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Emissions
Test Report

EUT Name: SkyeModule Gemini

Model No.: SM-GM

CFR 47 Part 15.225:2013 and RSS-210:2010

Prepared for:

Brad Alcorn
SkyeTek, Inc.
1732 Wazee St, Ste 202
Denver, CO 80202 U.S.A.
Tel: (720) 328-3425
Fax: (720) 228 2400

Prepared by:

TUV Rheinland of North America, Inc.
1279 Quarry Lane, Ste. A
Pleasanton, CA 94566
Tel: (925) 249-9123
Fax: (925) 249-9124
http://www.tuv.com/

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Revisions

Revision No.	Date MM/DD/YYYY	Reason for Change	Author
0	04/28/2014	Original Document	N/A
1	05/01/2014	Revised FCC ID number from “WX4-GEMINI003” to “WX4GEMINI003” (throughout report).	J. Luong
2	05/20/2014	Revised FCC ID number from “WX4GEMINI003” To “WZ4GEMINI003” (throughout report).	J. Luong

Note: Latest revision report will replace all previous reports.

Statement of Compliance

Manufacturer:	SkyeTek, Inc. 1732 Wazee St, Ste 202 Denver, CO 80202 (720) 328-3425
Requester / Applicant:	Brad Alcorn
Name of Equipment:	SkyeModule Gemini
Model No.	SM-GM
Type of Equipment:	Industrial, Scientific, or Medical (ISM)
Application of Regulations:	CFR 47 Part 15.225:2013 and RSS-210:2010
Test Dates:	March 14, 2014 to March 20, 2014

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.

Digitally signed by Conan Boyle
DN: cn=Conan Boyle, o=TUV Rheinland of North America, ou=SFR EMC, email=cboyle@us.tuv.com, c=US
Date: 2014.05.20 10:29:14 -07'00'

Jeremy Luong	March 21, 2014	Conan Boyle	May 20, 2014 (Reissue Date)
Test Engineer	Date	Laboratory Signature	Date

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

Industry Canada

1 Executive Summary

1.1 Scope

This report is intended to document the status of conformance with the requirements of the CFR 47 Part 15.225:2013 and RSS-210:2010 based on the results of testing performed on March 14, 2014 through March 20, 2014 on the SkyeModule Gemini Model SM-GM manufactured by SkyeTek, 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
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	Class B	**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**

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, Emissions

Per CISPR 16-4-2	**U_{lab}**	**U_{cispr}**
Radiated Disturbance @ 10 meters		
30 – 1,000 MHz	2.25 dB	4.51 dB
Radiated Disturbance @ 3 meters		
30 – 1,000 MHz	2.26 dB	4.52 dB
1 – 6 GHz	2.12 dB	4.25 dB
6 – 40 GHz	2.47 dB	4.93 dB
Conducted Disturbance @ Mains Terminals		
150 kHz – 30 MHz	1.09 dB	2.18 dB
Disturbance Power		
30 MHz – 300 MHz	3.92 dB	4.3 dB

Table 3: Summary of Uncertainties, Radio

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 SkyeModule™ Gemini marks the next generation of SkyeTek HF reader modules. The Gemini is a low-cost, and ultra-low power, MIFARE and NFC reader/writer module. A cutting edge ARM Cortex microcontroller and latest HF transceiver technology coupled with the reader's intelligent operating system make this module the most versatile HF RFID module at the bottom tier price point. Manufactured in accordance with ISO 9001 and ISO 13485, quality is a top priority for all SkyeTek modules.

Features:

- 13.56 MHz HF RFID
- Optional Keyboard Wedge Firmware
- Small Footprint: 40x38mm
- Reads and writes to transponders based on ISO14443A
- Crypto1 MIFARE Classic authentication
- Wide input power supply range: 2 to 5.5V
- Sleep mode current down to 10uA
- Easy migration to and from the SkyeModule M2 and SkyeModule M4
- Supported host interfaces include USB, TTL level RS232, SPI, I2C

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 SkyeModule Gemini uses a permanently integrated antenna.

- PCB antenna integrated in RFID Reader PCB
- Antenna Type: Inductive Loop Antenna
- Antenna Size: 1.5” x 1.45” Square

4 Emissions

Testing was performed in accordance with CFR 47 Part 15.225:2013 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.

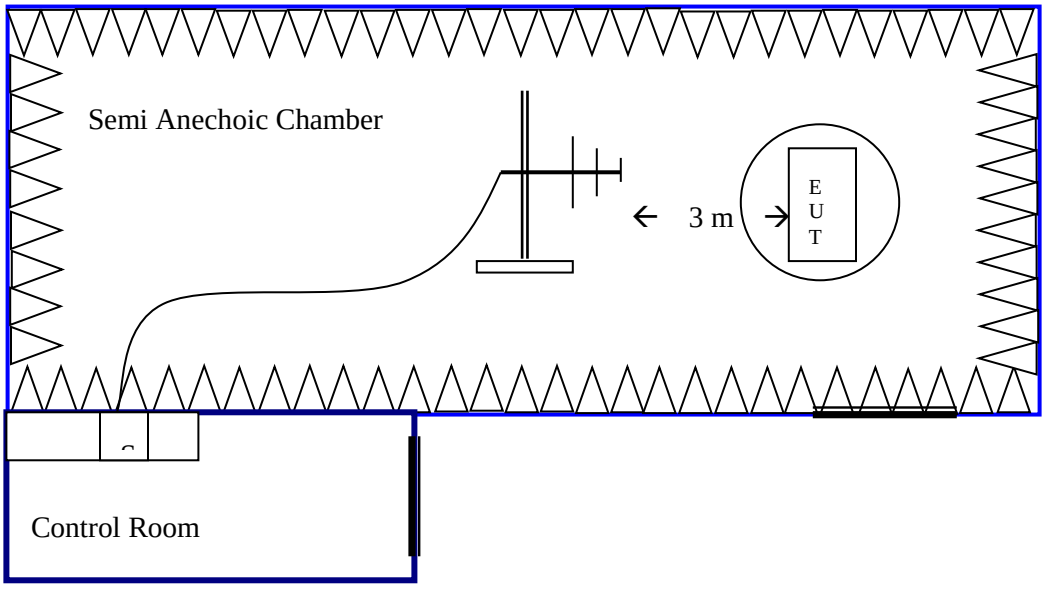
The RF fundamental field strengths shall not exceed CFR47 Part 15.225 (a):2013 and RSS-210 A2.6 (a):2010.

The field strength of any emission in the band of 13.553 and 13.567 MHz 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 on production sample S/N 3G3913320. 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 4: RF Fundamental Field Strength – Test Results

Test Conditions: Radiated Measurement, Normal Temperature and Voltage only						
Antenna Type: Integrated			**Power Setting:** Fixed at Chipset			
Signal State: Modulated			**Duty Cycle:** See below.			
Ambient Temp.: 23 °C			**Relative Humidity:**30 %			
Operating Frequency:	**Test Results**					
13.56 MHz	**Measured Level [dBuV/m]**	**Loop Position**	**Table [degree]**	**Antenna [cm]**	**Limit [dBuV/m]**	**Margin [dB]**
10% ASK Modulation						
X-Axis	55.45	0	74	100	124.00	-68.55
	44.57	90	343	100	124.00	-79.43
Y-Axis	61.46	0	78	100	124.00	-62.54
	57.91	90	360	100	124.00	-66.09
Z-Axis	61.53	0	181	100	124.00	-62.47
	58.31	90	86	100	124.00	-65.69
100% ASK Modulation						
X-Axis	52.89	0	202	100	124.00	-71.11
	53.51	90	330	100	124.00	-70.49
Y-Axis	61.85	0	84	100	124.00	-62.15
	59.16	90	0	100	124.00	-64.84
Z-Axis	62.06	0	184	100	124.00	-61.94
	59.89	90	358	100	124.00	-64.11
Note: 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.

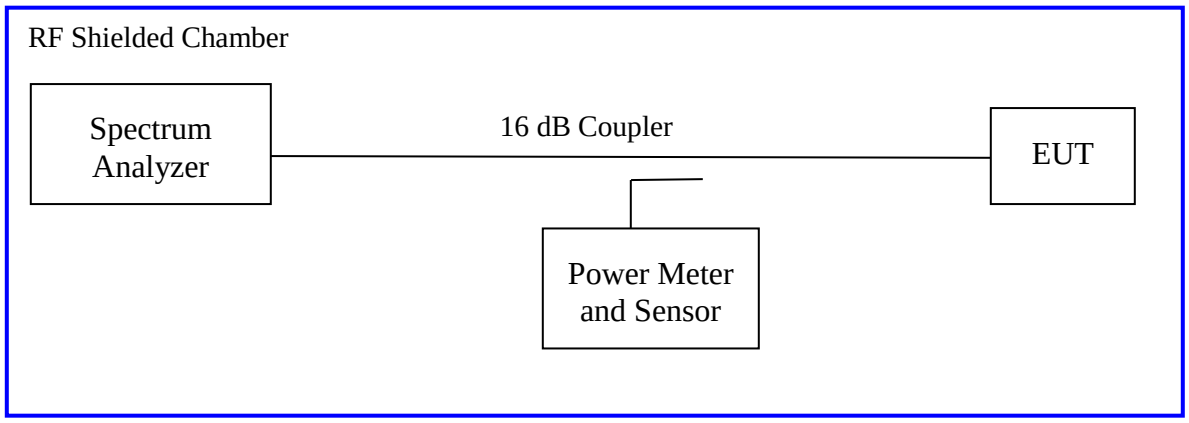
The 20dB bandwidth is defined the bandwidth of 20 dBr from highest transmitted level of the fundamental frequency.

The bandwidth shall be documented per Section CFR47 15.215(c) 2013 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 the production sample S/N 3G42130413. 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 5: Occupied Bandwidth – Test Results

Test Conditions: Conducted Measurement, Normal Temperature and Voltage only			
Antenna Type: Integrated		**Power Setting:** Fixed at Chipset	
Signal State: Modulated		**Duty Cycle:** See below	
Ambient Temp.: 23 °C		**Relative Humidity:**30%	
Occupied Bandwidth for 13.56 MHz RFID			
Mode	**Limit (kHz)**	**99% BW (kHz)**	**20 dB BW (kHz)**
10% ASK Modulation	Na	3.2265	3.4068
100% ASK Modulation	Na	3.5070	3.7475
Note: All lower and upper markers of 99% Bandwidth and 20 dB Bandwidth are within the allowable band; 13.553 MHz to 13.567 MHz			

Table 6: 20 dB Bandwidth Frequency – Test Results

Test Conditions: Conducted Measurement, Normal Temperature and Voltage only				
Antenna Type: Integrated		**Power Setting:** Fixed at Chipset		
Signal State: Modulated		**Duty Cycle:** See Below		
Ambient Temp.: 23 °C		**Relative Humidity:**30%		
20 dB Bandwidth Frequencies for 13.56 MHz RFID				
Mode	**Occupied Band Limit (MHz)**	**Lower Freq. (MHz)**	**Upper Freq. (MHz)**	**Results**
10% ASK Modulation	13.553 < X < 13.567	13.558426	13.561834	Pass
100% ASK Modulation	13.553 < X < 13.567	13.558266	13.562014	Pass
Note: All lower and upper markers of 20 dB Bandwidth are within the allowable band; 13.553 MHz to 13.567 MHz; where X is the lower frequency and upper frequency.				

