1601 North A.W. Grimes Blvd., Suite B
Round Rock, TX 78665
e-mail: info@ptitest.com
(512) 244-3371 Fax: (512) 244-1846

February 6, 2015

F. Scott Yeager
Universal Repeater
P.O. Box 912
Llano, TX 78743

Dear Scott:

Thank you for allowing Professional Testing (EMI), Inc. an opportunity to perform testing for Universal Repeater LLC. Enclosed is the Wireless Certification Report for the SatMAX. This report can be used to demonstrate compliance with FCC requirements for wireless devices in the United States.

If you have any questions, please contact me.

Sincerely,

Jeffrey A. Lenk
President

Attachment

Project 14426-10

**SatMAX**

**Wireless Certification Report**

Prepared for:

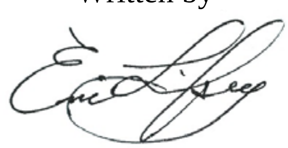
Universal Repeater LLC

By

Professional Testing (EMI), Inc.
1601 North A.W. Grimes Blvd., Suite B
Round Rock, Texas 78665

February 6, 2015

Written by



Eric Lifsey
Test Engineer

**Revision History**

| Revision Number | Description | Date |
| --- | --- | --- |
| 00 | Draft 2 | April 22, 2013 |
| 03 | Revised to ACB comments | February 11, 2014 |
| 04 | Revised per ACB comments | March 7, 2014 |
| 05 | Revised per ACB comments | September 5, 2014 |
| 06 | Revised per ACB comments | February 6, 2015 |
| | | |

# Table of Contents

NOTICE:

PROFESSIONAL TESTING

## Certificate of Compliance

Applicant: Universal Repeater LLC
Applicant's Address: P.O. Box 912
Llano, TX 78743

FCC ID: 05NURSATMAX3UIRID
Model: SatMAX
Project Number: 14426-10

The **SatMAX Transceiver** by **Universal Repeater LLC**, was tested utilizing the following documents and found to be in compliance with the required criteria on the indicated test date.

| 47 CFR, Part 25, 24.202(a)(4)(i) | | |
|---|---|---|
| Section Reference | Parameter | Date |
| 25.204(a), 25.216(f), 2.1046 | Conducted Output Power | February 5, 2014 |
| 25.216(f), 25.216(i) | Spurious Low Edge, Conducted at Antenna Terminals | March 4, 2013 |
| 25.202(f)(3), 2.1051 | Conducted Spurious/Harmonic Emissions at Antenna Terminals | March 4, 2013 |
| 2.1053 | Field Strength of Radiated Spurious/Harmonic Emissions (1 GHz to 17 GHz) | February 15, 2013 |
| 15.107 | Mains Conducted Emissions, Class A | February 15, 2013 |
| 2.1091(c) | Maximum Permissible Exposure | January 31, 2014 |
| - | Amplifier Overload & Bandwidth | February 4, 2014 |

I, Jeffrey A. Lenk, for Professional Testing (EMI), Inc., being familiar with the FCC rules and test procedures, have reviewed the test setup, measured data, and this report. I believe them to be true and accurate.

Jeffrey A. Lenk
President

This report has been reviewed and accepted by Universal Repeater LLC. The undersigned is responsible for ensuring that the SatMAX Transceiver by Universal Repeater LLC, will continue to comply with the applicable rules.

____________________________________
Representative of Universal Repeater LLC

# 1.0 Introduction

## 1.1 Scope

This report describes the extent to which the equipment under test (EUT) conformed to the intentional radiator requirements of the United States.

Professional Testing (EMI), Inc., (PTI) follows the guidelines of National Institute of Standards and Technology (NIST) for all uncertainty calculations, estimates, and expressions thereof for electromagnetic compatibility testing. The procedures of TIA/EIA 603 were used for making all radiated enclosure and mains emission measurements.

## 1.2 EUT Description

The EUT is the **SatMAX** by **Universal Repeater LLC**, a device to extend the range of Iridium satellite cellular devices into buildings or structures that would otherwise present excessive loss to satellite signals. It is composed of two individual analog RF amplifiers, designated Uplink and Downlink, housed in a portable enclosure. The enclosure includes an AC power supply/charger and backup battery. It is supplied with four external Iridium antennas and long RF cables with separation requirements to avoid RF feedback. The system as tested consisted of the following:

**Table 1.2.1: Equipment Under Test**

| Manufacturer | Model | Serial # | Description |
|---|---|---|---|
| Universal Repeater LLC | SatMAX | None | Satellite repeater |

## 1.3 EUT Operation

The EUT was exercised in a manner consistent with normal operations. The two RF amplifiers operate over identical bands of frequencies but have significantly different power outputs.

The 1$^{st}$ amplifier receives Iridium satellite signals on the outdoor downlink antenna (commonly on the roof of the host structure), then drives another antenna positioned inside the structure to radiate the signals to Iridium phones. Due to proximity of the Iridium phones, this amplifier has a much lower power output than the other amplifier.

The 2$^{nd}$ amplifier provides the reverse signal path up to the satellite. The received signals from Iridium phones inside the structure are amplified and sent to the outdoor uplink antenna to the Iridium satellites. This amplifier has a much higher power output to overcome the greater path loss. As this antenna is only effective on the roof of a structure, the exposure to its RF fields are limited to that area.

Cavity bandpass filtering is added to the outputs of both RF amplifiers to suppress unwanted harmonic or spurious emissions.

No frequency conversion takes place. No RF oscillators are present in the design.

The SatMAX is housed in a durable portable enclosure to allow rapid deployment in adverse environmental conditions.

**Photograph 1.3.1: EUT Front and Back**

## 1.4 Modifications to Equipment

No modifications were made to the EUT during the performance of the test program.

## 1.5 Test Site

Measurements were made at the PTI semi-anechoic facility designated Site 45 (FCC 459644, IC 3036B-1) in Austin, Texas. The site is registered with the FCC under Section 2.948 and Industry Canada per RS-212, and is subsequently confirmed by laboratory accreditation (NVLAP). The test site is located at 11400 Burnet Road, Austin, Texas 78758, while the main office is located at 1601 North A.W. Grimes Boulevard, Suite B, Round Rock, Texas, 78665.

## 2.0 Applicable Documents and Clauses

This device operates on frequencies assigned to the Iridium satellite communication services, as such 47 CFR, Part 25, applies as shown below.

**Table 2.0.1: Applicable Documents**

| Document # | Title/Description |
|---|---|
| 47 CFR | Part 25 – Satellite Communications |
| 47 CFR | Part 15 – 15.107 AC Mains Conducted Emissions |
| TIA/EIA-603C 2004 | Land Mobile FM or PM Communications Equipment, Measurement and Performance Standards |

**Table 2.0.2: Applicable Clauses**

| Clause Subject | Section References | Required? | Result |
|---|---|---|---|
| Conducted Output Power | 25.204(a), 25.216, 2.1046 | Yes | Pass |
| Spurious Low Edge, Conducted at Terminals | 25.216(f) | Yes | Pass |
| Conducted Spurious/Harmonic Emissions at Antenna Terminals | 25.202(f), 2.1051 | Yes | Pass |
| Field Strength of Radiated Spurious/Harmonic Emissions (1 GHz to 17 GHz) | 25.202(f), 2.1053 | Yes | Pass |
| Mains Conducted Emissions, Class A[1] | 15.107 | Yes | Pass |
| Frequency Stability[2] | 25.202(d), 2.1055 | N/A | N/A |
| Occupied Bandwidth, 20 dB[2] | 2.1049 | N/A | N/A |
| Maximum Permissible Exposure[3] | Reported separately. | Yes | Pass |
| Application Report Requirements | 2.1033(c) | Yes | N/A |
| Amplifier Overload & Bandwidth | - | Yes | Yes |

[1]This device generates and uses RF energy in the form of a switching power supply, such that 47 CFR, Part 15, applies. Therefore conducted emissions were measured.

[2]This device uses RF signals by amplification only and does not contain any oscillators, modulators, or mixing stages. Therefore a measurement of frequency stability and occupied bandwidth is not applicable. However, additional tests of input vs output bandwidth are presented.

[3]This device operates at 1.6 GHz such that the FCC 2.1091(c) criteria for Part 25 devices apply as follows: "… operate at frequencies above 1.5 GHz and their ERP is 3 watts or more."

## 3.0 Conducted Output Power

Conducted output power measurements were made on the two sections of the EUT. The lowest, center, and highest operating frequency channels of the Iridium band were investigated for each.

### 3.1 Test Procedure

The test configuration for one amplifier setup is diagrammed in Figure 3.1.1. Except for radiated emission tests, the Source signal for the EUT was supplied by an Iridium simulator card. The simulator card was controlled by a laptop PC which allowed channel selection. Attenuation of the Source signal was required to emulate the path loss of an actual application and drive the amplifier to full output. Output attenuation was provided to protect the Spectrum Analyzer from excessive power.

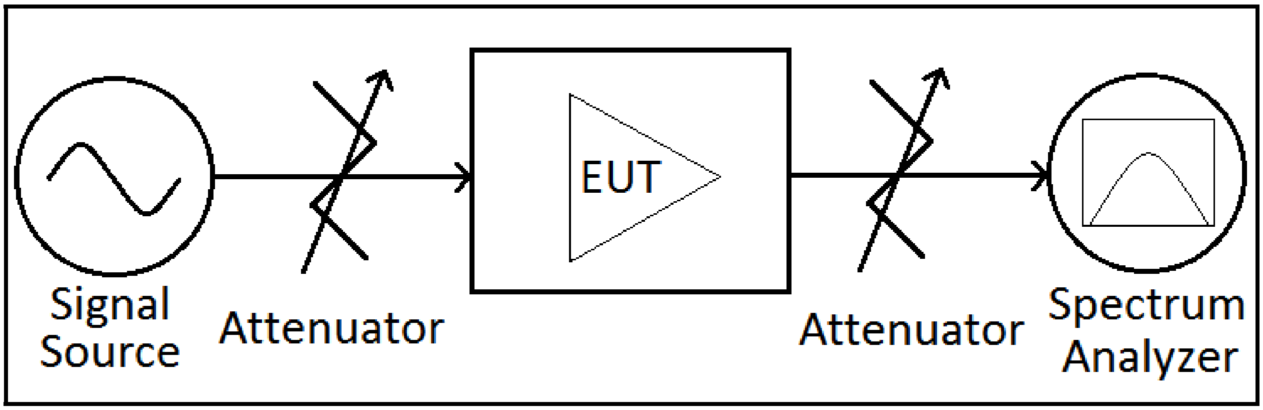



**Figure 3.1.1: Conducted Power Output Test Setup**

In the case of radiated spurious emission tests, the USB Iridium emulator proved to be a source of high unwanted emissions and so a signal generator was substituted.

### 3.2 Test Criteria

| Section Reference | Parameter | Date(s) |
|---|---|---|
| 25.204(a), 25.216, 2.1046 | Conducted Output Power | February 5, 2014 |

### 3.3 Test Results

The conducted output power measurements for the EUT were taken on the date(s) cited above. Measured maximum output power, taken from the overload measurement of each amplifier, is added to antenna gain to arrive at EIRP level and compared to the limit.

The EUT was found to be in compliance with the applicable requirements.

### 3.3.1 Uplink

| Uplink at Saturation* | | | | | | |
|---|---|---|---|---|---|---|
| Channel MHz | Corrected Peak Power (dBm) | Antenna Gain (dBi) | Power With Antenna Gain (dBm) | Power In Limit Terms (dBW) | Limit EIRP (dbW) | Margin (dB) |
| 1616 | 36.0 | 4.4 | 40.4 | 10.4 dBW | 40 | -29.6 |
| 1621 | 38.4 | 4.4 | 42.8 | 12.8 dBW | 40 | -27.2 |
| 1626.5 | 38.1 | 4.4 | 42.5 | 12.5 dBW | 40 | -27.5 |

*Measured at point of no change or saturation.

### 3.3.2 Downlink

| Downlink at Saturation* | | | | | | |
|---|---|---|---|---|---|---|
| Channel MHz | Corrected Peak Power (dBm) | Antenna Gain (dBi) | Power With Antenna Gain (dBm) | Power In Limit Terms (dBW) | Limit EIRP (dbW) | Margin (dB) |
| 1616 | 9.1 | 4.4 | 13.5 | -16.5 dBW | 40 | -56.5 |
| 1621 | 13.9 | 4.4 | 18.3 | -11.7 dBW | 40 | -51.7 |
| 1626.5 | 13.6 | 4.4 | 18.0 | -12.0 dBW | 40 | -52.0 |

*Measured at point of no change or saturation.

### 3.3.3 Antenna

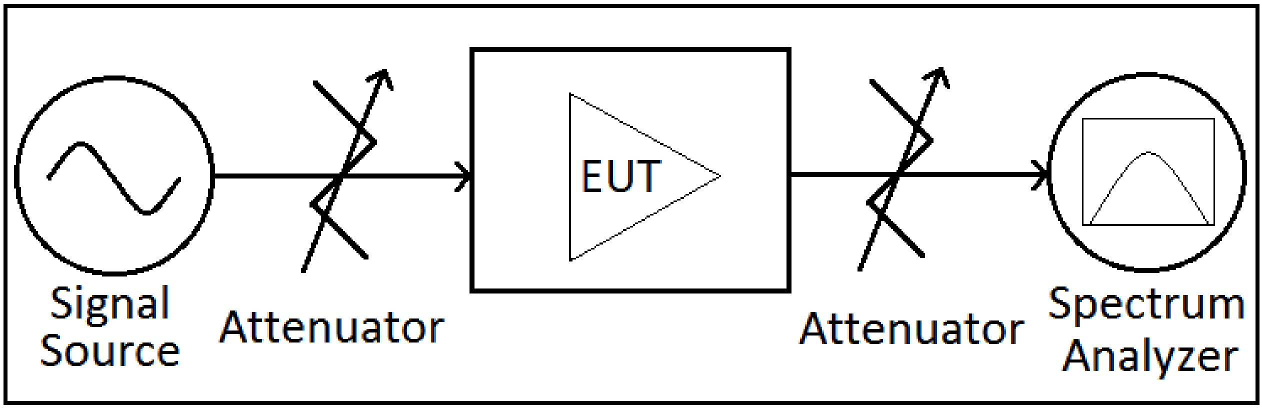
| Antenna Manufacturer and Model | Specifications |
|---|---|
| Antcom Corporation<br>S3IR16RR-P-XT-1 | Frequency: 1610.0-1626.5 MHz<br>Polarization: RHCP<br>Gain: +4.4 dBi<br>Axial Ratio: 2.0dB<br>Impedance: 50 OHMS<br>Size: 3.50 in diameter (88.90 mm)<br>Height: 0 .583 in. (14.81 mm) |
| Source: http://www.iridium.com/ | |


# 4.0 Spurious Emission Low Edge

Measurements of spurious emissions per the required limits at antenna terminals were taken on the EUT to determine the compliance as follows.

## 4.1 Test Procedure

The test configuration for one section is diagrammed below. The Source signal for the EUT was supplied by an Iridium simulator card. The simulator card was controlled by a laptop PC which allowed channel selection. Attenuation of the Source signal was required to emulate the path loss of an actual application and drive the amplifier to full output. Output attenuation was provided to protect the Spectrum Analyzer from excessive power.




## 4.2 Test Criteria

| Section Reference | Parameter | Date |
|---|---|---|
| 25.216(c), 25.216(f) | Emission Bottom Edge, Conducted at Terminals | March 4, 2013 |

This test limits unwanted emissions on two specified bands below the lowest operating frequency. The first band for 25.216(c) is a flat limit while the $2^{nd}$ band for 25.216(f) has a sloping limit. The limit is expressed in units of dBW and converted below to dBm. This measurement is done for non-discrete emissions using resolution bandwidth of 1 MHz with video bandwidth of 3 MHz. Results are adjusted upward by antenna gain of 4.4 dBi.

The EUT has no signal generating capability, no oscillators, and consequently no mixing products possible. Therefore the 700 Hz bandwidth discrete signal measurement of 25.216(c) is not applicable.

| Section Reference | Frequency Range | Limit (/MHz) |
|---|---|---|
| 25.216(c) | 1.559 to 1.605 GHz | -70 dBW (-40 dBm) |
| 25.216(f) | 1.605 to 1.610 GHz | -70 dBW to -10 dBW (linear interpolation) |

The sloping limits from 1.605 to 1.610 GHz were interpolated and a minimum of four frequencies were selected to investigate.

## 4.3 Test Results

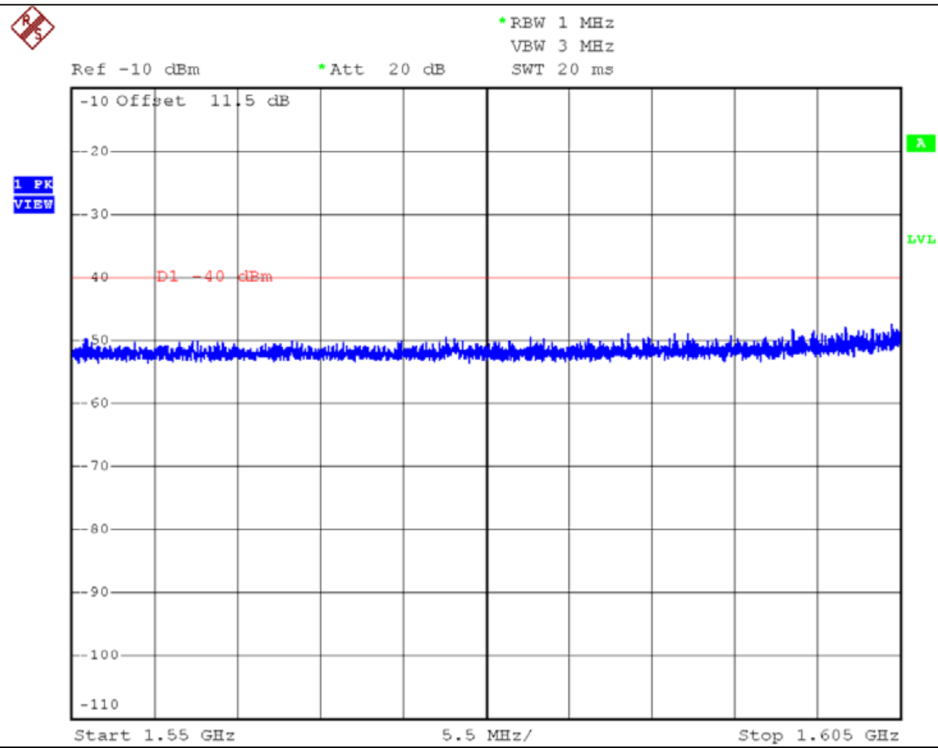
For the downlink amplifier, it was found that no signals could be seen and instead the noise floor levels were recorded.

