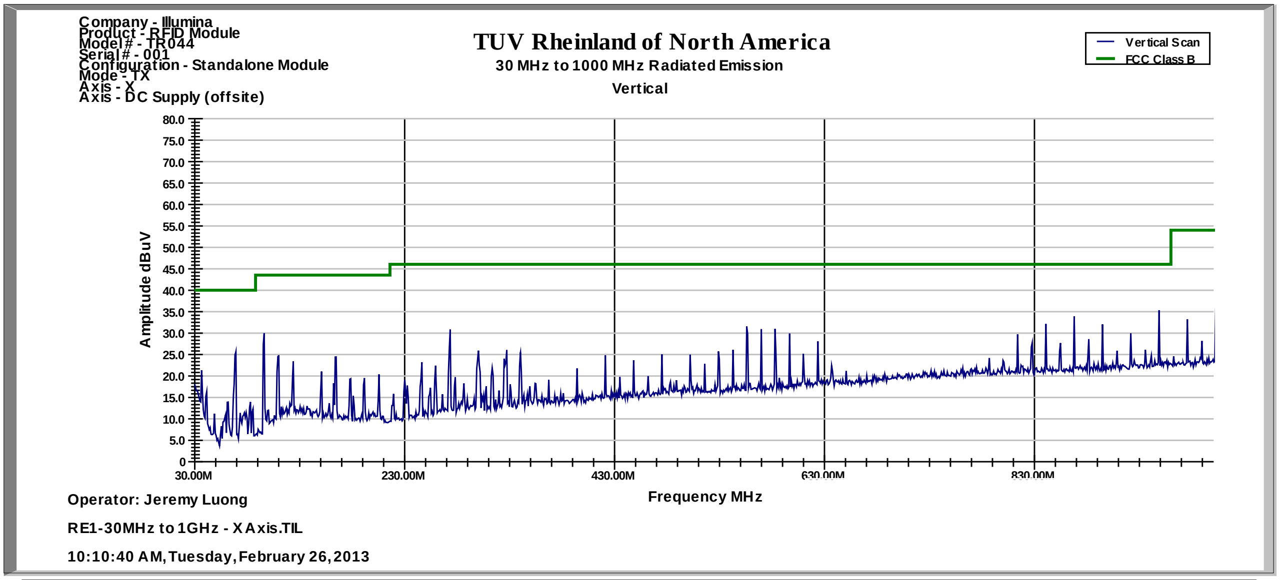
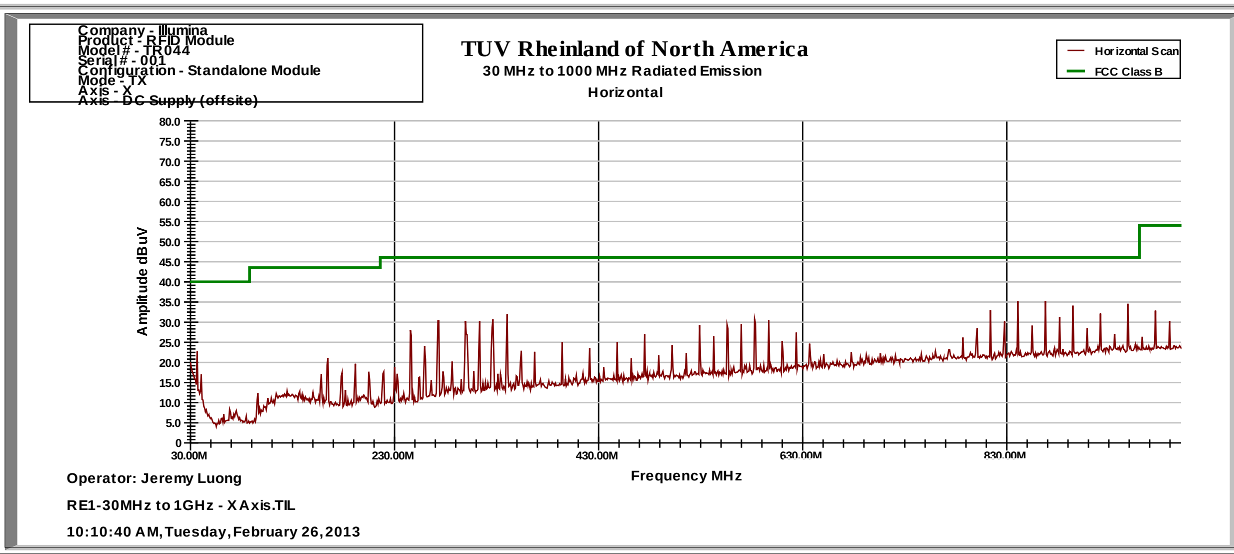
EUT Name	RFID Reader	**Date**	Feb 28, 2013
EUT Model	TR-001-44	**Temp / Hum in**	23°C / 37%rh
EUT Serial	001	**Temp / Hum out**	N/A
EUT Config.	Standalone Module Orientation X axis	**Line AC**	120V/60Hz
Standard	CFR47 Part 15 Subpart C	**RBW / VBW**	120kHz / 300kHz
Dist/Ant Used	3m / JB3	**Performed by**	Jeremy Luong

30MHz to 1000MHz





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EUT Name	RFID Reader	**Date**	February 28, 2013
EUT Model	TR-001-44	**Temp / Hum in**	22°C / 37%rh
EUT Serial	001	**Temp / Hum out**	N/A
EUT Config.	Standalone Module Orientation Y axis	**Line AC / Freq**	120 Vac / 60Hz
Standard	CFR47 Part 15 Subpart C	**RBW / VBW**	120 kHz/ 300 kHz
Dist/Ant Used	3m / 6511 & JB3	**Performed by**	Jeremy Luong

Frequency	Peak	QP	Ave.	Limit	Margin (QP)	Margin (Ave)	Turntable	Height	Ant	Note
MHz	dBuV/m	dBuV/m	dBuV/m	dBuV/m	dB	dB	degree	cm		
0.028	55.38	47.30	45.91	127.10	-79.81	-81.20	284	100	0	Spurious
0.038	52.56	44.40	42.76	126.38	-81.98	-83.62	90	100	0	Spurious
0.081	46.23	38.16	36.11	123.34	-85.18	-87.23	115	100	0	Spurious
0.505	48.68	43.07	36.89	73.67	-30.60	-36.78	264	100	0	Spurious
1.045	39.31	35.98	29.81	68.85	-32.87	-39.04	264	100	0	Spurious
13.560	63.81	63.06	63.05	124.00	-60.94	-60.95	90	100	0	Fundamental
0.674	45.67	40.20	33.87	72.16	-31.96	-38.29	0	100	90	Spurious
1.203	38.74	34.54	28.34	67.45	-32.91	-39.11	375	100	90	Spurious
13.560	65.98	65.92	65.90	124.00	-58.08	-58.10	196	100	90	Fundamental
27.120	21.11	15.36	9.44	69.50	-54.14	-60.06	313	100	90	Spurious

Spec Margin = E-Field QP – Limit, E-Field QP = FIM QP+ Total CF ± Uncertainty
Total CF= Amp Gain + Cable Loss + ANT Factor

Combined Standard Uncertainty $u_c(y) = \pm 3.2$ dB Expanded Uncertainty $U = ku_c(y)$ $k = 2$ for 95% confidence

Note: 1. MiSeq System configured with Cool Master PS, Ferrite bead, Rev. B., 9.1.6 FPGA
2. RBW/VBW Setting:
9 kHz to 150 kHz; RBW = 200Hz, VBW = 1kHz
150 kHz to 30 MHz; RBW = 9kHz, VBW = 30kHz
30 MHz to 1000 MHz; RBW = 120kHz, VBW = 300kHz

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EUT Name	RFID Reader	**Date**	February 28, 2013
EUT Model	TR-001-44	**Temp / Hum in**	22°C / 37%rh
EUT Serial	001	**Temp / Hum out**	N/A
EUT Config.	Standalone Module Orientation X axis	**Line AC / Freq**	120 Vac / 60Hz
Standard	CFR47 Part 15 Subpart C	**RBW / VBW**	120 kHz/ 300 kHz
Dist/Ant Used	3m / 6511 & JB3	**Performed by**	Jeremy Luong

Emission Freq (MHz)	ANT Polar (H/V)	ANT Pos (cm)	Table Pos (deg)	FIM (Pk) Pk (dBuV/m)	FIM QP/Ave (dBuV/m)	Total CF dBuV	E-Field QP/Ave (dBuV/m)	Spec Limit (dBuV/m)	Spec Margin (dB)	Type
30MHz to 1000MHz										
94.91	V	132	131	46.44	46.53	-16.48	30.05	43.52	-13.47	46.44
271.19	V	107	324	40.42	40.28	-11.07	29.21	46.02	-16.81	40.42
949.17	V	108	174	39.78	39.77	-0.20	39.57	46.02	-6.45	39.78
271.19	H	109	89	49.78	49.46	-10.95	38.51	46.02	-7.51	49.78
325.43	H	105	288	43.13	43.10	-9.77	33.33	46.02	-12.69	43.13
338.99	H	111	300	41.97	42.07	-9.72	32.35	46.02	-13.67	41.97
867.82	H	103	134	40.89	40.51	-1.01	39.50	46.02	-6.52	40.89

Spec Margin = E-Field QP – Limit, E-Field QP = FIM QP+ Total CF ± Uncertainty
Total CF= Amp Gain + Cable Loss + ANT Factor

Combined Standard Uncertainty $u_c(y)$ = ± 3.2 dB Expanded Uncertainty $U = ku_c(y)$ k = 2 for 95% confidence

Note: 1. MiSeq System configured with Cool Master PS, Ferrite bead, Rev. B., 9.1.6 FPGA
2. RBW/VBW Setting:
9 kHz to 150 kHz; RBW = 200Hz, VBW = 1kHz
150 kHz to 30 MHz; RBW = 9kHz, VBW = 30kHz
30 MHz to 1000 MHz; RBW = 120kHz, VBW = 300kHz

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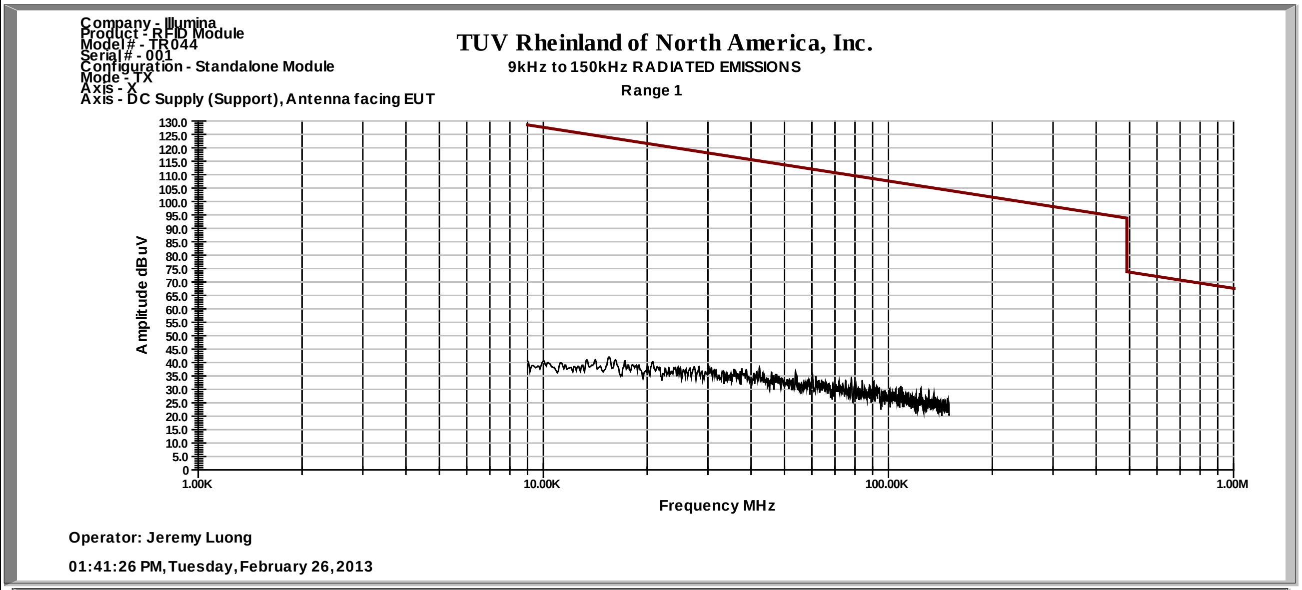
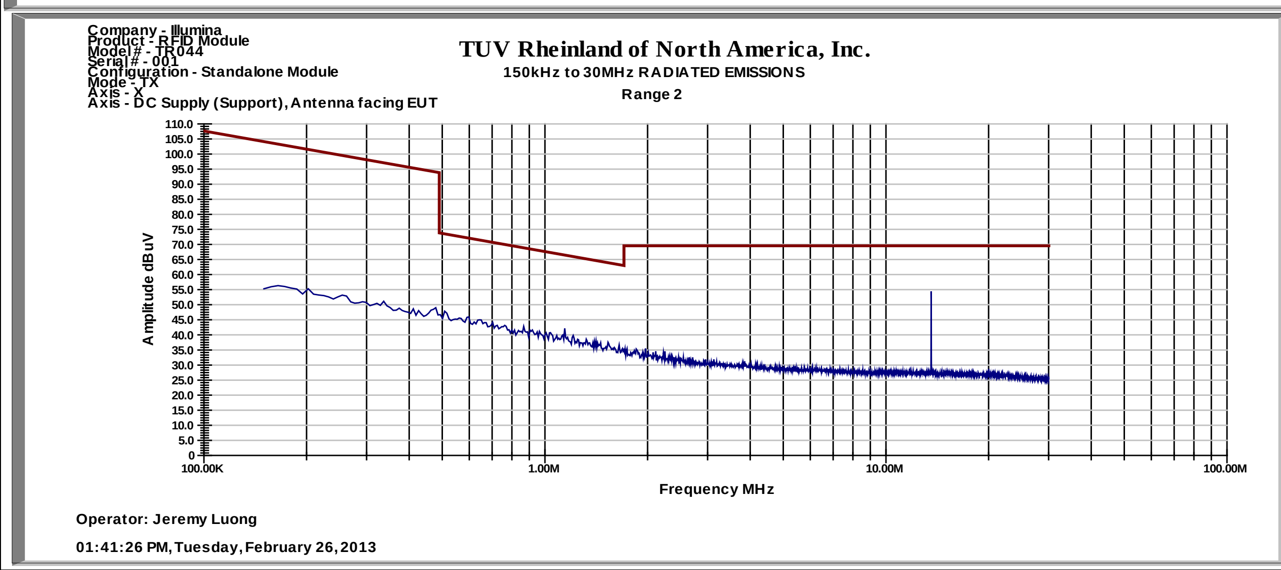
EUT Name	RFID Reader	**Date**	February 28, 2013
EUT Model	TR-001-44	**Temp / Hum in**	22°C / 37%rh
EUT Serial	001	**Temp / Hum out**	N/A
EUT Config.	Standalone Module Orientation X axis	**Line AC / Freq**	120 Vac / 60Hz
Standard	CFR47 Part 15 Subpart C	**RBW / VBW**	120 kHz/ 300 kHz
Dist/Ant Used	3m / 6511 & JB3	**Performed by**	Jeremy Luong