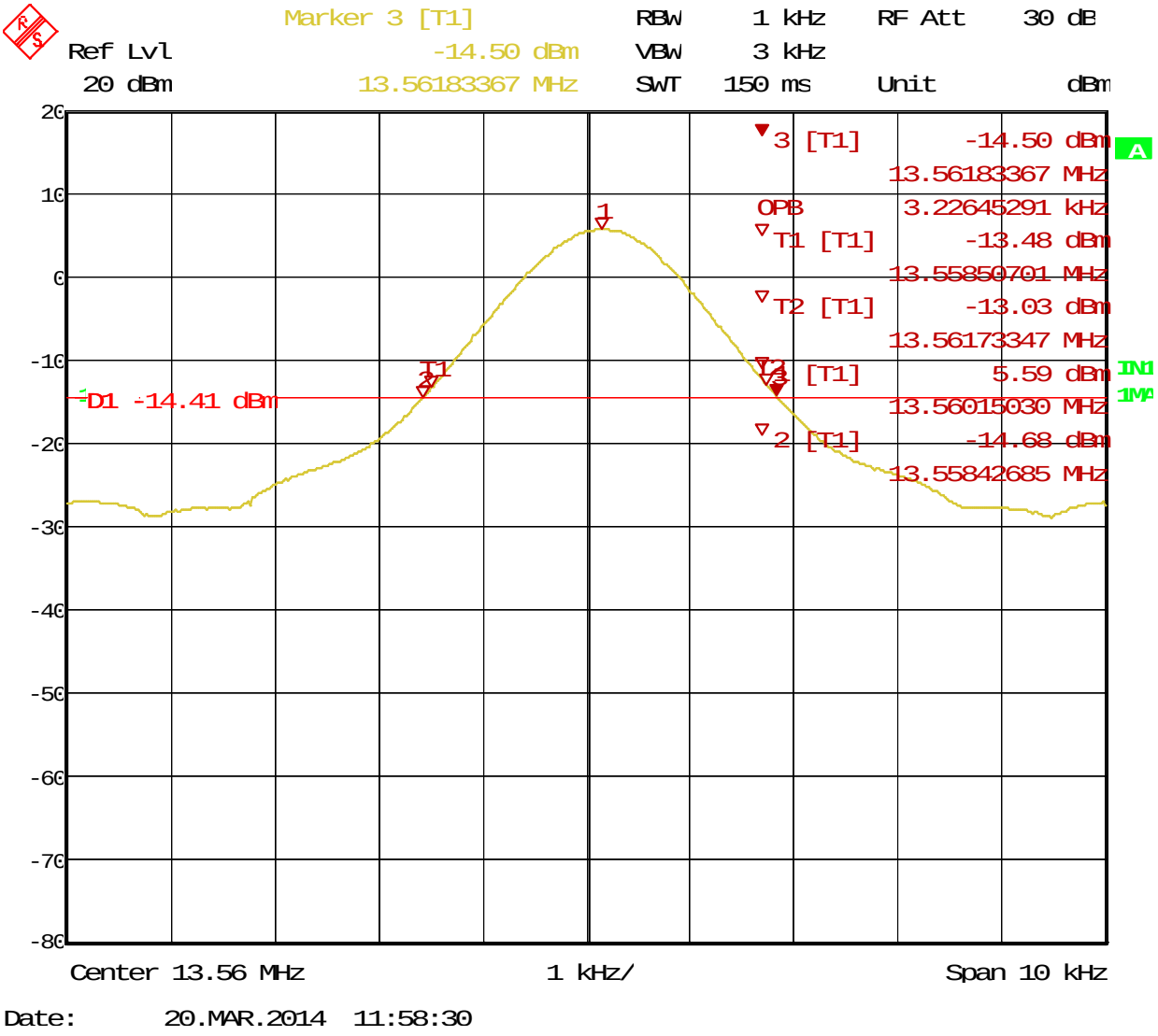


Figure 1: Occupied Bandwidth at 10% ASK Modulation

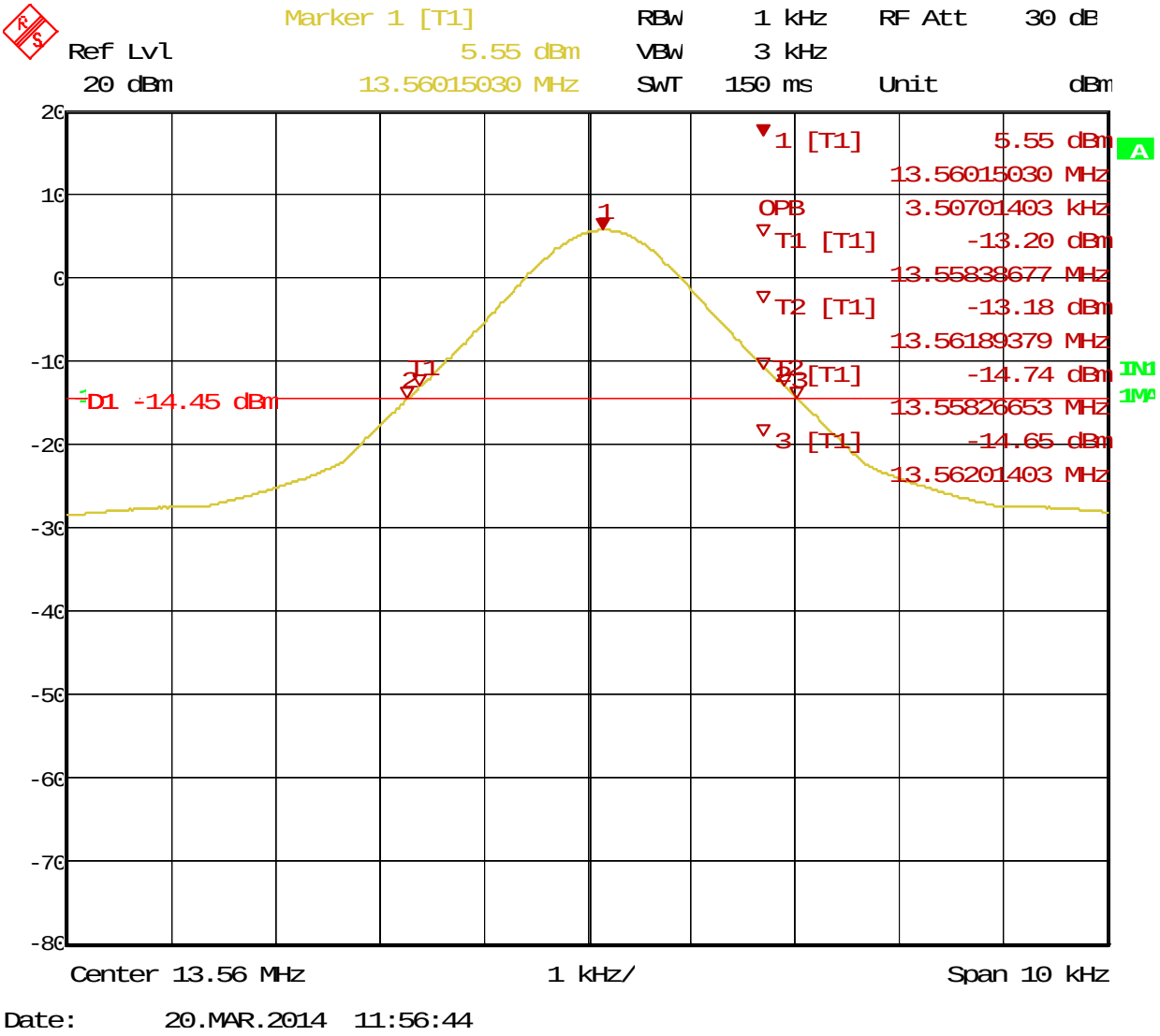


Figure 2: Occupied Bandwidth at 100% ASK Modulation

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.

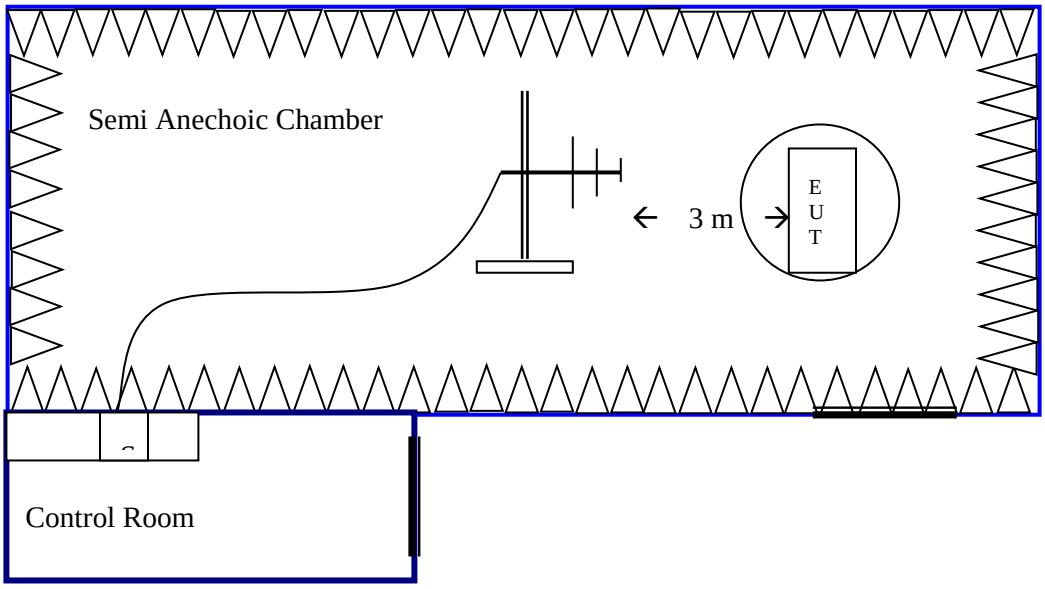
Table 7: Out of Band Emissions Limit

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) 2013 and *RSS-210 A2.6.* (b) (c)*: 2010*. This test was performed on the production sample SN: 3G39130338. 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 8: Out of Band Emissions – Test Results

Test Conditions: Radiated Measurement, Normal Temperature and Voltage only					
Antenna Type: Integrated		**Power Setting:** Fixed Output at chipset			
Signal State: Modulated		**Duty Cycle:** 100 %			
Ambient Temp.: 23 °C		**Relative Humidity:**30%			
Modulation	**Orientation**	**Antenna Position**	**Spectrum Mask (12 to 15MHz)**	**Limit**	**Result**
10% ASK	X-Axis	0	Plot #3	See Table 6	Pass
		90	Plot #4		Pass
	Y-Axis	0	Plot #5	See Table 6	Pass
		90	Plot #6		Pass
	Z-Axis	0	Plot #7	See Table 6	Pass
		90	Plot #8		Pass
100% ASK	X-Axis	0	Plot #9	See Table 6	Pass
		90	Plot #10		Pass
	Y-Axis	0	Plot #11	See Table 6	Pass
		90	Plot #12		Pass
	Z-Axis	0	Plot #13	See Table 6	Pass
		90	Plot #14		Pass
Note: All maximized emissions within 12 MHz to 15 MHz are below the spectrum mask limit per Table 6.					

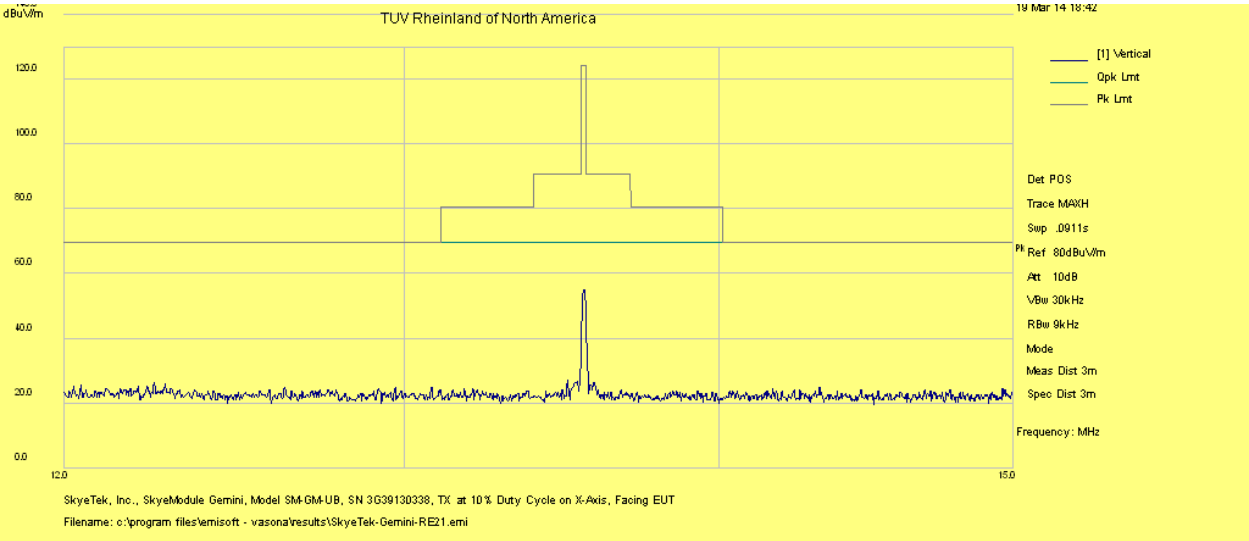


Figure 3: Out of Band Spectrum Mask for 10% ASK at 0 Degree Loop Antenna (X axis)

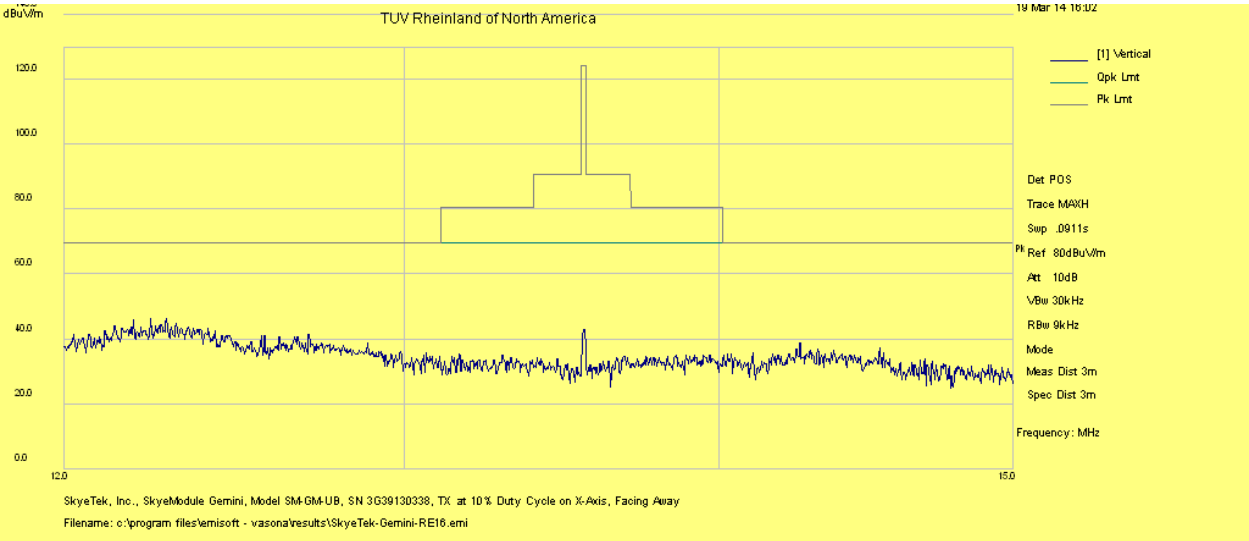


Figure 4: Out of Band Spectrum Mask for 10% ASK at 90 Degree Loop Antenna (X axis)

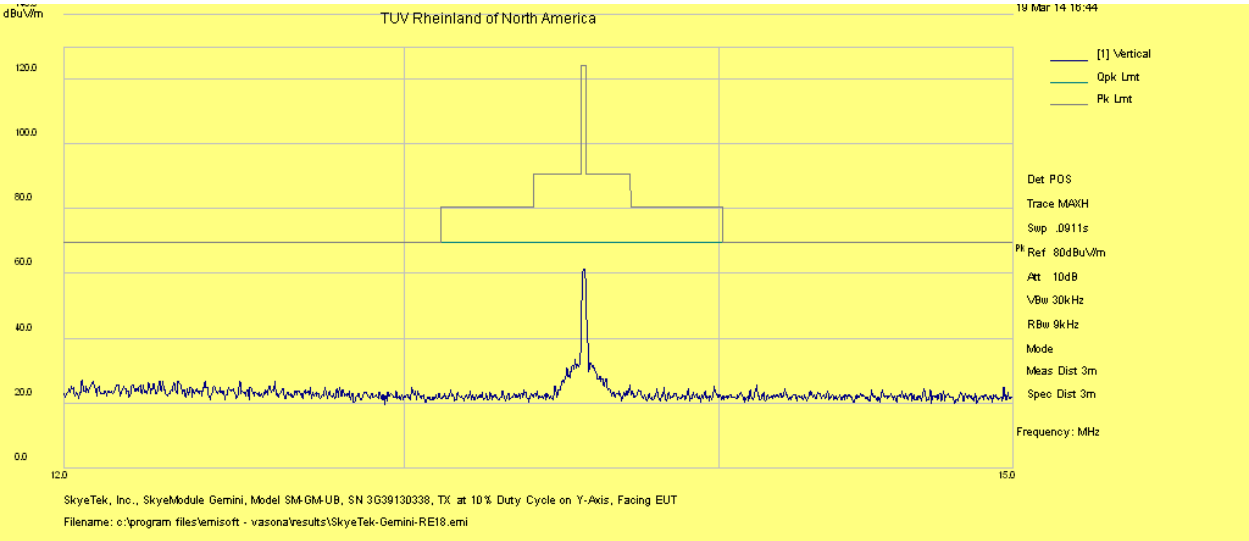


Figure 5: Out of Band Spectrum Mask for 10% ASK at 0 Degree Loop Antenna (Y axis)

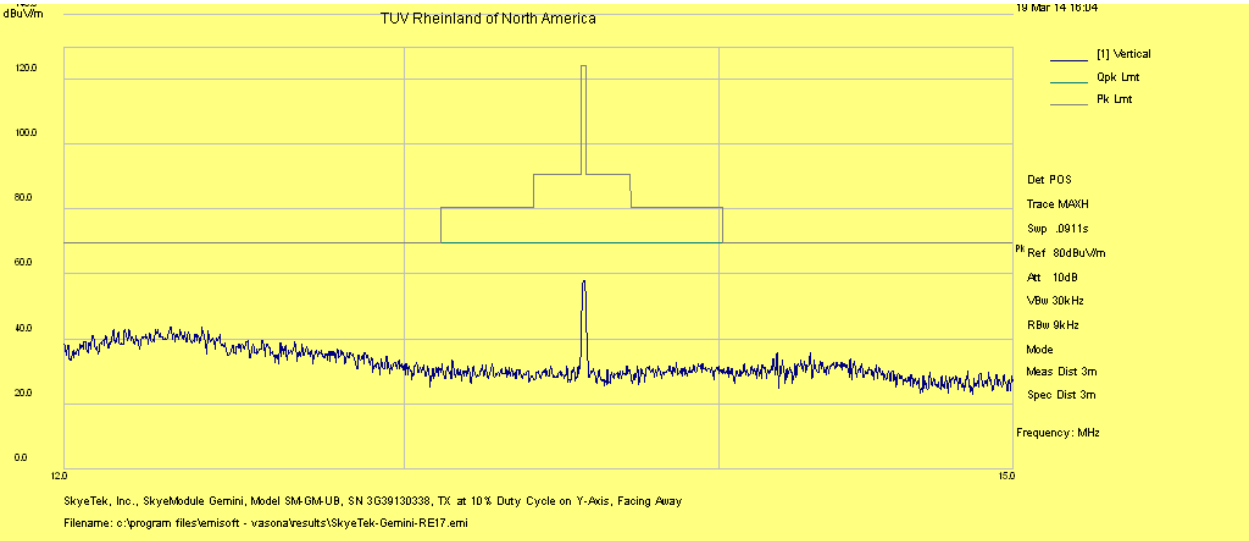


Figure 6: Out of Band Spectrum Mask for 10% ASK at 90 Degree Loop Antenna (Y axis)