### 4.3.1 Uplink

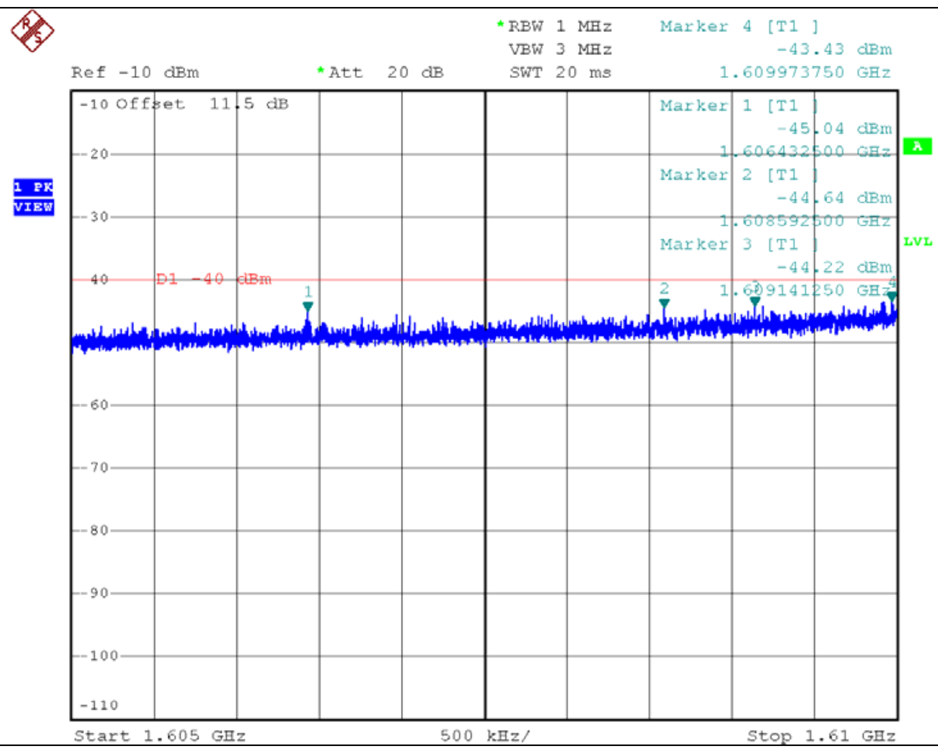
In this test measurement factors were directly added to the spectrum analyzer amplitude offset. This includes external attenuation and cable loss. The results can be seen directly on the plots below with highest points selected for the table below.

| Frequency (GHz) | Measured Level (dBm) | Antenna Gain*** Added (dBm) | Clause Limit (dBW/MHz) | Restated Limit (dBm) | Margin (dB) |
|---|---|---|---|---|---|
| 1.60000* | -48.00* | -43.60 | -70.00 | -40.00 | -3.60 |
| 1.60643 | -45.02 | -40.62 | -52.84** | -22.84** | -17.8 |
| 1.60859 | -44.65 | -40.25 | -26.92** | 3.08** | -43.3 |
| 1.60914 | -44.22 | -39.82 | -20.32** | 9.68** | -49.5 |
| 1.60997 | -43.43 | -39.03 | -10.36** | 19.64** | -58.7 |

*Visually taken from plot as highest signal over the whole plot.
** Calculated limit from interpolation of 25.216(f) limits.
*** Antenna gain 4.4 dBi.




Uplink - Conducted Antenna Port – Spurious Emission Low Edge – 1.55 GHz to 1.605 GHz




Uplink - Conducted Antenna Port – Spurious Emission Low Edge – 1.605 GHz to 1.610 GHz

Note that the -40 dBm (-70 dBW) limit line appears above but is only relevant at the lowest edge of the plot as the limit slopes upward with increasing frequency.

### 4.3.2 Downlink

In this test factors were added to uncorrected spectrum analyzer measurements using a spreadsheet. The power levels were low such that external attenuation was not required.

***Professional Testing (EMI), Inc.***

Conducted RF Port Measurements: DOWNLINK

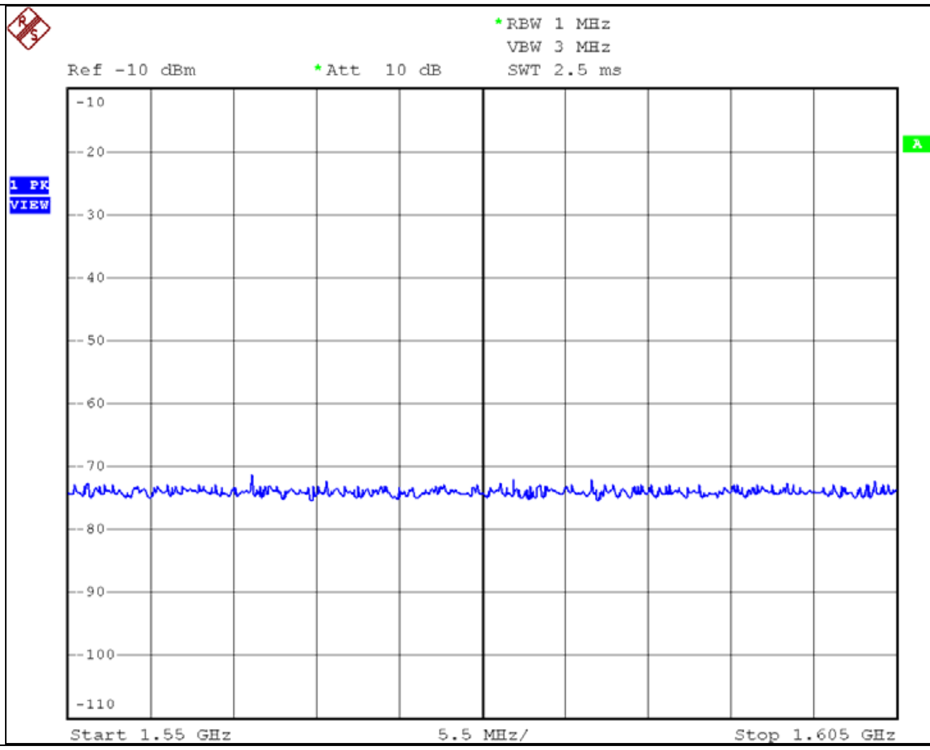
| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Client: | Universal Repeater | | Preamp: | 2 | | | | |
| Test Date: | March 4, 2013 | | EUT: | Downlink Amplifier | | | | |
| Voltage: | 110 VAC 60 Hz | | Serial #: | 0 | | | | |
| Frequency: | n/a | | Project #: | 14426 | | | | |
| Technician: | Eric Lifsey | | Test Type: | 25.216(c)(f) | | Class: | N/A | |

*Corrected Level = Recorded Level - Amplifier Gain + Antenna Factor + Cable Loss*

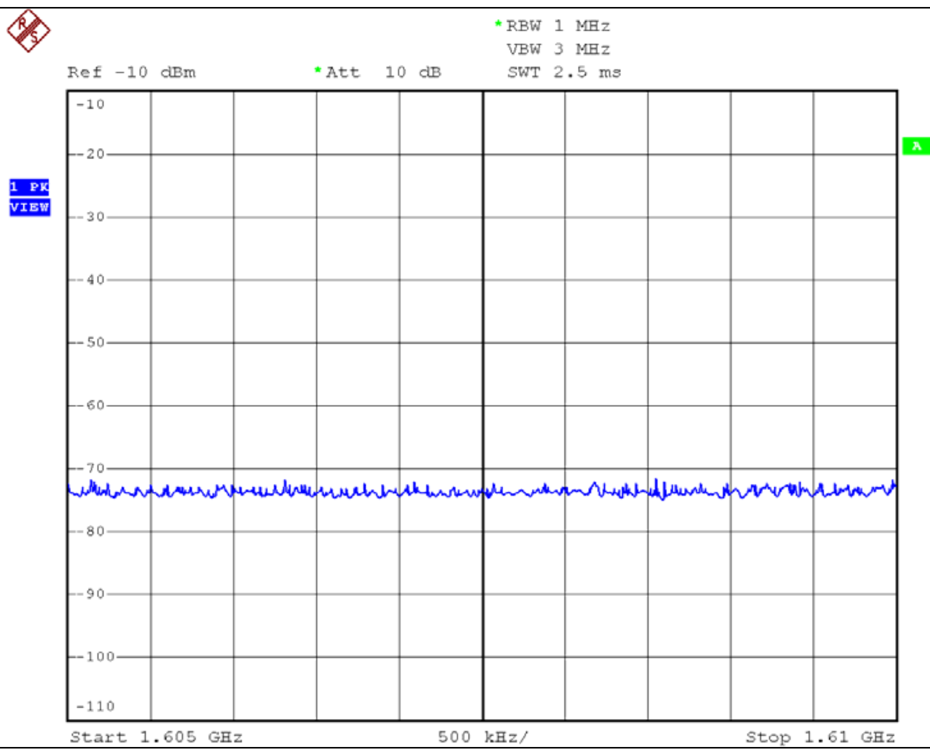
| Frequency (GHz) | FCC Section | Recorded Level (dBm) | Attenuator Loss (dB) | Cable Loss (dB) | Corrected Level dBm | Limit (dBm) | Margin (dB) | Detector Function |
|---|---|---|---|---|---|---|---|---|
| 1.605 | 25.216(f) | -71 | 0.0 | 1.52 | -69.5 | -40 | -29.5 | peak |
| 1.606 | 25.216(f) | -71 | 0.0 | 1.52 | -69.5 | -28 | -41.5 | peak |
| 1.607 | 25.216(f) | -71 | 0.0 | 1.53 | -69.5 | -16 | -53.5 | peak |
| 1.608 | 25.216(f) | -71 | 0.0 | 1.53 | -69.5 | -4 | -65.5 | peak |
| 1.609 | 25.216(f) | -71 | 0.0 | 1.53 | -69.5 | 8 | -77.5 | peak |
| 1.610 | 25.216(f) | -71 | 0.0 | 1.53 | -69.5 | 20 | -89.5 | peak |

No signals were present so noise floor levels were recorded above.

The measurements shown in the table above does not include the antenna gain of 4.4 dBi. Since the worse-case margin would be -25.1 dB with antenna gain added, the exercise of adding antenna gain to the measurements is omitted.




Downlink - Conducted Antenna Port – Spurious Emission Low Edge – 1.55 GHz to 1.605 GHz




Downlink - Conducted Antenna Port – Spurious Emission Low Edge – 1.605 GHz to 1.610 GHz

# 5.0 Spurious Emissions at Antenna Terminals

Measurements of spurious emissions at antenna terminals were taken on the EUT to determine the compliance as follows.

## 5.1 Test Procedure

The test configuration for one section is diagrammed in Figure 5.1.1. The Source signal for the EUT was supplied by an Iridium simulator card. The simulator card was controlled by a laptop PC which allowed channel selection. Attenuation of the Source signal was required to emulate the path loss of an actual application and drive the amplifier to full output. Output attenuation was provided to protect the Spectrum Analyzer from excessive power.

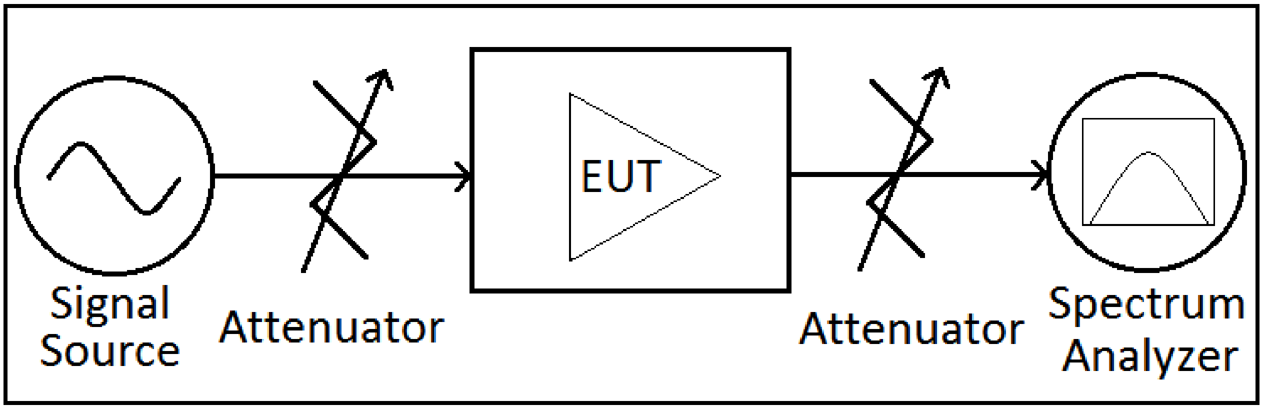



**Figure 5.1.1: Spurious Emissions at Antenna Terminals Test Setup**

## 5.2 Test Criteria

| Guideline | Section Number | Required? | Result |
|---|---|---|---|
| Conducted Spurious/Harmonic Emissions at Antenna Terminals | 25.202(f)(3), 2.1051 | Yes | Pass |

Per 25.202(f)(3) applicable clause, emissions in any 4 kHz band, outside 250% of the authorized bandwidth, are to be attenuated by 43 + 10 log (Power) in dB. Attenuation is determined below:

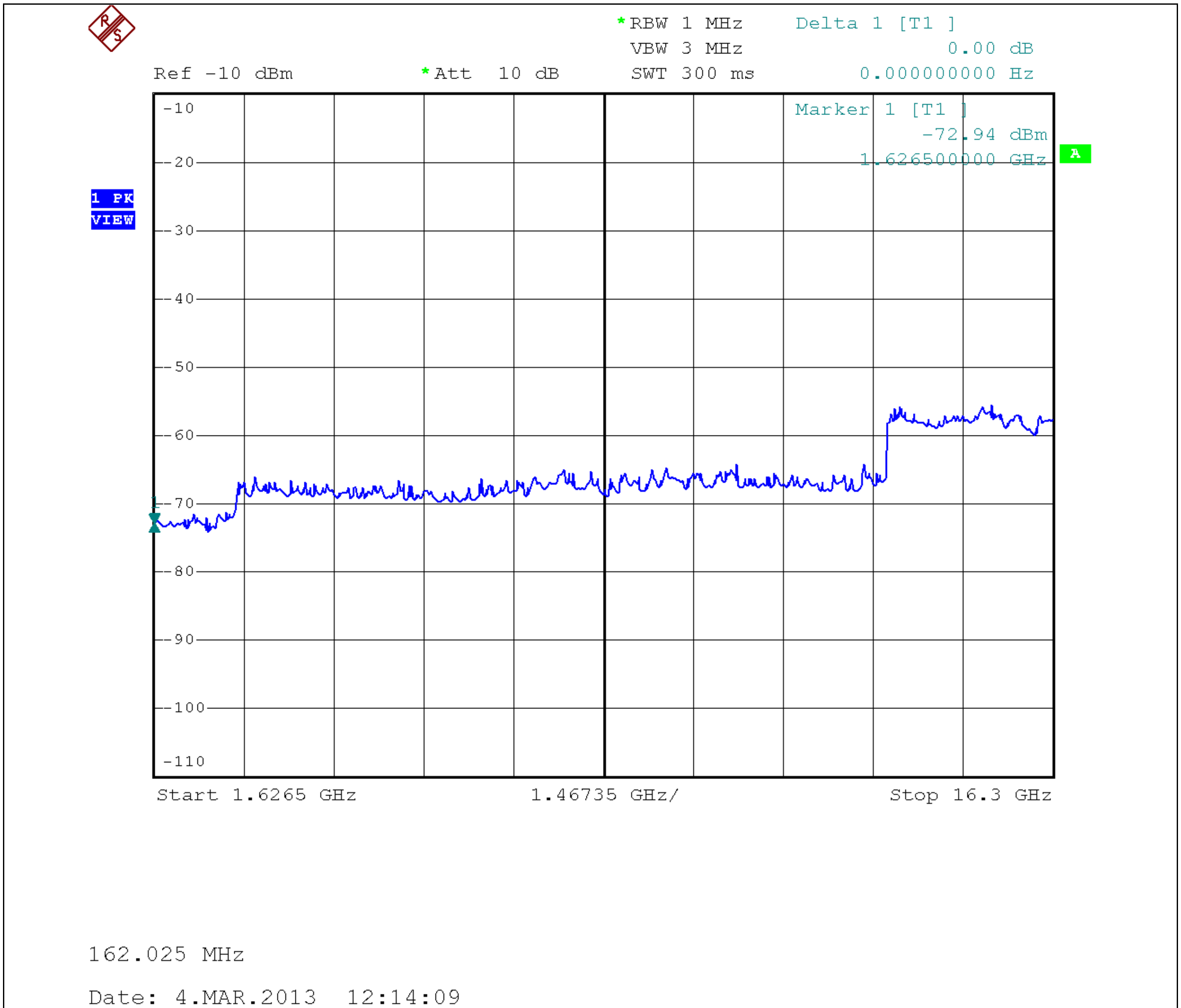
| EUT Section | Measured Power (dBm) | Correction Factors Attn(dB)+Cable(dB) | Corrected Power (dBm) | Power In Linear Terms | 25.202(f)(3) Attenuation (dB) | Limit Per 25.202(f)(3) (dBm) |
|---|---|---|---|---|---|---|
| Uplink | -12.00 | 40.35 + 1.54 = 41.89 | 29.89 | 975 mW | 42.9 | -13 |
| Downlink | -16.28 | 0 + 1.54 = 1.54 | -14.74 | 33.6 mW | 28.26 | -43 |

Note that per 25.216(f), protection of aeronautical radio navigation, specifies the limit of -70dBW also applies which converts to -40 dBm and is applied to the frequency range of 1605 to 1610 MHz.

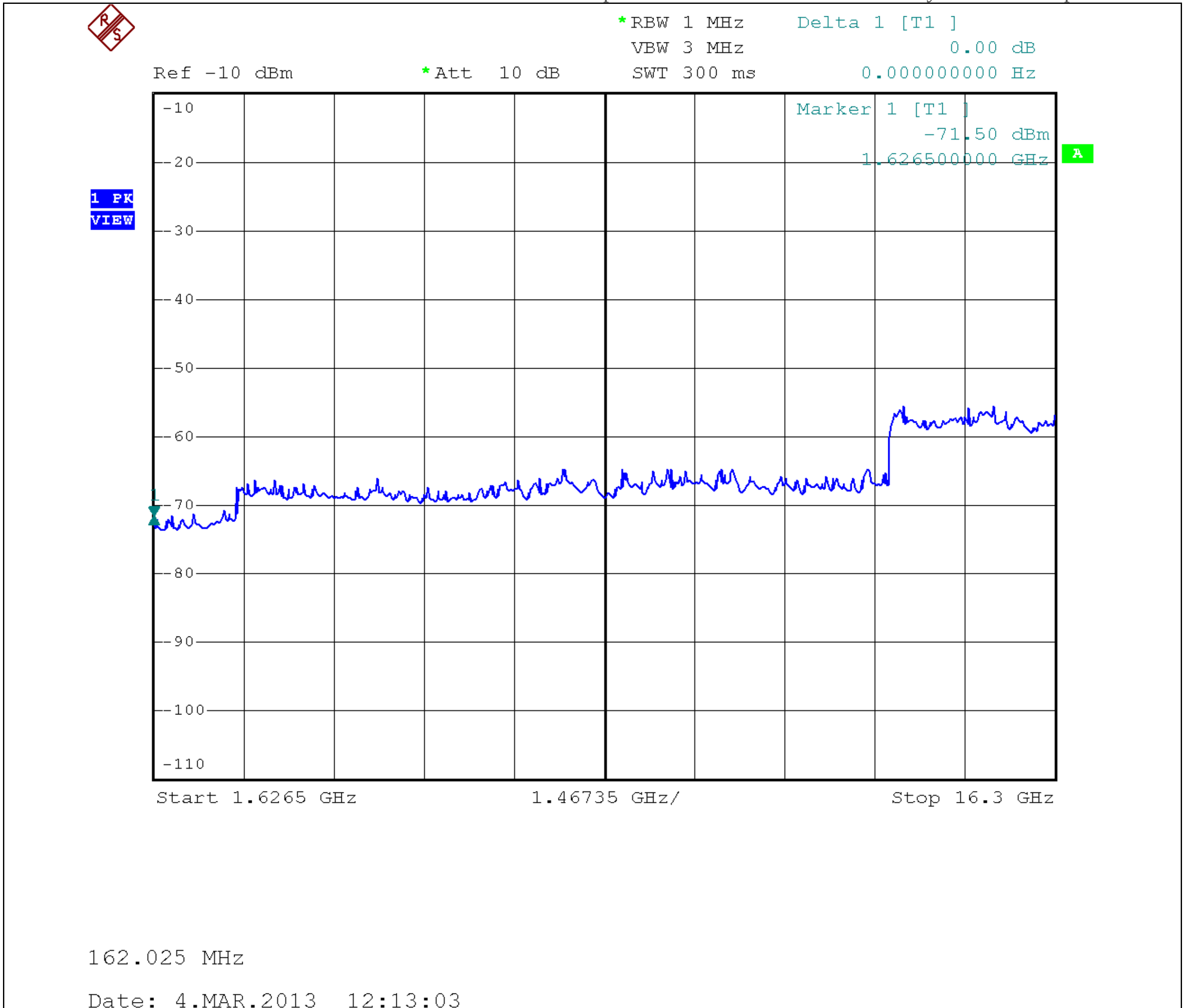
## 5.3 Test Results

EUT was found to be in compliance with applicable requirements.