9KHz to 30MHz





Notes: 9 kHz to 150 kHz; RBW = 200Hz, VBW = 1kHz
150 kHz to 30 MHz; RBW = 9kHz, VBW = 30kHz

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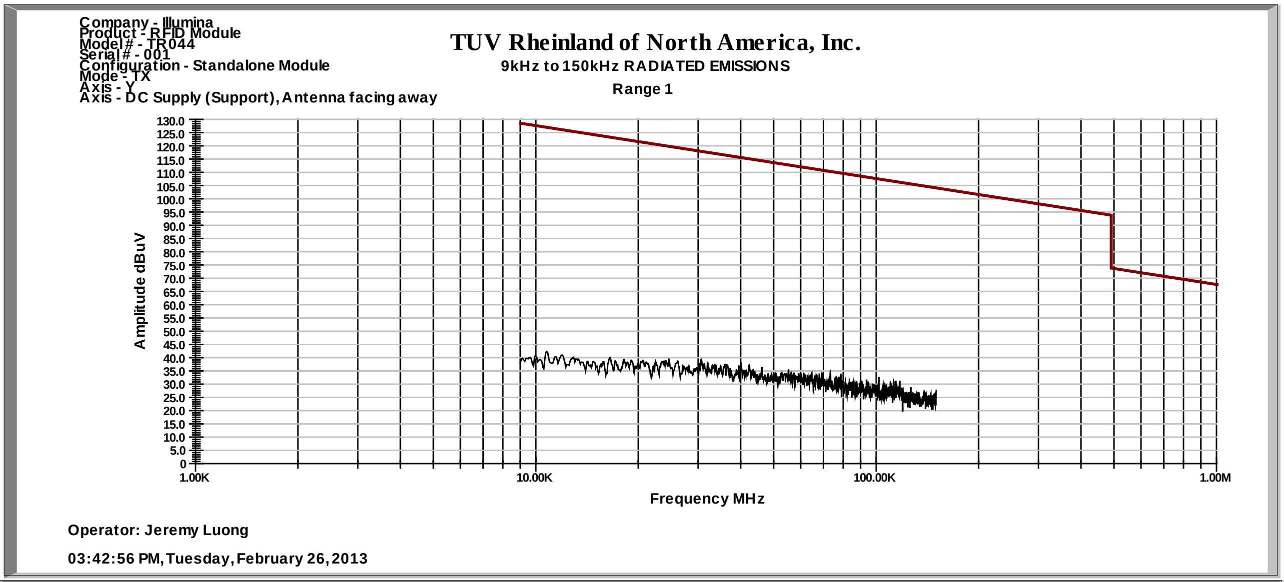
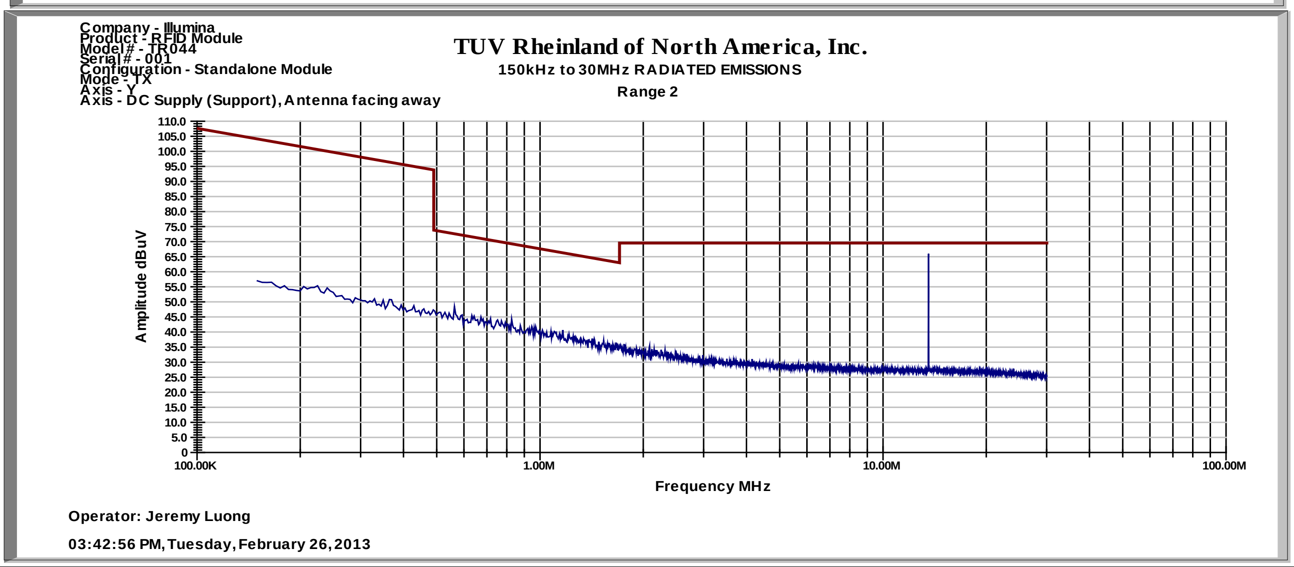
EUT Name	RFID Reader	**Date**	Feb 28, 2013
EUT Model	TR-001-44	**Temp / Hum in**	23°C / 37%rh
EUT Serial	001	**Temp / Hum out**	N/A
EUT Config.	Standalone Module Orientation Y axis	**Line AC**	120V/60Hz
Standard	CFR47 Part 15 Subpart C	**RBW / VBW**	120kHz / 300kHz
Dist/Ant Used	3m / JB3	**Performed by**	Jeremy Luong

9KHz to 30MHz





Notes: 9 kHz to 150 kHz; RBW = 200Hz, VBW = 1kHz
150 kHz to 30 MHz; RBW = 9kHz, VBW = 30kHz

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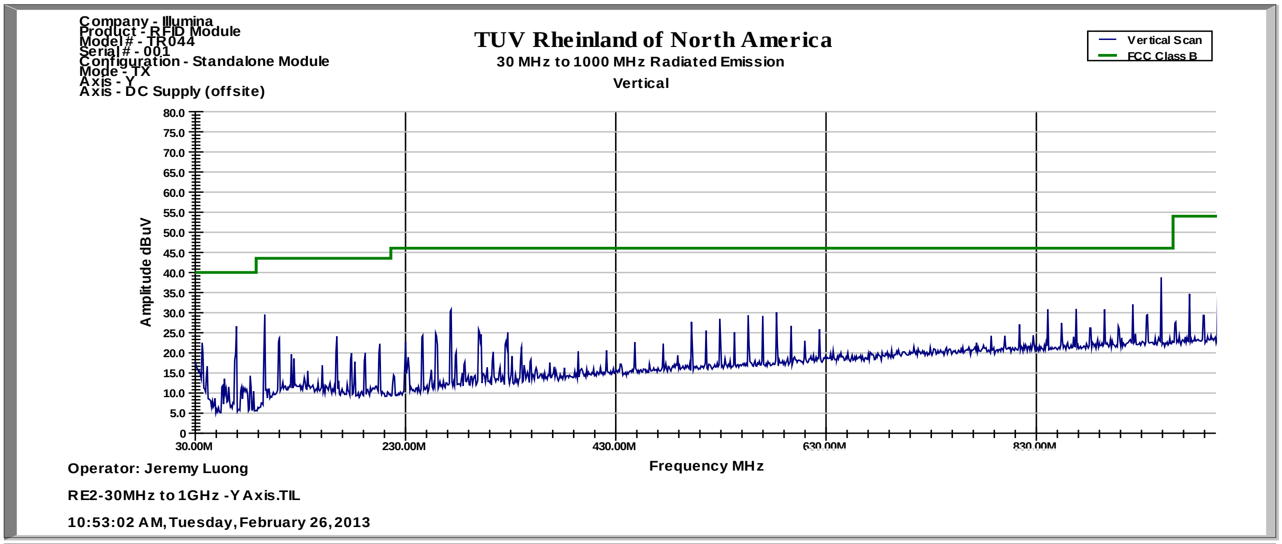
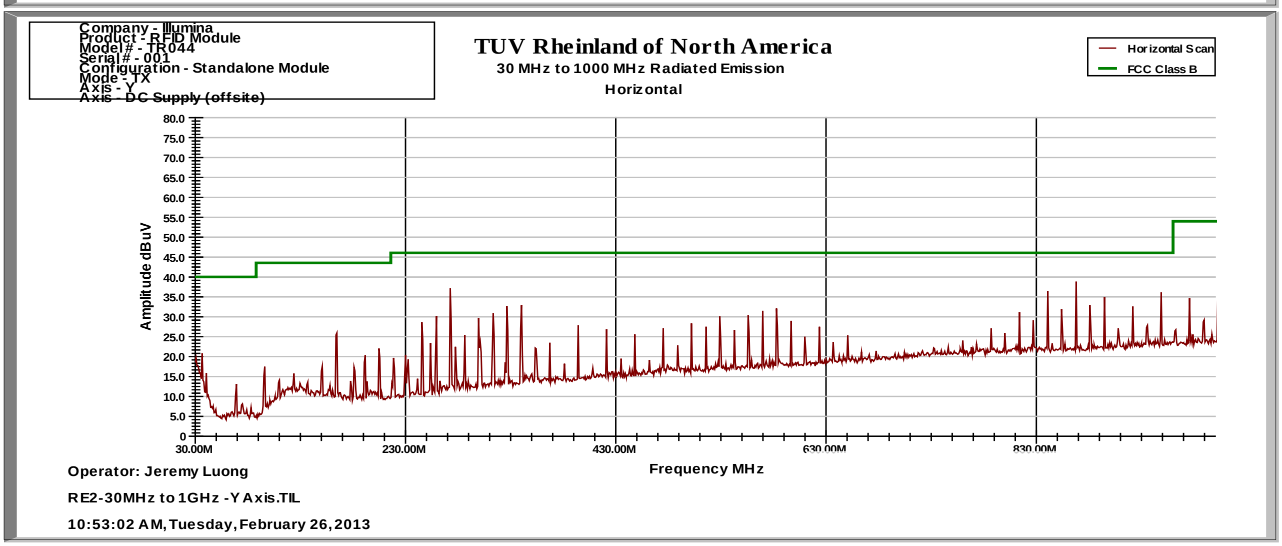
EUT Name	RFID Reader	**Date**	Feb 28, 2013
EUT Model	TR-001-44	**Temp / Hum in**	23°C / 37%rh
EUT Serial	001	**Temp / Hum out**	N/A
EUT Config.	Standalone Module, Orientation Y axis	**Line AC**	120V/60Hz
Standard	CFR47 Part 15 Subpart C	**RBW / VBW**	120kHz / 300kHz
Dist/Ant Used	3m / JB3	**Performed by**	Jeremy Luong

30MHz to 1000MHz





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EUT Name	RFID Reader	**Date**	February 28, 2013
EUT Model	TR-001-44	**Temp / Hum in**	22°C / 37%rh
EUT Serial	001	**Temp / Hum out**	N/A
EUT Config.	Standalone Module, Orientation Z axis	**Line AC / Freq**	120 Vac / 60Hz
Standard	CFR47 Part 15 Subpart C	**RBW / VBW**	120 kHz/ 300 kHz
Dist/Ant Used	3m / 6511 & JB3	**Performed by**	Jeremy Luong

Frequency	Peak	QP	Ave.	Limit	Margin (QP)	Margin (Ave)	Turntable	Height	Ant	Note
MHz	dBuV/m	dBuV/m	dBuV/m	dBuV/m	dB	dB	degree	cm		
0.037	52.36	45.18	42.93	126.48	-81.29	-83.54	296	100	0	Spurious
0.178	55.39	52.24	46.22	116.34	-64.10	-70.12	174	100	0	Spurious
1.045	37.85	34.94	29.91	68.85	-33.91	-38.94	174	100	0	Spurious
13.560	63.41	63.29	63.29	124.00	-60.71	-60.71	171	100	0	Fundamental
0.038	51.21	44.77	42.33	126.42	-81.65	-84.09	0	100	90	Spurious
0.322	52.37	47.03	40.94	105.91	-58.88	-64.97	375	100	90	Spurious
13.560	66.25	66.21	66.20	124.00	-57.79	-57.80	240	100	90	Fundamental
27.119	19.83	15.31	9.23	69.50	-54.19	-60.27	189	100	90	Spurious