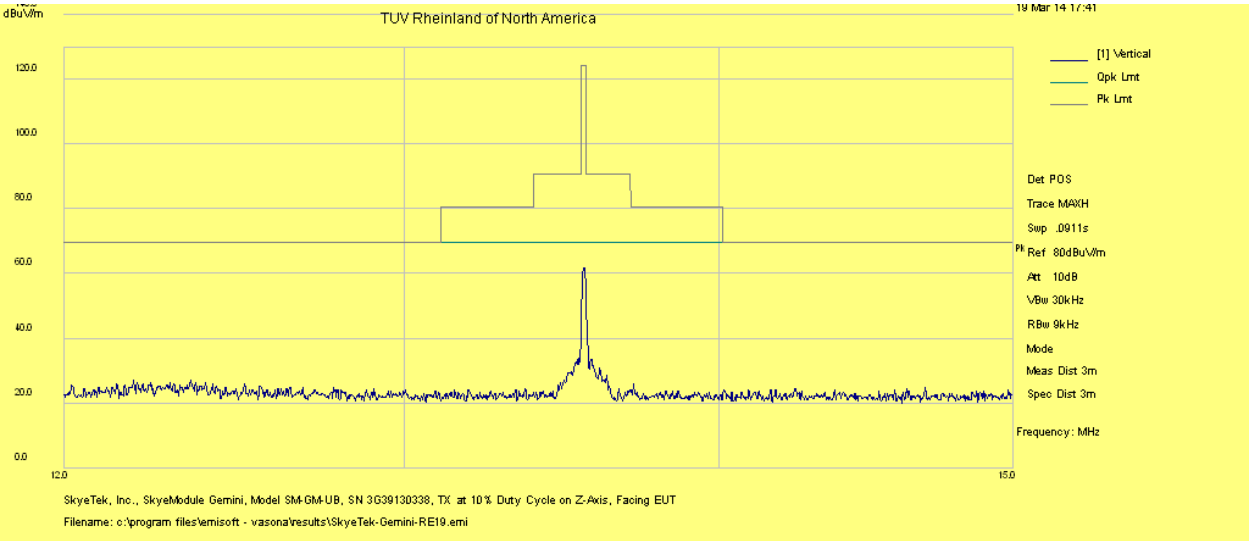


Figure 7: Out of Band Spectrum Mask for 10% ASK at 0 Degree Loop Antenna (Z axis)

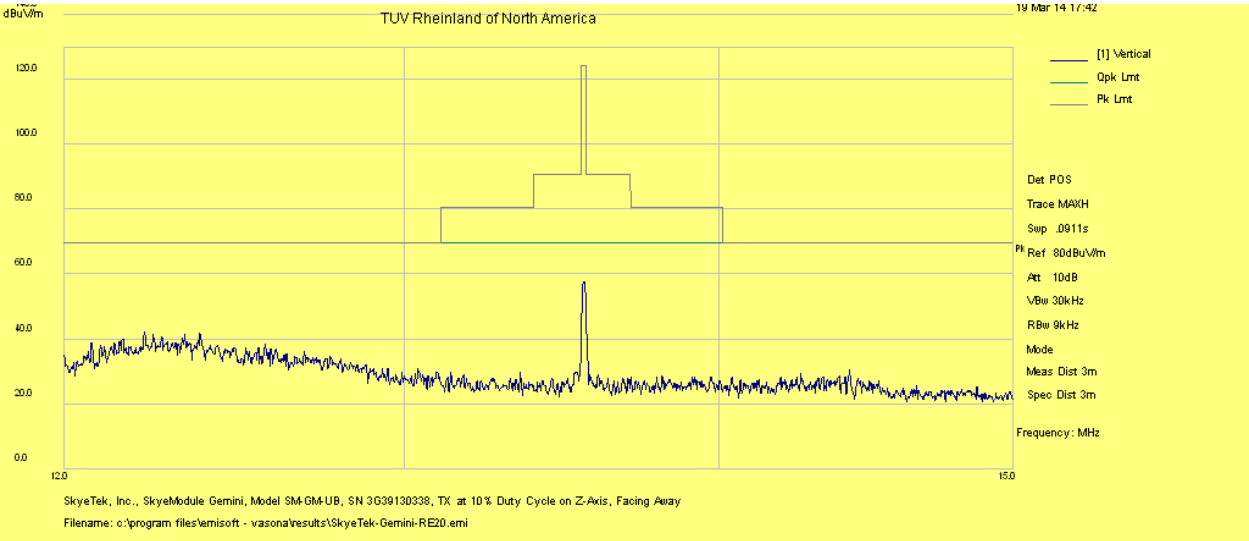


Figure 8: Out of Band Spectrum Mask for 10% ASK at 90 Degree Loop Antenna (Z axis)

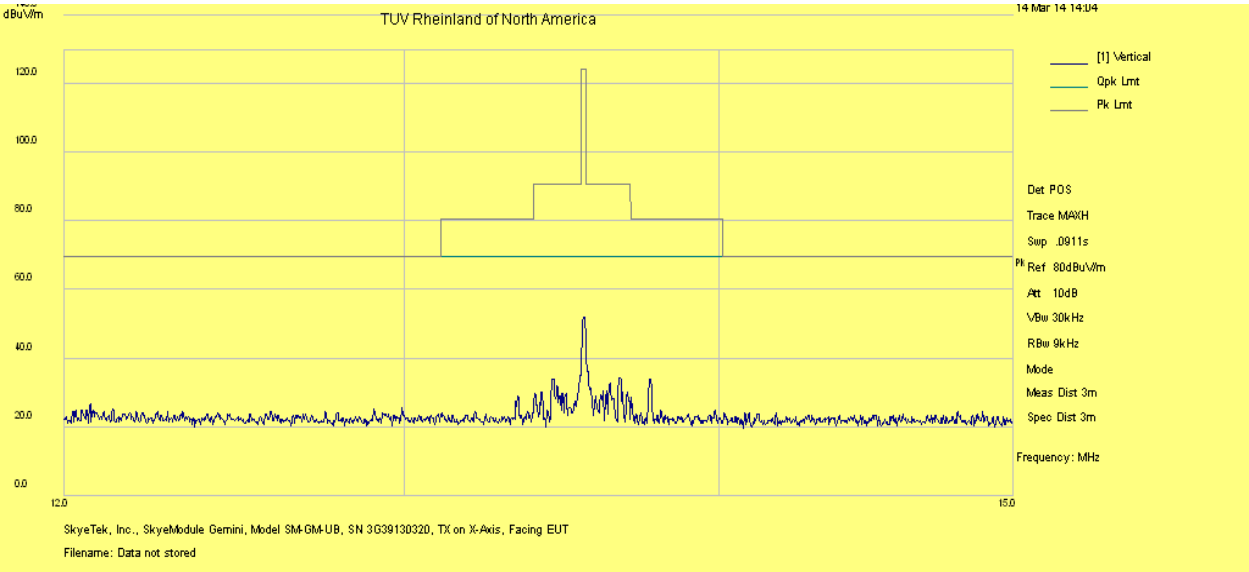


Figure 9: Out of Band Spectrum Mask for 100% ASK at 0 Degree Loop Antenna (X axis)

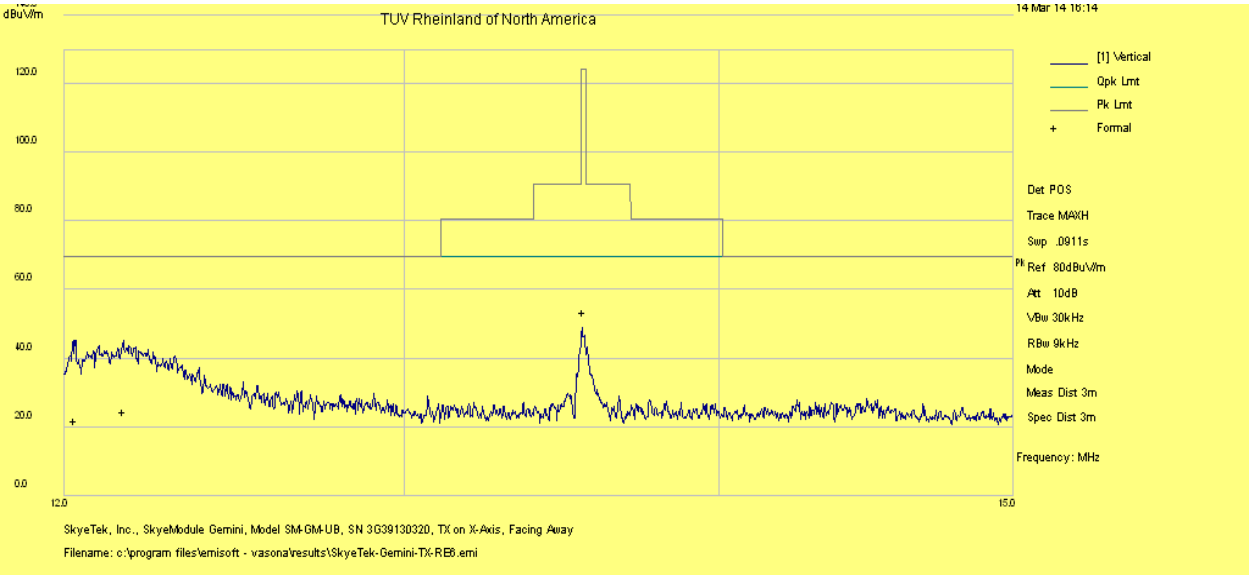


Figure 10: Out of Band Spectrum Mask for 100% ASK at 90 Degree Loop Antenna (X axis)

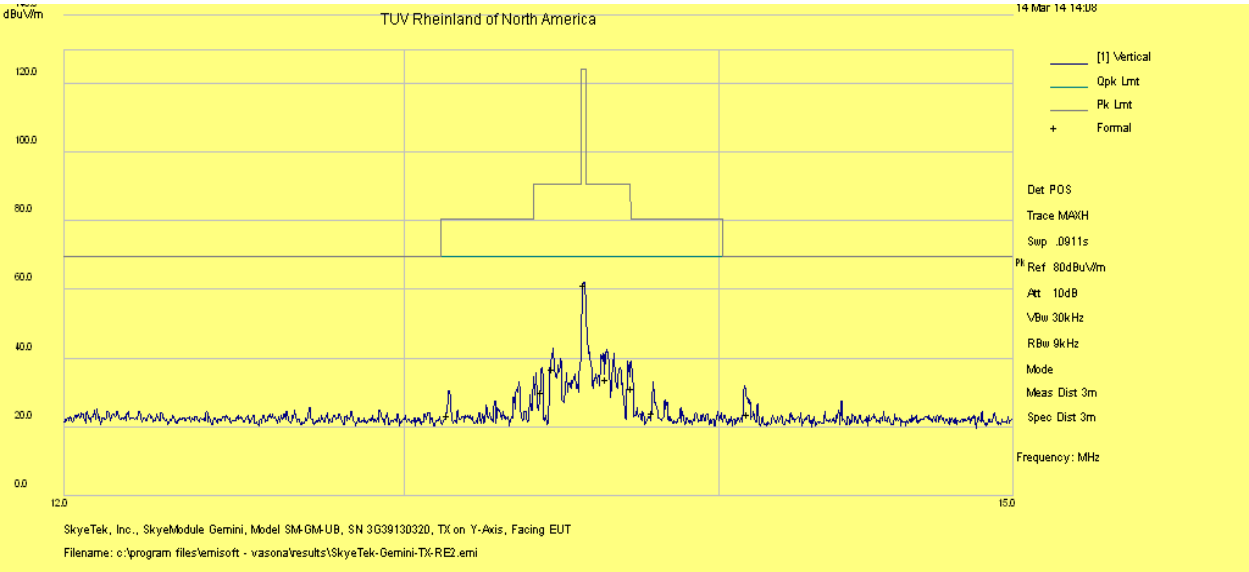


Figure 11: Out of Band Spectrum Mask for 100% ASK at 0 Degree Loop Antenna (Y axis)

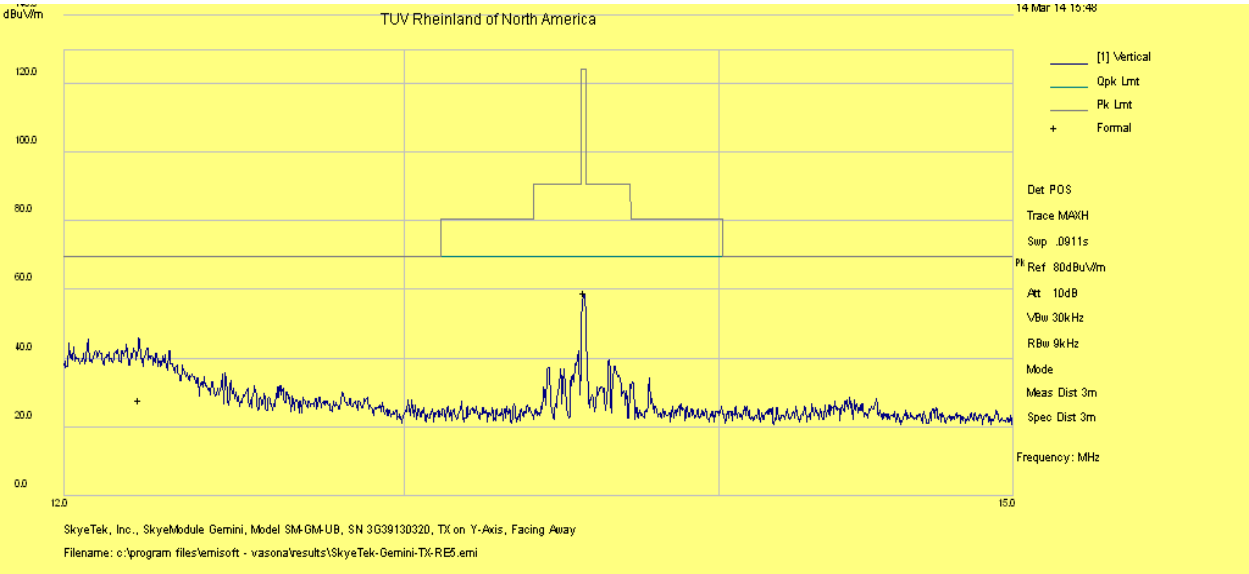


Figure 12: Out of Band Spectrum Mask for 100% ASK at 90 Degree Loop Antenna (Y axis)

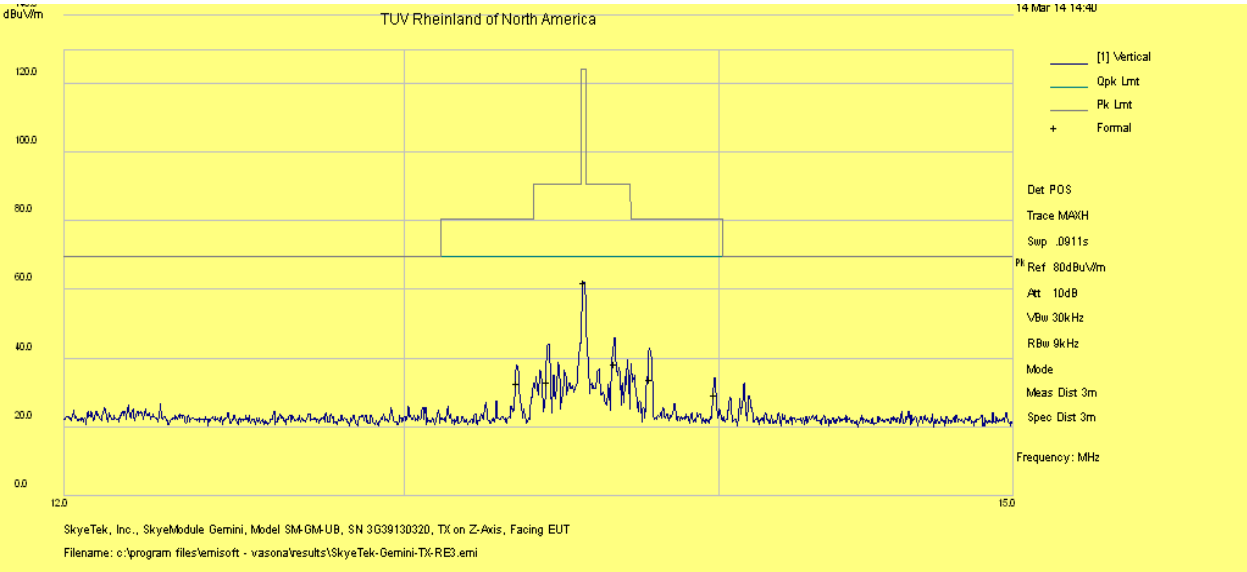


Figure 13: Out of Band Spectrum Mask for 100% ASK at 0 Degree Loop Antenna (Z axis)

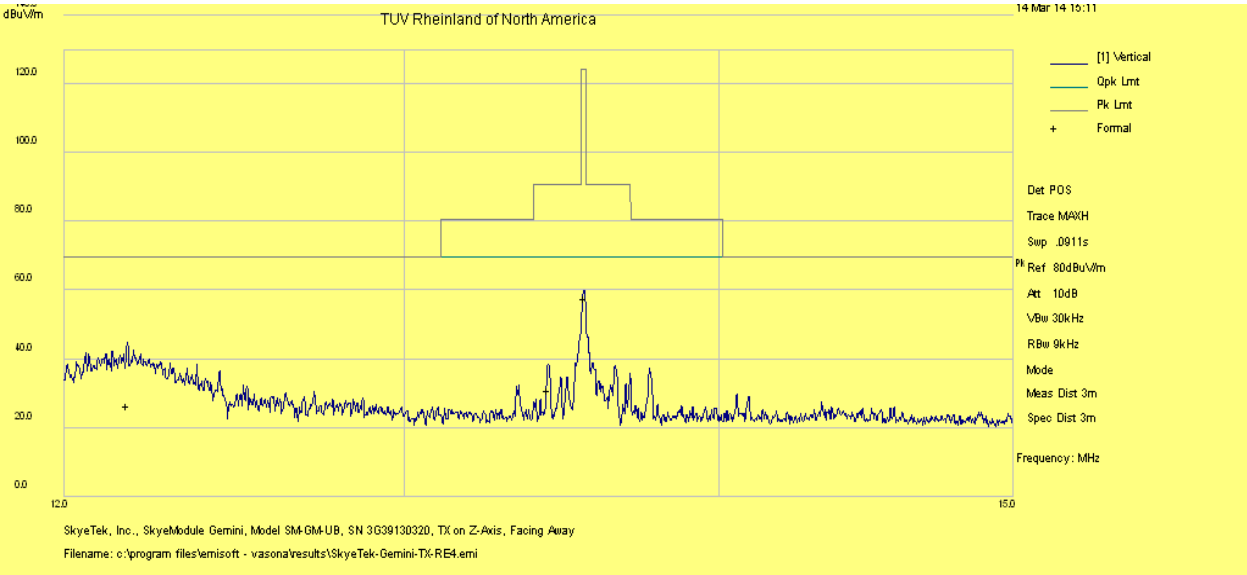


Figure 14: Out of Band Spectrum Mask for 100% ASK at 90 Degree Loop Antenna (Z axis)

4.4 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.