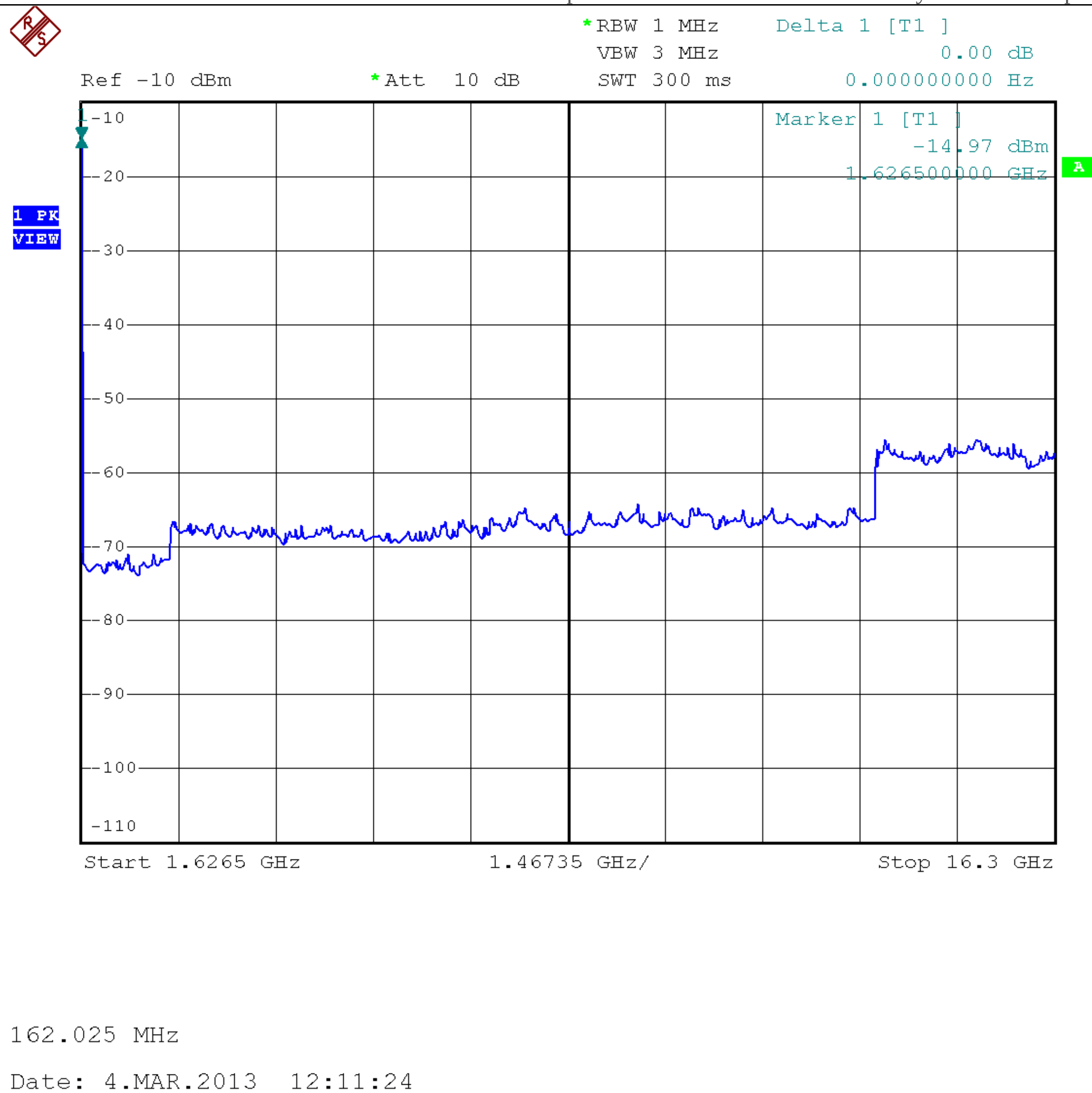
### 5.3.1 Uplink




Uplink - Conducted Antenna Port - Low Channel Spurious and Harmonics

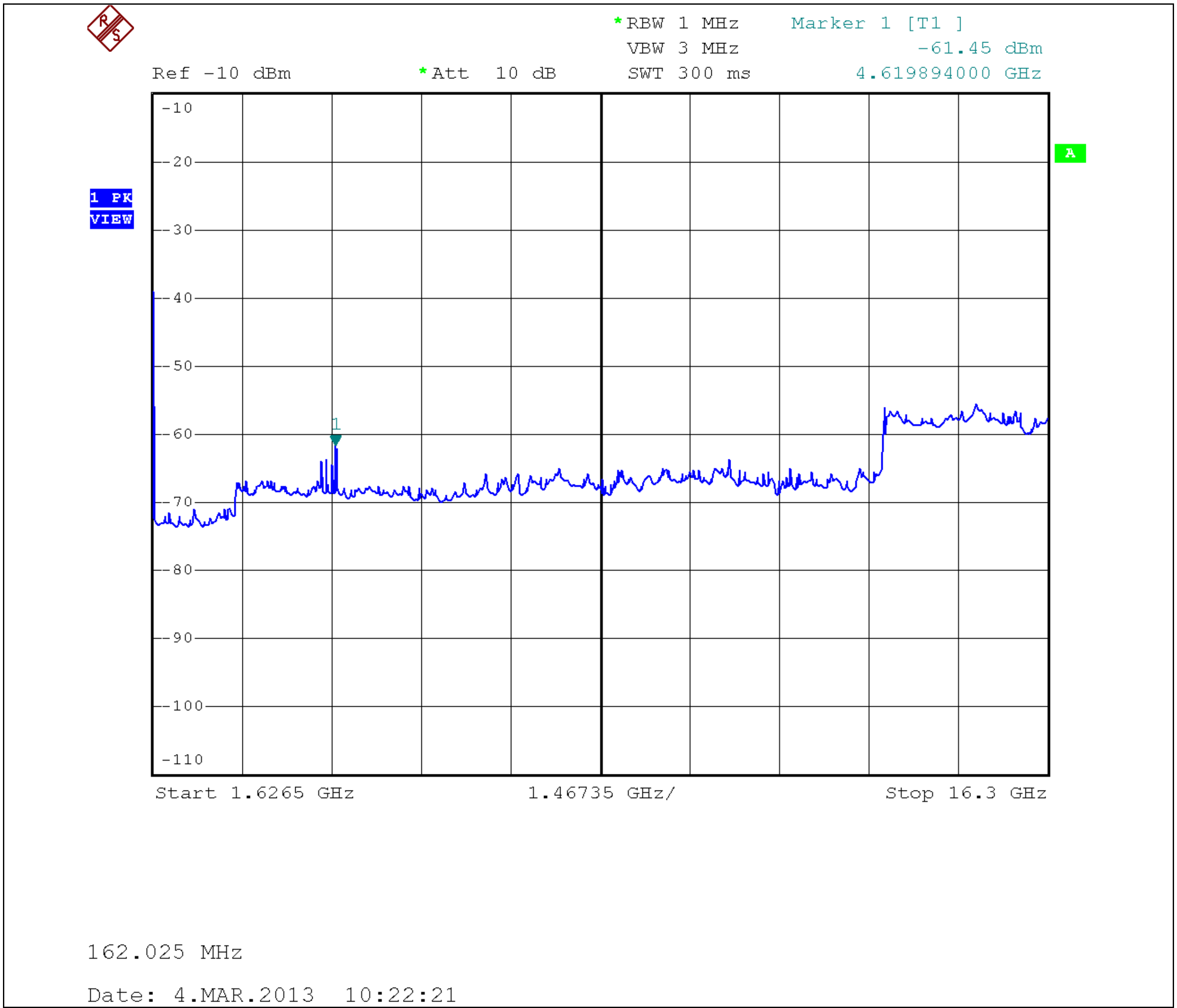



Uplink - Conducted Antenna Port - Center Channel Spurious and Harmonics

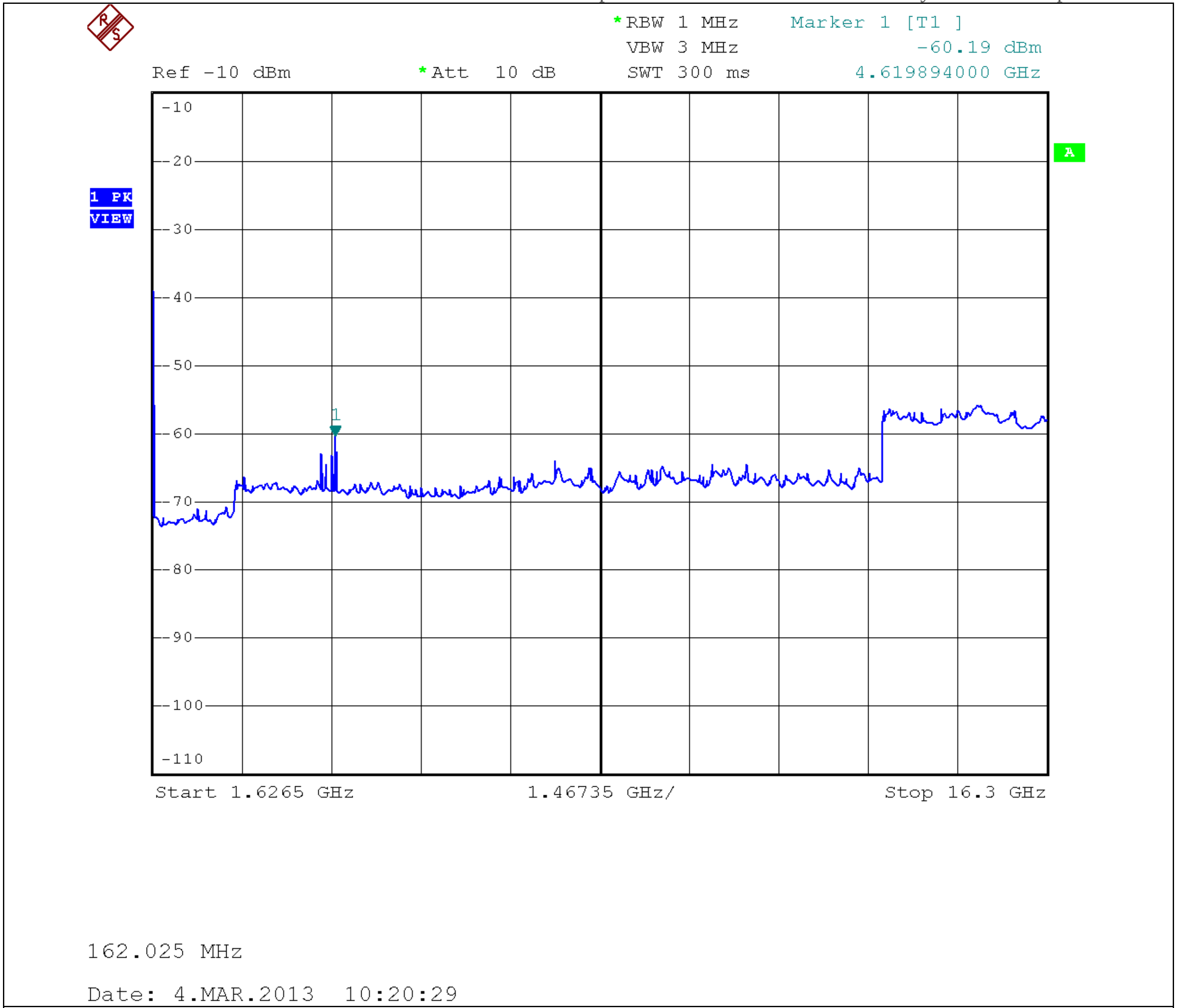



Uplink - Conducted Antenna Port - High Channel Spurious and Harmonics

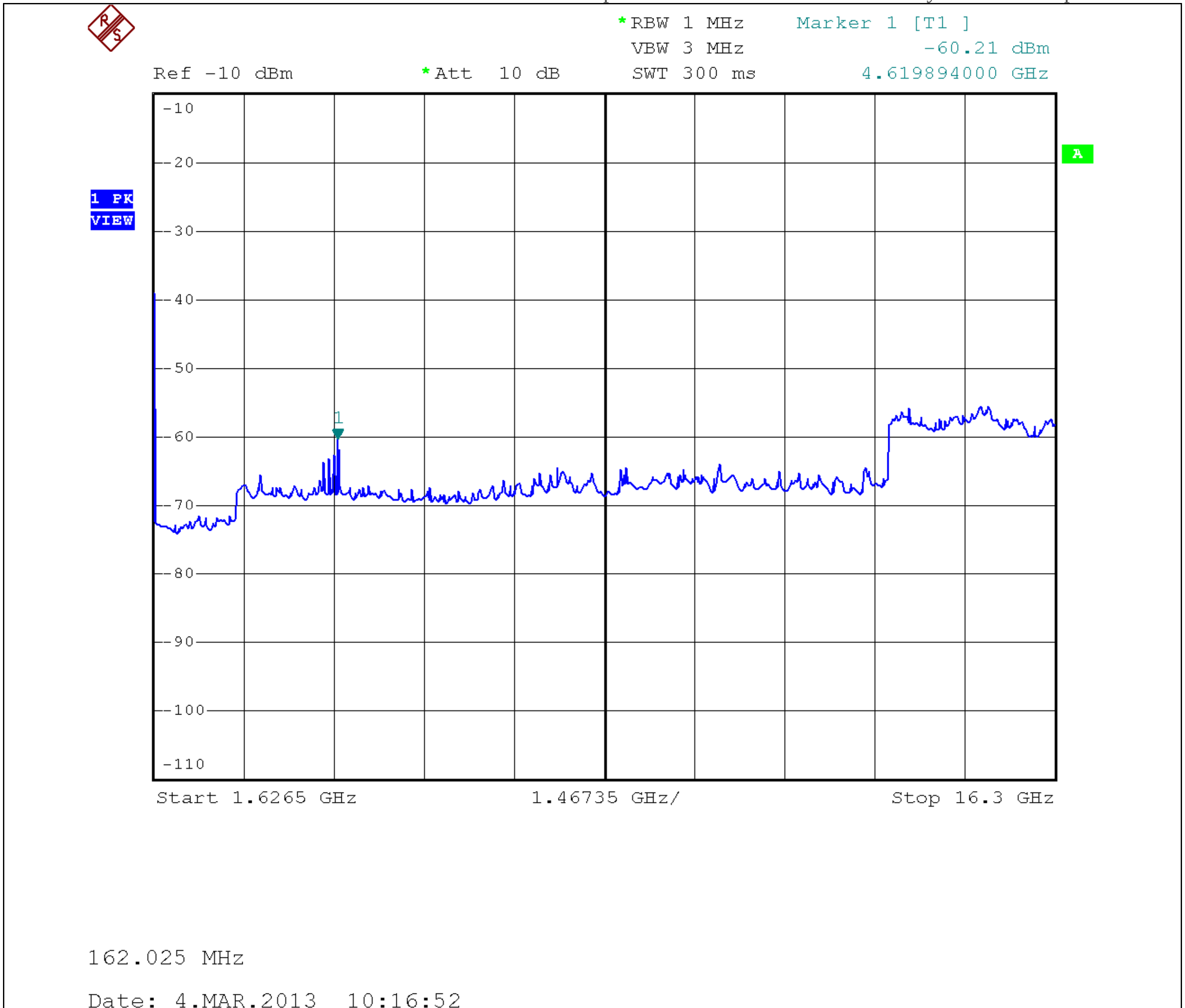
### 5.3.2 Downlink




Downlink - Conducted Antenna Port - High Channel Spurious and Harmonics




Downlink - Conducted Antenna Port - Low Channel Spurious and Harmonics




Downlink - Conducted Antenna Port - Center Channel Spurious and Harmonics

# 6.0 Field Strength of Spurious Emissions

Out of band spurious/harmonic emissions measurements were performed on the EUT to determine compliance to 47 CFR, Part 25.

## 6.1 Test Procedure

The EUT was placed on a non-conductive table 0.8 meters above the ground plane. The table was centered on a rotating turntable at a distance of 3 meters from the measurement antenna.

The EUT transmit ports are terminated in a non-radiating fashion as this test is to measure radio frequency emissions radiated from the enclosure. The source signal was supplied by a signal generator located in the sub-chamber room below the turntable.

Spurious/harmonic emissions above 1 GHz peak were measured with average and peak detection with a resolution bandwidth of 1 MHz and measured at a distance of 3 meters. A diagram showing the test setup is given as Figure 7.1.1.