Spec Margin = E-Field QP – Limit, E-Field QP = FIM QP+ Total CF ± Uncertainty
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Note: 1. MiSeq System configured with Cool Master PS, Ferrite bead, Rev. B., 9.1.6 FPGA
2. RBW/VBW Setting:
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150 kHz to 30 MHz; RBW = 9kHz, VBW = 30kHz
30 MHz to 1000 MHz; RBW = 120kHz, VBW = 300kHz

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EUT Name	RFID Reader	**Date**	Feb 28, 2013
EUT Model	TR-001-44	**Temp / Hum in**	22°C / 37%rh
EUT Serial	001	**Temp / Hum out**	N/A
EUT Config.	Standalone Module, Orientation Z axis	**Line AC / Freq**	120 Vac / 60Hz
Standard	CFR47 Part 15 Subpart C	**RBW / VBW**	120 kHz/ 300 kHz
Dist/Ant Used	3m / 6511 & JB3	**Performed by**	Jeremy Luong

Emission Freq (MHz)	ANT Polar (H/V)	ANT Pos (cm)	Table Pos (deg)	FIM (Pk) Pk (dBuV/m)	FIM QP/Ave (dBuV/m)	Total CF dBuV	E-Field QP/Ave (dBuV/m)	Spec Limit (dBuV/m)	Spec Margin (dB)	Type
30MHz to 1000MHz										
583.07	H	108	302	39.89	39.83	-5.43	34.40	46.02	-11.62	Spurious
949.16	H	108	261	33.83	33.42	0.42	33.84	46.02	-12.18	Spurious
94.92	V	112	257	47.76	48.35	-16.48	31.87	43.52	-11.65	Spurious
271.19	V	188	146	43.29	43.06	-11.07	31.99	46.02	-14.03	Spurious
528.82	V	105	220	41.49	41.02	-6.98	34.04	46.02	-11.98	Spurious
555.94	V	106	167	42.35	42.10	-6.46	35.64	46.02	-10.38	Spurious
949.18	V	107	243	38.16	38.18	-0.20	37.98	46.02	-8.04	Spurious

Spec Margin = E-Field QP – Limit, E-Field QP = FIM QP+ Total CF ± Uncertainty
Total CF= Amp Gain + Cable Loss + ANT Factor

Combined Standard Uncertainty $u_c(y)$ = ± 3.2 dB Expanded Uncertainty $U = ku_c(y)$ k = 2 for 95% confidence

Note: 1. MiSeq System configured with Cool Master PS, Ferrite bead, Rev. B., 9.1.6 FPGA
2. RBW/VBW Setting:
9 kHz to 150 kHz; RBW = 200Hz, VBW = 1kHz
150 kHz to 30 MHz; RBW = 9kHz, VBW = 30kHz
30 MHz to 1000 MHz; RBW = 120kHz, VBW = 300kHz

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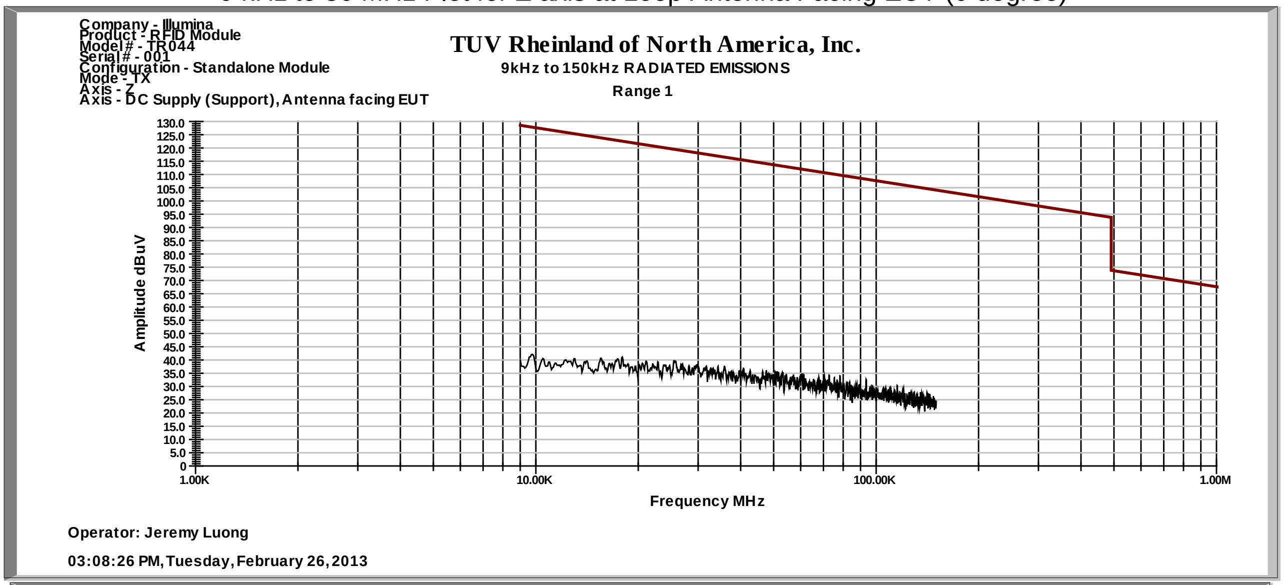
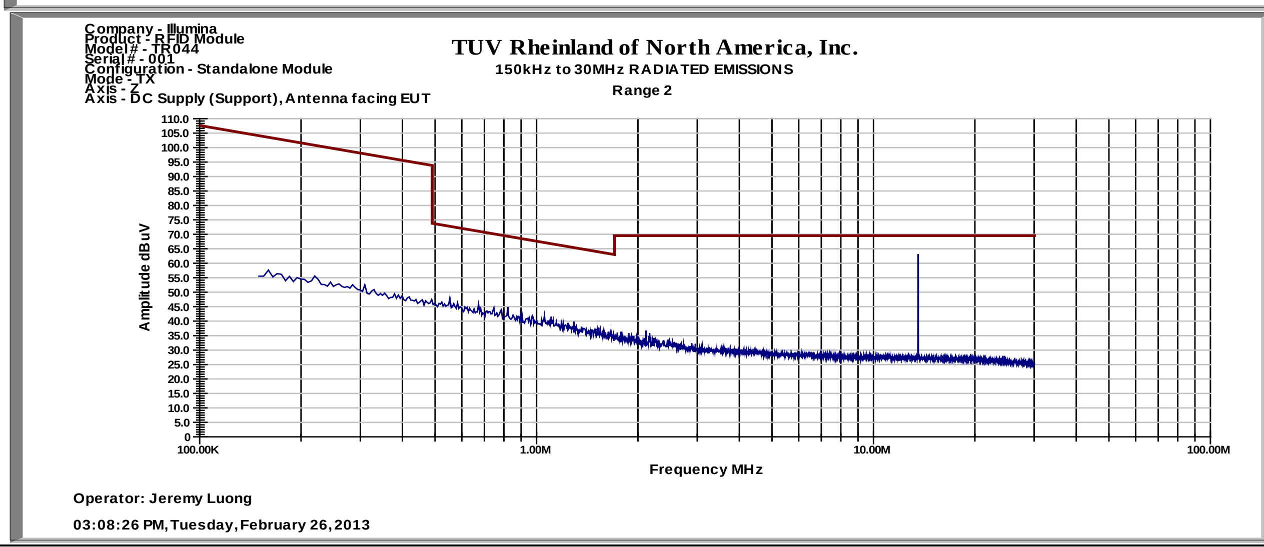
EUT Name	RFID Reader	**Date**	Feb 28, 2013
EUT Model	TR-001-44	**Temp / Hum in**	22°C / 37%rh
EUT Serial	001	**Temp / Hum out**	N/A
EUT Config.	Standalone Module Orientation Z axis	**Line AC**	120V/60Hz
Standard	CFR47 Part 15 Subpart C	**RBW / VBW**	See below
Dist/Ant Used	3m / 6511	**Performed by**	Jeremy Luong

9 kHz to 30 MHz Plot for Z axis at Loop Antenna Facing EUT (0 degree)





Notes: 9 kHz to 150 kHz; RBW = 200Hz, VBW = 1kHz
150 kHz to 30 MHz; RBW = 9kHz, VBW = 30kHz

SOP 1 Radiated Emissions

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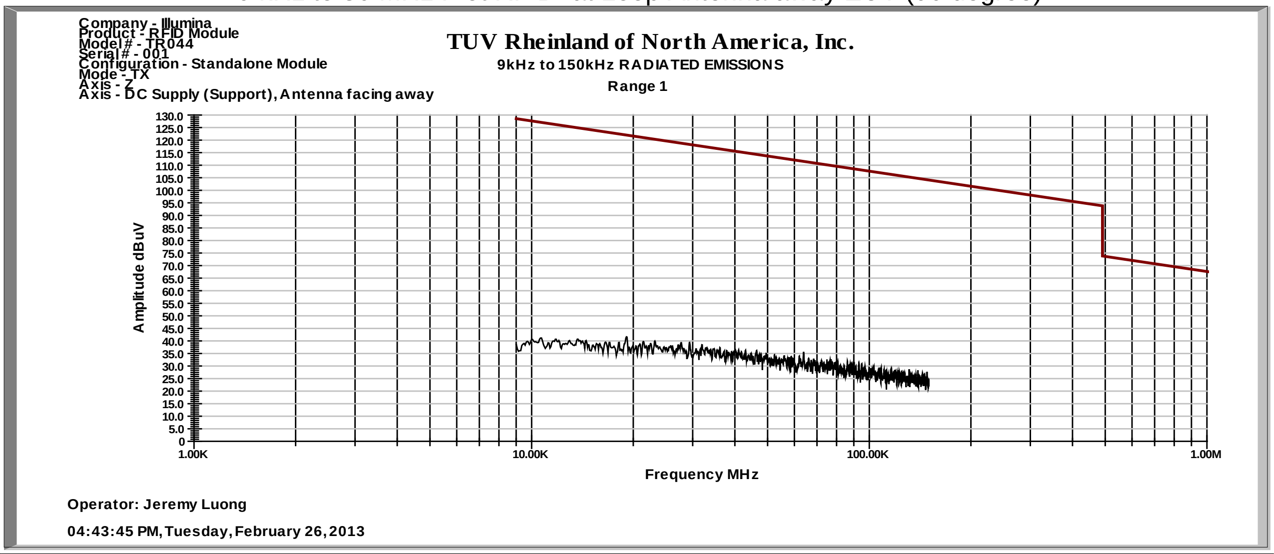
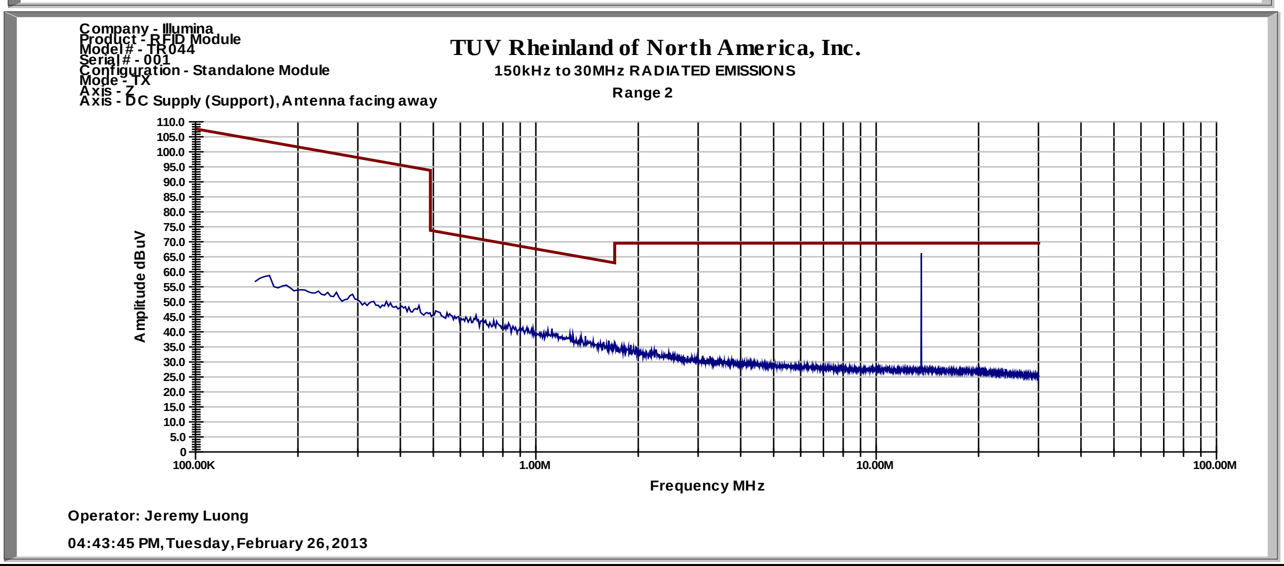
EUT Name	RFID Reader	**Date**	Feb 28, 2013
EUT Model	TR-001-44	**Temp / Hum in**	22°C / 37%rh
EUT Serial	001	**Temp / Hum out**	N/A
EUT Config.	Standalone Module orientation Z axis	**Line AC**	120V/60Hz
Standard	CFR47 Part 15 Subpart C	**RBW / VBW**	See below
Dist/Ant Used	3m / 6511	**Performed by**	Jeremy Luong

9 kHz to 30 MHz Plot RFID at Loop Antenna away EUT (90 degree)





Notes: 9 kHz to 150 kHz; RBW = 200Hz, VBW = 1kHz
150 kHz to 30 MHz; RBW = 9kHz, VBW = 30kHz