4.4.1 Test Methodology

4.4.1.1 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.

4.4.1.2 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 all three orthogonal axis at the worst modulation; 100% ASK.

4.4.1.3 Deviations

None.

4.4.2 Transmitter Spurious Emission Limit

The spurious emissions of the transmitter shall not exceed the values in CFR47 Part 15.205, 15.209: 2013 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

4.4.3 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	SkyeModule Gemini	**Date**	March 14, 2014
EUT Model	SM-GM	**Temp / Hum in**	23°C / 30%rh
EUT Serial	3G39130320	**Temp / Hum out**	N/A
EUT Config.	Standalone Module Orientation X axis	**Line AC / Freq**	5 Vdc (via host PC)
Standard	CFR47 Part 15 Subpart C	**RBW / VBW**	See Below
Dist/Ant Used	3m / 6511 & JB3	**Performed by**	Jeremy Luong

Freq.	Raw	Cbl	AF	Level	Det.	Pol.	Height	Azimuth	Limit	Margin	Result
MHz	dBuV/m	dB	dB	dBuV/m		0/90	cm	deg	dBuV/m	dB	
12.91	6.23	0.38	10.67	17.28	QP	0	100	193	69.50	-52.22	Pass
13.35	14.25	0.39	10.66	25.29	QP	0	100	319	69.50	-44.21	Pass
13.46	15.82	0.39	10.65	26.86	QP	0	100	142	69.50	-42.64	Pass
13.56	40.85	0.39	10.65	51.89	QP	0	100	202	69.50	-17.61	Pass
13.66	17.62	0.39	10.65	28.66	QP	0	100	145	69.50	-40.84	Pass
13.77	17.86	0.40	10.64	28.90	QP	0	100	186	69.50	-40.60	Pass
20.19	8.70	0.50	10.20	19.30	QP.	0	100	276	69.50	-50.20	Pass
0.06	29.13	0.03	12.21	41.37	QP	90	100	308	112.09	-70.71	Pass
8.25	8.54	0.30	10.85	19.68	QP	90	100	156	69.50	-49.82	Pass
12.03	10.96	0.36	10.71	22.03	QP	90	100	325	69.50	-47.47	Pass
12.17	13.37	0.36	10.70	24.44	QP	90	100	304	69.50	-45.06	Pass
13.56	42.47	0.39	10.65	53.51	QP	90	100	330	69.50	-15.99	Pass
15.95	9.94	0.42	10.51	20.87	QP	90	100	227	69.50	-48.63	Pass
17.94	17.50	0.45	10.31	28.26	QP	90	100	18	69.50	-41.25	Pass
27.12	6.20	0.56	8.90	15.66	QP	90	100	198	69.50	-53.84	Pass
45.53	36.38	0.73	-17.06	20.06	QP	V	174	258	40.00	-19.94	Pass
50.74	36.94	0.77	-19.25	18.47	QP	V	247	330	40.00	-21.53	Pass
51.74	35.78	0.78	-19.49	17.07	QP	V	183	264	40.00	-22.93	Pass
71.99	37.60	0.93	-18.92	19.61	QP	V	191	74	40.00	-20.39	Pass
114.79	36.10	1.20	-13.70	23.60	QP.	V	161	1	43.50	-19.90	Pass
379.70	41.09	2.28	-11.52	31.85	QP	V	190	310	46.00	-14.15	Pass
406.84	40.76	2.37	-10.90	32.23	QP	V	111	174	46.00	-13.77	Pass
461.06	44.09	2.54	-10.35	36.27	QP	V	101	180	46.00	-9.73	Pass

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. RBW/VBW Setting:
9 kHz to 150 kHz; RBW = 200Hz, VBW = 1kHz
150 kHz to 30 MHz; RBW = 9kHz, VBW = 30kHz
30MHz to 1 GHz; RBW = 120kHz, VBW = 300kHz

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EUT Name	SkyeModule Gemini	**Date**	March 14, 2014
EUT Model	SM-GM	**Temp / Hum in**	23°C / 30%rh
EUT Serial	3G39130320	**Temp / Hum out**	N/A
EUT Config.	Standalone Module Orientation Y axis	**Line AC / Freq**	5 Vdc (via host PC)
Standard	CFR47 Part 15 Subpart C	**RBW / VBW**	See Below
Dist/Ant Used	3m / 6511 & JB3	**Performed by**	Jeremy Luong

Freq.	Raw	Cbl	AF	Level	Det.	Pol.	Height	Azimuth	Limit	Margin	Result
MHz	dBuV/m	dB	dB	dBuV/m		0/90	cm	deg	dBuV/m	dB	
0.30	34.60	0.05	11.20	45.85	QP	0	100	310	97.97	-52.12	Pass
0.36	33.24	0.06	11.14	44.44	QP	0	100	212	96.60	-52.16	Pass
13.13	12.35	0.38	10.67	23.40	QP	0	100	290	69.50	-46.10	Pass
13.43	18.99	0.39	10.65	30.03	QP	0	100	108	69.50	-39.47	Pass
13.46	25.89	0.39	10.65	36.93	QP	0	100	98	69.50	-32.57	Pass
13.56	50.32	0.39	10.65	61.37	QP	0	100	84	69.50	-8.13	Pass
13.63	22.79	0.39	10.65	33.83	QP	0	100	270	69.50	-35.67	Pass
13.71	20.29	0.39	10.64	31.33	QP	0	100	304	69.50	-38.17	Pass
13.78	13.15	0.40	10.64	24.19	QP	0	100	255	69.50	-45.32	Pass
14.09	12.55	0.40	10.63	23.58	QP	0	100	91	69.50	-45.92	Pass
0.06	44.58	0.03	12.21	56.82	QP	90	100	28	112.09	-55.27	Pass
8.00	9.82	0.29	10.90	21.02	QP	90	100	211	69.50	-48.49	Pass
12.21	16.99	0.36	10.70	28.06	QP	90	100	108	69.50	-41.44	Pass
13.56	48.12	0.39	10.65	59.16	QP	90	100	0	69.50	-10.34	Pass
15.91	9.20	0.42	10.51	20.13	QP	90	100	58	69.50	-49.37	Pass
17.70	16.74	0.45	10.33	27.52	QP	90	100	220	69.50	-41.98	Pass
27.12	14.60	0.56	8.90	24.06	QP	90	100	254	69.50	-45.44	Pass
37.86	29.28	0.67	-11.63	18.32	QP	V	116	174	40.00	-21.68	Pass
39.09	29.97	0.67	-12.76	17.88	QP	V	277	314	40.00	-22.12	Pass
40.61	35.30	0.70	-13.90	22.10	QP	V	265	202	40.00	-17.90	Pass
45.19	33.84	0.73	-16.89	17.68	QP	V	218	84	40.00	-22.32	Pass
49.86	31.62	0.77	-19.11	13.28	QP	V	333	55	40.00	-26.72	Pass
72.03	39.42	0.93	-18.92	21.42	QP	V	135	276	40.00	-18.58	Pass
406.82	41.30	2.40	-10.90	32.80	QP	V	123	118	46.00	-13.20	Pass
461.05	44.70	2.50	-10.40	36.90	QP	V	104	160	46.00	-9.10	Pass

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. RBW/VBW Setting:
9 kHz to 150 kHz; RBW = 200Hz, VBW = 1kHz
150 kHz to 30 MHz; RBW = 9kHz, VBW = 30kHz
30MHz to 1 GHz; RBW = 120kHz, VBW = 300kHz

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EUT Name	SkyeModule Gemini	**Date**	March 14, 2014
EUT Model	SM-GM	**Temp / Hum in**	23°C / 30%rh
EUT Serial	3G39130320	**Temp / Hum out**	N/A
EUT Config.	Standalone Module Orientation Z axis	**Line AC / Freq**	5 Vdc (via host PC)
Standard	CFR47 Part 15 Subpart C	**RBW / VBW**	See Below
Dist/Ant Used	3m / 6511 & JB3	**Performed by**	Jeremy Luong

Freq.	Raw	Cbl	AF	Level	Det.	Pol.	Height	Azimuth	Limit	Margin	Result
MHz	dBuV/m	dB	dB	dBuV/m		0/90	cm	deg	dBuV/m	dB	
13.35	21.80	0.39	10.66	32.84	QP	0	100	36	69.50	-36.66	Pass
13.45	22.28	0.39	10.65	33.33	QP	0	100	45	69.50	-36.17	Pass
13.56	50.98	0.39	10.65	62.02	QP	0	100	184	69.50	-7.48	Pass
13.66	27.45	0.39	10.65	38.49	QP	0	100	353	69.50	-31.01	Pass
13.77	22.97	0.40	10.64	34.01	QP	0	100	54	69.50	-35.49	Pass
13.99	18.35	0.40	10.63	29.38	QP	0	100	172	69.50	-40.12	Pass
27.02	6.10	0.56	8.92	15.58	QP	0	100	118	69.50	-53.92	Pass
0.06	43.97	0.03	12.21	56.21	QP	90	100	212	112.08	-55.88	Pass
8.06	12.59	0.29	10.89	23.77	QP	90	100	190	69.50	-45.73	Pass
12.18	15.24	0.36	10.70	26.31	QP	90	100	245	69.50	-43.20	Pass
13.45	19.74	0.39	10.65	30.79	QP	90	100	264	69.50	-38.71	Pass
13.56	46.63	0.39	10.65	57.67	QP	90	100	44	69.50	-11.83	Pass
15.92	9.93	0.42	10.51	20.86	QP	90	100	355	69.50	-48.64	Pass
17.69	17.22	0.45	10.33	28.00	QP	90	100	184	69.50	-41.50	Pass
27.12	14.74	0.56	8.90	24.20	QP	90	100	230	69.50	-45.30	Pass
39.09	29.81	0.67	-12.75	17.72	QP	V	242	74	40.00	-22.28	Pass
40.60	35.60	0.70	-13.80	22.40	QP	V	177	125	40.00	-17.60	Pass
43.70	31.00	0.70	-16.00	15.70	QP	V	377	316	40.00	-24.30	Pass
44.94	37.22	0.73	-16.75	21.20	QP	V	119	48	40.00	-18.80	Pass
50.45	38.30	0.80	-19.20	19.80	QP	V	211	260	40.00	-20.20	Pass
379.69	39.52	2.28	-11.52	30.28	QP	V	139	228	46.00	-15.72	Pass
406.82	40.98	2.37	-10.90	32.45	QP	V	120	172	46.00	-13.55	Pass
461.07	45.00	2.50	-10.40	37.20	QP	V	99	152	46.00	-8.80	Pass

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. RBW/VBW Setting:
9 kHz to 150 kHz; RBW = 200Hz, VBW = 1kHz
150 kHz to 30 MHz; RBW = 9kHz, VBW = 30kHz
30MHz to 1 GHz; RBW = 120kHz, VBW = 300kHz

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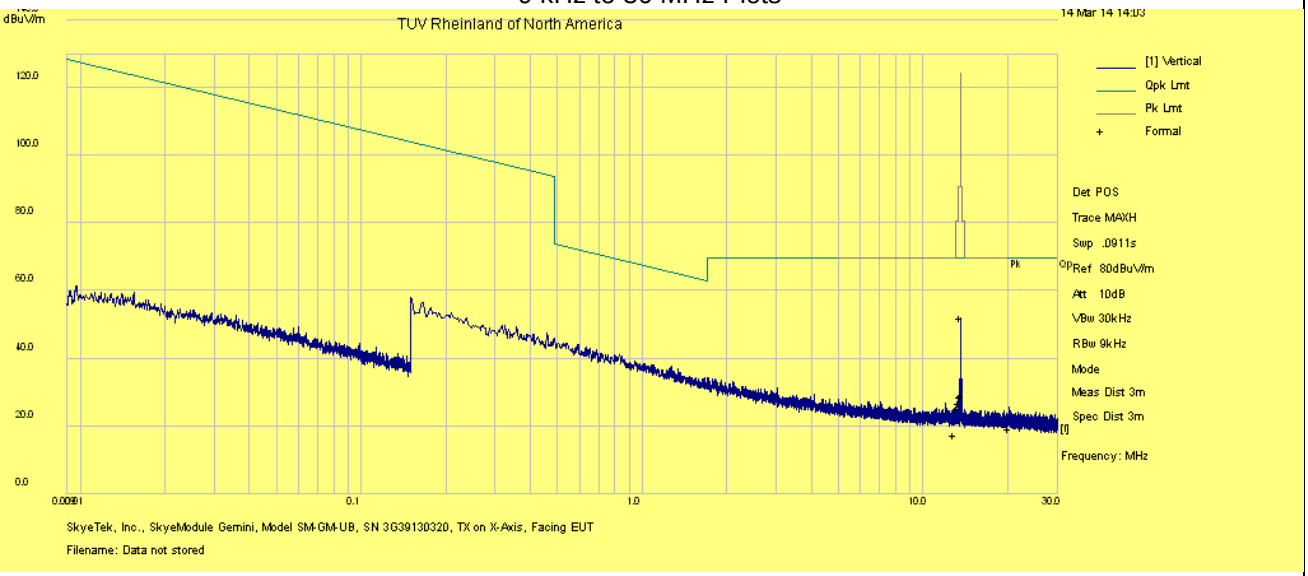
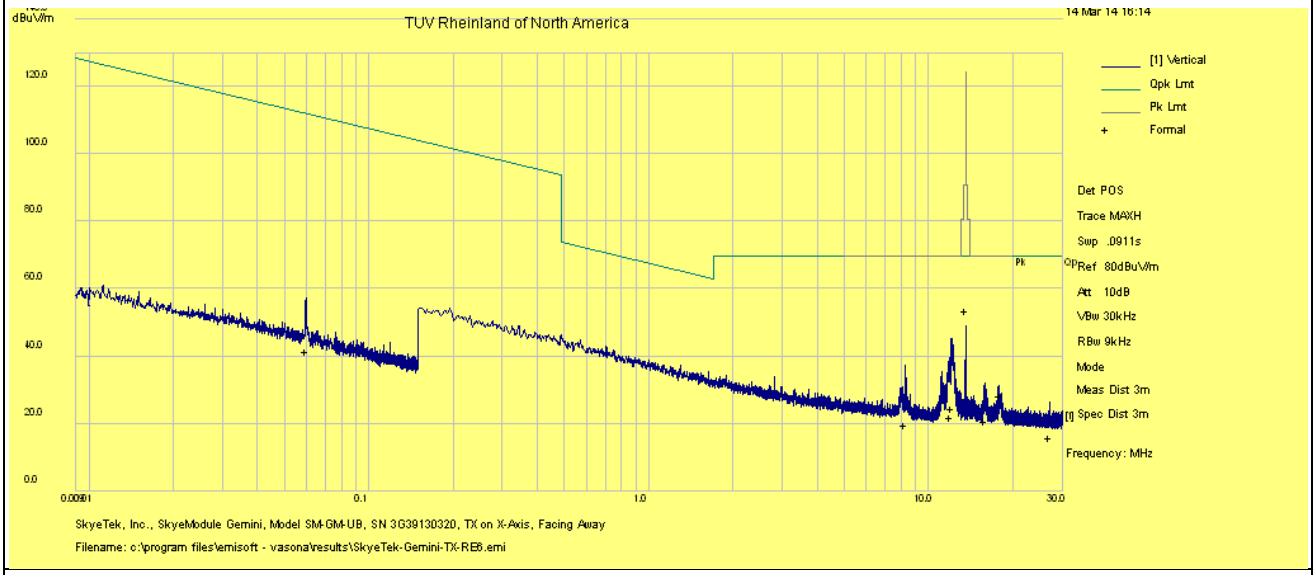
EUT Name	SkyeModule Gemini	**Date**	March 14, 2014
EUT Model	SM-GM	**Temp / Hum in**	23°C / 30%rh
EUT Serial	3G39130320	**Temp / Hum out**	N/A
EUT Config.	Standalone Module Orientation X axis	**Line AC**	5 Vdc (via Host PC)
Standard	CFR47 Part 15 Subpart C	**RBW / VBW**	See below
Dist/Ant Used	3m / 6511	**Performed by**	Jeremy Luong

9 kHz to 30 MHz Plots





Notes: 9 kHz to 150 kHz; RBW = 200Hz, VBW = 1kHz
150 kHz to 30 MHz; RBW = 9kHz, VBW = 30kHz
The highest emission on the plots is the fundamental signal at 13.56 MHz.