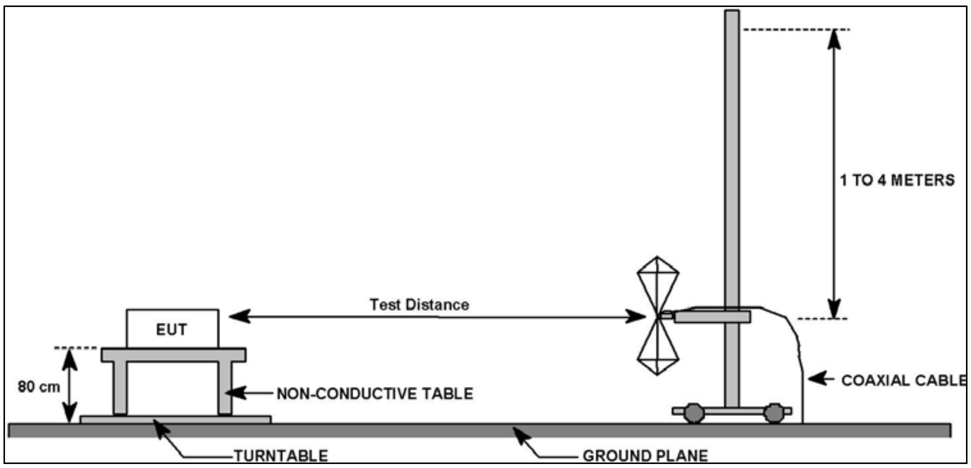



**Figure 7.1.1: Field Strength of Spurious Emissions Test Setup**

## 6.2 Test Criteria

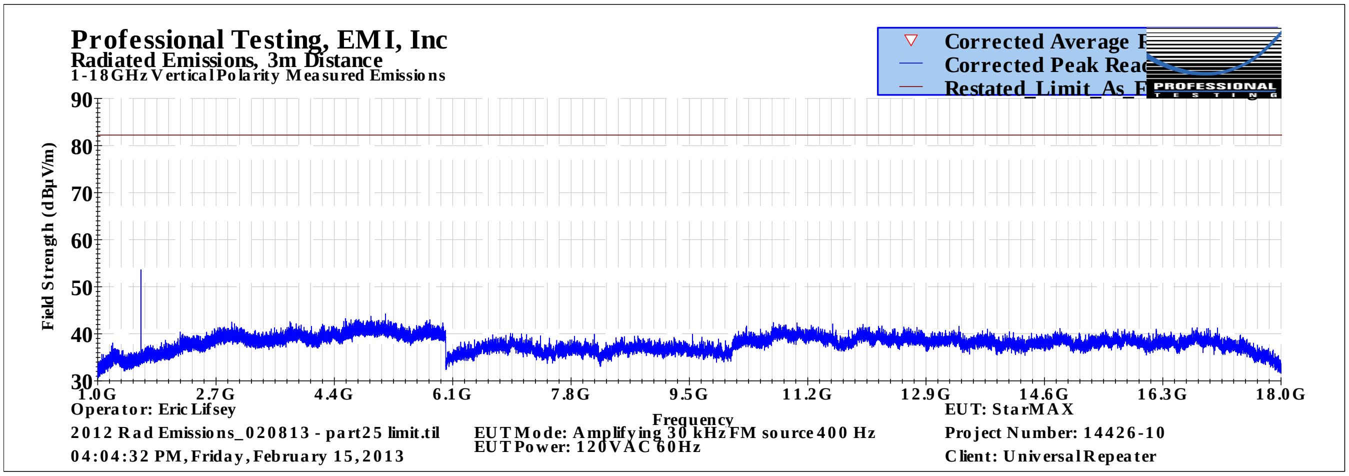
| Clause Subject | Section Number | Required? | Result |
|---|---|---|---|
| Field Strength of Radiated Spurious/Harmonic Emissions (1 GHz to 17 GHz) | 25.202(f), 2.1053 | Yes | Pass |

| Conducted Port Emission Limit dBm | Limit Restated as Field Strength At 3 meters dBμV/m |
|---|---|
| -13.0 | 82.2 |

## 6.3 Test Results

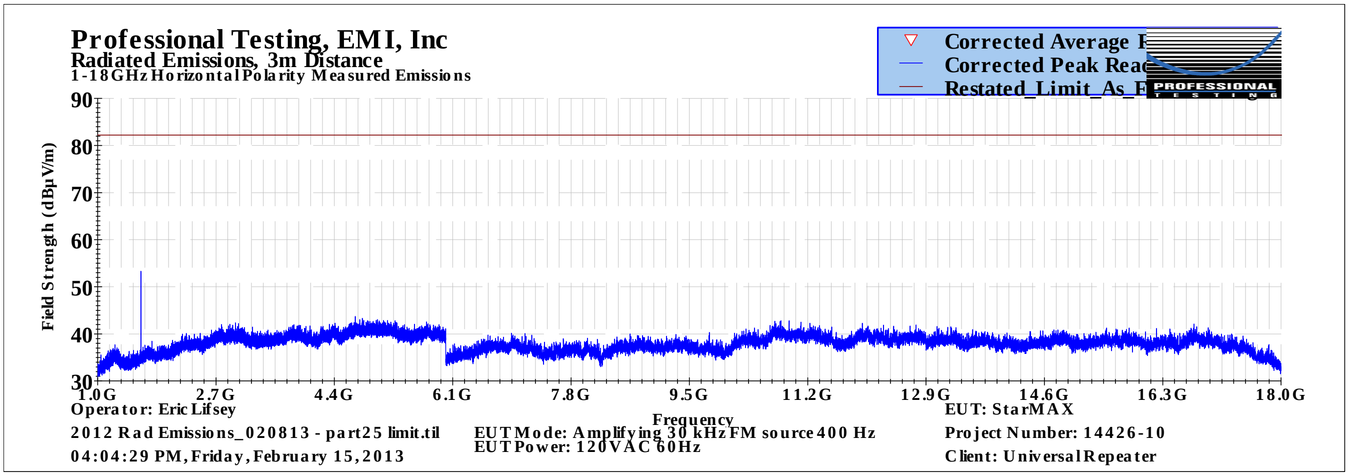
Emissions were measured and compared to the limit stated as field strength. No emissions were found within 20 dB of the limit; as such antenna substitution measurements were not necessary.

**Table 7.3.1: Field Strength of Spurious Emissions, 1 to 18 GHz, Vertical Polarity**




No signals detected other than in-band intentional signal.

**Table 7.3.2: Field Strength of Spurious Emissions, 1 to 18 GHz, Horizontal Polarity**




No signals detected other than in-band intentional signal.

# 7.0 Mains Conducted Emissions

Measurements of mains conducted emissions were taken on the EUT to determine the compliance to CFR 47, Part 15.

## 7.1 Test Procedure

The EUT was placed on a non-conductive table 0.8 meters above the floor and 0.4 meters from the conductive reference plane (wall). The EUT is powered through a line impedance stabilization network (LISN) that provides a measurement tap and a termination approximating 50 Ohms in the measurement range of 150 kHz to 30 MHz. A spectrum analyzer is connected, in turn, to each mains line measurement tap and software is employed to measure the radio frequency noise generated by the EUT.

The EUT transmit ports are terminated in a non-radiating fashion as this test is to measure radio frequency emissions conducted on the mains.

## 7.2 Test Criteria

| Clause Subject | Section Number | Required? | Result |
|---|---|---|---|
| Mains Conducted Emissions, Class A | 15.107 | Yes | Pass |

## 7.3 Test Results

## Table 8.3.1: Mains Conducted Emissions, Neutral Line

| Professional Testing, EMI, Inc. | | | |
|---|---|---|---|
| Test Method: | ANSI C63.4–2009: Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz (incorporated by reference, see §15.38). | | |
| In accordance with: | FCC Part 15.107 - Code of Federal Regulations Part 47, Subpart B - Unintentional Radiators, Conducted Emissions Limits | | |
| Section: | 15.107 | | |
| Test Date(s): | 2/15/2013 | EUT Serial #: | none |
| Customer: | Universal Repeater | EUT Part #: | none |
| Project Number: | 14426-10 | Test Technician: | Eric Lifsey |
| Purchase Order #: | 0 | Supervisor: | Rob McCollough |
| Equip. Under Test: | SatMAX | Witness' Name: | Charlie Thompson |

| Conducted Emissions Test Results Data Sheet - Neutral Lead | | | | | | | Page: | 1 of | 2 |
|---|---|---|---|---|---|---|---|---|---|
| EUT Line Voltage: | | | 120 | VAC | EUT Line Frequency: | | | 60 | Hz |
| Frequency Measured (MHz) | Peak Detector Reading (dBµV) | Quasi-peak Detector Reading (dBµV) | Quasi-peak Detector Limit (dBµV) | Quasi-peak Detector Margin (dB) | Quasi-peak Detector Test Results | Average Detector Reading (dBµV) | Average Detector Limit (dBµV) | Average Detector Margin (dB) | Average Detector Test Results |
| 0.45569 | 52.2 | 49 | 56.8 | -7.8 | PASS | 31.5 | 46.8 | -15.3 | PASS |
| 0.4574 | 52.4 | 49.3 | 56.7 | -7.4 | PASS | 31.6 | 46.7 | -15.2 | PASS |
| 0.45858 | 52.2 | 49.3 | 56.7 | -7.4 | PASS | 31.9 | 46.7 | -14.8 | PASS |
| 0.50016 | 43.7 | 34.9 | 56 | -21.1 | PASS | 11.7 | 46 | -34.3 | PASS |
| 0.5697 | 43.5 | 36.9 | 56 | -19.1 | PASS | 20.5 | 46 | -25.5 | PASS |
| 0.6812 | 34.3 | 30.1 | 56 | -25.9 | PASS | 11.1 | 46 | -34.9 | PASS |
| 7.4158 | 41.1 | 39.5 | 60 | -20.5 | PASS | 37.9 | 50 | -12.1 | PASS |
| 7.575 | 42.8 | 40.7 | 60 | -19.3 | PASS | 39.5 | 50 | -10.5 | PASS |
| 8.045 | 41.7 | 39.5 | 60 | -20.5 | PASS | 38.4 | 50 | -11.6 | PASS |
| 8.2026 | 41.8 | 40.1 | 60 | -19.9 | PASS | 39.1 | 50 | -10.9 | PASS |

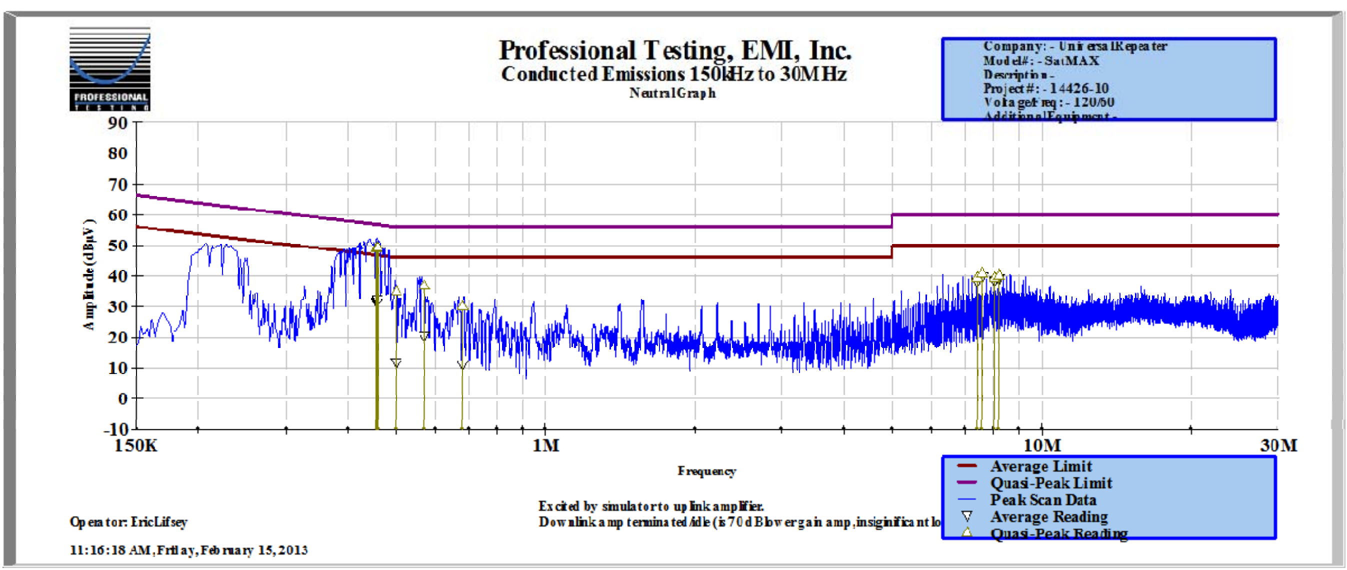
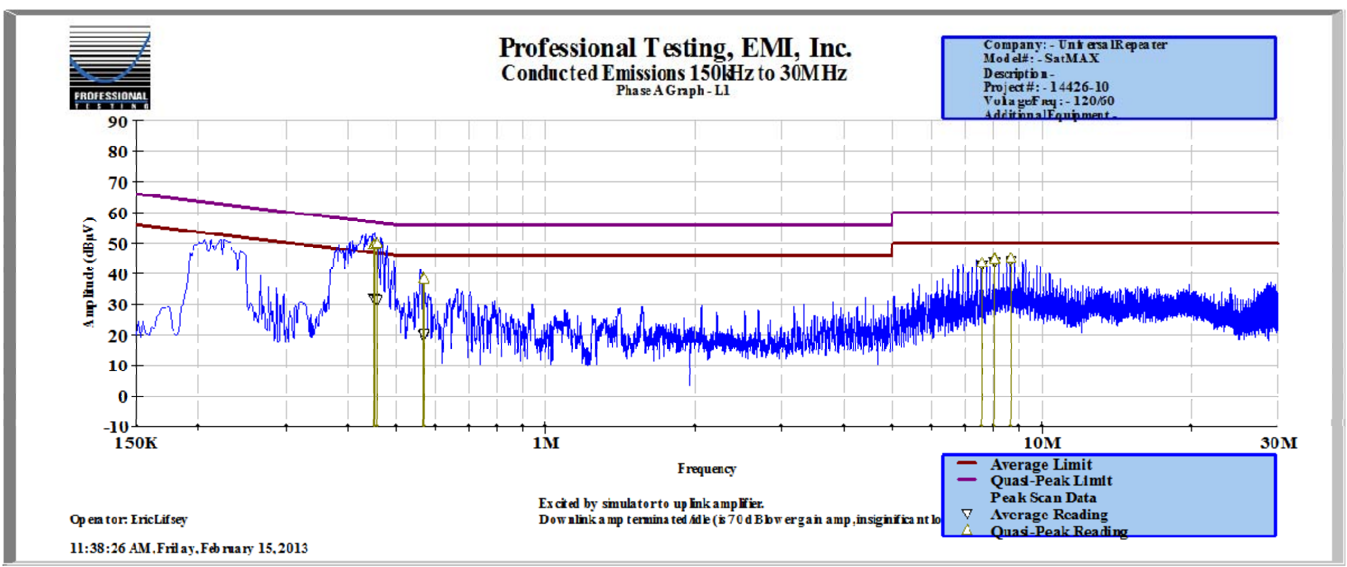


**Table 8.3.2: Mains Conducted Emissions, Phase Line**

| Professional Testing, EMI, Inc. | | | |
|---|---|---|---|
| Test Method: | ANSI C63.4–2009: Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz (incorporated by reference, see §15.38). | | |
| In accordance with: | FCC Part 15.107 - Code of Federal Regulations Part 47, Subpart B - Unintentional Radiators, Conducted Emissions Limits | | |
| Section: | 15.107 | | |
| Test Date(s): | 2/15/2013 | EUT Serial #: | none |
| Customer: | Universal Repeater | EUT Part #: | none |
| Project Number: | 14426-10 | Test Technician: | Eric Lifsey |
| Purchase Order #: | 0 | Supervisor: | Rob McCollough |
| Equip. Under Test: | SatMAX | Witness' Name: | Charlie Thompson |

| Conducted Emissions Test Results Data Sheet - Phase Lead (Line 1) | | | | | | | Page: | 2 | of 2 |
|---|---|---|---|---|---|---|---|---|---|
| EUT Line Voltage: | | | 120 | VAC | EUT Line Frequency: | | | 60 | Hz |
| Frequency Measured (MHz) | Peak Detector Reading (dBµV) | Quasi-peak Detector Reading (dBµV) | Quasi-peak Detector Limit (dBµV) | Quasi-peak Detector Margin (dB) | Quasi-peak Detector Test Results | Average Detector Reading (dBµV) | Average Detector Limit (dBµV) | Average Detector Margin (dB) | Average Detector Test Results |
| 0.45061 | 53.5 | 49.7 | 56.9 | -7.2 | PASS | 31.9 | 46.9 | -14.9 | PASS |
| 0.45175 | 53.4 | 49.5 | 56.8 | -7.4 | PASS | 31.7 | 46.8 | -15.2 | PASS |
| 0.45727 | 53.4 | 49.8 | 56.7 | -6.9 | PASS | 31.5 | 46.7 | -15.3 | PASS |
| 0.5678 | 44 | 38.6 | 56 | -17.4 | PASS | 20.3 | 46 | -25.7 | PASS |
| 0.5681 | 42.1 | 38.5 | 56 | -17.5 | PASS | 19.8 | 46 | -26.2 | PASS |
| 0.5696 | 42.1 | 38.4 | 56 | -17.6 | PASS | 20.4 | 46 | -25.6 | PASS |
| 7.5708 | 45 | 43.6 | 60 | -16.4 | PASS | 43 | 50 | -7 | PASS |
| 8.0438 | 45.8 | 45 | 60 | -15 | PASS | 43.9 | 50 | -6.1 | PASS |
| 8.044 | 45.1 | 44.6 | 60 | -15.4 | PASS | 43.9 | 50 | -6.1 | PASS |
| 8.674 | 46.2 | 45 | 60 | -15 | PASS | 44.4 | 50 | -5.6 | PASS |



# 8.0 Equipment Lists

## 8.1 Spurious Radiated Emissions

| | | | |
|---|---|---|---|
| **Test Date(s):** | **2/15/2013** | **EUT Serial #:** | **0** |
| **Customer:** | **Universal Repeater** | **EUT Part #:** | **0** |
| **Project Number:** | **14426-10** | **Test Technician:** | **Eric Lifsey** |
| **Purchase Order #:** | **0** | **Supervisor:** | **Rob McCollough** |
| **Equip. Under Test:** | **SatMAX** | **Witness' Name:** | **Charlie Thompson** |

| **Radiated Emissions Test Equipment List** | | | | | |
|---|---|---|---|---|---|
| **Tile! Software Version:** | | **4.2.A, May 23, 2010, 08:38:52 AM** | | | |
| **Test Profile:** | | **Radiated Emissions_Profile Version October 12, 2011** | | | |
| **Asset #** | **Manufacturer** | **Model** | **Equipment Nomenclature** | **Serial Number** | **Calibration Due Date** |
| 1509A | Narda | 3022 | Coupler, Bi-Directional 1-4GHz | 40063 | N/A |
| 1780 | ETS-Lindgren | 3117 | Antenna, Double Ridged Guide Horn, 1 - 18 GHz | 00110313 | 2/4/2014 |
| 1930 | Agilent | E4440A-239 | Spectrum Analyzer, 3 Hz - 26.5 GHz | MY45304903 | 6/19/2013 |
| 1325 | EMCO | 1050 | Controller, Antenna Mast | 9003-1461 | N/A |
| C027 | N/A | LMR-400 | Cable Coax, N-N, 0.6m | none | 11/1/2013 |
| 1327 | EMCO | 1050 | Controller, Antenna Mast | none | N/A |
| 0942 | EMCO | 11968D | Turntable, 4ft. | 9510-1835 | N/A |
| 1969 | HP | 11713A | Attenuator/Switch Driver | 3748A04113 | N/A |
| 1509B | HP | 8491B-003 | Attenuator, N, 3dB | 21897 | N/A |
| 1594 | Miteq | AFS44-00102650 | Amplifier, 1-26.5GHz, 42dB | none | 10/15/2013 |
| 2004 | Miteq | AFS44-00101800-2S-10P-44 | Amplifier, 40dB, .1-18GHz | 0 | 11/26/2013 |
| C030 | N/A | LMR-400 | Cable Coax, N-N, 2.5m | none | N/A |

## 8.2 Mains Conducted Emissions

| Professional Testing, EMI, Inc. | | | |
|---|---|---|---|
| **Test Method:** | **ANSI C63.4–2009: Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz (incorporated by reference,** | | |
| **In accordance with:** | **FCC Part 15.107 - Code of Federal Regulations Part 47, Subpart B - Unintentional Radiators, Conducted Emissions Limits** | | |
| **Section:** | **15.107** | | |
| **Test Date(s):** | **2/15/2013** | **EUT Serial #:** | **none** |
| **Customer:** | **Universal Repeater** | **EUT Part #:** | **none** |
| **Project Number:** | **14426-10** | **Test Technician:** | **Eric Lifsey** |
| **Purchase Order #:** | **0** | **Supervisor:** | **Rob McCollough** |
| **Equip. Under Test:** | **SatMAX** | **Witness' Name:** | **Charlie Thompson** |

| Conducted Emissions Test Equipment List | | | | | |
|---|---|---|---|---|---|
| **Tile! Software Version:** | | **4.1.A.0, April 14, 2009, 11:01:00PM** | | | |
| **Test Profile:** | | **Profile#: CE_2010.til, dated December 16, 2010** | | | |
| **Asset #** | **Manufacturer** | **Model** | **Equipment Nomenclature** | **Serial Number** | **Calibration Due Date** |
| 991 | HP | 8568B | Spectrum Analyzer 100Hz-1.5GHz | 2633A00659 | 3/14/2013 |
| 992 | HP | 85662A | Spec Anal Dsply for AN0991 6dB | 2152A03784 | N/A |
| 0990 | HP | 85685A | RF Preselector | 3010A01119 | 7/3/2013 |
| 1281 | HP | 85650A | Quasi Peak Adapter (use with AN 1270) | HP | 3/27/2013 |
| 27 | EMCO | 3825/2 | LISN, 10kHz-100MHz | 9010-1708 | 9/17/2013 |
| 1173 | PTI | 100k HPF | Filter, High Pass, 100kHz | none | CBU |
| 1087 | PTI | PTI-ALF3 | Attenuator Limiter Filter | none | 5/6/2014 |
| C149 | PTI | None | Cable, RF, N-N, 30', Black | none | 9/4/2013 |
| C174 | none | none | Cable, RF, N-SMA, 16", Black | none | 9/4/2013 |
| C107 | N/A | 0 | Cable, N-N, 10m | none | 8/31/2013 |
| C108 | N/A | none | Cable, BNC, 3m | none | CBU |

## 8.3 Conducted Port Measurements

The following equipment was used to measure output power, bandwidth, and conducted spurious emissions.

| Conducted Port Measurements Equipment List | | | | | |
|---|---|---|---|---|---|
| **Asset #** | **Manufacturer** | **Model #** | **Description** | **Serial Number** | **Calibration Due** |
| 1342 | Rohde & Schwarz | FSP30 | Spectrum Analyzer | 100218 | January 29, 2014 |
| C247 | Pasternack | | Cable ~1.7m | | October 24, 2013 |
| C249 | Pasternack | | Cable ~0.5m | | February 6, 2014 |
| C250 | Pasternack | | Cable ~0.5m | | February 6, 2014 |
| 0856 | Narda | 702-60 | Step Attenuator, 60 dB, DC-12.4 GHz | 04105 | February 6, 2014 |

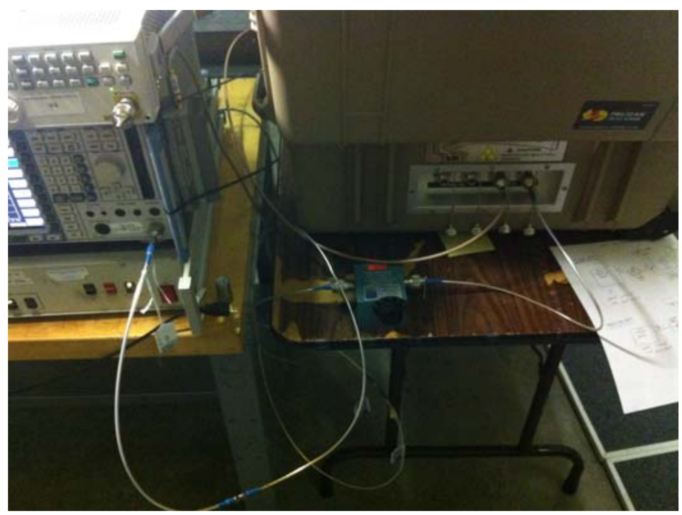
## 8.4 Support Equipment

The following equipment supplied and/or controlled the source signal used to drive the amplifiers to rated output power.