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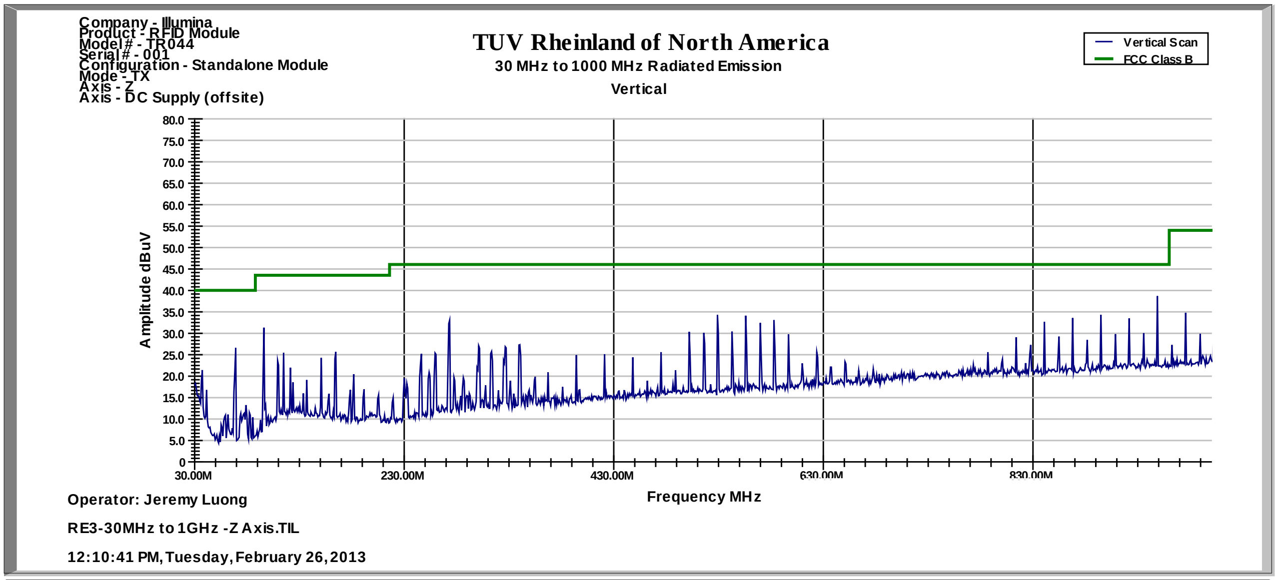
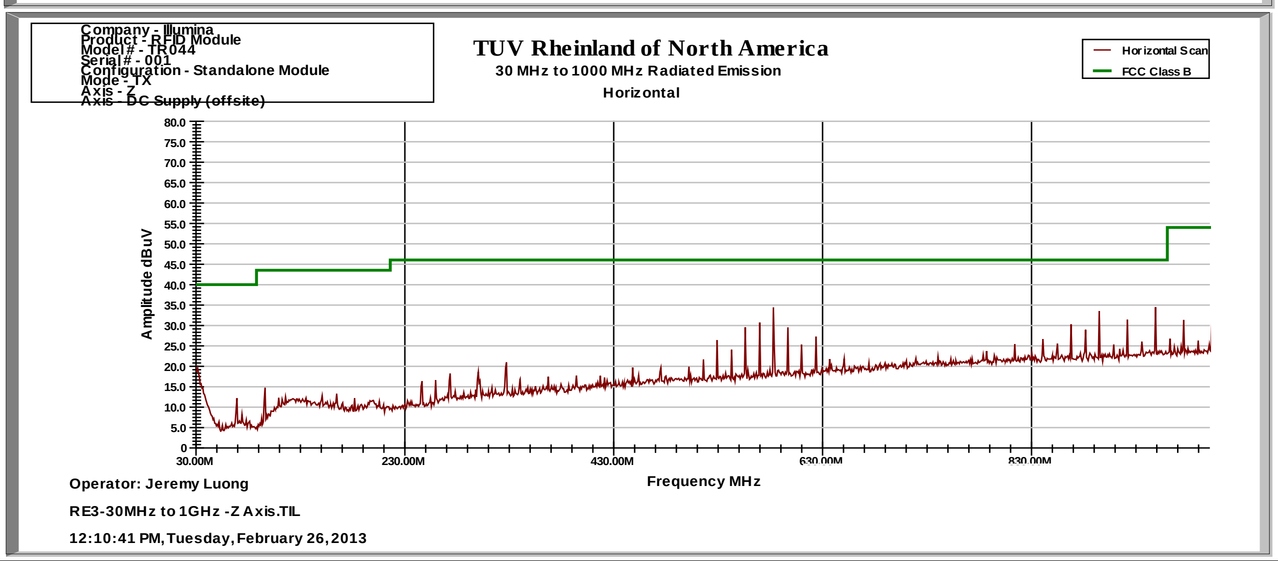
EUT Name	RFID Reader	**Date**	Feb 28, 2013
EUT Model	TR-001-44	**Temp / Hum in**	23°C / 37%rh
EUT Serial	001	**Temp / Hum out**	N/A
EUT Config.	Standalone Module, Orientation Z axis	**Line AC**	120V/60Hz
Standard	CFR47 Part 15 Subpart C	**RBW / VBW**	120kHz / 300kHz
Dist/Ant Used	3m / JB3	**Performed by**	Jeremy Luong

30MHz to 1000MHz





4.5.4 Sample Calculation

The field strength is calculated by subtracting the Amplifier Gain and adding the Cable Loss and Antenna Correction Factor to the measured reading. The basic equation is as follows:

Field Strength (dBμV/m) = FIM - AMP + CBL + ACF

Where: FIM = Field Intensity Meter (dBμV)
AMP = Amplifier Gain (dB)
CBL = Cable Loss (dB)
ACF = Antenna Correction Factor (dB/m)

$$\mu V/m = 10^{\frac{dB\mu V/m}{20}}$$

4.6 AC Conducted Emissions

Testing was performed in accordance with ANSI C63.4: 2003. These test methods are listed under the laboratory's A2LA Scope of Accreditation.

This test measures the levels emanating from the EUT's AC input port, thus evaluating the potential for the EUT to cause radio frequency interference to other electronic devices.

The AC conducted emissions of equipment under test shall not exceed the values in CFR47 Part 15.207: 2010 and RSS 210: 2010.

4.6.1 Test Methodology

A test program that controls instrumentation and data logging was used to automate the AC Power Line Conducted emission test procedure. The frequency range of interest was divided into sub-ranges such as to yield a frequency resolution of 9 kHz. Each phase and neutral of the AC power line were measured with respect to ground. Measurements were performed using a set of 50μH / 50Ω LISNs.

Testing is either performed in 5m Chamber. The setup photographs clearly identify which site was used. The vertical ground plane used in the semi-anechoic chamber is a 2m x 2m solid aluminum frame and panel, and it is bonded to the horizontal ground plane.

In the case of tabletop equipment, the EUT is placed on a 1.0m x 1.5m non-conductive table 80cm above the ground plane and 40cm from a vertical ground reference plane. The rear of the EUT was positioned flush with the backside of the table and directly over the LISNs. The power and I/O cables were routed over the edge of the table and bundled approximately 40cm from the ground plane. Support equipment was powered from a separate LISN.

4.6.1.1 Deviations

There were no deviations from this test methodology.

4.6.2 Test Results

As originally tested, the EUT was found to be compliant to the requirements of the test standard(s).

Table 8: AC Conducted Emissions – Test Results

Test Conditions: Conducted Measurement at Normal Conditions only		
Antenna Type: Internal	**Power Level:** Fixed	
AC Power: 120 Vac/60 Hz	**Configuration:** Tabletop	
Ambient Temperature: 22° C	**Relative Humidity:** 37% RH	
Configuration	**Frequency Range**	**Test Result**
Line 1 (Hot)	0.15 to 30 MHz	Pass
Line 2 (Neutral)	0.15 to 30 MHz	Pass

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EUT Name	RFID Reader	**Date**	Feb 27, 2013
EUT Model	TR-001-44	**Temp / Hum in**	23° C / 37% rh
EUT Serial	001	**Temp / Hum out**	N/A
EUT Config.	Standalone Module	**Line AC / Freq**	120Vac/60Hz
Standard	CFR47 Part 15.207	**RBW / VBW**	9kHz / 30 kHz
Lab/LISN	5m Chamber /ComPower, Line 1	**Performed by**	Jeremy Luong

Frequency	**Quasi-Peak**	**Average**	**QP Limit**	**Ave Limit**	**QP Margin**	**Ave Margin**
MHz	**dBuV**	**dBuV**	**dBuV**	**dBuV**	**dB**	**dBuV**
0.1500	39.74	22.15	66.00	56.00	-26.26	-33.85
0.4983	31.39	24.04	56.05	46.05	-24.66	-22.01
0.5919	40.78	33.21	56.00	46.00	-15.22	-12.79
0.6419	30.28	22.57	56.00	46.00	-25.72	-23.43
0.7349	29.83	22.73	56.00	46.00	-26.17	-23.27
0.9550	30.17	21.92	56.00	46.00	-25.83	-24.08
1.0586	32.87	25.68	56.00	46.00	-23.13	-20.32
13.5597	47.90	46.74	60.00	50.00	-12.10	-3.26

Spec Margin = QP./Ave. - Limit, ± Uncertainty

Combined Standard Uncertainty $u_c(y)$ = ± 1.2 dB   Expanded Uncertainty $U = ku_c(y)$ k = 2 for 95% confidence

Notes: Targus AC Adapter. Terminate Antenna w/ 50Ohm

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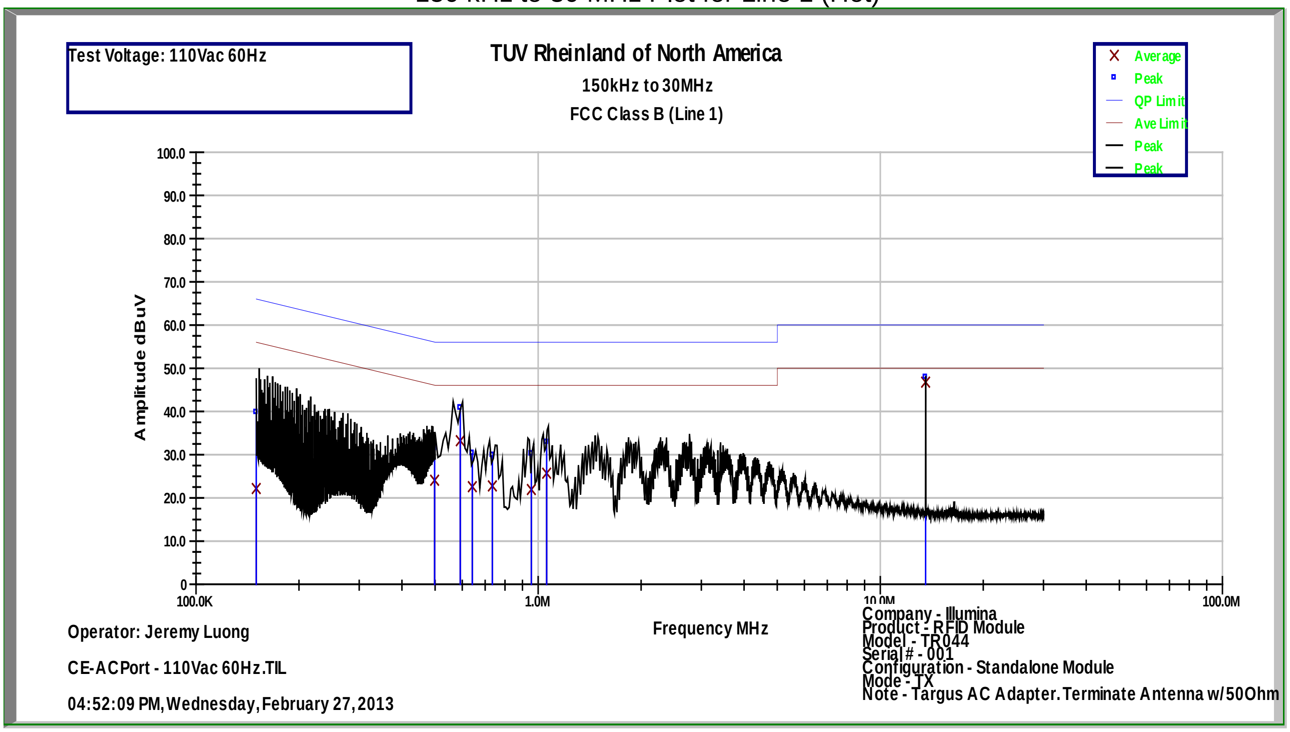
EUT Name	RFID Reader	**Date**	Feb 27, 2013
EUT Model	TR-001-44	**Temp / Hum in**	23° C / 37% rh
EUT Serial	001	**Temp / Hum out**	N/A
EUT Config.	RFID #1 with Attached Antenna	**Line AC**	120Vac/60Hz
Standard	CFR47 Part 15.207	**RBW / VBW**	9kHz / 30 kHz
Lab/LISN	5m Chamber / ComPower, Line 1	**Performed by**	Jeremy Luong

150 kHz to 30 MHz Plot for Line 1 (Hot)



Notes: Meet FCC Class B limit.