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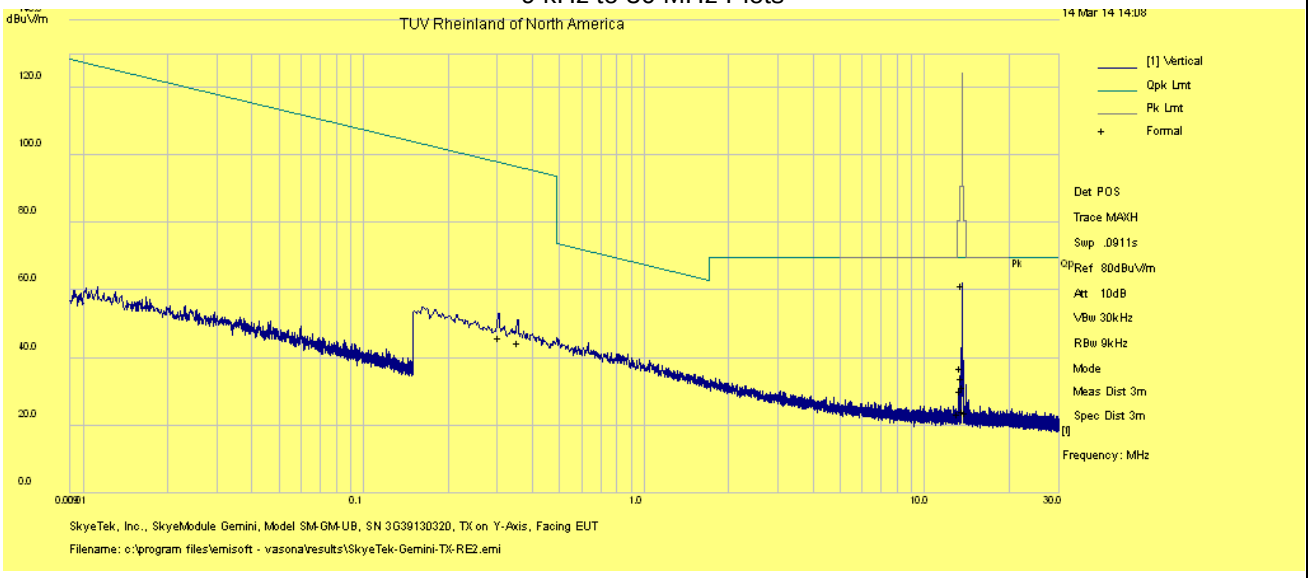
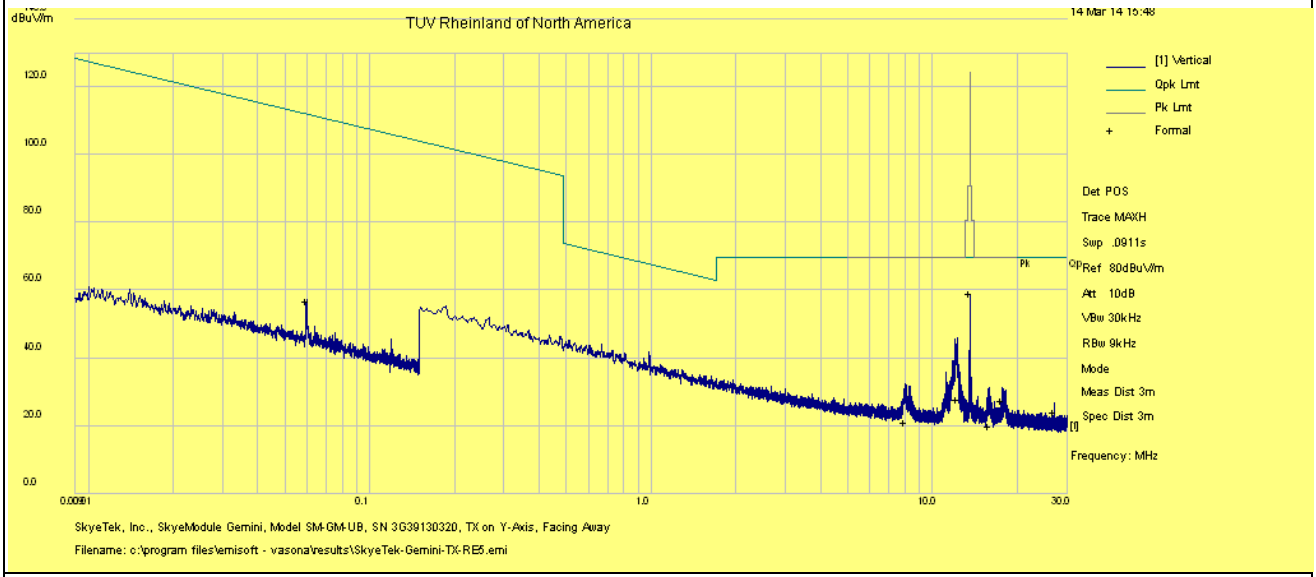
EUT Name	SkyeModule Gemini	**Date**	March 14, 2014
EUT Model	SM-GM	**Temp / Hum in**	23°C / 30%rh
EUT Serial	3G39130320	**Temp / Hum out**	N/A
EUT Config.	Standalone Module Orientation Y axis	**Line AC**	5 Vdc (via Host PC)
Standard	CFR47 Part 15 Subpart C	**RBW / VBW**	See below
Dist/Ant Used	3m / 6511	**Performed by**	Jeremy Luong

9 kHz to 30 MHz Plots





Notes: 9 kHz to 150 kHz; RBW = 200Hz, VBW = 1kHz
150 kHz to 30 MHz; RBW = 9kHz, VBW = 30kHz
The highest emission on the plots is the fundamental signal at 13.56 MHz.

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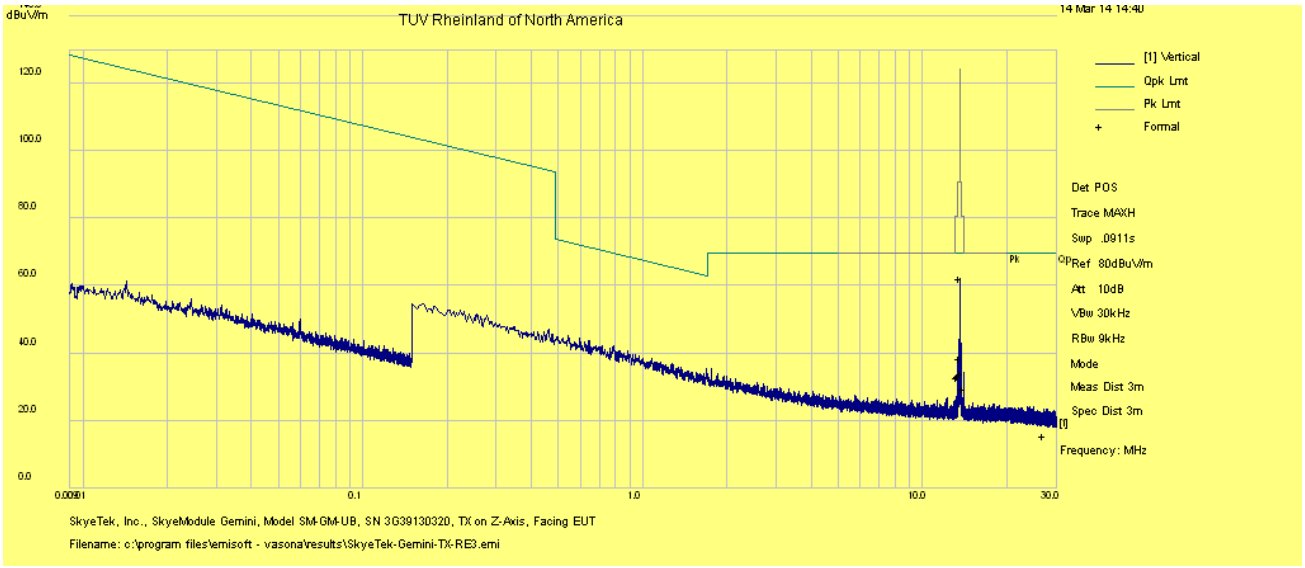
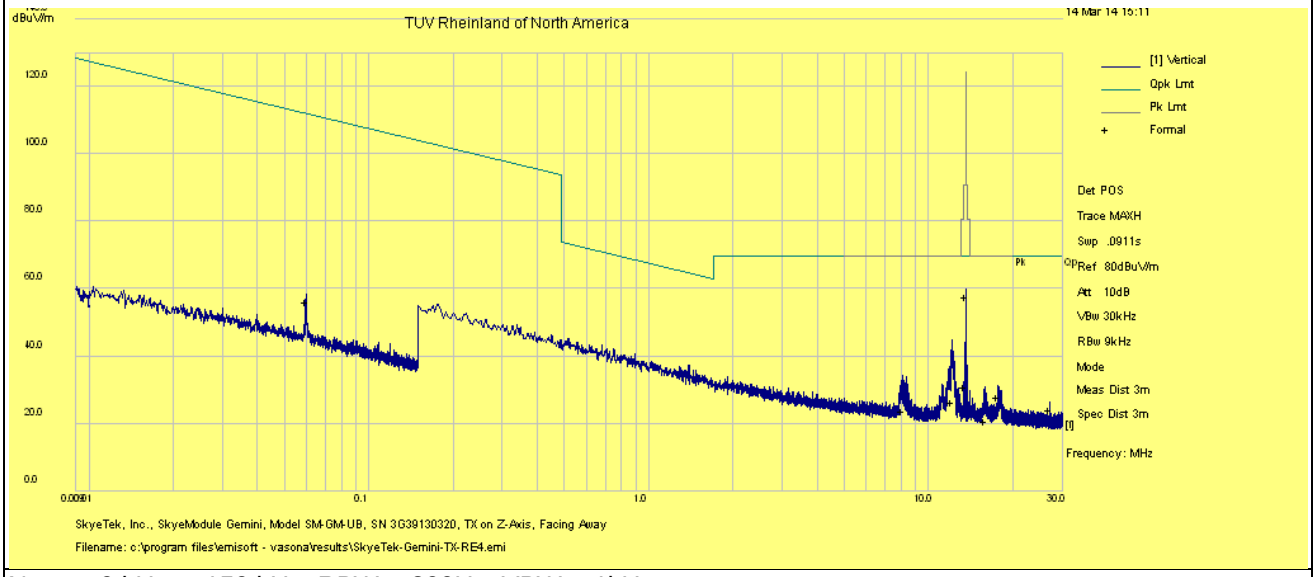
EUT Name	SkyeModule Gemini	**Date**	March 14, 2014
EUT Model	SM-GM	**Temp / Hum in**	23°C / 30%rh
EUT Serial	3G39130320	**Temp / Hum out**	N/A
EUT Config.	Standalone Module Orientation Z axis	**Line AC**	5 Vdc (via Host PC)
Standard	CFR47 Part 15 Subpart C	**RBW / VBW**	See below
Dist/Ant Used	3m / 6511	**Performed by**	Jeremy Luong

9 kHz to 30 MHz Plots





Notes: 9 kHz to 150 kHz; RBW = 200Hz, VBW = 1kHz
150 kHz to 30 MHz; RBW = 9kHz, VBW = 30kHz
The highest emission on the plots is the fundamental signal at 13.56 MHz.

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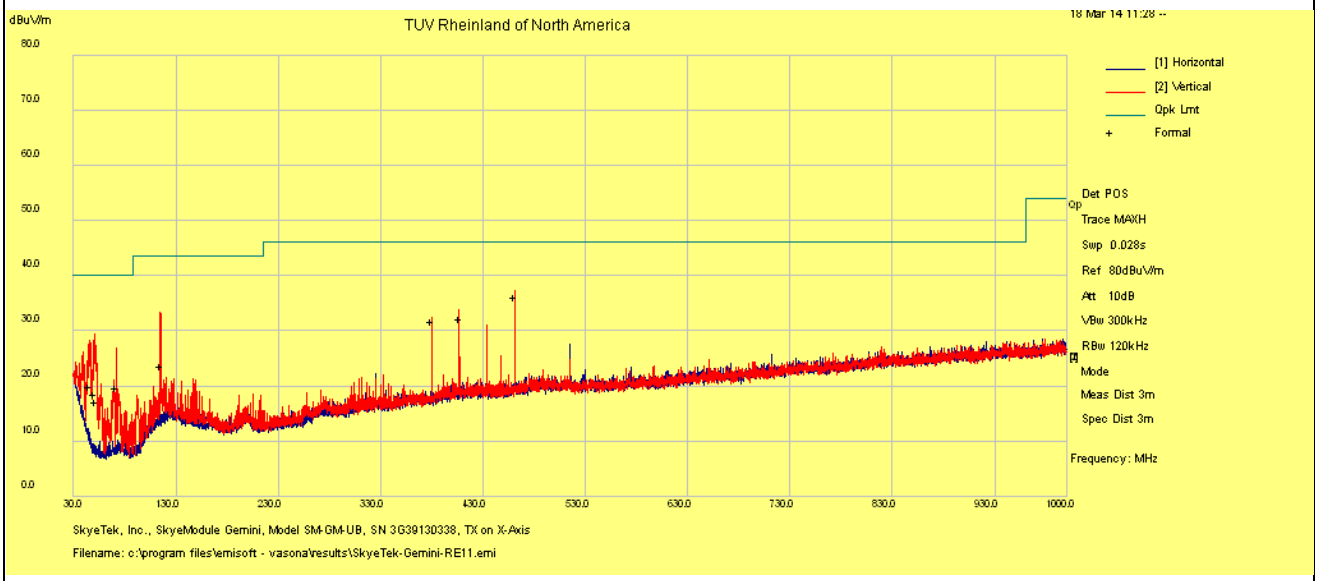
EUT Name	SkyeModule Gemini	**Date**	March 18, 2014
EUT Model	SM-GM	**Temp / Hum in**	23°C / 31%rh
EUT Serial	3G39130338	**Temp / Hum out**	N/A
EUT Config.	Standalone Module Orientation X axis	**Line AC**	5 Vdc (via Host PC)
Standard	CFR47 Part 15 Subpart C	**RBW / VBW**	120kHz / 300kHz
Dist/Ant Used	3m / JB3	**Performed by**	Jeremy Luong

30MHz to 1000MHz



Note: Prescan was performed in peak mode.