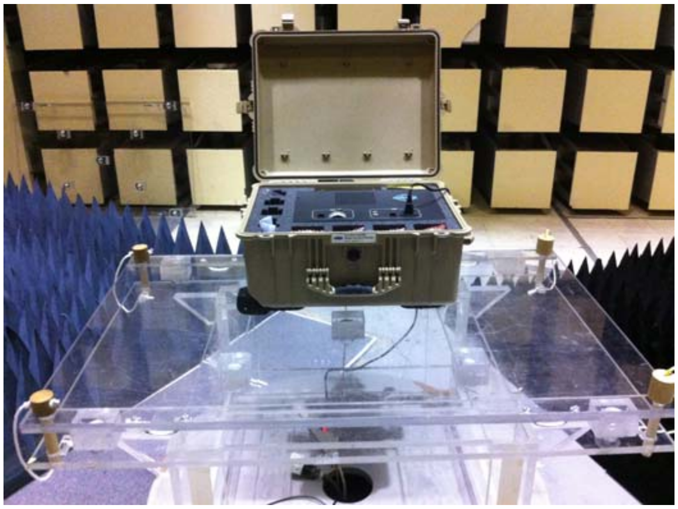
| Asset # | Description | Model | S/N | Calibration Due |
|---|---|---|---|---|
| Customer | Laptop | Dell unspecified | Unspecified | Not Required |
| Customer | 9253 USB Iridium Emulator Card & Software | Unspecified | Unspecified | Not Required |
| Customer | 100 dB Step Attenuator | Unspecified | Unspecified | Not Required |
| Customer | Cables, misc | None | None | Not Required |

## 8.5 Setup Photographs

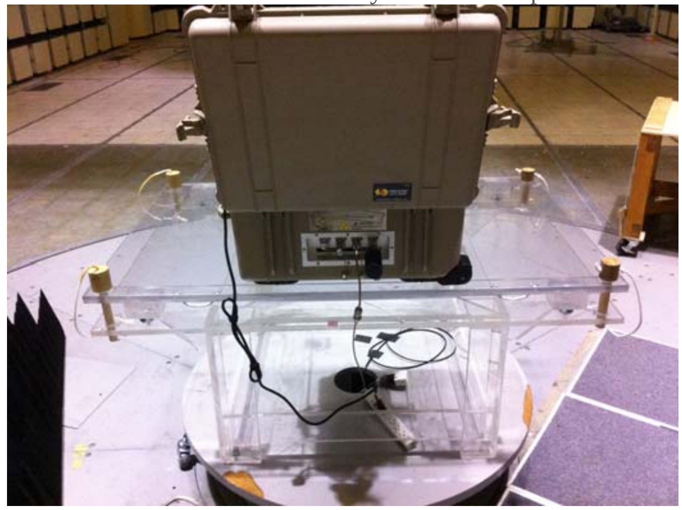
Conducted Output Tests (Power, BW, Spurious)



Conducted Output Tests (Power, BW, Spurious)

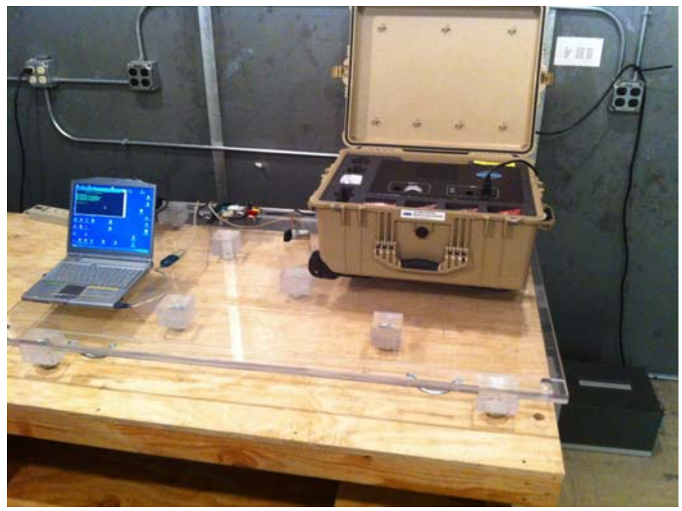


Radiated Spurious Tests

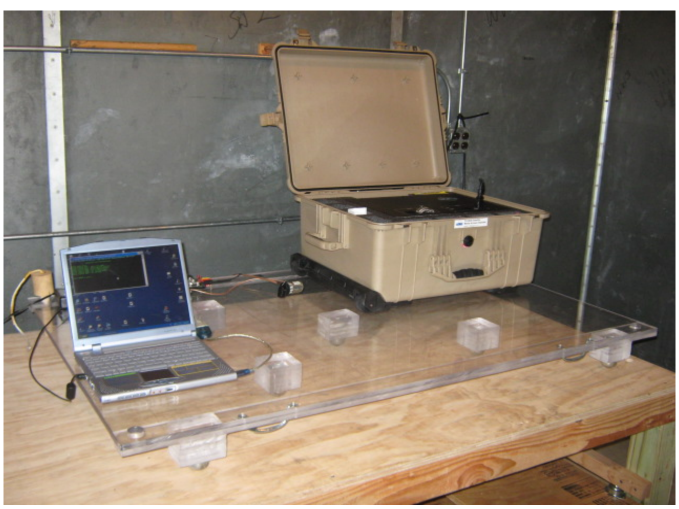


Radiated Spurious Tests

Signal Source for Radiated Spurious Tests



Mains Conducted Emission Test



Mains Conducted Emission Test

Mains Conducted Emission Test

# 9.0 Amplifier Overload

Performance of harmonic suppression was measured while subject to overload conditions.

## 9.1 Criteria

Limit is -13 dBm for conducted port emissions.

## 9.2 Procedure

For each amplifier section, and each of 3 standard channels, apply an unmodulated CW signal from a signal generator and increase the level in 1 dB steps to find the point where output power no longer increases by a corresponding 1 dB; record this level. Continue to apply 1 dB increases until the point where output power no longer changes, record this level as No Output Change (NOC) level.

Increase the signal generator by 10 dB above the NOC level. Record the conducted emissions in the harmonic range to 17 GHz for each of the 3 channels.

Measure the harmonic spectrum using 10 kHz resolution bandwidth for better detection of harmonics.

## 9.3 Results

The EUT suppresses output harmonics even when driven 10 dB beyond the point of no output change. See details below.

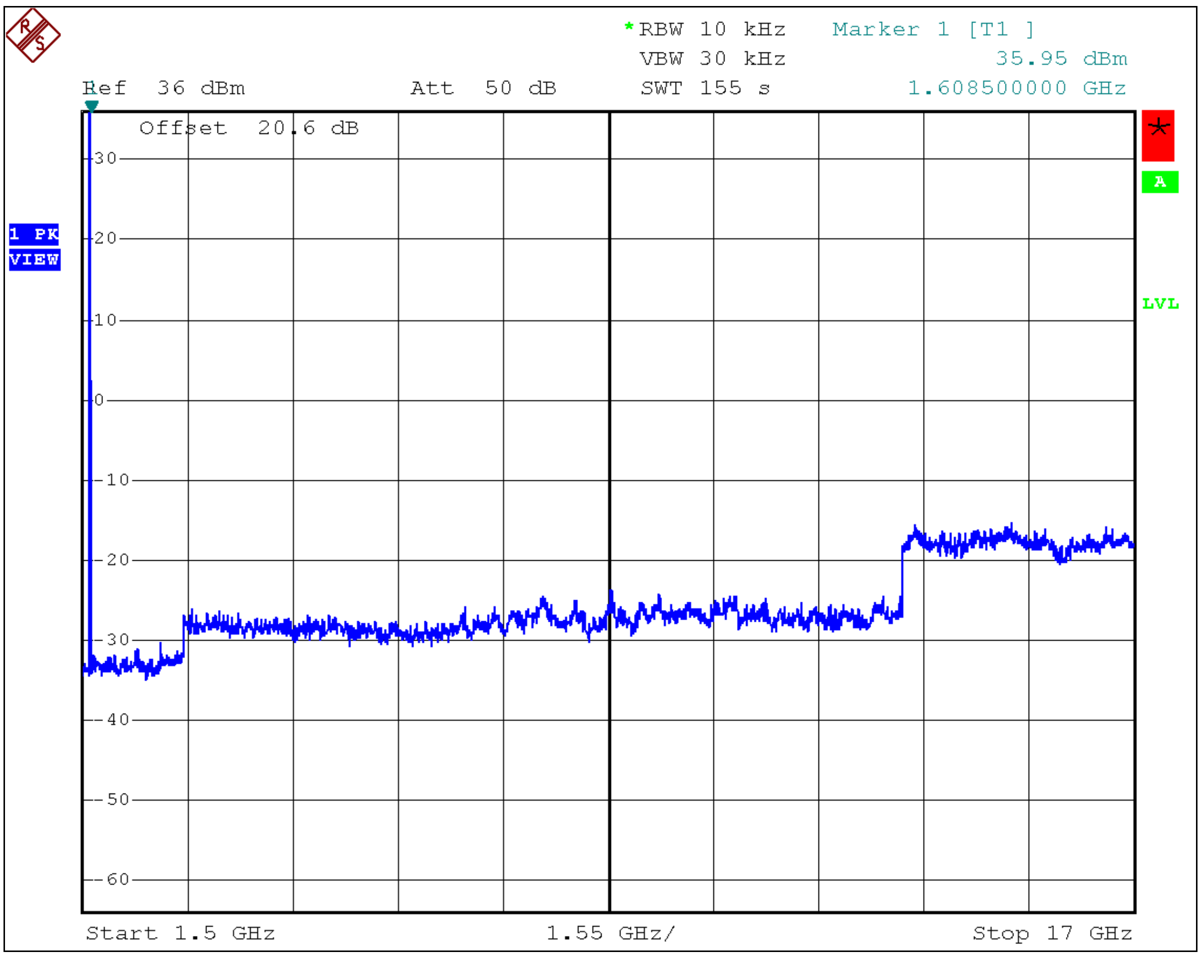
20 dB of external attenuation was employed. The losses were added as 20.6 dB to the spectrum analyzer displayed as an amplitude offset as can be confirmed in the upper left corner of the plot area. When a harmonic is measured, the additional losses are added numerically.

These measurements were performed from January 31, 2014 to February 5, 2014.

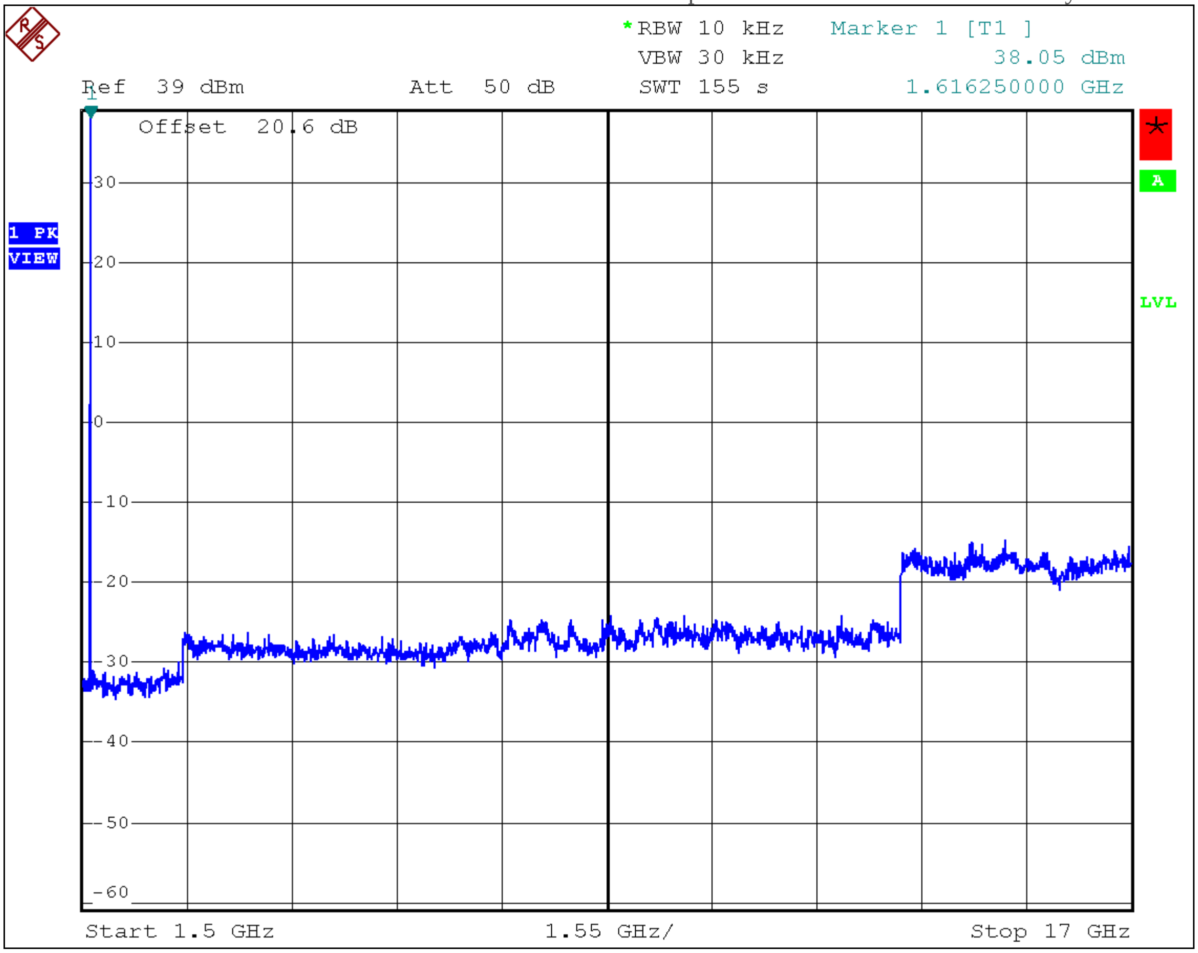
### 9.3.1 Uplink Amplifier

| Uplink Amplifier<br>Table of Input vs Output<br>At Gain Compression and Overload | | | | |
|---|---|---|---|---|
| Frequency<br>MHz | Input at Gain Compression Detected<br>dBm | Input at No Output Change Point<br>dBm | Power Output at No Output Change Point<br>dBm | Input for 10dB Overload Test Level<br>dBm |
| 1616.0 | -33 | -26 | 36.0 | -16 |
| 1621.0 | -34 | -27 | 38.4 | -17 |
| 1626.5 | -34 | -26 | 38.1 | -16 |

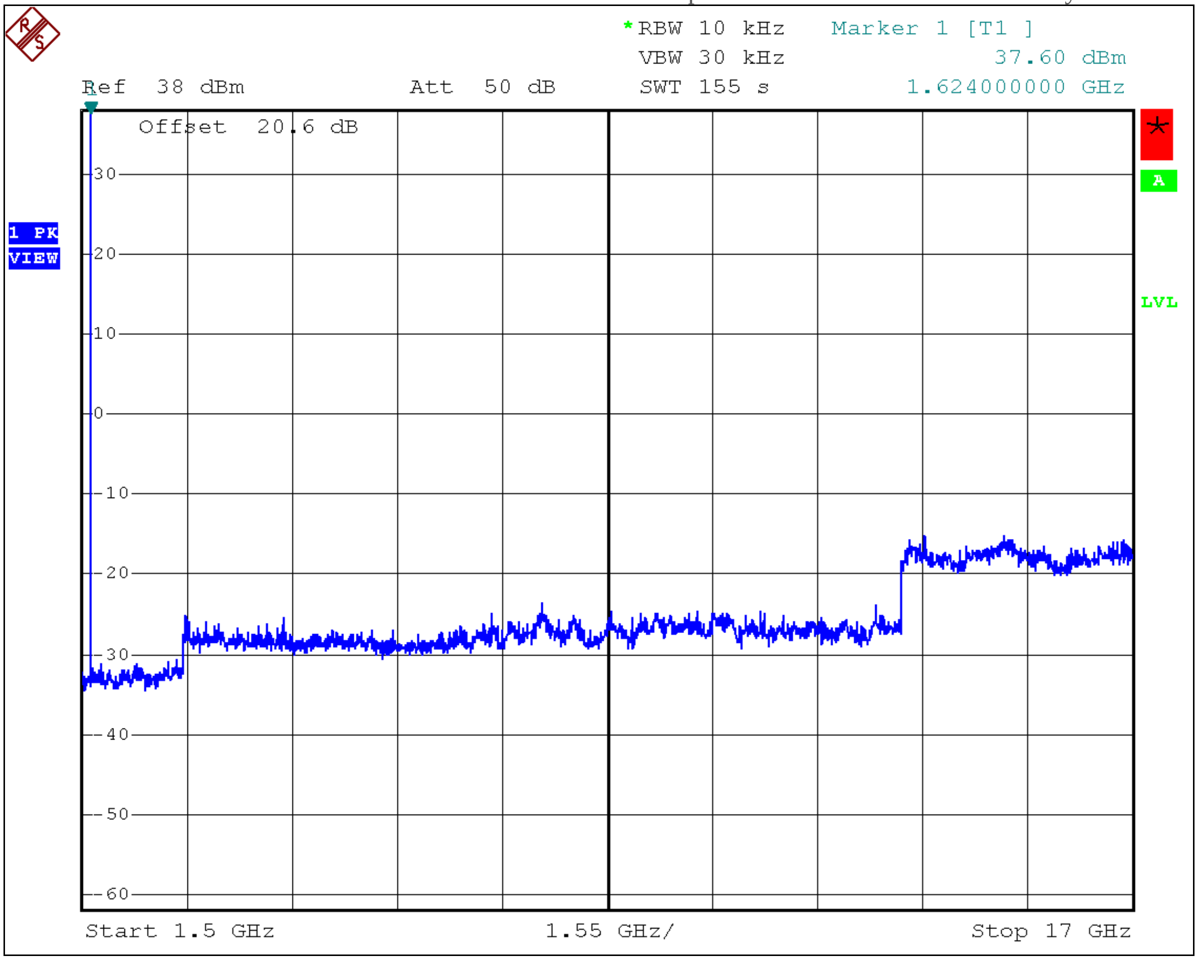
No harmonics were detected over the amplitude range of -50 to -60 dBc.