SOP 2 Conducted Emissions

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EUT Name	RFID Reader	**Date**	Feb 27, 2013
EUT Model	TR-001-44	**Temp / Hum in**	23° C / 37% rh
EUT Serial	001	**Temp / Hum out**	N/A
EUT Config.	Standalone Module	**Line AC / Freq**	120Vac/60Hz
Standard	CFR47 Part 15.107	**RBW / VBW**	9kHz / 30 kHz
Lab/LISN	5m Chamber / ComPower, Line 2	**Performed by**	Jeremy Luong

Frequency	**Quasi-Peak**	**Average**	**QP Limit**	**Ave Limit**	**QP Margin**	**Ave Margin**
MHz	**dBuV**	**dBuV**	**dBuV**	**dBuV**	**dB**	**dBuV**
0.1511	40.16	26.47	65.97	55.97	-25.81	-29.50
0.2855	31.17	24.67	62.13	52.13	-30.96	-27.46
0.4949	33.85	27.61	56.15	46.15	-22.30	-18.54
0.5940	42.00	35.23	56.00	46.00	-14.00	-10.77
0.6453	31.73	25.36	56.00	46.00	-24.27	-20.64
0.7450	29.63	22.60	56.00	46.00	-26.37	-23.40
0.9457	32.67	26.21	56.00	46.00	-23.33	-19.79
13.5594	47.27	45.73	60.00	50.00	-12.73	-4.27

Spec Margin = QP./Ave. - Limit, ± Uncertainty

Combined Standard Uncertainty $u_c(y)$ = ± 1.2 dB Expanded Uncertainty $U = ku_c(y)$ k = 2 for 95% confidence

Note - Targus AC Adapter. Terminate Antenna w/ 50Ohm

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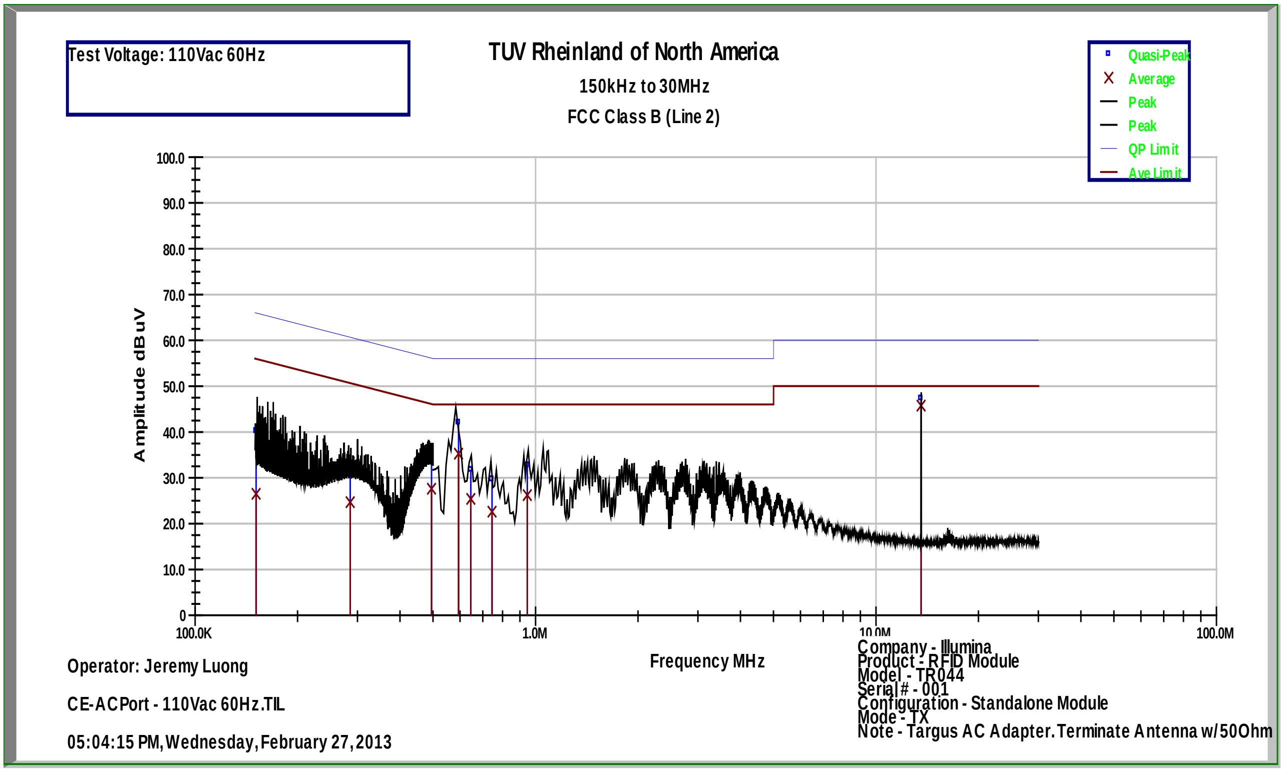
EUT Name	RFID Reader	**Date**	Feb 27, 2013
EUT Model	TR-001-44	**Temp / Hum in**	23° C / 37% rh
EUT Serial	001	**Temp / Hum out**	N/A
EUT Config.	RFID #1 with Attached Antenna	**Line AC**	120Vac/60Hz
Standard	CFR47 Part 15.107	**RBW / VBW**	9kHz / 30 kHz
Lab/LISN	5m Chamber/ ComPower, Line 2	**Performed by**	Jeremy Luong

150 kHz to 30 MHz Plot for Line 2 (Neutral)



Note: Meet FCC Class B Limit.

4.7 Frequency Stability

In accordance with 47 CFR Part 15.225(e) the frequency stability of RFID devices must be such that an emission is maintained within the band of operation under all conditions of normal operation as specified in the user's manual. The Manufacturer declares the operating temperature ranges of +0º to +35º C.

4.7.1 Test Methodology

The manufacturer of the equipment is responsible for ensuring that the frequency stability is such that emissions are always maintained within the band of operation under all conditions. This test performs according to ANSI C63.10-2009 Section 6.8

4.7.2 Manufacturer Declaration

The frequency stability of the reference oscillator sets the frequency stability of the RF transceiver signals. Per CFR47 Part 15.225 (e) and RSS 210 Sect. A2.6 (d), all of the RF signal should have ±0.01% or ±100ppm stability.
This stability accounts for room temp tolerance of the crystal oscillator circuit, frequency variation across temperature, and crystal ageing.

Worst case:
±100ppm at 13.56 GHz translates to a maximum frequency shift of ±1.356 kHz.

4.7.3 Test results

As originally tested, the EUT was found to be compliant to the requirements of the test standard(s).

Table 9: Frequency Stability – Test Results

Temperature	Time	-6 dB Lower Edge (MHz)	+6 dB Upper Edge (MHz)	Center Frequency (MHz)	PPM
0°C	Start	13.559680	13.559915	13.5597975	14.9
	2 Min.	13.559680	13.559915	13.5597975	14.9
	5 Min	13.559680	13.559910	13.5597990	14.8
	10 min	13.559685	13.559915	13.5598000	14.7
22°C	-	13.559685	13.559830	13.5597575	17.8
35°C	Start	13.559595	13.559880	13.5597375	19.3
	2 Min.	13.559620	13.559895	13.5597575	17.9
	5 Min	13.559605	13.559830	13.5597175	20.8
	10 min	13.559610	13.559845	13.5597275	20.1
Note: All frequency drifts from 13.56 MHz were less than ±100 ppm.					

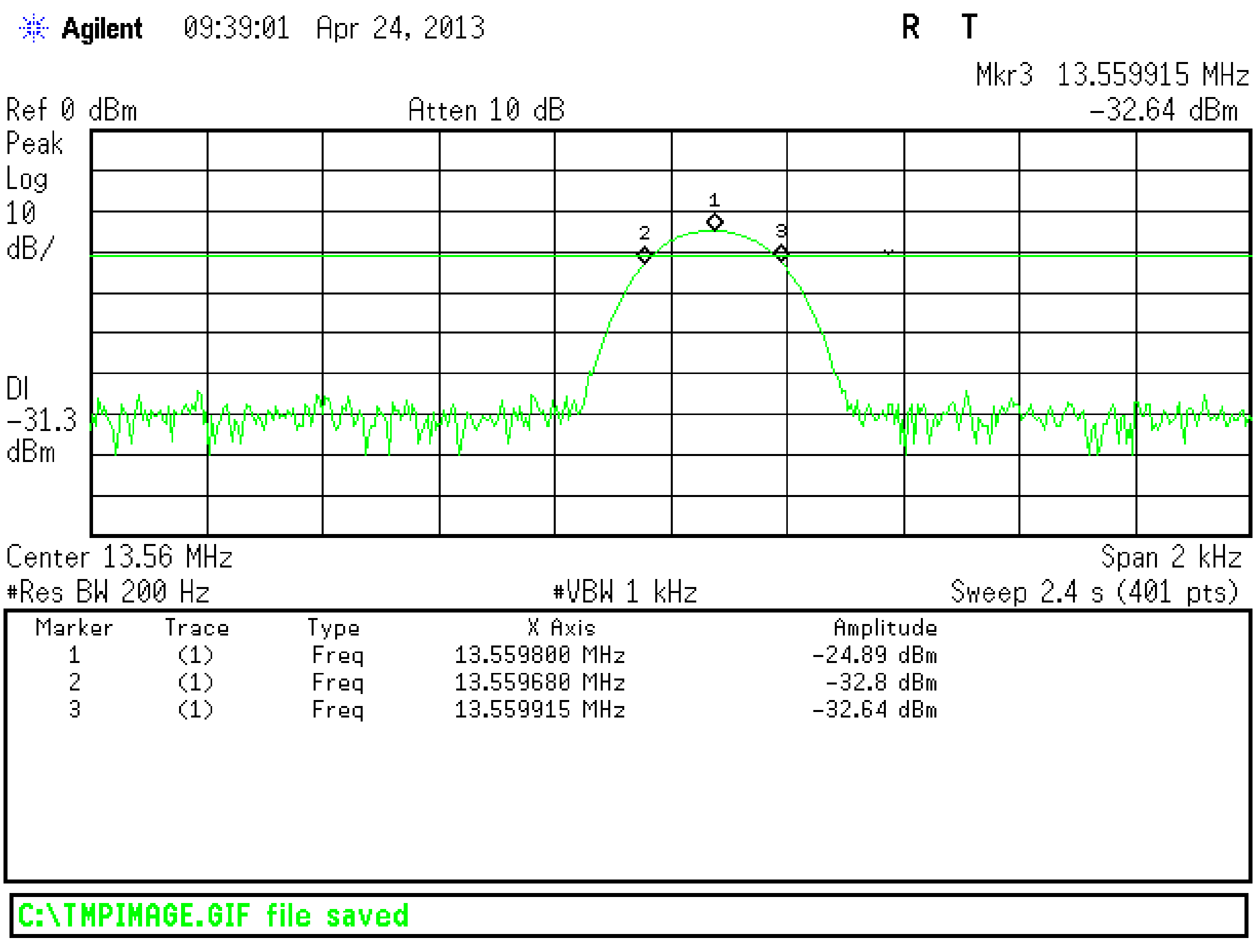


Figure 9: Frequency Stability at 0 °C - Start

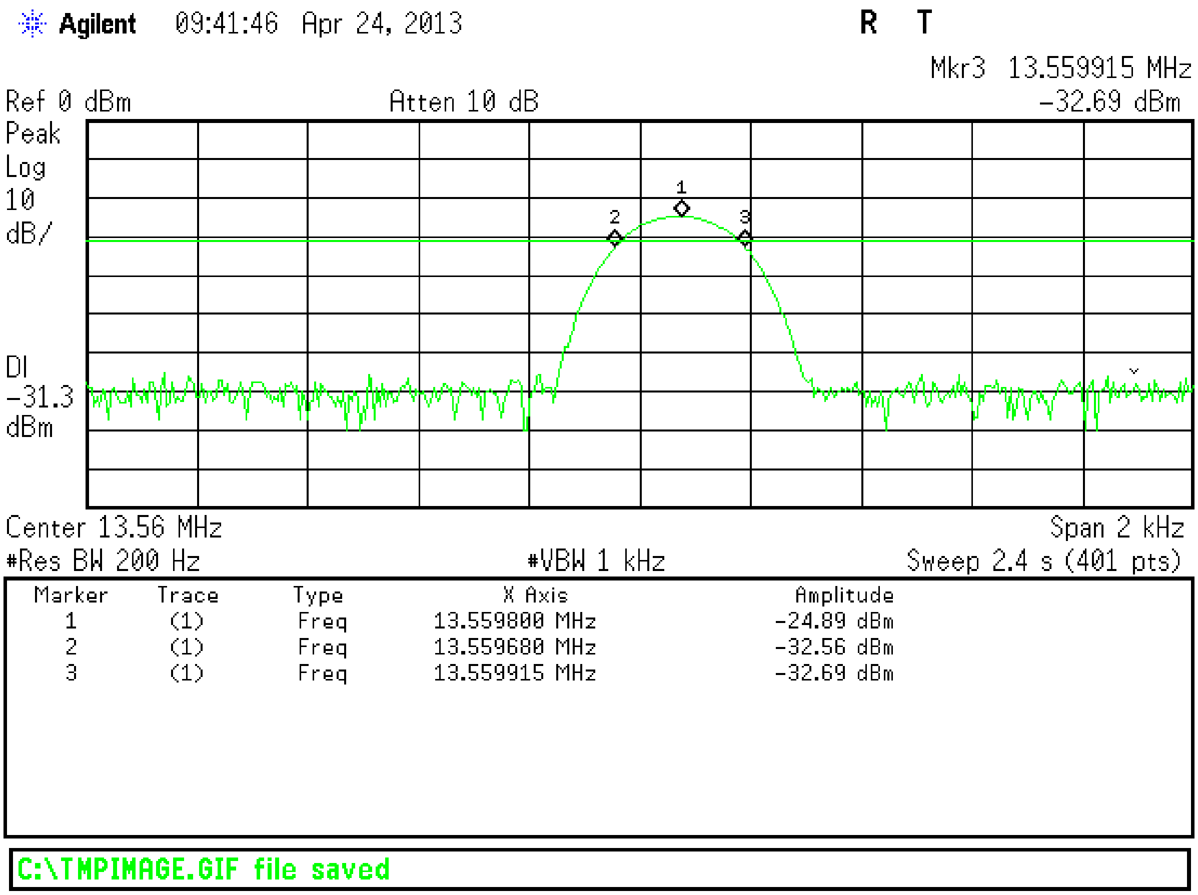


Figure 10: Frequency Stability at 0 °C – 2 min.