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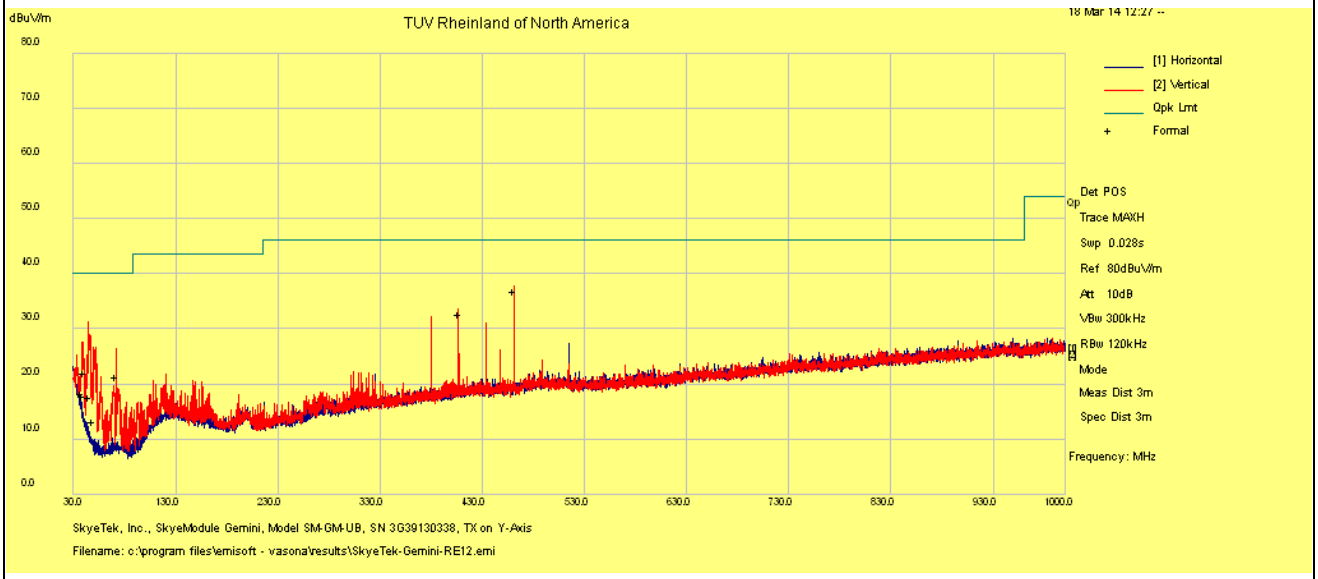
EUT Name	SkyeModule Gemini	**Date**	March 18, 2014
EUT Model	SM-GM	**Temp / Hum in**	23°C / 31%rh
EUT Serial	3G39130338	**Temp / Hum out**	N/A
EUT Config.	Standalone Module Orientation Y axis	**Line AC**	5 Vdc (via Host PC)
Standard	CFR47 Part 15 Subpart C	**RBW / VBW**	120kHz / 300kHz
Dist/Ant Used	3m / JB3	**Performed by**	Jeremy Luong

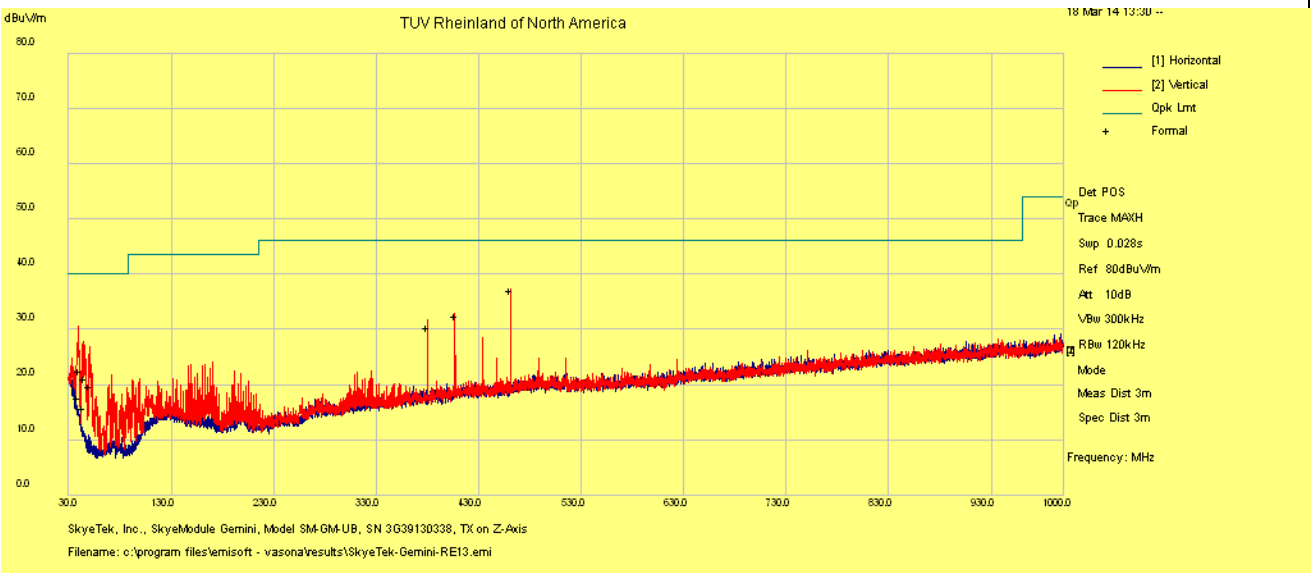
30MHz to 1000MHz



Note: Prescan was performed in peak mode.

SOP 1 Radiated Emissions		Tracking # 31460846.001 Page 9 of 9	
EUT Name	SkyeModule Gemini	**Date**	March 18, 2014
EUT Model	SM-GM	**Temp / Hum in**	23°C / 31%rh
EUT Serial	3G39130338	**Temp / Hum out**	N/A
EUT Config.	Standalone Module Orientation Z axis	**Line AC**	5 Vdc (via Host PC)
Standard	CFR47 Part 15 Subpart C	**RBW / VBW**	120kHz / 300kHz
Dist/Ant Used	3m / JB3	**Performed by**	Jeremy Luong

30MHz to 1000MHz



Note: Prescan was performed in peak mode.

4.4.4 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)

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

4.5 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.

4.5.1 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.

4.5.1.1 Deviations

There were no deviations from this test methodology.

4.5.2 Test Results

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

Table 9: AC Conducted Emissions – Test Results

Test Conditions: Conducted Measurement at Normal Conditions only		
Antenna Type: Internal	**Power Level:** Fixed	
AC Power: 110 Vac/60 Hz	**Configuration:** AC-DC Adapter	
Ambient Temperature: 22° C	**Relative Humidity:** 32% RH	
Configuration	**Frequency Range**	**Test Result**
Line 1 (Hot)	0.15 to 30 MHz	Pass
Line 2 (Neutral)	0.15 to 30 MHz	Pass

SOP 2 Conducted Emissions

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EUT Name	SkyeModule Gemini	**Date**	March 20, 2014
EUT Model	SM-GM	**Temp / Hum in**	22° C / 32% rh
EUT Serial	3G42130413	**Temp / Hum out**	N/A
EUT Config.	Standalone Module	**Line AC / Freq**	110Vac/60Hz
Standard	CFR47 Part 15.207	**RBW / VBW**	9kHz / 30 kHz
Lab/LISN	Lab 5 /ComPower, Line 1	**Performed by**	Jeremy Luong

Frequency	Raw	Cable Loss	Ins. Loss	Level	Detector	Line	Limit	Margin	Result
MHz	dBuV	dB	dB	dBuV		Line	dBuV	dB	
0.150	31.60	10.02	-0.10	41.52	QP	Live	66.00	-24.48	Pass
0.150	1.47	10.02	-0.10	11.39	Ave	Live	56.00	-44.61	Pass
0.253	24.06	10.03	-0.06	34.03	QP	Live	61.66	-27.63	Pass
0.253	5.67	10.03	-0.06	15.64	Ave	Live	51.66	-36.02	Pass
0.255	23.87	10.03	-0.06	33.84	QP	Live	61.58	-27.74	Pass
0.255	6.41	10.03	-0.06	16.38	Ave	Live	51.58	-35.20	Pass
0.430	21.36	10.03	-0.05	31.34	QP	Live	57.26	-25.92	Pass
0.430	4.73	10.03	-0.05	14.71	Ave	Live	47.26	-32.55	Pass
2.347	9.15	10.07	-0.04	19.18	QP	Live	56.00	-36.82	Pass
2.347	-2.61	10.07	-0.04	7.42	Ave	Live	46.00	-38.58	Pass
13.803	9.81	10.17	0.05	20.03	QP	Live	60.00	-39.97	Pass
13.803	3.95	10.17	0.05	14.17	Ave	Live	50.00	-35.83	Pass
19.999	9.98	10.20	0.15	20.33	QP	Live	60.00	-39.67	Pass
19.999	6.97	10.20	0.15	17.32	Ave	Live	50.00	-32.68	Pass

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: Tested with test jig as host. The module antenna port was terminated.

SOP 2 Conducted Emissions

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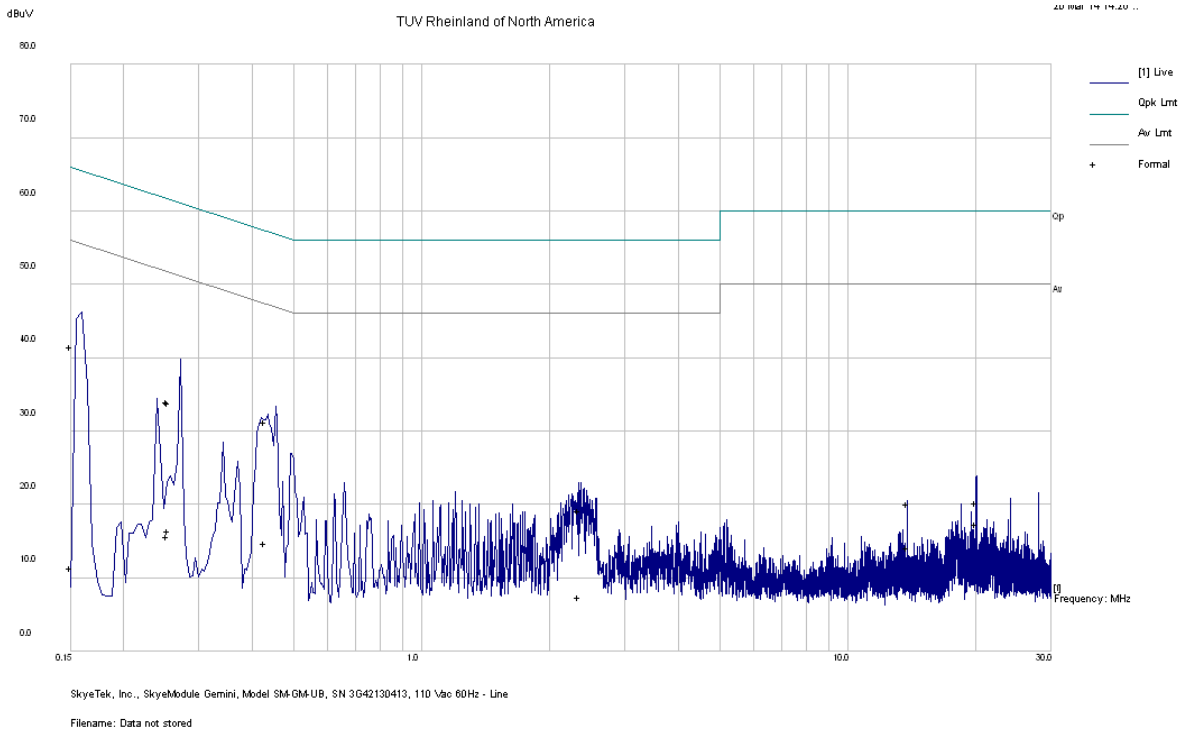
EUT Name	SkyeModule Gemini	**Date**	March 20, 2014
EUT Model	SM-GM	**Temp / Hum in**	22° C / 32% rh
EUT Serial	3G42130413	**Temp / Hum out**	N/A
EUT Config.	Standalone Module	**Line AC / Freq**	110Vac/60Hz
Standard	CFR47 Part 15.207	**RBW / VBW**	9kHz / 30 kHz
Lab/LISN	Lab 5 /ComPower, Line 1	**Performed 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	SkyeModule Gemini	**Date**	March 20, 2014
EUT Model	SM-GM	**Temp / Hum in**	22° C / 32% rh
EUT Serial	3G42130413	**Temp / Hum out**	N/A
EUT Config.	Standalone Module	**Line AC / Freq**	110Vac/60Hz
Standard	CFR47 Part 15.207	**RBW / VBW**	9kHz / 30 kHz
Lab/LISN	Lab 5 /ComPower, Line 2	**Performed by**	Jeremy Luong

Frequency	Raw	Cable Loss	Ins. Loss	Level	Detector	Line	Limit	Margin	Result
MHz	dBuV	dB	dB	dBuV			dBuV	dB	
0.171	32.49	10.02	-0.09	42.42	QP	Neutral	64.89	-22.47	Pass
0.171	10.66	10.02	-0.09	20.59	Ave	Neutral	54.89	-34.30	Pass
0.271	22.20	10.03	-0.06	32.17	QP	Neutral	61.08	-28.91	Pass
0.271	3.55	10.03	-0.06	13.52	Ave	Neutral	51.08	-37.56	Pass
0.373	12.36	10.03	-0.05	22.34	QP	Neutral	58.43	-36.09	Pass
0.373	-16.01	10.03	-0.05	-6.03	Ave	Neutral	48.43	-54.46	Pass
0.458	19.30	10.03	-0.05	29.28	QP	Neutral	56.72	-27.44	Pass
0.458	1.94	10.03	-0.05	11.92	Ave	Neutral	46.72	-34.80	Pass
0.878	11.34	10.04	-0.04	21.34	QP	Neutral	56.00	-34.66	Pass
0.878	-4.37	10.04	-0.04	5.63	Ave	Neutral	46.00	-40.37	Pass
2.347	9.31	10.07	-0.04	19.34	QP	Neutral	56.00	-36.66	Pass
2.347	-2.96	10.07	-0.04	7.07	Ave	Neutral	46.00	-38.93	Pass
13.801	10.57	10.17	0.05	20.79	QP	Neutral	60.00	-39.21	Pass
13.801	4.65	10.17	0.05	14.87	Ave	Neutral	50.00	-35.13	Pass
20.000	10.13	10.20	0.15	20.48	QP	Neutral	60.00	-39.52	Pass
20.000	6.94	10.20	0.15	17.29	Ave	Neutral	50.00	-32.71	Pass
24.000	7.21	10.23	0.24	17.68	QP	Neutral	60.00	-42.32	Pass
24.000	4.16	10.23	0.24	14.63	Ave	Neutral	50.00	-35.37	Pass
26.118	-1.92	10.24	0.28	8.60	QP	Neutral	60.00	-51.40	Pass
26.118	-8.12	10.24	0.28	2.40	Ave	Neutral	50.00	-47.60	Pass
28.000	10.93	10.24	0.34	21.51	QP	Neutral	60.00	-38.49	Pass
28.000	9.44	10.24	0.34	20.02	Ave	Neutral	50.00	-29.98	Pass

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: Tested with test jig as host. The module antenna port was terminated.