Low Channel (Fundamental visible on left.)




Middle Channel (Fundamental visible on left.)



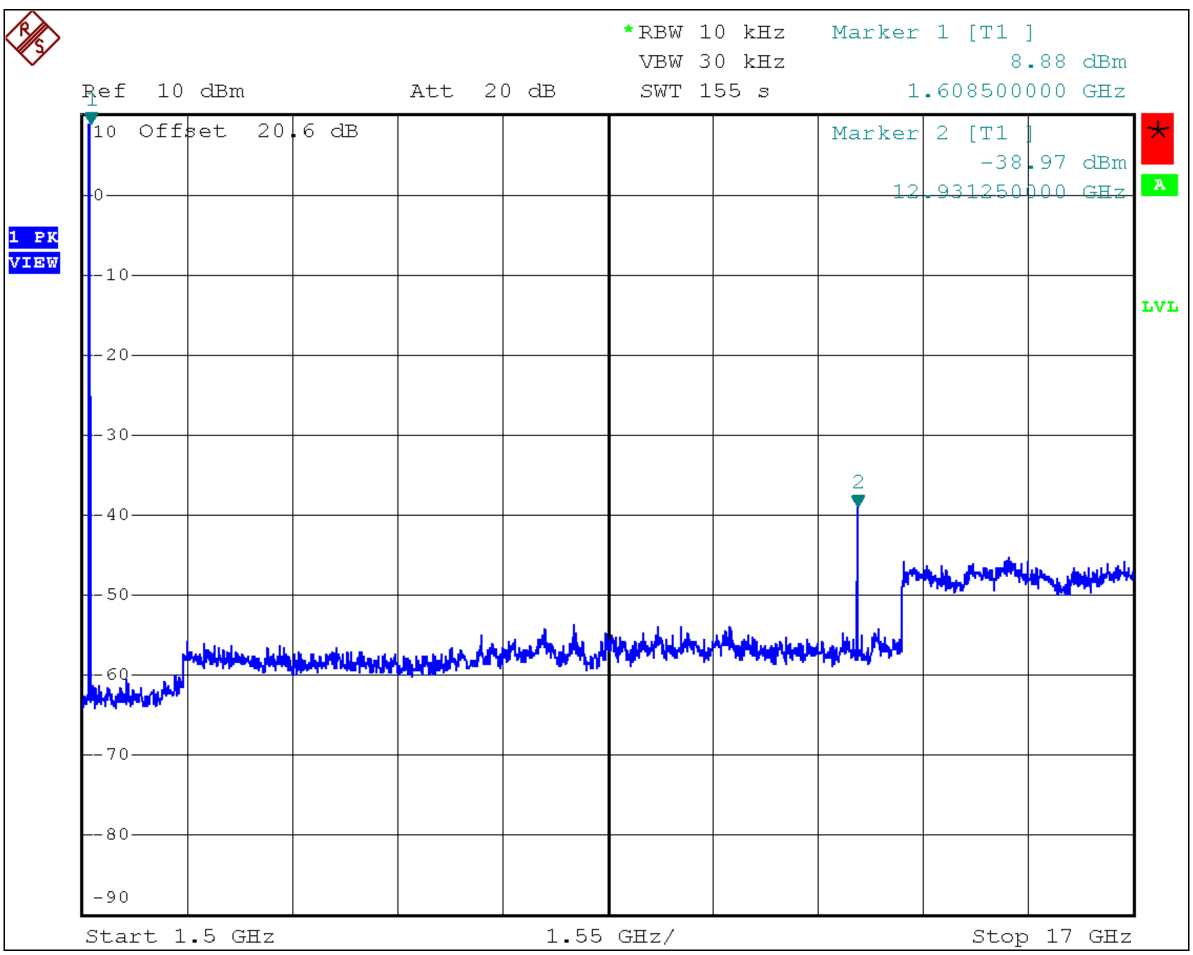

High Channel (Fundamental visible on left.)

### 9.3.2 Downlink Amplifier

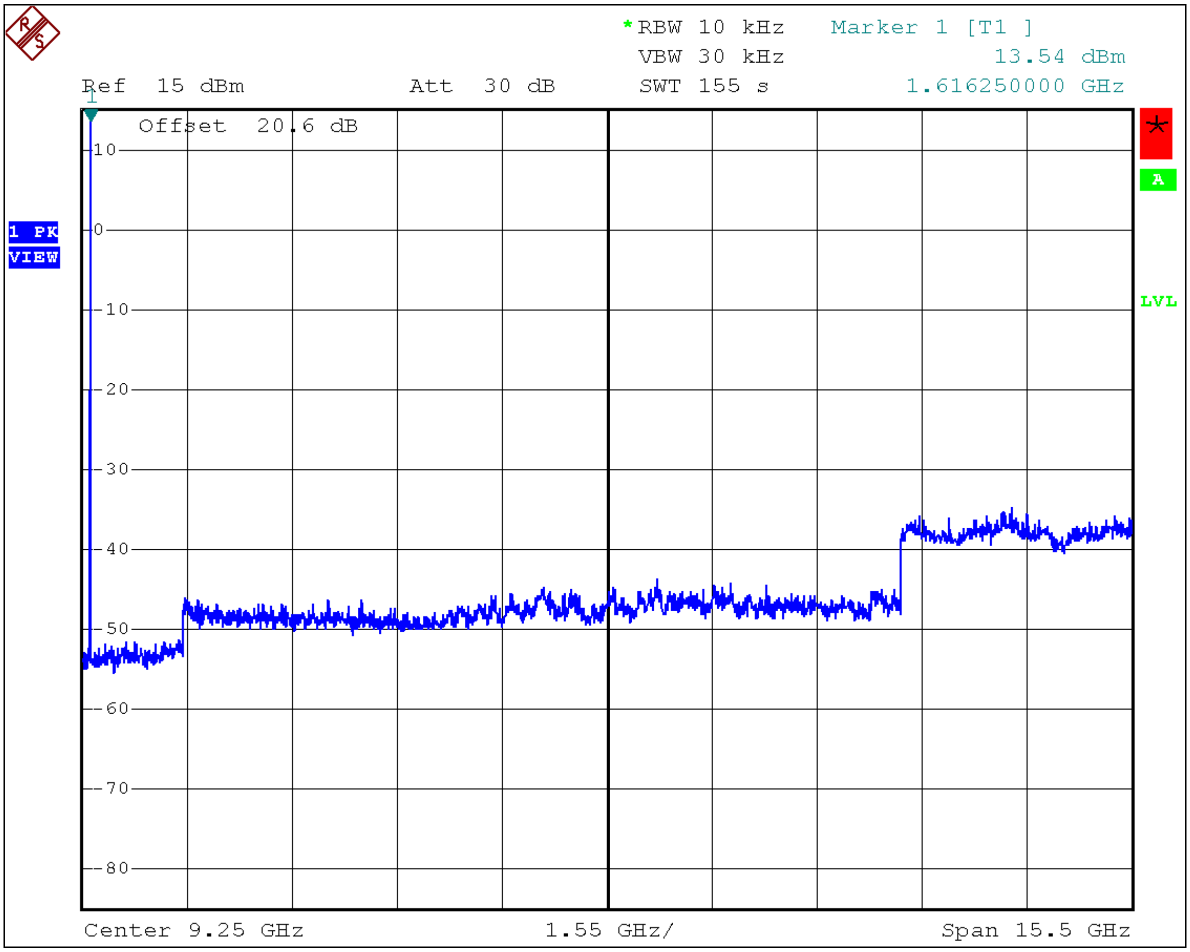
| Downlink Amplifier<br>Table of Input vs Output<br>At Gain Compression and Overload | | | | |
|---|---|---|---|---|
| Frequency MHz | Input at Gain Compression Detected dBm | Input at No Output Change Point dBm | Power Output at No Output Change Point dBm | Input for 10dB Overload Test Level dBm |
| 1616.0 | -56 | -35 | 9.1 | -25 |
| 1621.0 | -56 | -35 | 13.9 | -25 |
| 1626.5 | -56 | -35 | 13.6 | -25 |

| Downlink Amplifier - Table of Harmonics Detected | | | | | |
|---|---|---|---|---|---|
| Frequency MHz | Measured Raw dBm | Additional Cable Factor dB | Corrected Level dBm | Reference Power Output Level dBm | Suppressed Below Carrier dBc |
| 12931 | -38.9 | 2.3 | -36.6 | 8.9 | -45.5 |
| 13218 | -43.7 | 2.3 | -41.4 | 8.9 | -50.3 |

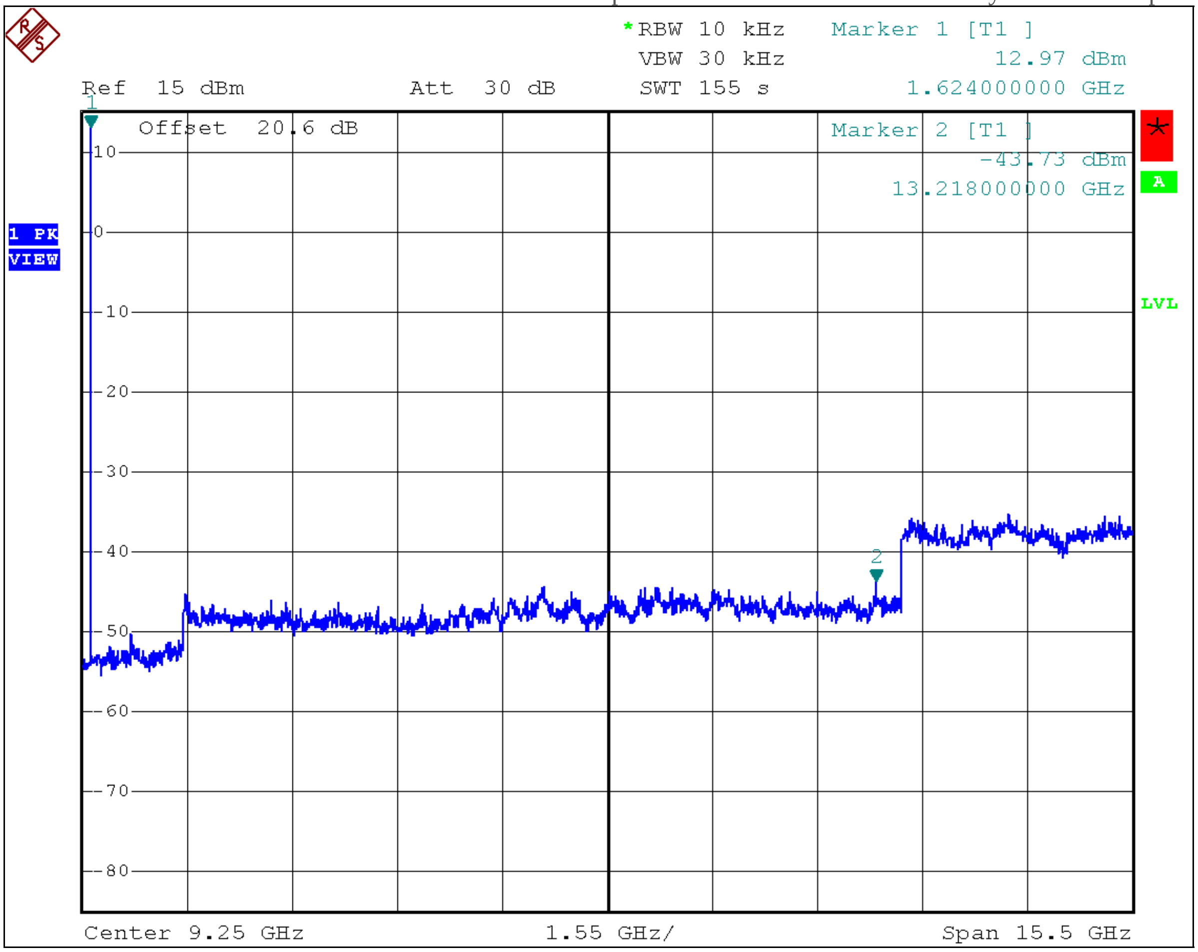
Signals in the table above are outside of restricted bands.




Low Channel (Fundamental visible on left.)



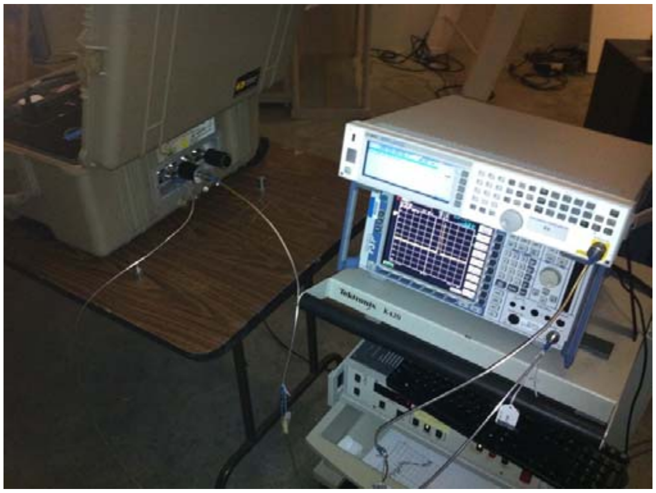
Middle Channel (Fundamental visible on left.)



High Channel (Fundamental visible on left.)

## 9.4 Setup Photographs

Overload, EUT



Overload, Equipment Setup

## 9.5 Equipment List

| Equipment List | | | | |
|---|---|---|---|---|
| **Asset #** | **Manufacturer** | **Model #** | **Description** | **Calibration Due** |
| ALN-077 | Rohde & Schwarz | FSP-30 | Spectrum Analyzer | 2015-01-29 |
| 1816 | Agilent | N5181A | Signal Generator | 2014-09-27 |
| A105 | Narda | 768A-20 | 20 dB 20 W Power Attenuator | 2014-02-15 |
| C248 | Pasternack | Cable | Cable, low loss | 2014-03-13 |

# 10.0 Bandwidth Input/output

Performance of bandwidth output vs input is compared.

## 10.1 Criteria

Bandwidth of the output signal should be closely the same as the input bandwidth.

## 10.2 Procedure

For each amplifier section, and each of 3 standard channels, apply a 1000 Hz tone with 300 kHz deviation FM modulated signal from a signal generator and set it to the amplitude recorded previously as the No Output Change (NOC) level. Record the bandwidth as 20 dB.

Record the bandwidth for the source signal for each of the 3 channels and compare.

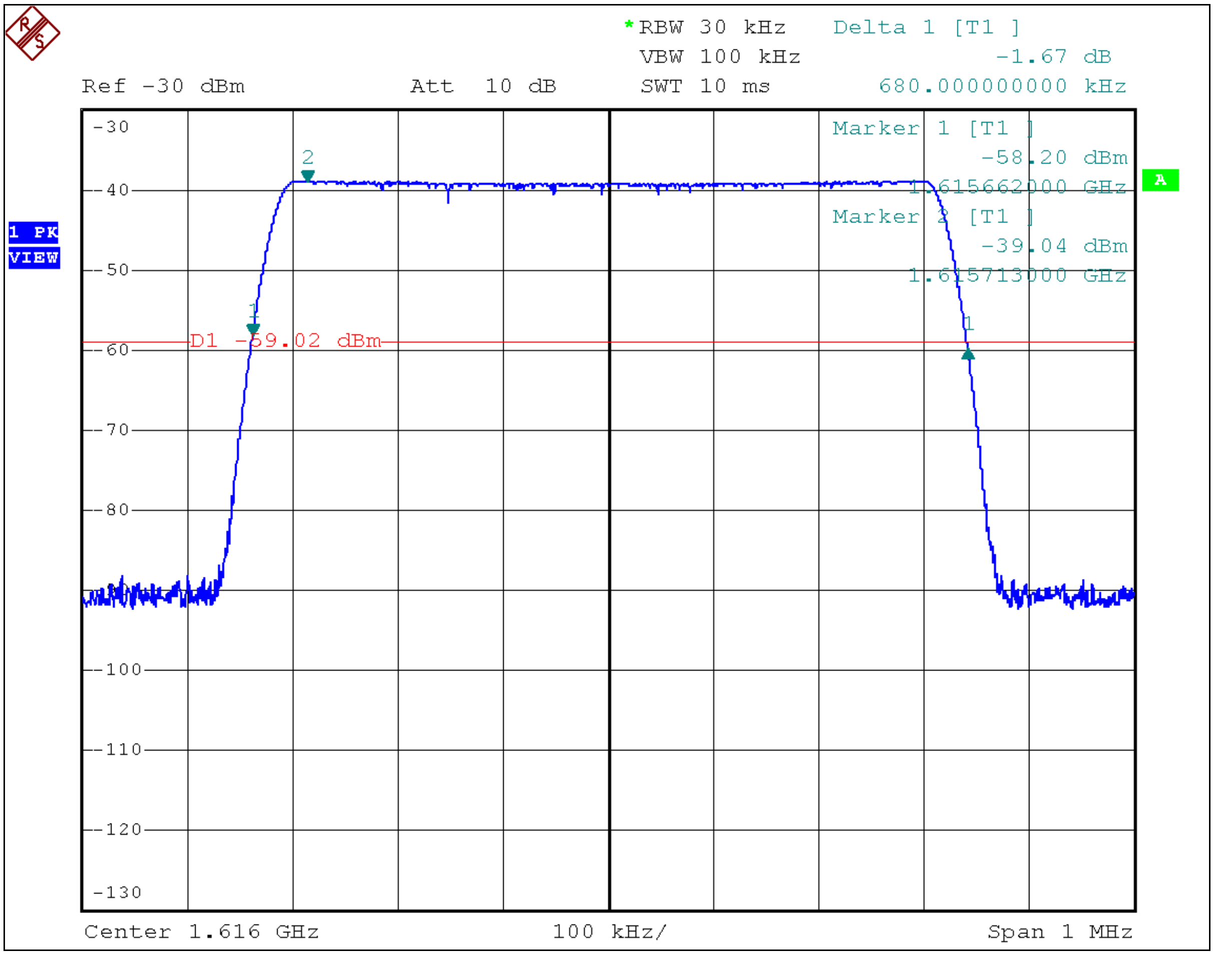
## 10.3 Results

No significant departure in bandwidth was recorded in the output of the amplifiers when compared to the original signal generator source signal.