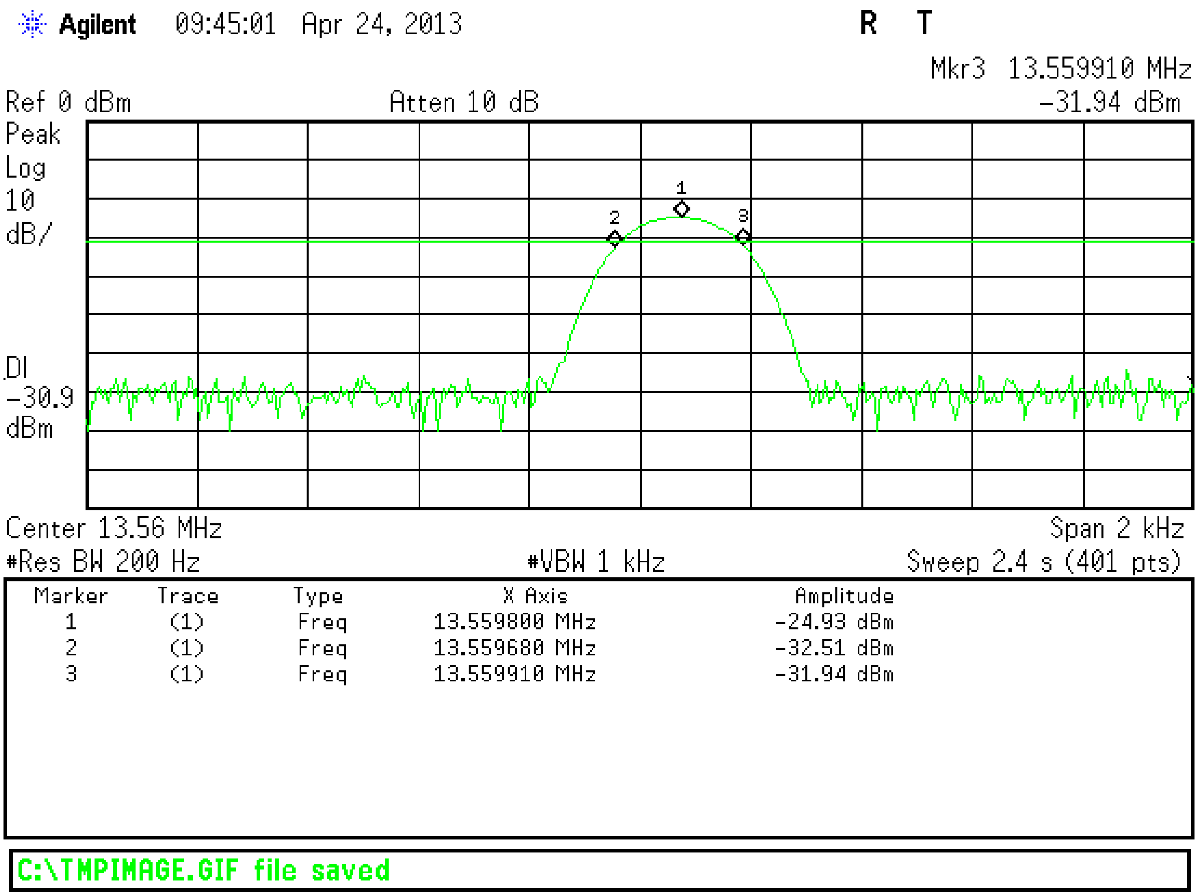


Figure 11: Frequency Stability at 0 °C – 5 min.

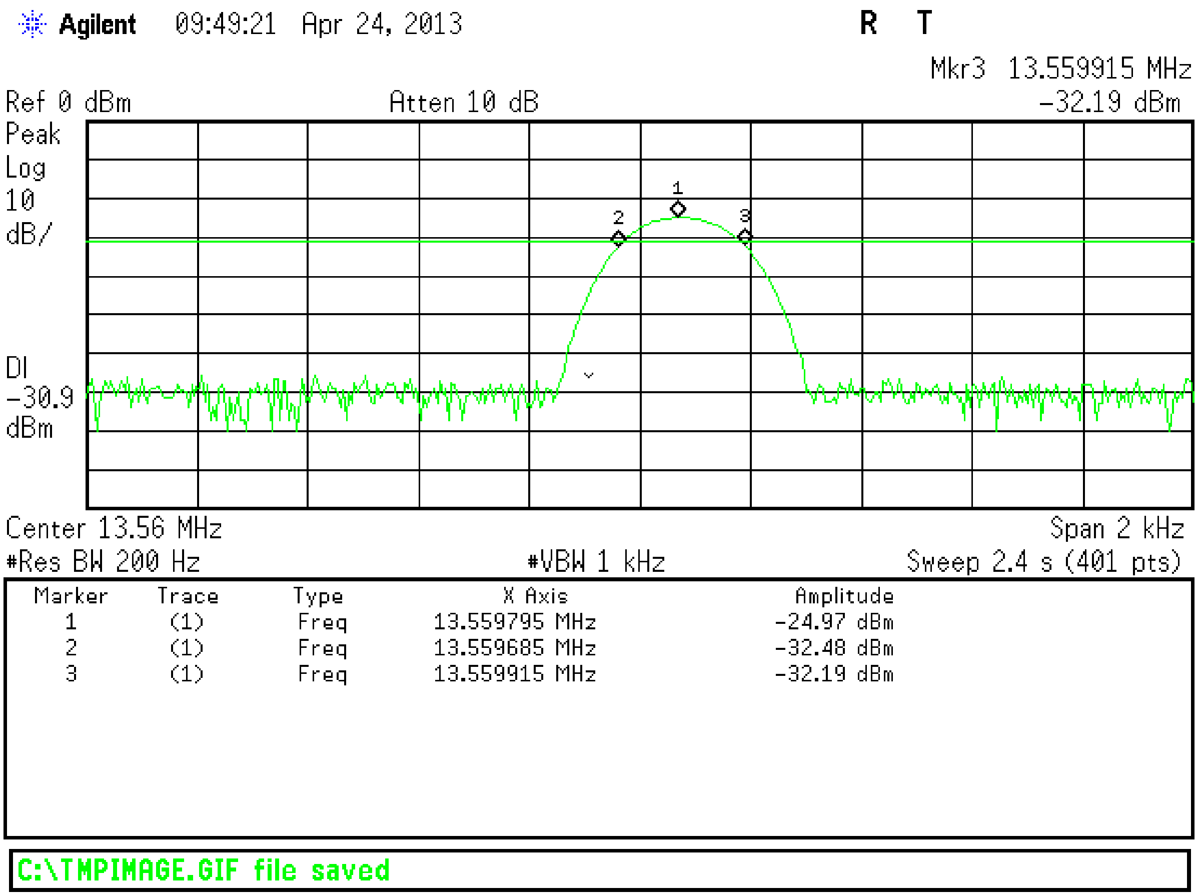


Figure 12: Frequency Stability at 0 °C – 10 min.

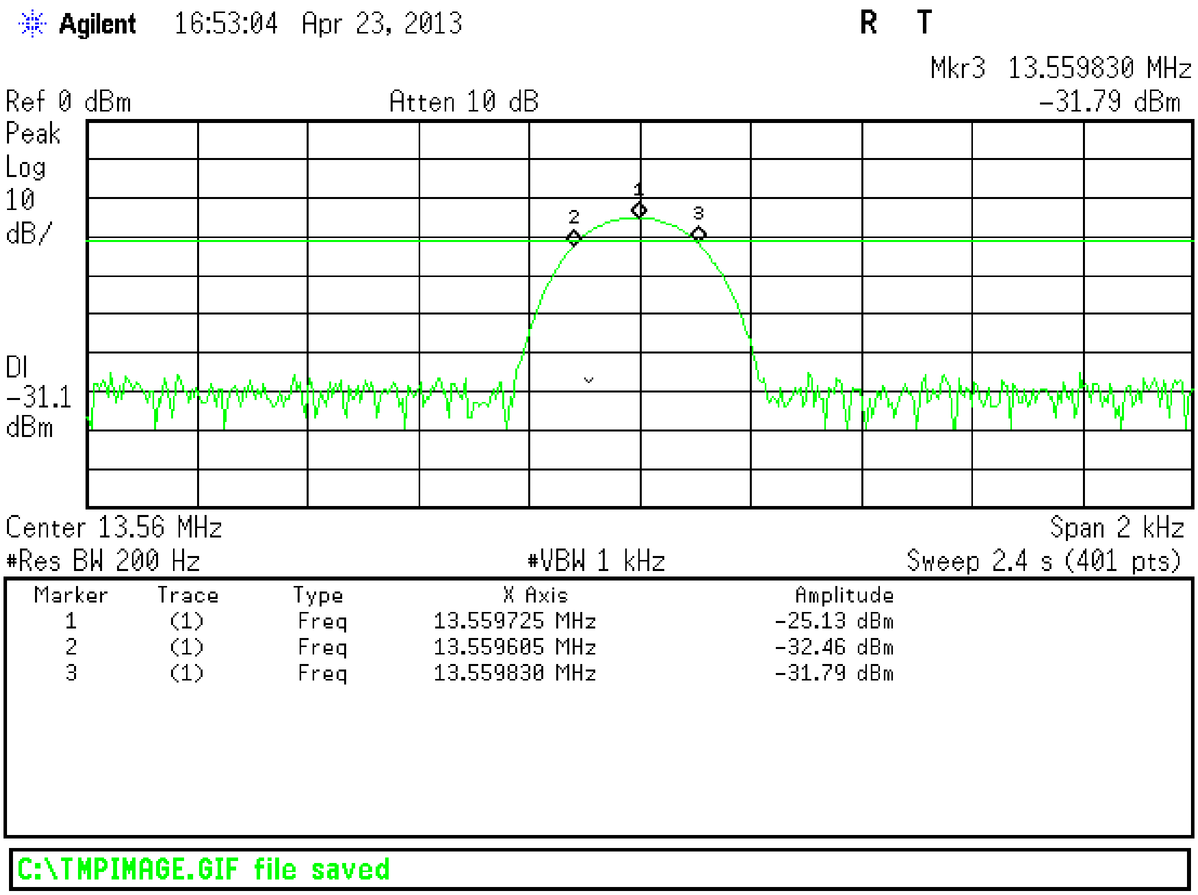
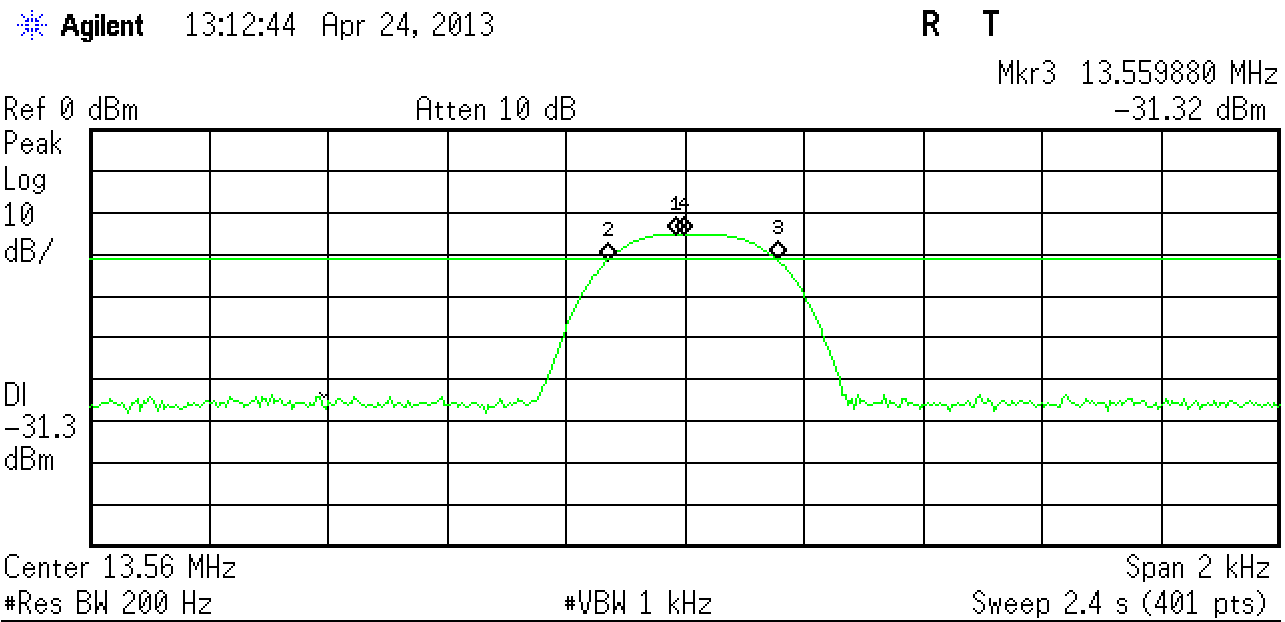


Figure 13: Frequency Stability at 22 °C



Marker	Trace	Type	X Axis	Amplitude
1	(1)	Freq	13.559710 MHz	-25.28 dBm
2	(1)	Freq	13.559595 MHz	-31.41 dBm
3	(1)	Freq	13.559880 MHz	-31.32 dBm
4	(1)	Freq	13.559725 MHz	-25.32 dBm