SOP 2 Conducted Emissions

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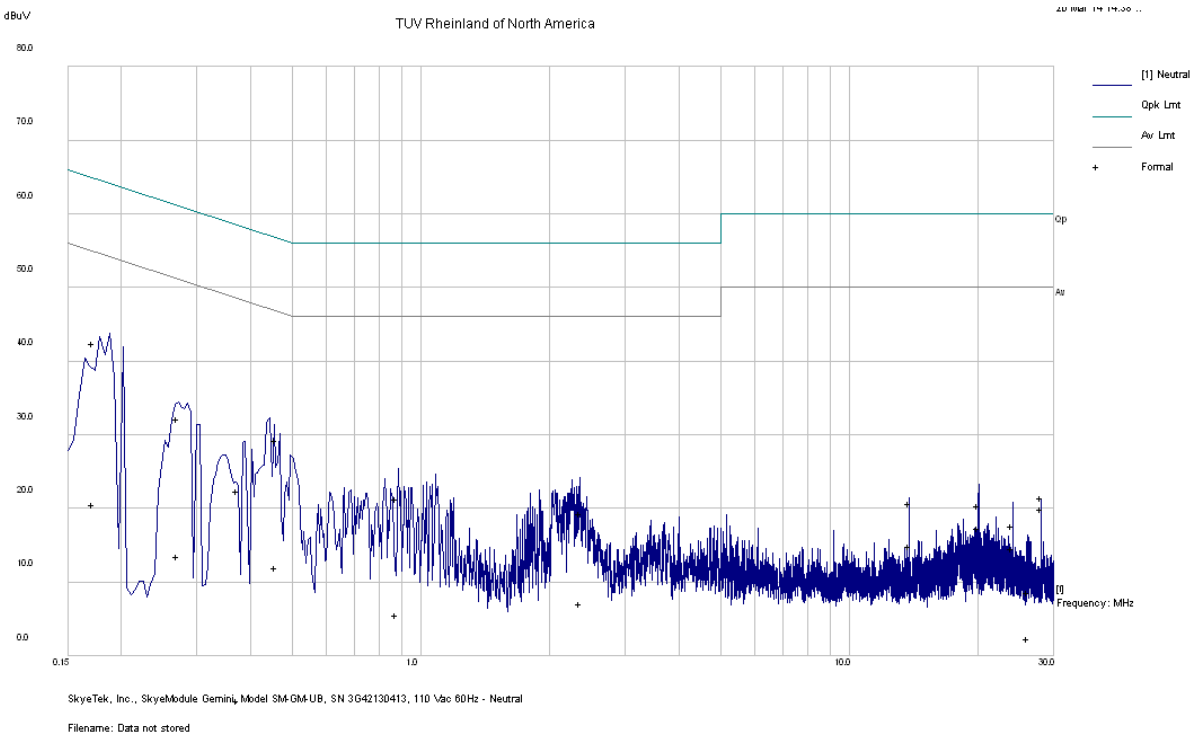
EUT Name	SkyeModule Gemini	**Date**	March 20, 2014
EUT Model	SM-GM	**Temp / Hum in**	22° C / 32% rh
EUT Serial	3G42130413	**Temp / Hum out**	N/A
EUT Config.	Standalone Module	**Line AC / Freq**	110Vac/60Hz
Standard	CFR47 Part 15.207	**RBW / VBW**	9kHz / 30 kHz
Lab/LISN	Lab 5 /ComPower, Line 2	**Performed by**	Jeremy Luong

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



Notes: Meet FCC Class B limit.

4.6 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 -20º to +70º C.

4.6.1 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

4.6.2 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.

The frequency stability was conducted on the production sample, SN: 3G42130413.

4.6.3 Test results

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

Table 10: Frequency Stability – Test Results

Temperature	Time	PPM
-20°C	Start	6.64
	2 Min.	7.19
	5 Min	7.28
	10 min	7.14
-10°C	Start	11.80
	2 Min.	11.80
	5 Min	11.80
	10 min	11.75
0°C	Start	12.63
	2 Min.	12.68
	5 Min	12.72
	10 min	12.63
10°C	Start	11.89
	2 Min.	11.62
	5 Min	11.57
	10 min	11.52
20°C	Start	9.91
	2 Min.	9.59
	5 Min	9.59
	10 min	9.59
30°C	Start	8.57
	2 Min.	8.30
	5 Min	8.30
	10 min	8.30
40°C	Start	6.64
	2 Min.	6.36
	5 Min	6.36
	10 min	6.36
50°C	Start	5.90
	2 Min.	5.90
	5 Min	5.90
	10 min	5.90
60°C	Start	6.59
	2 Min.	6.91
	5 Min	6.96
	10 min	7.01
70°C	Start	9.63
	2 Min.	9.86
	5 Min	9.86
	10 min	9.91
Note: All frequency drifts from 13.56 MHz were less than ±100 ppm.		

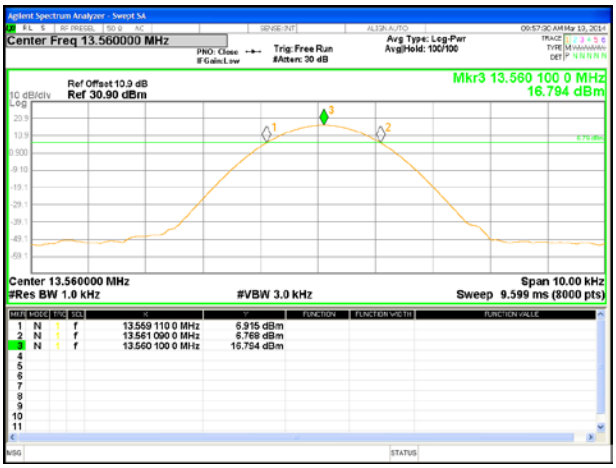


Figure 15: Frequency Stability at -20° C (Start)

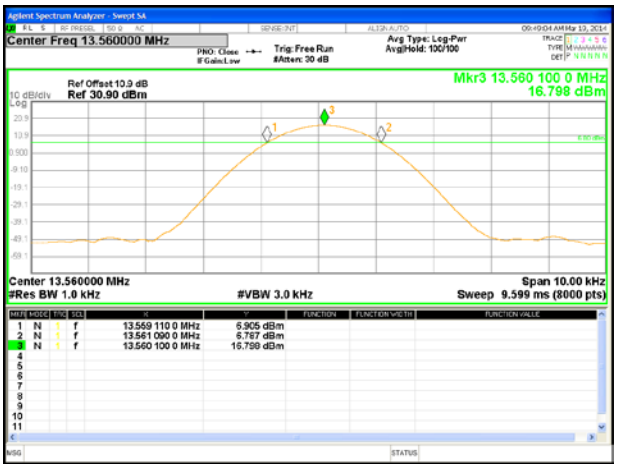


Figure 16: Frequency Stability at -20° C (2 Min.)

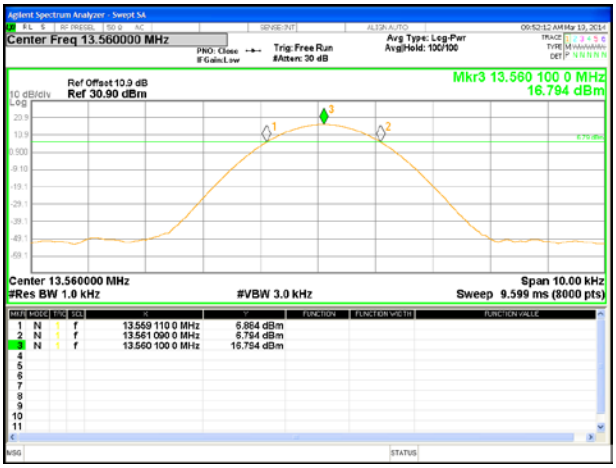


Figure 17: Frequency Stability at -20° C (5 Min.)

Figure 18: Frequency Stability at -20° C (10 Min.)

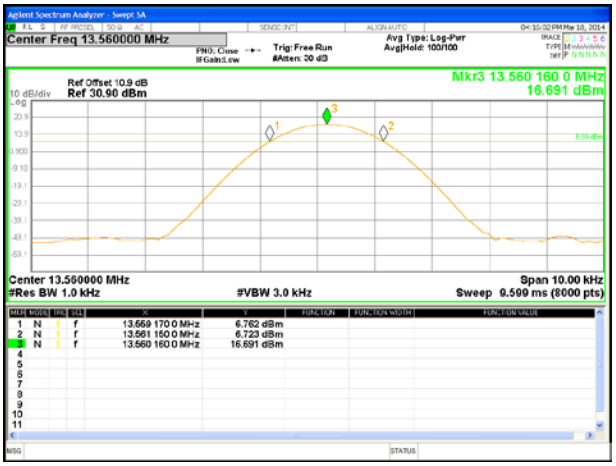


Figure 19: Frequency Stability at -10° C (Start)

Figure 20: Frequency Stability at -10° C (2 Min.)

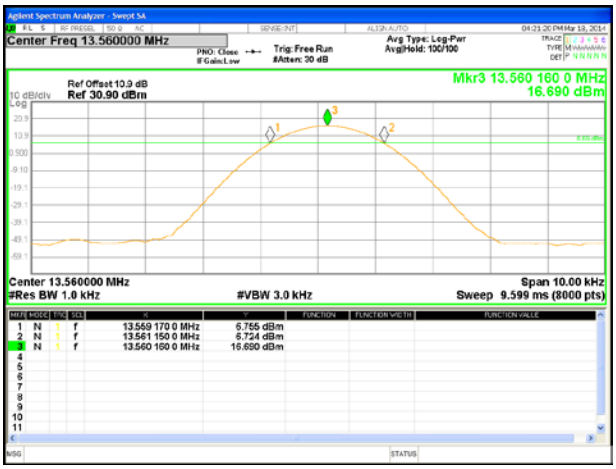


Figure 21: Frequency Stability at -10° C (5 Min.)

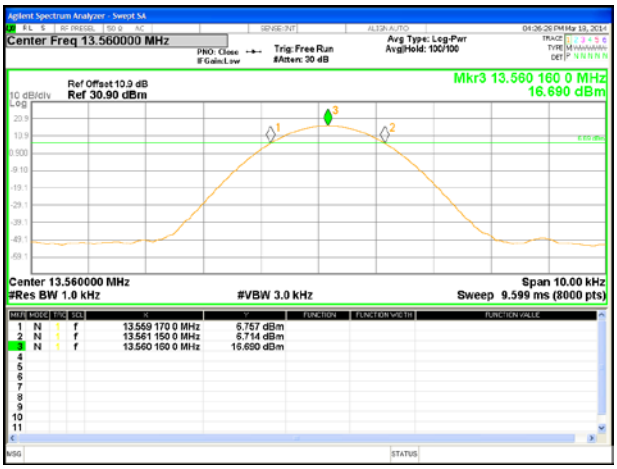


Figure 22: Frequency Stability at -10° C (10 Min.)

Figure 23 Frequency Stability at 0° C (Start)

Figure 24 Frequency Stability at 0° C (2 Min.)

Figure 25: Frequency Stability at 0° C (5 Min.)

Figure 26: Frequency Stability at 0° C (10 Min.)

Figure 27: Frequency Stability at 10° C (Start)

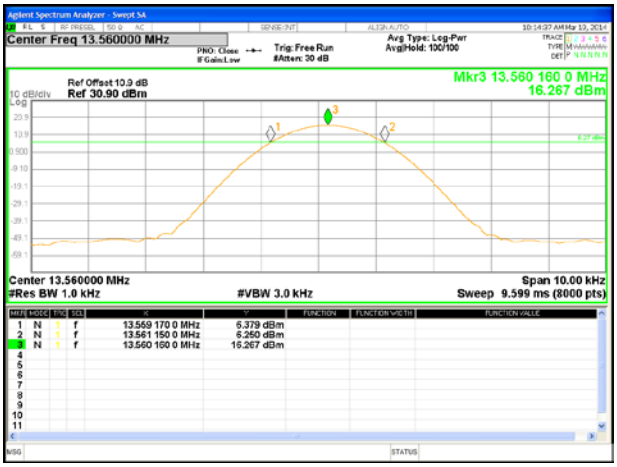


Figure 28: Frequency Stability at 10° C (2 Min.)

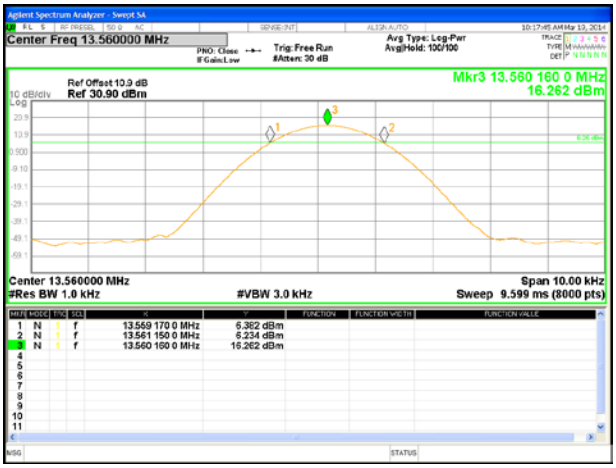


Figure 29: Frequency Stability at 10° C (5 Min.)

Figure 30: Frequency Stability at 10° C (10 Min.)

Figure 31: Frequency Stability at 20° C (Start)

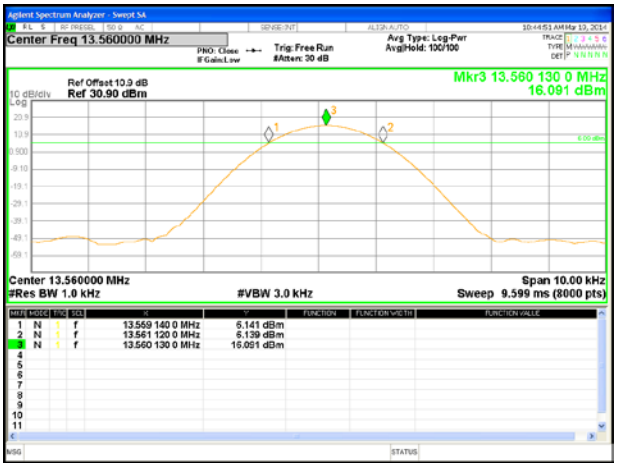


Figure 32: Frequency Stability at 20° C (2 Min.)

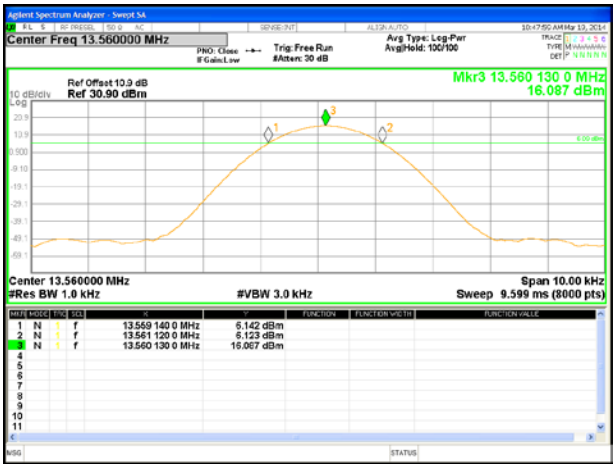


Figure 33: Frequency Stability at 20° C (5 Min.)

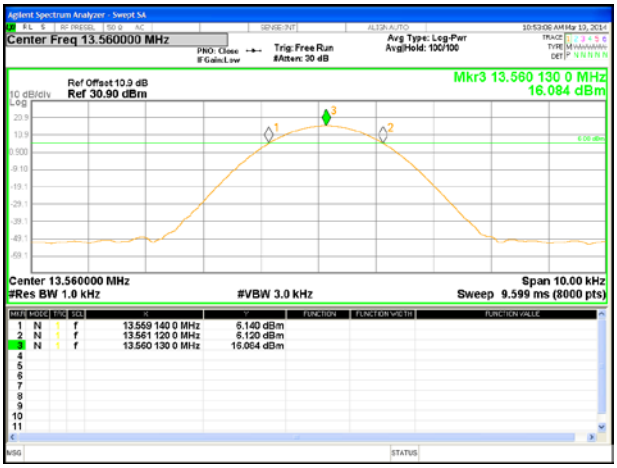


Figure 34: Frequency Stability at 20° C (10 Min.)

Figure 35: Frequency Stability at 30° C (Start)

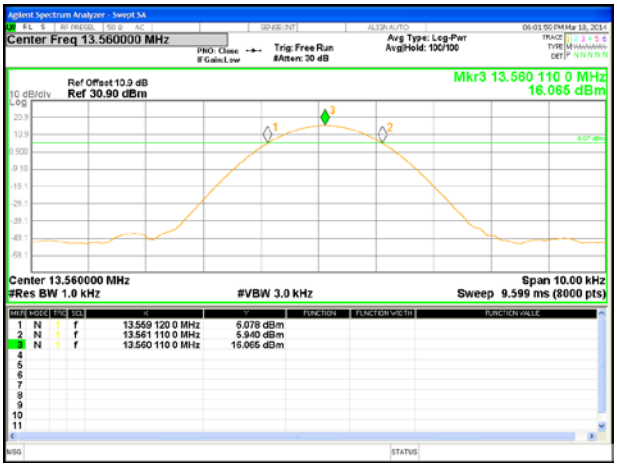


Figure 36: Frequency Stability at 30° C (2 Min.)