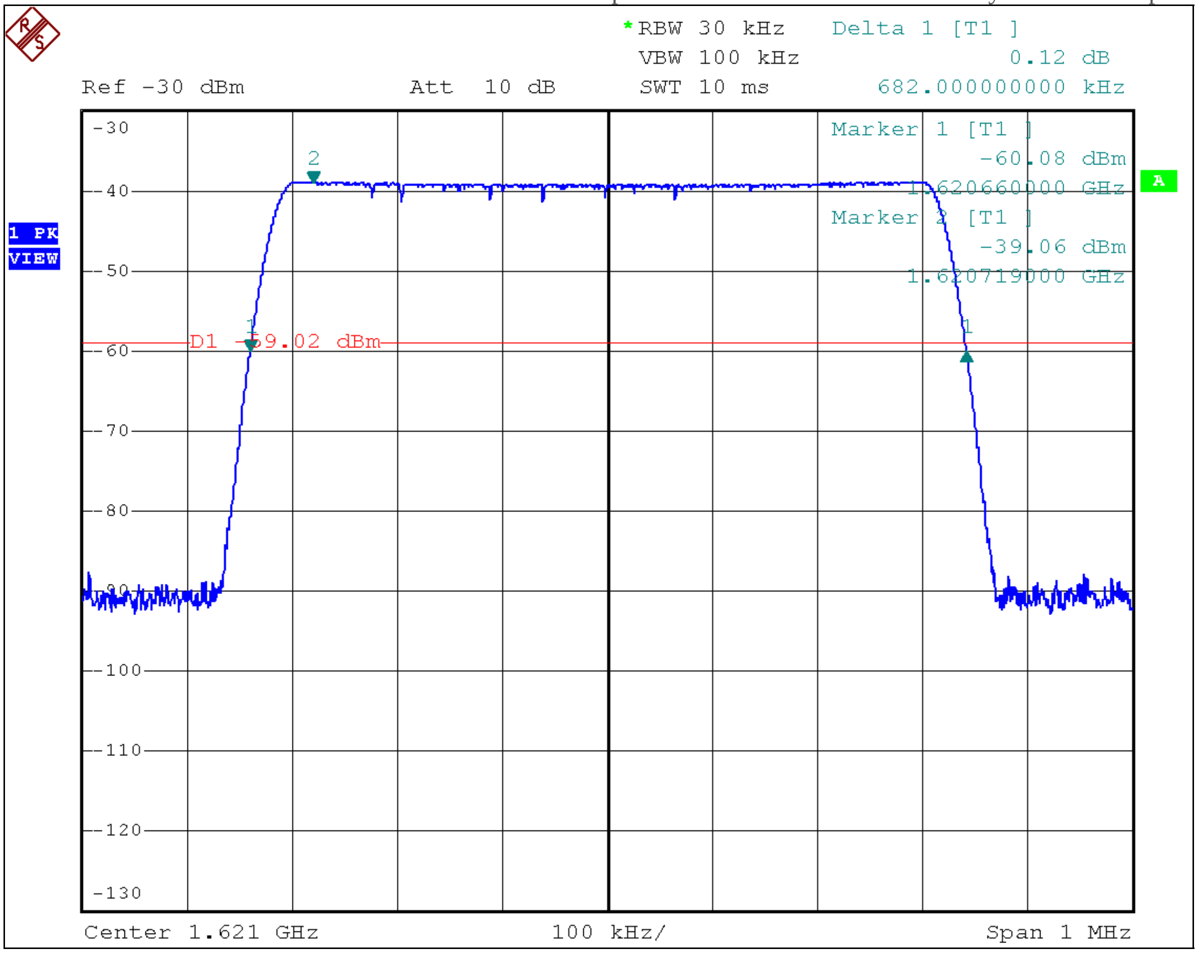
| Uplink Amplifier - Table of Bandwidth Measurements | | | |
|---|---|---|---|
| Frequency MHz | Generator Sourced Input Bandwidth kHz | Uplink Amplifier Output Bandwidth kHz | Downlink Amplifier Output Bandwidth kHz |
| 1616 | 680 | 678* | 674* |
| 1621 | 682 | 680 | 680 |
| 1626.5 | 680 | 680 | 680 |

*Note that it was discovered after test that the low channel frequency should have been 1616.5 MHz instead of 1616.0 MHz. This explains the sloping output obtained on the low output channel of both amplifiers and the slight influence on bandwidth; it is likely the effects of being near the cavity filter band-stops.