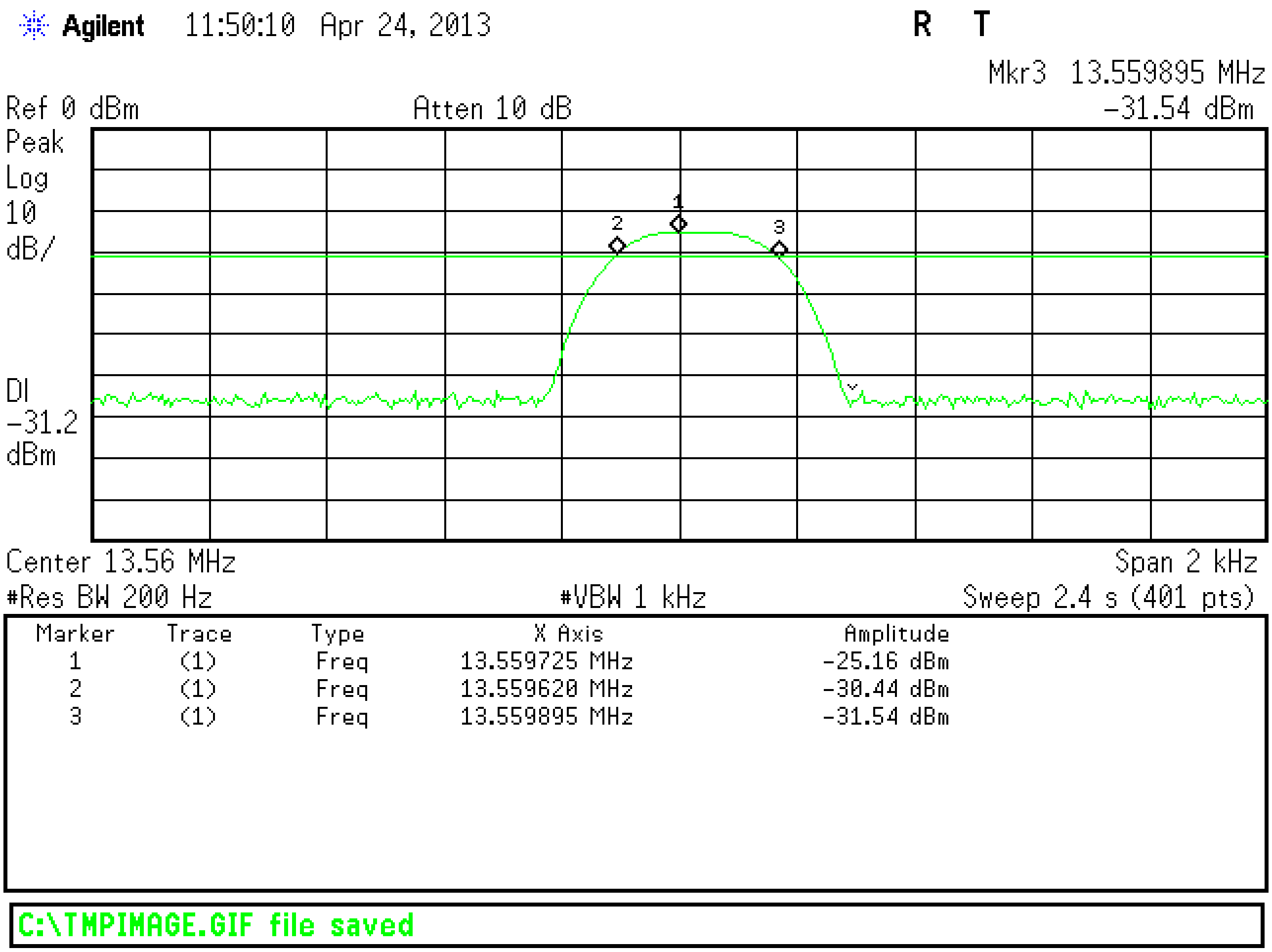


Figure 14: Frequency Stability at 35 °C – 2 min.

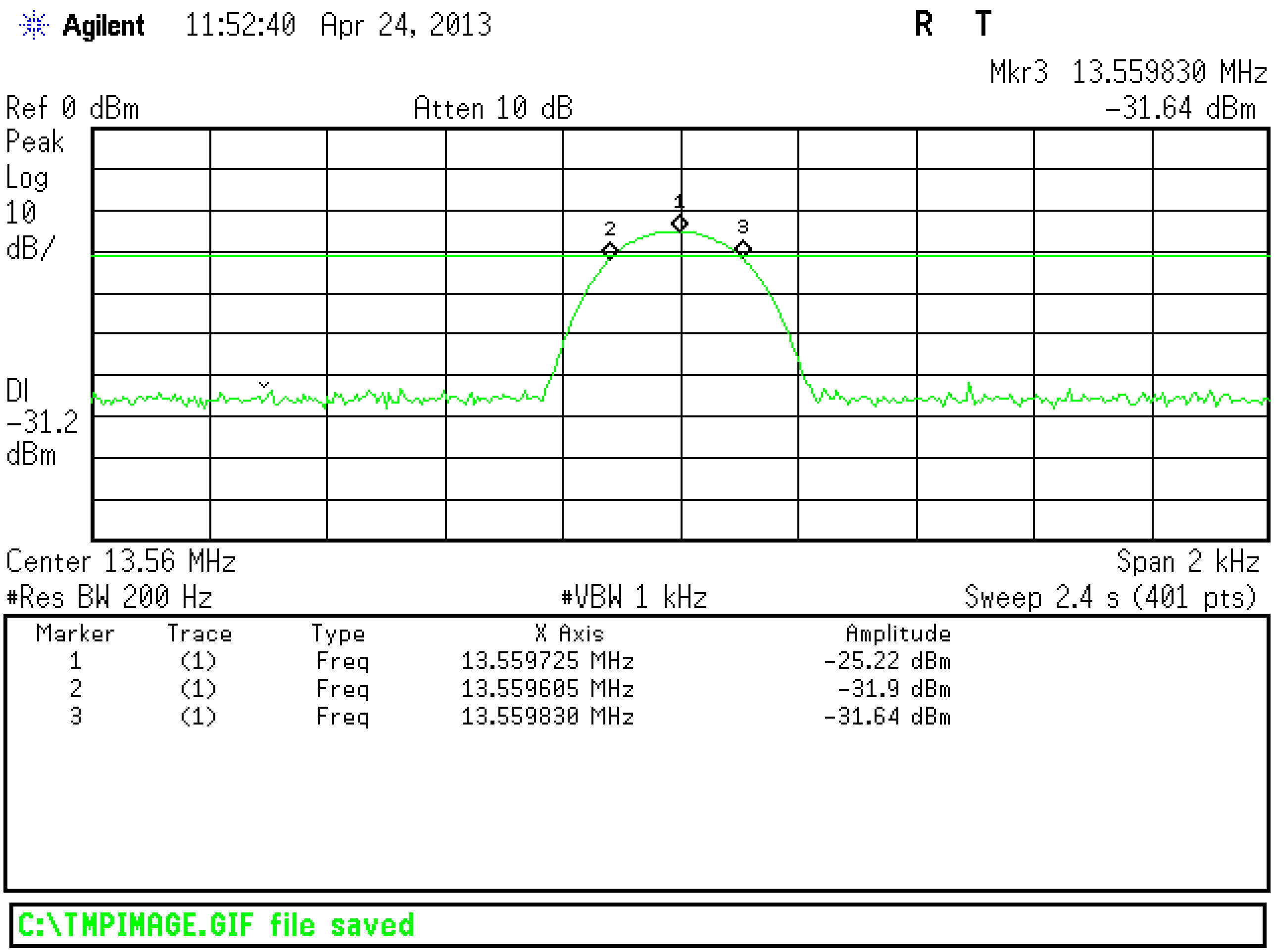


Figure 15: Frequency Stability at 35 °C – 5 min.

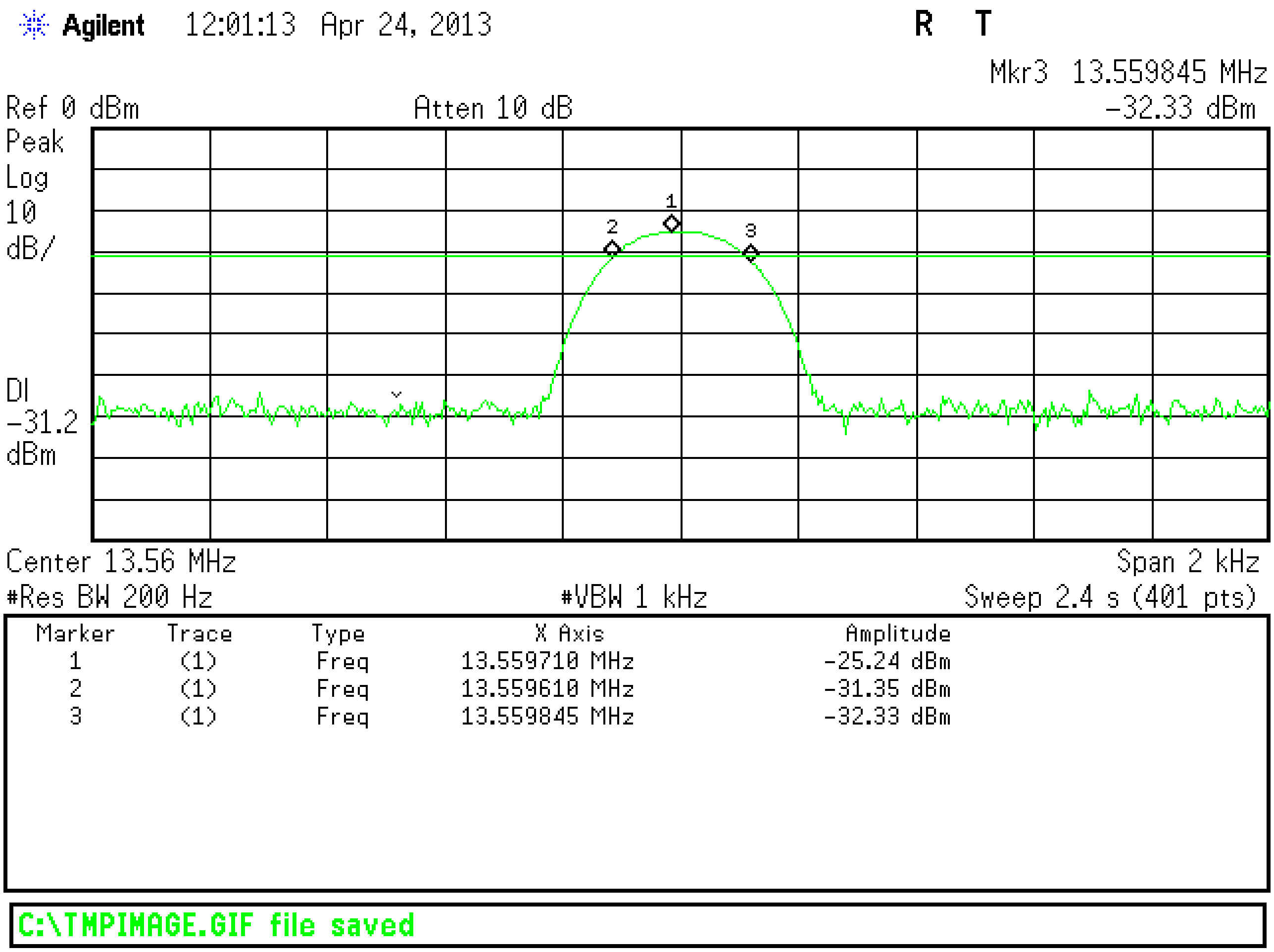


Figure 16: Frequency Stability at 35 °C – 10 min

4.8 Voltage Variation

In accordance with 47 CFR Part 15.31 (e) intentional radiators, measurements of the variation of the input power or the radiated signal level of the fundamental frequency component of the emission, as appropriate, shall be performed with the supply voltage varied between 85% and 115% of the nominal rated supply voltage. For battery operated equipment, the equipment tests shall be performed using a new battery.

4.8.1 Test Methodology

The ac supply voltage was varied between 85% and 115% of the nominal rated supply voltage. The fundamental frequency was observed during the variation. The RF ID standalone module was powered 5V DC by programmable power supply. The voltage was varied from 4.75VDC to 5.75VDC mean while the fundamental frequencies were observed and recorded for the maximum drift in ppm; part per millions.

4.8.2 Test results

As originally tested, the EUT was found to be compliant to the requirements of the test standard(s). The fundamental frequencies drifted less than ±100ppm.

Table 10: Voltage Variation – Test Results

Temperature	-6 dB Lower Edge (MHz)	+6 dB Upper Edge (MHz)	Center Frequency (MHz)	PPM
4.75V DC	13.559615	13.559880	13.5597475	18.65
5.00V DC	13.559605	13.559830	13.5597175	20.87
5.75V DC	13.559620	13.559840	13.5597300	19.91
Note: All frequency drifts were less than ±100 ppm from 13.56 MHz No frequency change was observed with time.				