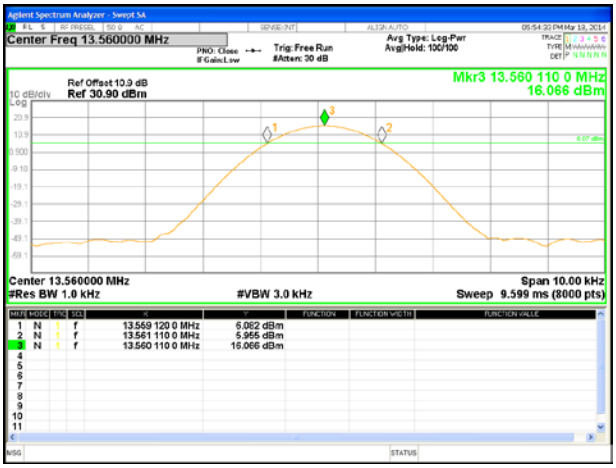


Figure 37: Frequency Stability at 30° C (5 Min.)

Figure 38: Frequency Stability at 30° C (10 Min.)

Figure 39: Frequency Stability at 40° C (Start)

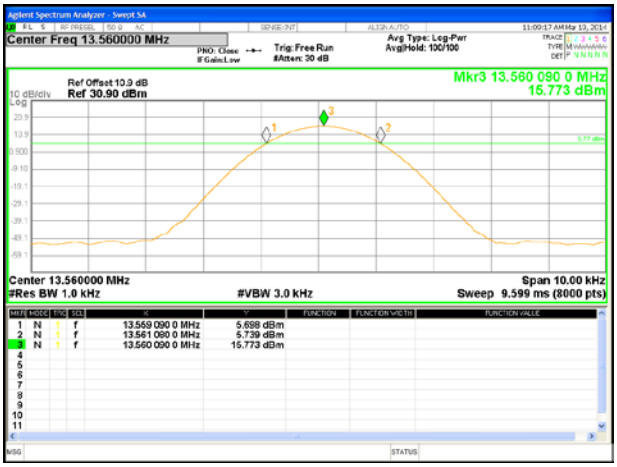


Figure 40: Frequency Stability at 40° C (2 Min.)

Figure 41: Frequency Stability at 40° C (5 Min.)

Figure 42: Frequency Stability at 40° C (10 Min.)

Figure 43: Frequency Stability at 50° C (Start)

Figure 44: Frequency Stability at 50° C (2 Min.)

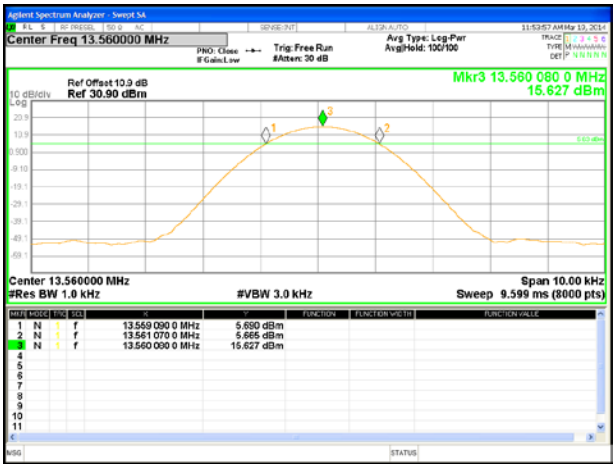


Figure 45: Frequency Stability at 50° C (5 Min.)

Figure 46: Frequency Stability at 50° C (10 Min.)

Figure 47: Frequency Stability at 60° C (Start)

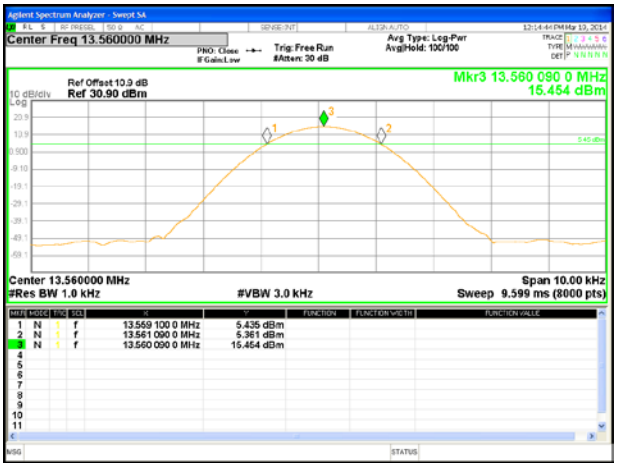


Figure 48: Frequency Stability at 60° C (2 Min.)

Figure 49: Frequency Stability at 60° C (5 Min.)

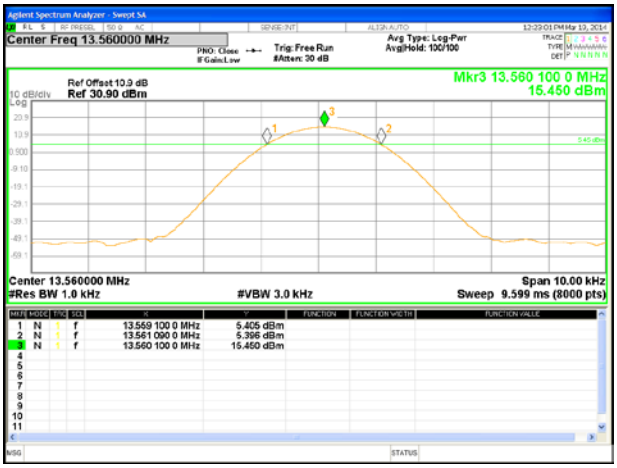


Figure 50: Frequency Stability at 60° C (10 Min.)

Figure 51: Frequency Stability at 70° C (Start)

Figure 52: Frequency Stability at 70° C (2 Min.)

Figure 53: Frequency Stability at 70° C (5 Min.)

Figure 54: Frequency Stability at 70° C (10 Min.)

4.7 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.

4.7.1 Test Methodology

The RFID reader was designed to operating within 4.25 Vdc to 5.75 Vdc . The fundamental frequency was observed during the variation. The RFID module was powered by 5 Vdc by variable DC power supply. The voltage input on the USB connection was varied from 4.25 Vdc to 5.75 Vdc mean while the fundamental frequencies were observed and recorded for the maximum drift in ppm; part per millions.

The voltage variation was conducted on the production sample, SN: 3G42130413.

4.7.2 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 11: Voltage Variation – Test Results

Voltage	PPM
4.25V DC	11.80
5.00V DC	11.80
5.75V DC	11.80
Note: All frequency drifts were less than ±100 ppm from 13.56 MHz No frequency change was observed with time.	

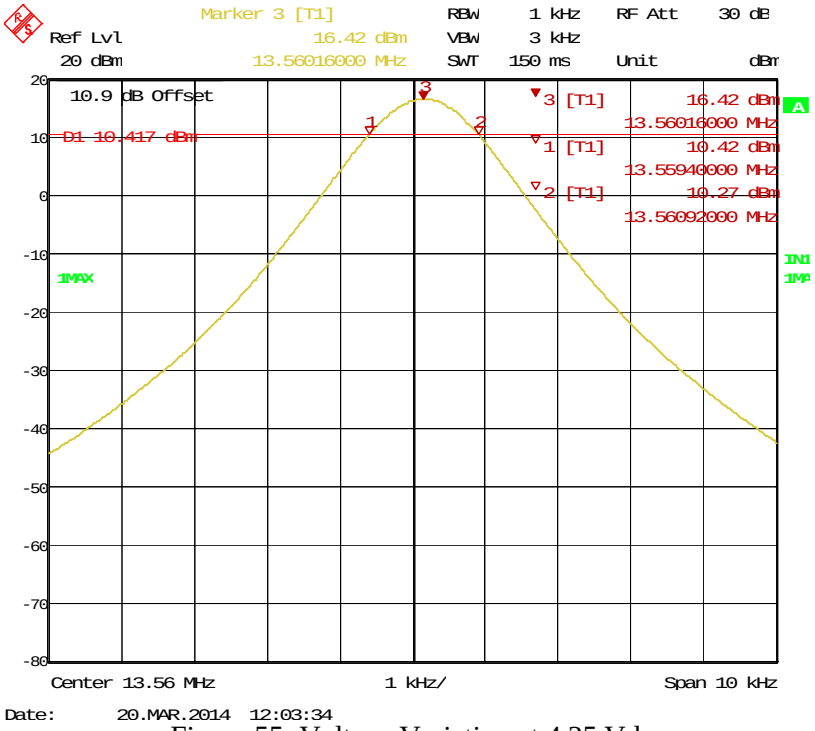


Figure 55: Voltage Variation at 4.25 Vdc

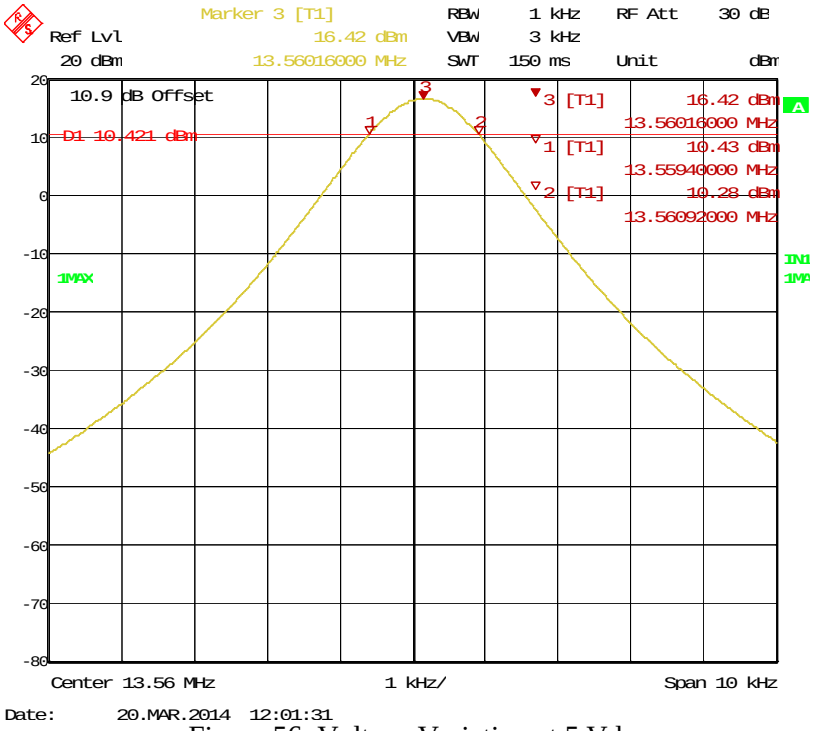


Figure 56: Voltage Variation at 5 Vdc

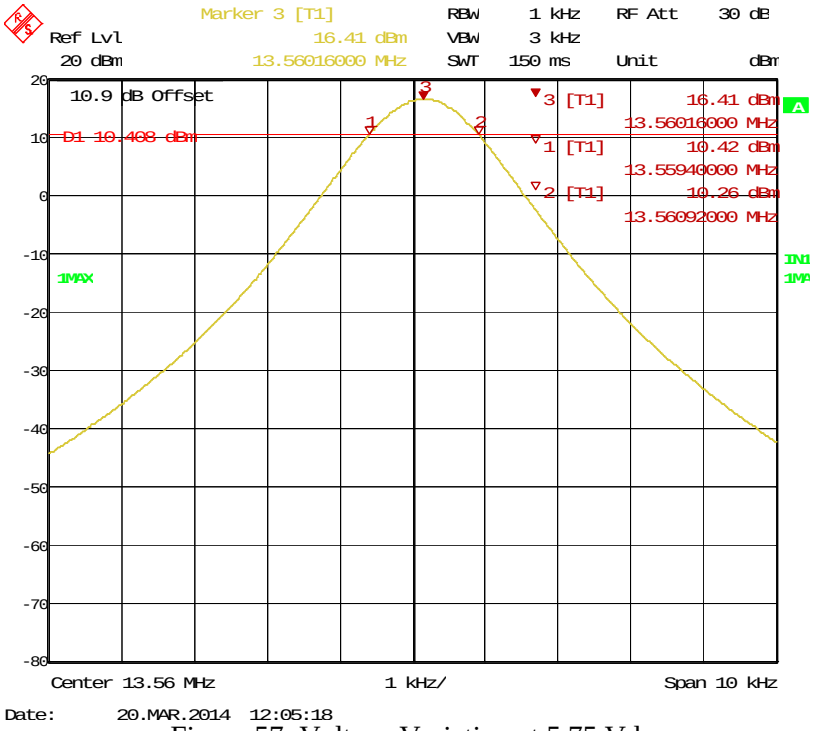


Figure 57: Voltage Variation at 5.75 Vdc

5 Test Equipment List

5.1 Equipment List

Equipment	Manufacturer	Model #	Serial/Inst #	Last Cal mm/dd/yy	Next Cal mm/dd/yy
Spectrum Analyzer	Agilent	N9038A	MY52260210	01/08/2014	02/08/2015
Amplifier	Hewlett Packard	8447D	2944A07996	01/07/2014	02/07/2015
Bilog Antenna	Sunol Science	JB3	A102606	05/15/2012	05/15/2014
Loop Antenna	ETS-Lindgren	6502	62531	10/04/2012	10/04/2014
EMI Receiver	Hewlett Packard	8546A	3325A00168	11/14/2013	11/14/2014
Preselector	Hewlett Packard	85460A	3330A00174	11/14/2013	11/14/2014
Line Impedance Network Stabilization	Com-Power	L1-215	12100	01/28/2014	02/28/2015
Transient Limiter	Com-Power	LIT930	531582	01/08/2014	02/08/2015
Spectrum Analyzer	Rohde & Schwarz	ESIB40	832427/002	01/08/2014	02/08/2015
Thermo Chamber	ESPEC	BTZ-133	0613436	03/17/2014	03/17/2015
Thermometer	Fluke	52II	96480032	08/07/2013	08/07/2014
Digital Multimeter	Fluke	83III	84590116	01/07/2014	01/07/2015
DC Power Supply	Agilent	E3634A	MY400004331	01/07/2014	02/07/2015

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 12: Customer Information

Company Name	SkyeTek, Inc.
Address	1732 Wazee St, Ste 202
City, State, Zip	Denver, CO 80202 U.S.A.
Country	U.S.A.
Phone	(720) 328-3425
Fax	(720) 228 2400

Table 13: Technical Contact Information

Name	Brad Alcorn
E-mail	brad.alcorn@skyetek.com
Phone	(720) 328-3425
Fax	(720) 228 2400

6.3 Equipment Under Test (EUT)

Table 14: EUT Specifications

EUT Specification	
Dimensions:	0.178"H 1.505"W 1.575"D
Power Supply:	5 Vdc via USB Power or host
Environment	Indoor / Outdoor
Operating Temperature Range:	-20 to 70 degrees C
Multiple Feeds:	☐ Yes and how many ☒ No.
Hardware Version	V3
RFID Software Version	SkyeWare v4
Operating Mode	RFID Reader
Transmitter Frequency Band	13.56 MHz
Chipset Rated Power Output	125 mW
Power Setting @ Operating Channel	Fixed: power controlled by FPGA firmware.
Antenna Type	Inductive Loop Antenna
Modulation Type	☐ AM ☐ FM ☐ Phase ☒ Other describe: ASK
Data Rate	106 kbps
Max. Duty Cycle	100%
Type of Equipment	☐ Table Top ☐ Wall-mount ☐ Floor standing cabinet ☒ Other *describe: Module*.

Table 15: 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?
USB	USB	Yes	3 ft	M
Note: USB cable was mainly used for providing DC power during testing.				

Table 16: Supported Equipment

Equipment	Manufacturer	Model	Serial	Used for
Laptop	Dell Computers	PP04X	CN-0JF240-48643-684-1549	Set RFID mode.
Test jig	SkyeTek, Inc.	SP-IB-00-5.3	1402260028	Hosting module.
Note: None				

Table 17: Description of Sample used for Testing

Device	Serial Number	Configuration	Used For
SkyeModule Gemini	3G3913320 3G39130338	Radiated Samples	Max. Carrier Field Strength Out of Band Emission TX Spurious Radiated Emission AC Conducted Emission
SkyeModule Gemini	3G42130413	Conducted Sample	Occupied Bandwidth Frequency Stability Voltage Variation
Note: None.			

Table 18: Description of Test Configuration used for Radiated Measurement.

Device	Antenna	Mode	Setup Description
SkyeModule Gemini	Internal	Transmit & Receive	EUT all 3 axis
Note: Testing was performed for all 3 orthogonal axis.			

6.4 Test Specifications

Testing requirements

Table 19: Test Specifications

Emissions and Immunity	
Standard	Requirement
CFR 47 Part 15.225:2013	All
RSS-210 Iss. 8 2010	All

END OF REPORT