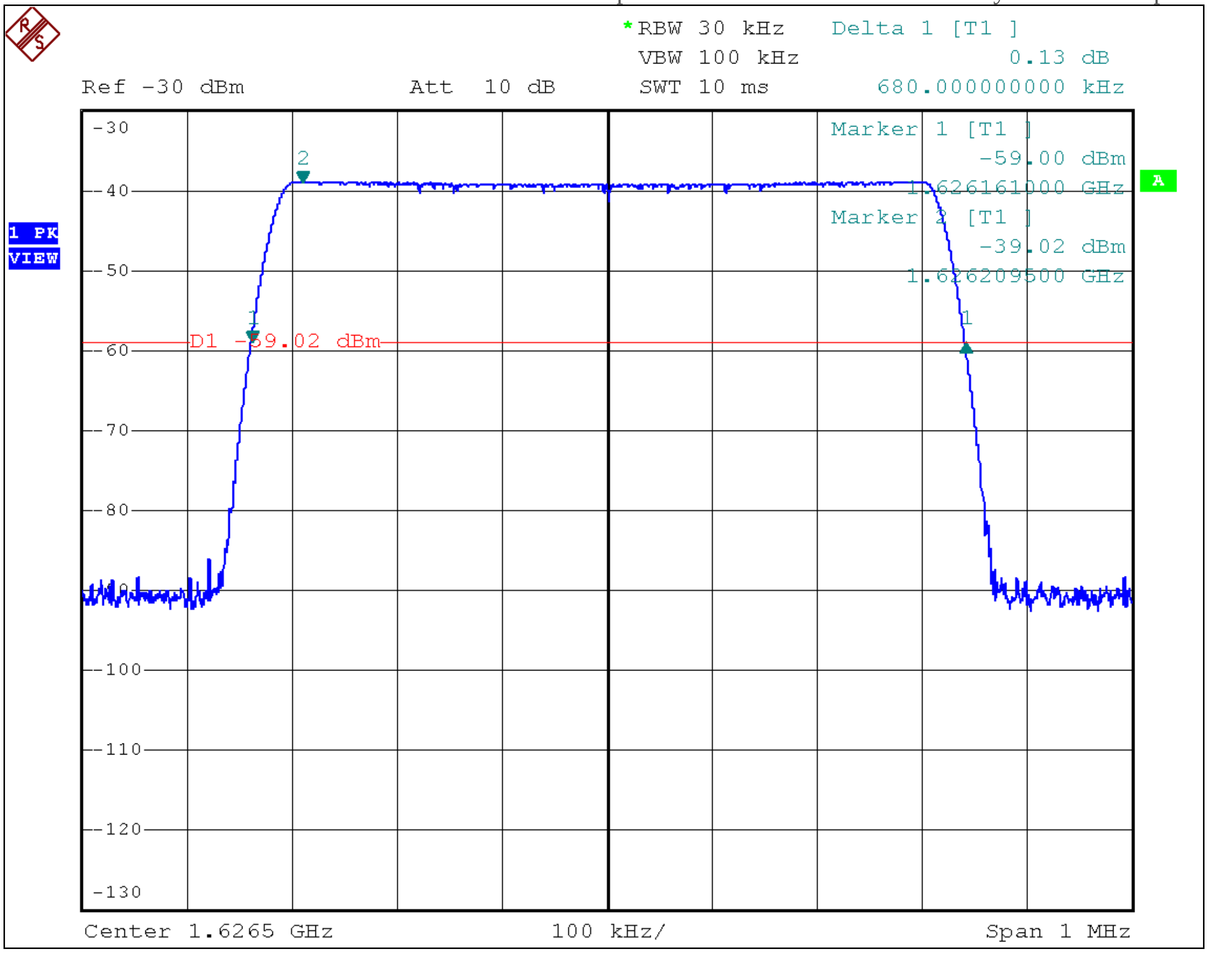
### 10.3.1 Source Signal Bandwidth




Source Signal Bandwidth –Low Channel

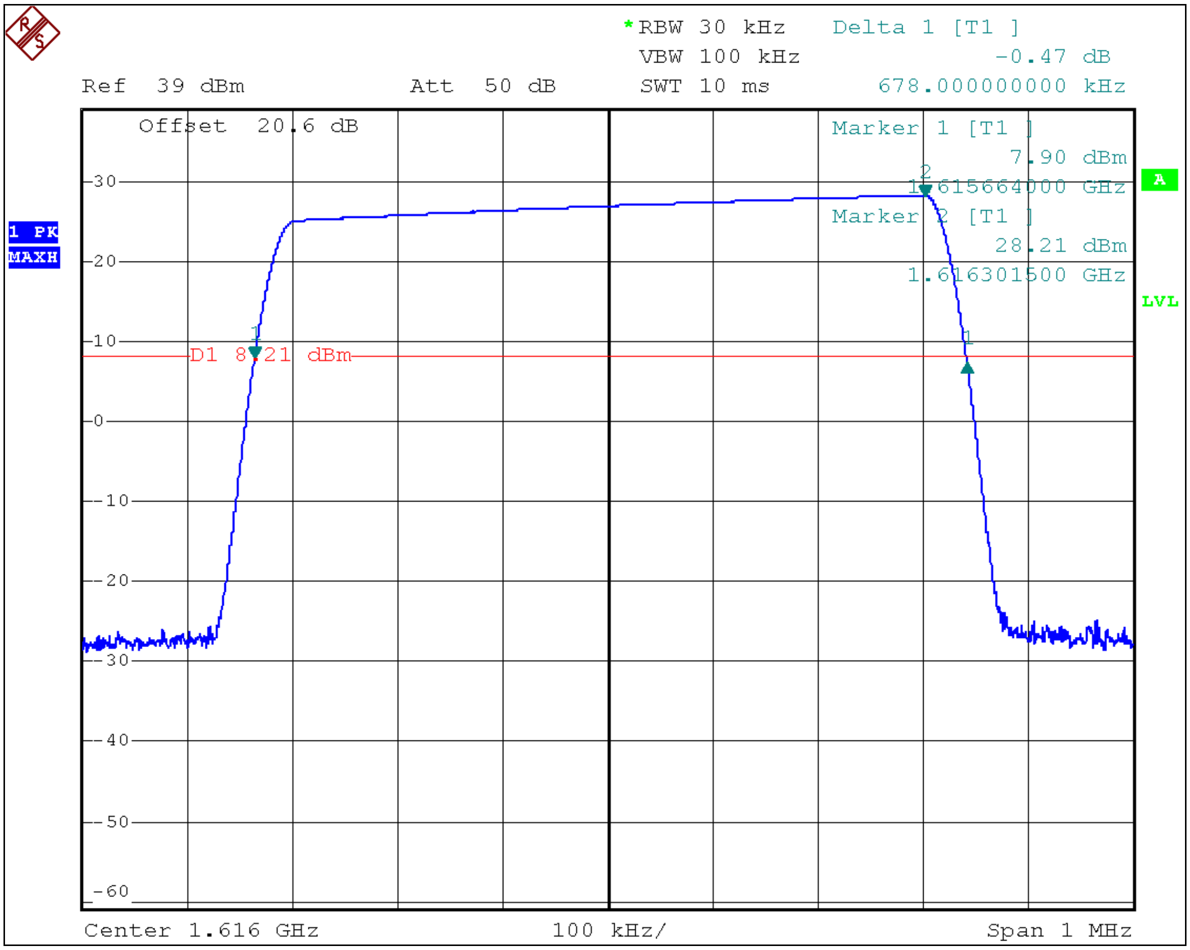



Source Signal Bandwidth –Middle Channel

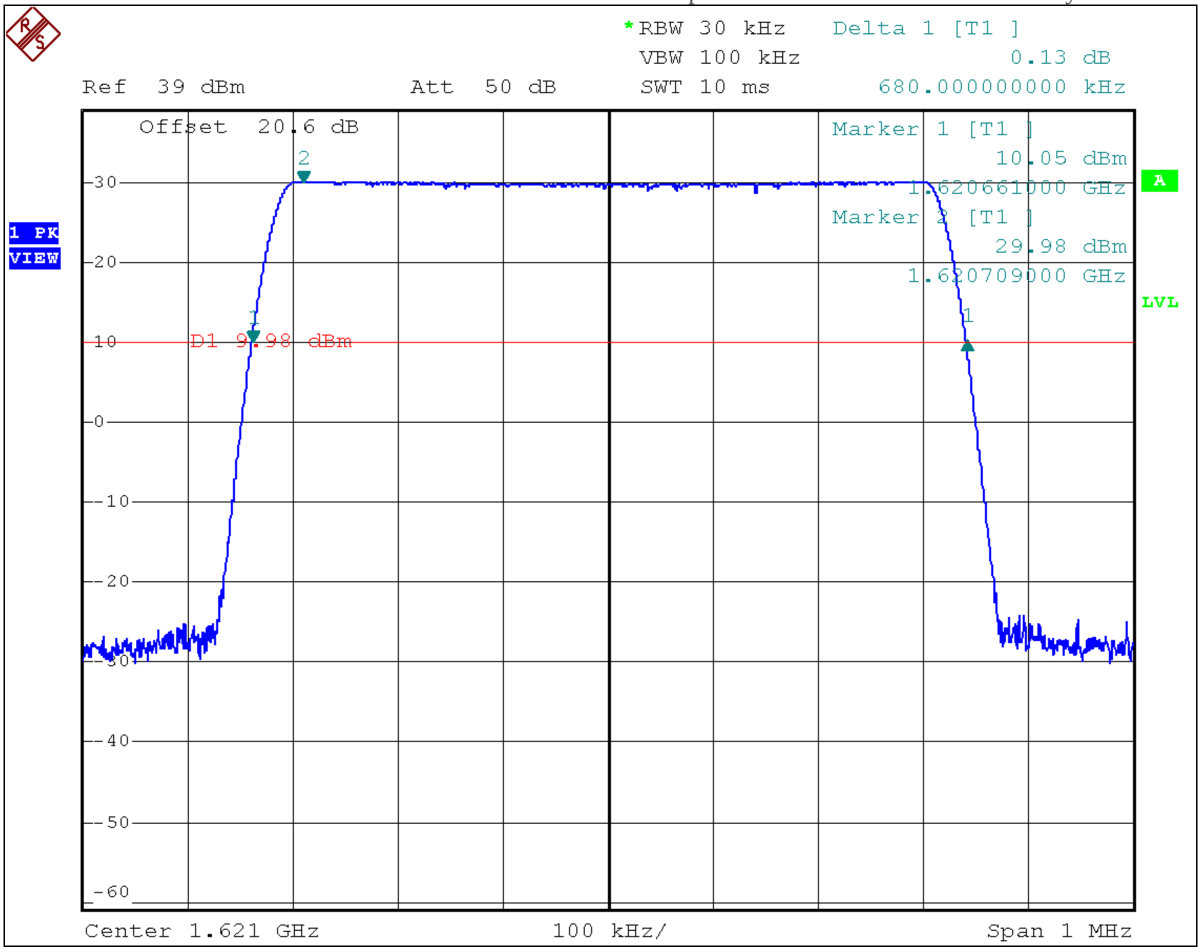



Source Signal Bandwidth – High Channel

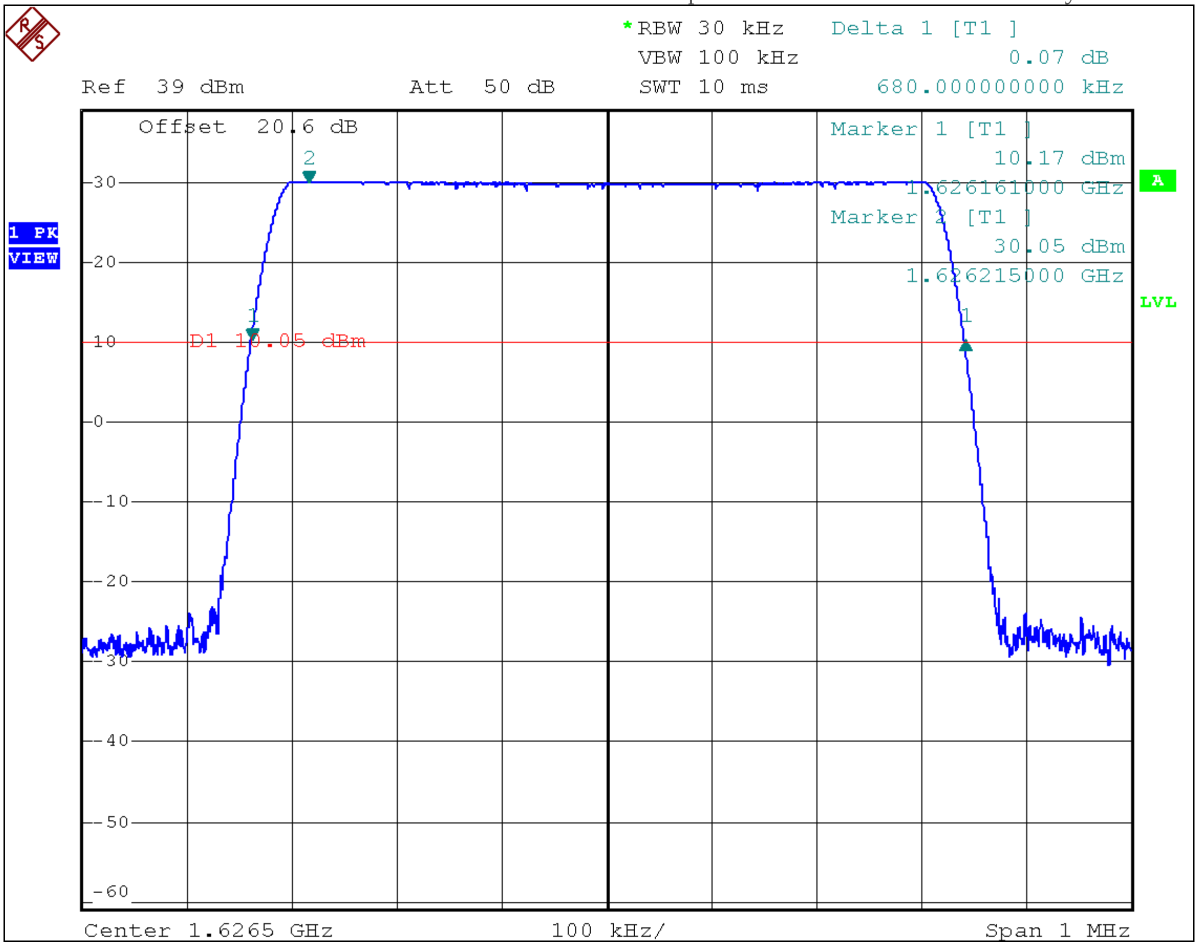
### 10.3.2 Uplink Output Bandwidth




Uplink Output Bandwidth – Low Channel

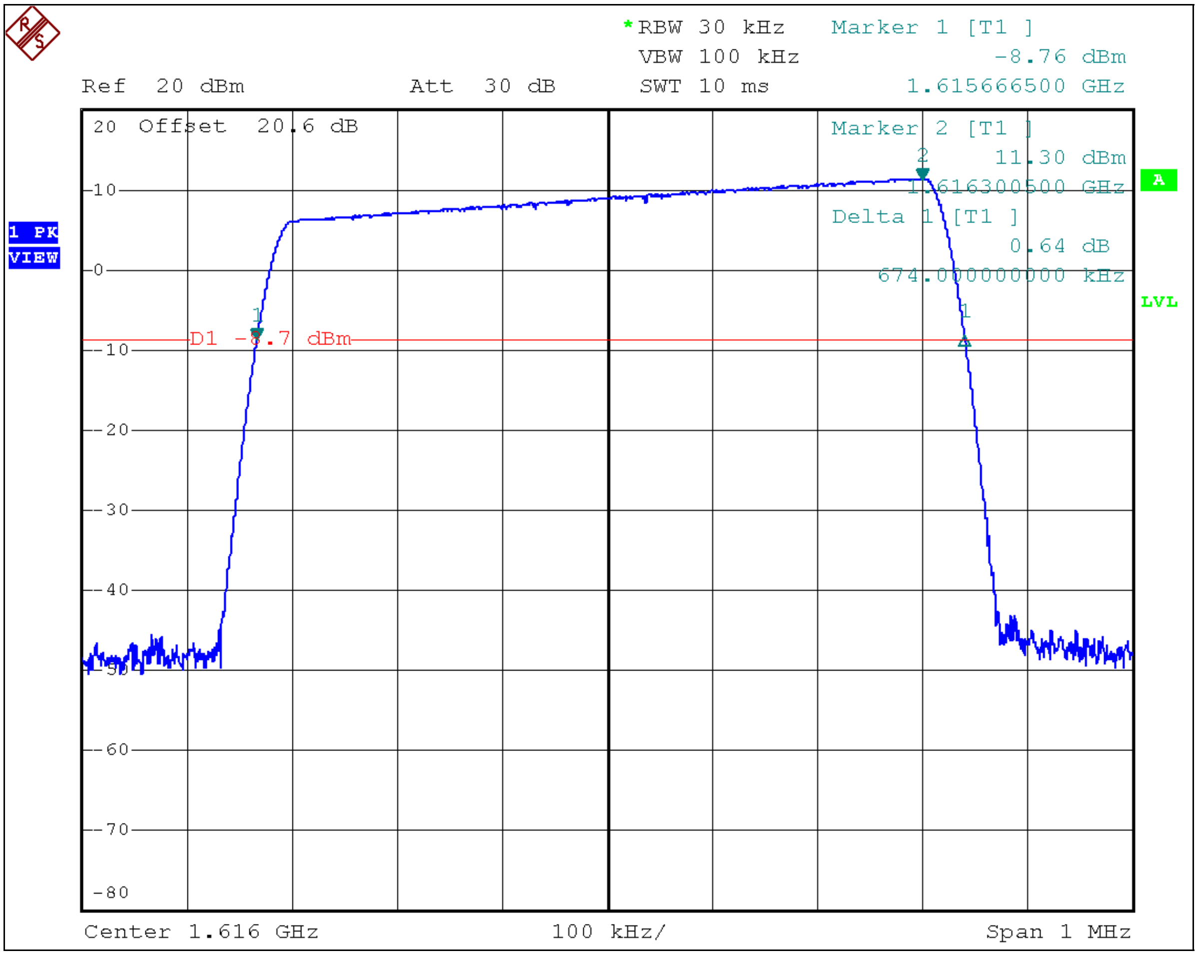



Uplink Output Bandwidth – Middle Channel

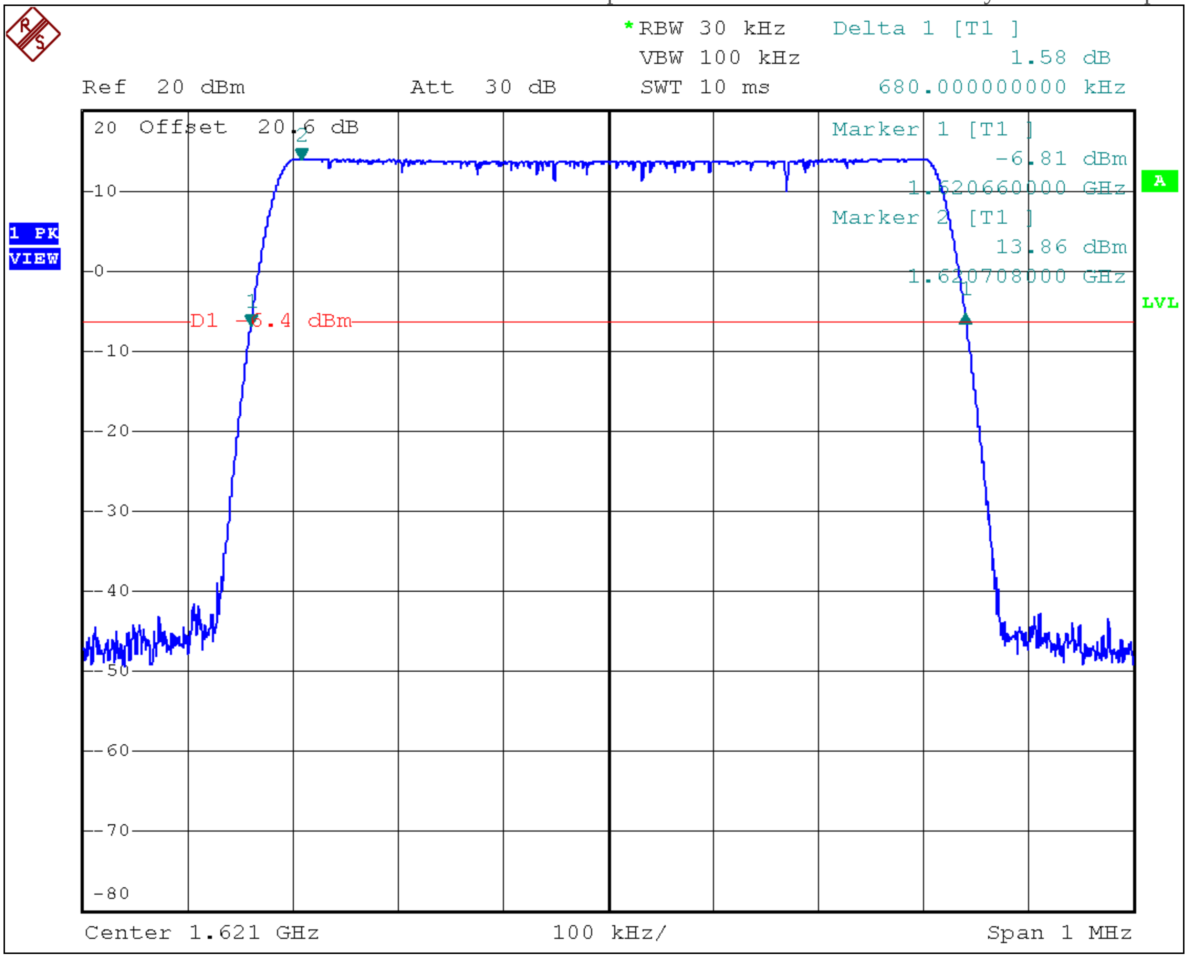


Uplink Output Bandwidth – High Channel

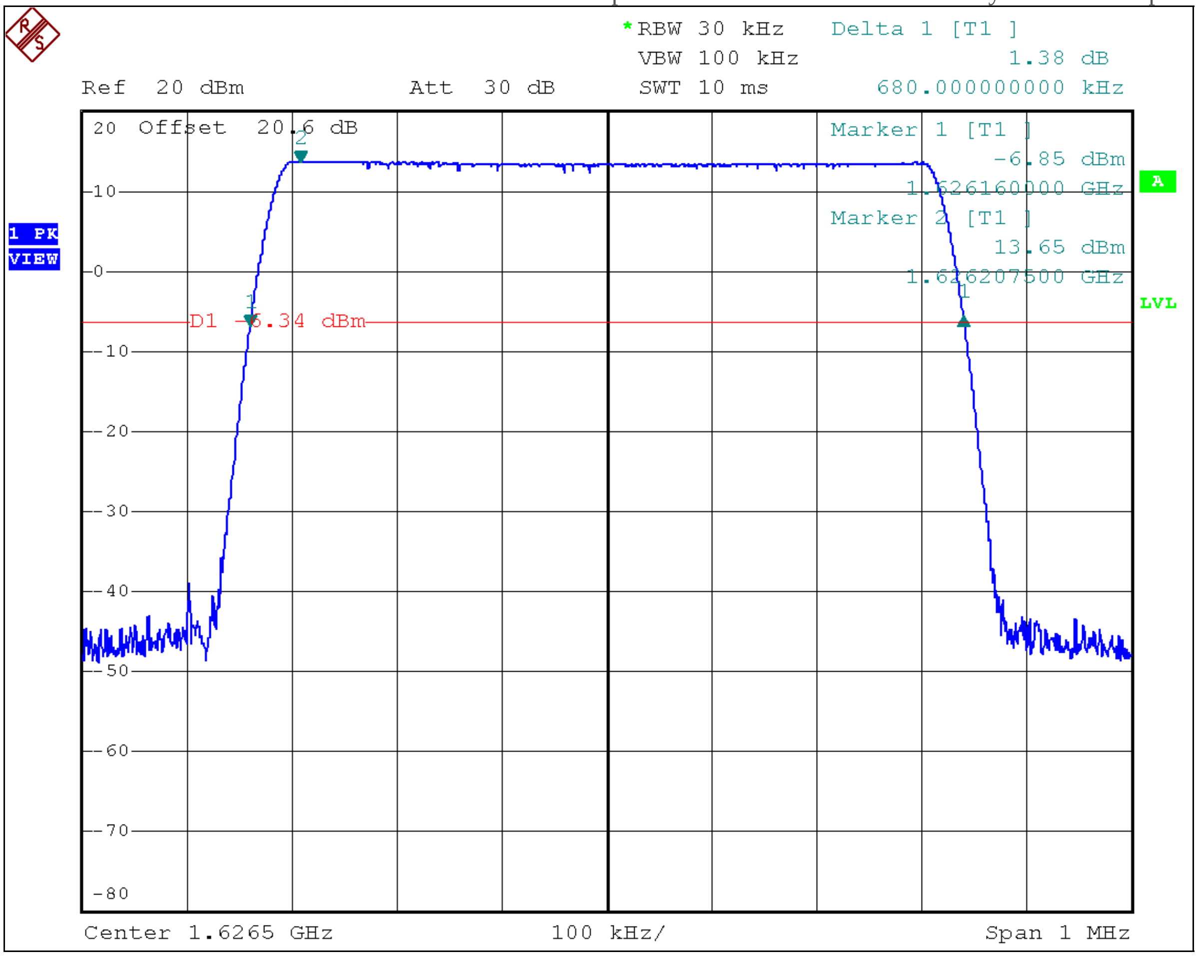
### 10.3.3 Downlink Output Bandwidth




Downlink Output Bandwidth – Low Channel



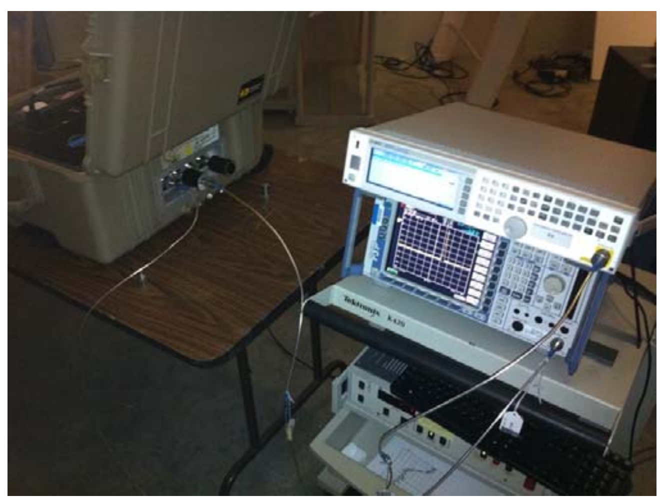
Uplink Output Bandwidth – Middle Channel




Uplink Output Bandwidth – High Channel

## 10.4 Setup Photographs

Bandwidth, EUT



Bandwidth, Equipment Setup

## 10.5 Equipment List

| Equipment List | | | | |
|---|---|---|---|---|
| **Asset #** | **Manufacturer** | **Model #** | **Description** | **Calibration Due** |
| ALN-077 | Rohde & Schwarz | FSP-30 | Spectrum Analyzer | 2015-01-29 |
| 1816 | Agilent | N5181A | Signal Generator | 2014-09-27 |

# 11.0 Amplifier DC Power Requirement

## 11.1 Criteria

Report measured voltage and current input to the amplifier output stage.

## 11.2 Procedure

Apply a full NOC signal level as determined previously to the amplifier input with resistive termination of the output. Then directly measure DC current and voltage for the amplifier(s) and record.

## 11.3 Results

The amplifiers are modules and the final stage could not be isolated from the entire module. Therefore the module power requirement is reported below. Also note that the fans for the uplink module were powered on the same circuit.

| Table of DC Power Requirements | | |
|---|---|---|
| Amplifier Section | Voltage (V) | Current (mA) |
| Uplink | 11.6 | 2610 |
| Downlink | 11.6 | 130 |

## 11.4 Equipment List

| Equipment List | | | | |
|---|---|---|---|---|
| **Asset #** | **Manufacturer** | **Model #** | **Description** | **Calibration Due** |
| 1096 | Extech | 380941 | AC/DC Clamp Multimeter | 2014-09-18 |
| 1816 | Agilent | N5181A | Signal Generator | 2014-09-27 |

# 12.0 Carrier-Off State Emissions

## 12.1 Criteria

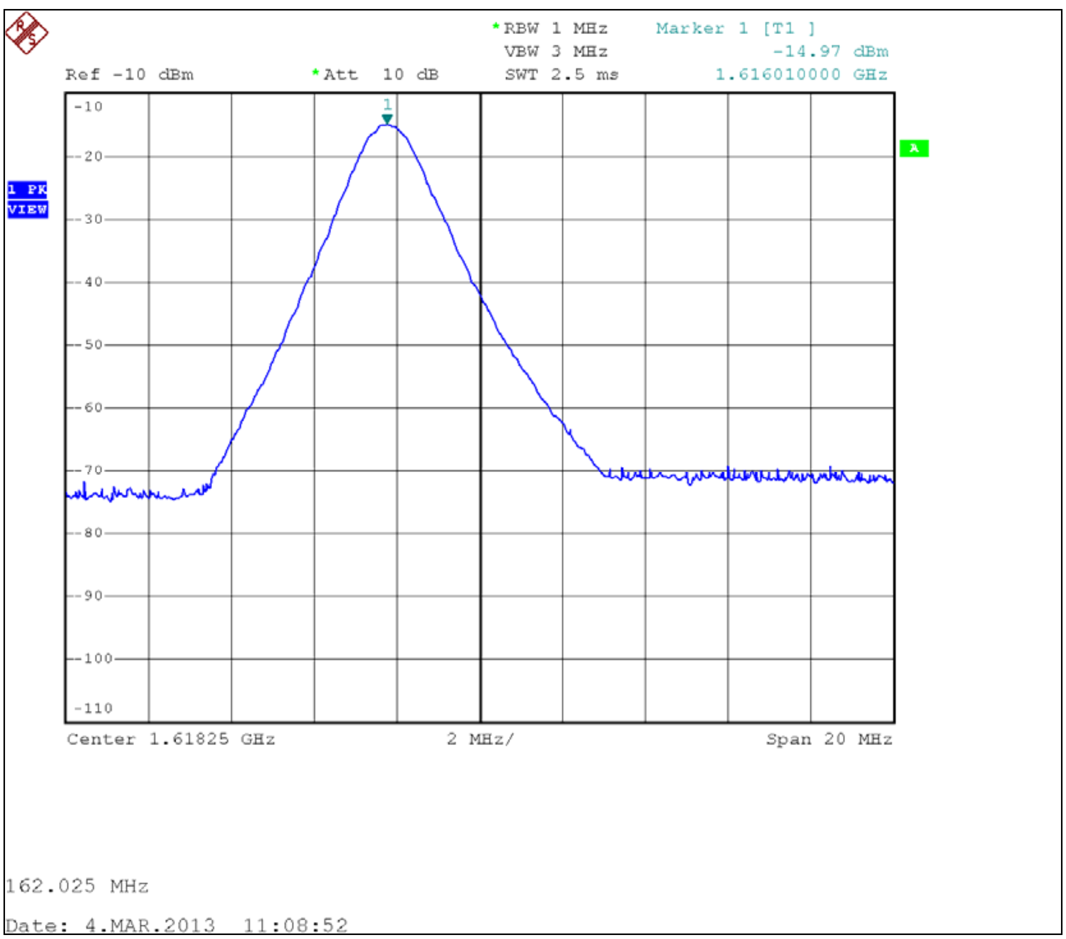
Per 25.216(i) the limit on carrier-off state emissions is -80 dBW/MHz in the 1559-1610 MHz band and averaged over any two millisecond interval. An RMS detector shall be employed.

## 12.2 Procedure

Emissions are measured to insure there is no signal above the limit in the frequency band of interest when the carrier signal is removed.

## 12.3 Results

There is no capacity in this amplifier to generate signals other than noise floor. The noise floor can be deduced with high confidence from a measurement taken while the amplifier was in the active state with a signal near the low end of the band. The recorded measurement (below) shows an in-band signal at 1616 MHz. The sweep begins at 1608.25 MHz. Observe the noise floor presented at the left of the plot as it is below -60 dBm (-90 dBW) with carrier. (Add 11.5 dB for coupler + cable loss.) With carrier off, the noise could be lower but not higher. Also, the noise floor on the left of the signal is lower than on the right of the signal; this is from the nearby cavity filters low skirt. Further attenuation of noise can be expected. Since there is no capability to produce narrowband signals nor additional noise, any emission lower than 1608.25 MHz can be safely predicted to be no higher than shown. The EUT satisfies the criteria.



**Uplink Amplifier in Active State, Examination of Noise Floor at Band Edge, Peak Detectio**n, Max Hold

## Appendix: Policy, Rationale, and Evaluation of EMC Measurement Uncertainty

All uncertainty calculations, estimates and expressions thereof shall be in accordance with NIST policy. Since PTI operates in accordance with NIST (NVLAP) Handbook 150-11: 2007, all instrumentation having an effect on the accuracy or validity of tests shall be periodically calibrated or verified traceable to national standards by a competent calibration laboratory. The certificates of calibration or verification on this instrumentation shall include estimates of uncertainty as required by NIST Handbook 150-11.

### 1. Rationale and Summary of Expanded Uncertainty.

Each piece of instrumentation at PTI that is used in making measurements for determining conformance to a standard (or limit), shall be assessed to evaluate its contribution to the overall uncertainty of the measurement in which it is used. The assessment of each item will be based on either a type A evaluation or a type B evaluation. Most of the evaluations will be type B, since they will be based on the manufacturer's statements or specifications of the calibration tolerances, or uncertainty will be stated along with a brief rationale for the type of evaluation and the resulting stated uncertainties.

The individual uncertainties included in the combined standard uncertainty for a specific test result will depend on the configuration in which the item of instrumentation is used. The combination will always be based on the law of propagation of uncertainty. Any systematic effects will be accommodated by including their uncertainties, in the calculation of the combined standard uncertainty; except that if the direction and amount of the systematic effect cannot be determined and separated from its uncertainty, the whole effect will be treated as uncertainty and combined along with the other elements of the test setup.

Type A evaluations of standard uncertainty will usually be based on calculating the standard deviation of the mean of a series of independent observations, but may be based on a least-squares curve fit or the analysis of variance for unusual situations. Type B evaluations of standard uncertainty will usually be based on manufacturer's specifications, data provided in calibration reports, and experience. The type of probability distribution used (normal, rectangular, a priori, or u-shaped) will be stated for each Type B evaluation.

In the evaluation of the uncertainty of each type of measurement, the uncertainty caused by the operator will be estimated. One notable operator contribution to measurement uncertainty is the manipulation of cables to maximize the measured values of radiated emissions. The operator contribution to measurement uncertainty is evaluated by having several operators independently repeat the same test. This results in a Type A evaluation of operator-contributed measurement uncertainty.

A summary of the expanded uncertainties of PTI measurements is shown as Table 1. These are the worst-case uncertainties considering all operative influence factors.

**Table 1: Summary of Measurement Uncertainties for Site 45**

| Type of Measurement | Frequency Range | Meas. Dist. | Expanded Uncertainty U, dB (k=2) |
|---|---|---|---|
| Mains Conducted Emissions | 150 kHz to 30 MHz | N/A | 2.9 |
| Telecom Conducted Emissions | 150 kHz to 30 MHz | N/A | 2.8 |
| Radiated Emissions | 30 to 1,000 MHz | 10 m | 4.8 |
| | 1 to 18 GHz | 3 m | 5.7 |

**End of Report**

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