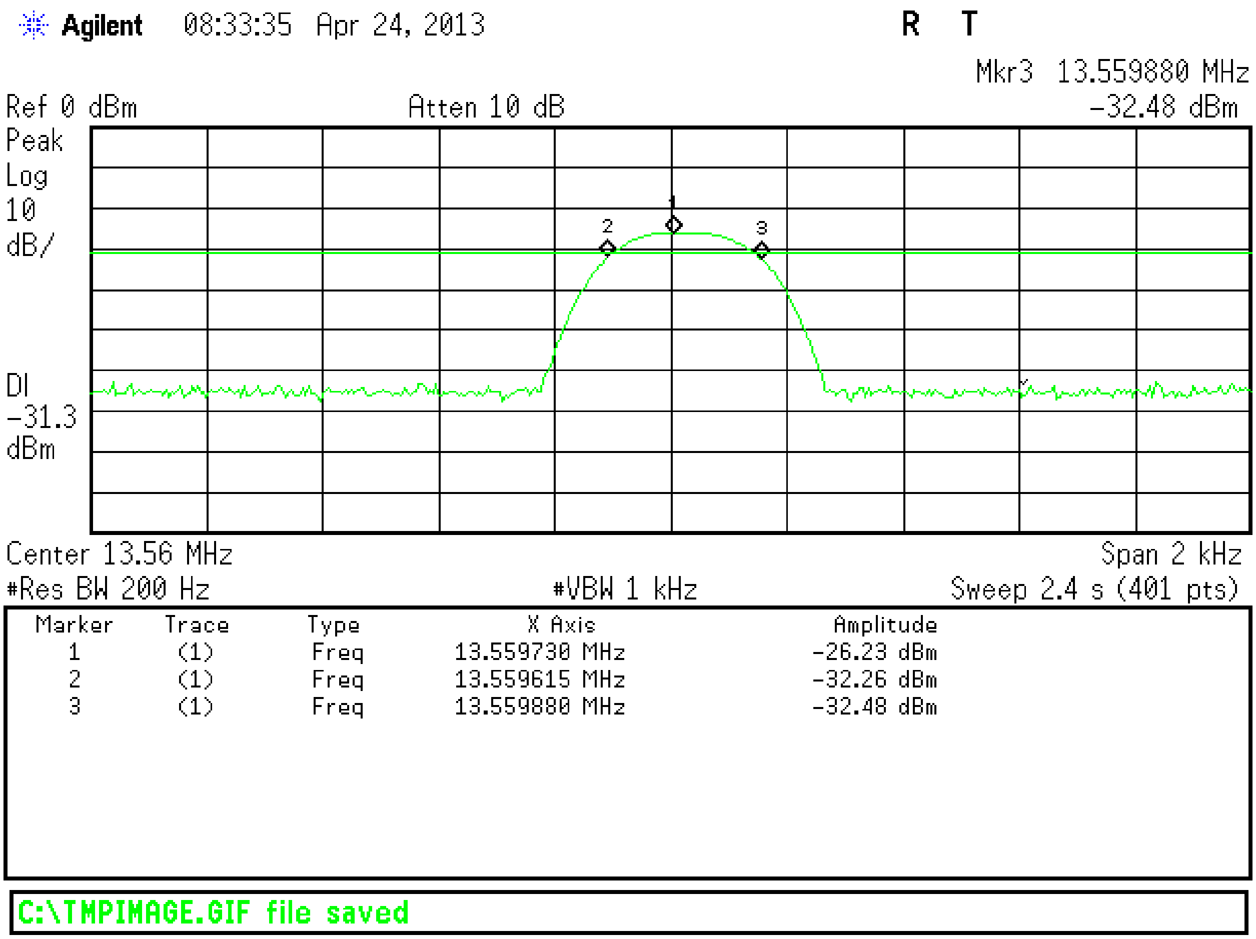


Figure 17: Voltage Variation at 4.75V DC

DC

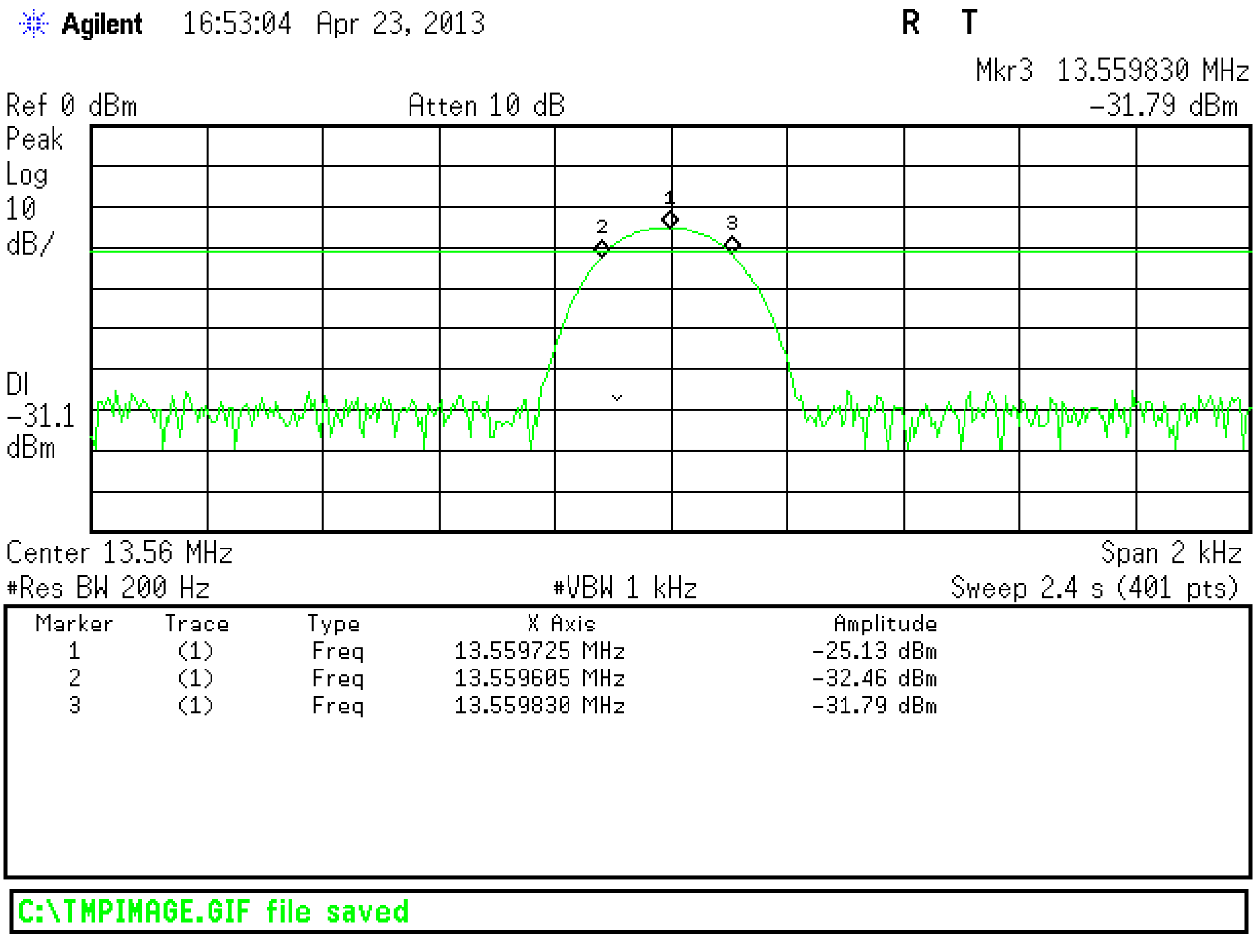


Figure 22: Voltage Variation at 5V DC

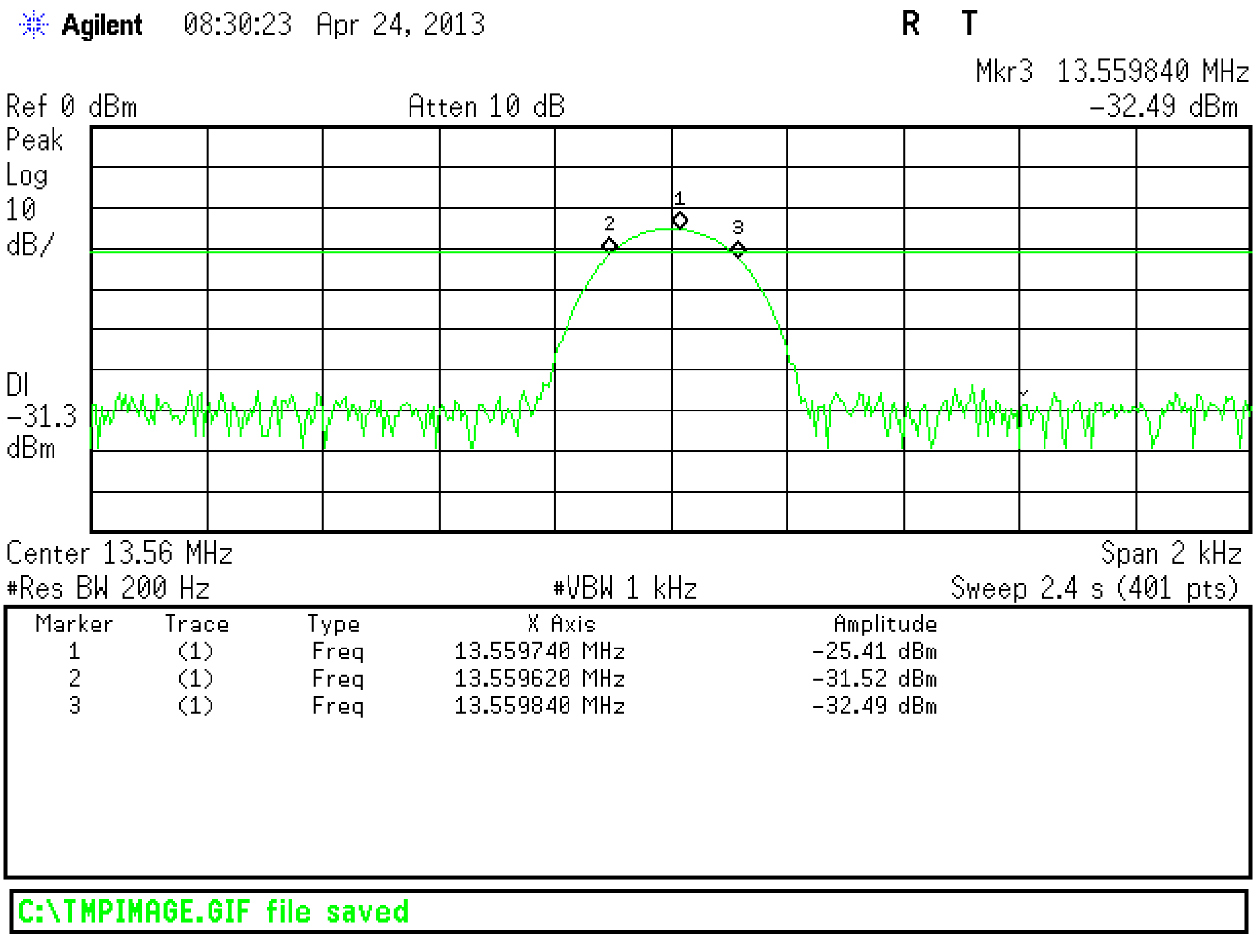


Figure 18: Voltage Variation at 5.75V DC

5 Test Equipment List

5.1 Equipment List

Equipment	Manufacturer	Model #	Serial/Inst #	Last Cal dd/mm/yy	Next Cal dd/mm/yy
Bilog Antenna	Sunol Science	JB3	A102606	05/15/2012	05/15/2014
Passive Loop Antenna	ETS-Lindgren	6511	66507	01/24/2013	01/24/2014
EMI Receiver	Hewlett Packard	8546A	3807A00445	01/18/2013	01/18/2014
Preselector	Hewlett Packard	85460A	3704A00407	01/18/2013	01/18/2014
Amplifier	Hewlett Packard	8447D	2944A07996	01/16/2013	01/16/2014
Spectrum Analyzer	Rhode&Schwarz	FSL6	100169	01/16/2013	01/16/2014
Spectrum Analyzer	Agilent	E4404B	MY41440636	10/02/2013	10/02/2014
Line Impedance Network Stabilization	Com Power	L1-200	12111	1/16/2013	1/16/2014
Thermo Chamber	ESPEC	BTZ-133	0613436	03/11/2013	03/11/2014
Digital Multimeter	Fluke	177	92780314	01/17/2013	01/17/2014

*** Calibration of equipment past due for re-calibration will be performed expeditiously. If any equipment is found to be out of tolerance at that time, affected customers will be notified accordingly.**

6 EMC Test Plan

6.1 Introduction

This section provides a description of the Equipment Under Test (EUT), configurations, operating conditions, and performance acceptance criteria. It is an overview of information provided by the manufacturer so that the test laboratory may perform the requested testing.

6.2 Customer

Table 11: Customer Information

Company Name	Illumina, Inc
Address	5200 Illumina Way.
City, State, Zip	San Diego, CA 92122
Country	USA
Phone	(510) 670-9319
Fax	(510) 670-9302

Table 12: Technical Contact Information

Name	Carol Rogers Escano
E-mail	cescano@illumina.com
Phone	(510) 670-9319
Fax	(510) 670-9302

6.3 Equipment Under Test (EUT)

Table 13: EUT Specifications

EUT Specification	
Dimensions:	8mm X 8mm X 40mm
Power Supply:	5 VDC, 67 mA
Environment	Controlled Laboratory
Operating Temperature Range:	0 to 35 degrees C
Multiple Feeds:	☐ Yes and how many ☒ No. RFID receives 5 Vdc from Host System power supply.
Hardware Version	1.2
RFID Software Version	Image file version 3.3
Operating Mode	RFID Reader
Transmitter Frequency Band	13.56 MHz
Chipset Rated Power Output	200 mW
Power Setting @ Operating Channel	Fixed. Power controls by FPGA firmware.
Antenna Type	Attached on board
Modulation Type	☐ AM ☐ FM ☐ Phase ☒ Other describe: OOK
Data Rate	26.4 kbit/s.
Max. Duty Cycle	53.3%
Type of Equipment	☒ Table Top ☐ Wall-mount ☐ Floor standing cabinet ☐ Other *describe: Host System*

Table 14: Interface Specifications

Interface Type	Cabled with what type of cable?	Is the cable shielded?	Maximum potential length of the cable?	Metallic (M), Coax (C), Fiber (F), or Not Applicable?
N/A	--	--	--	--
Note: No supporting device was used for testing				

Table 15: Supported Equipment

Equipment	Manufacturer	Model	Serial	Used for
RFID Tag				
Note: None				

Table 16: Description of Sample used for Testing

Device	Serial Number	Configuration	Used For
RFID Reader	001	Radiated Sample	Max. Carrier Field Strength Occupied Bandwidth Out of Band Emission TX Spurious Radiated Emission RX Spurious Radiated Emission AC Conducted Emission
RFID Module	002	Conducted Sample	Frequency Stability Voltage Variation
Note:			

Table 17: Description of Test Configuration used for Radiated Measurement.

Device	Antenna	Mode	Setup Description
RFID Reader	Internal	Transmit & Receive	EUT all 3 axis’s
Note: Testing was performed for all 3 orthogonal axis’s.			

6.4 Test Specifications

Testing requirements

Table 18: Test Specifications

Emissions and Immunity	
Standard	Requirement
CFR 47 Part 15.225: 2010	All
RSS 210 Iss. 8 2010	All