



# **MICROWAVE PATH SURVEY REPORT**

## **RADIO FREQUENCY INTERFERENCE (RFI) MEASUREMENT REPORT**

**Prepared For**

ViaSat

Albuquerque, NM

**Transmit and Receive Earth Station**

17-21 GHz and 27-31 GHz

**November 17, 2014**

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## SECTION 1

### INTRODUCTION AND BACKGROUND

#### 1.1 Introduction

On-site Radio Frequency Interference (RFI) measurements were performed on behalf of ViaSat, Inc. on November 17, 2014 at their proposed site in Albuquerque, NM. The purpose of these measurements was to determine the relative RFI levels in the 17-21 and 27-31 GHz common carrier frequency band and their impact on digital down-link satellite reception. Measurements were performed at one designated location. The purpose of this report is to document the results of these measurements and to present recommendations.

The analysis in this report is based upon the following:

- 4.1 Meter Antenna
- Satellite Arc: 55 to 115 Degrees West Longitude
- Frequency Range Considered: 17 to 21 GHz and 27-31 GHz
- Interference Objective: -156 dBW/1 MHz
- Type of Reception: Digital
- Measured Antenna Center Line: 6.5 Feet Above Ground Level

#### 1.2 Background

ViaSat, Inc is proposing to locate a new transmit/receive antenna at an existing location of 35° 5' 37.1" N and 106° 38' 44.8" W ViaSat, Inc had requested that Comsearch conduct RFI measurements at the facility to assess the interference potential. This facility is currently nonoperational and measurements were done at a point near the proposed antenna locations.

The measured site is identified on a portion of a topographic map shown in Figure 1.2-1. An aerial photo of the site location is shown in Figure 1.2-2. A photo of the measurement using a GPS is shown in Figure 1.2-3.



### 1.3 Constraints

The analysis in this report is based upon the following assumptions and constraints.

- The antenna selected will conform to the FCC reference pattern 32-25 Log $\theta$  as specified in 47CFR 25.209(a)(2).
- It is assumed that during the measurement period all of the terrestrial transmitters were active and operating at full transmit power for the licensed frequencies unless otherwise noted.
- The signal identification and frequencies analyzed are based upon information obtained from the various common carriers as to what frequencies were active at the time of the measurements and the traffic these frequencies were supposed to be carrying.
- The actual ground elevation of the site is based on the data from the topographic map.
- The interference objective of  $-156$  dBW/1 MHz used throughout this report is based upon estimated link budget parameters and is subject to change. ViaSat, Inc should review the system parameters for this down-link in order to verify the viability of this objective.

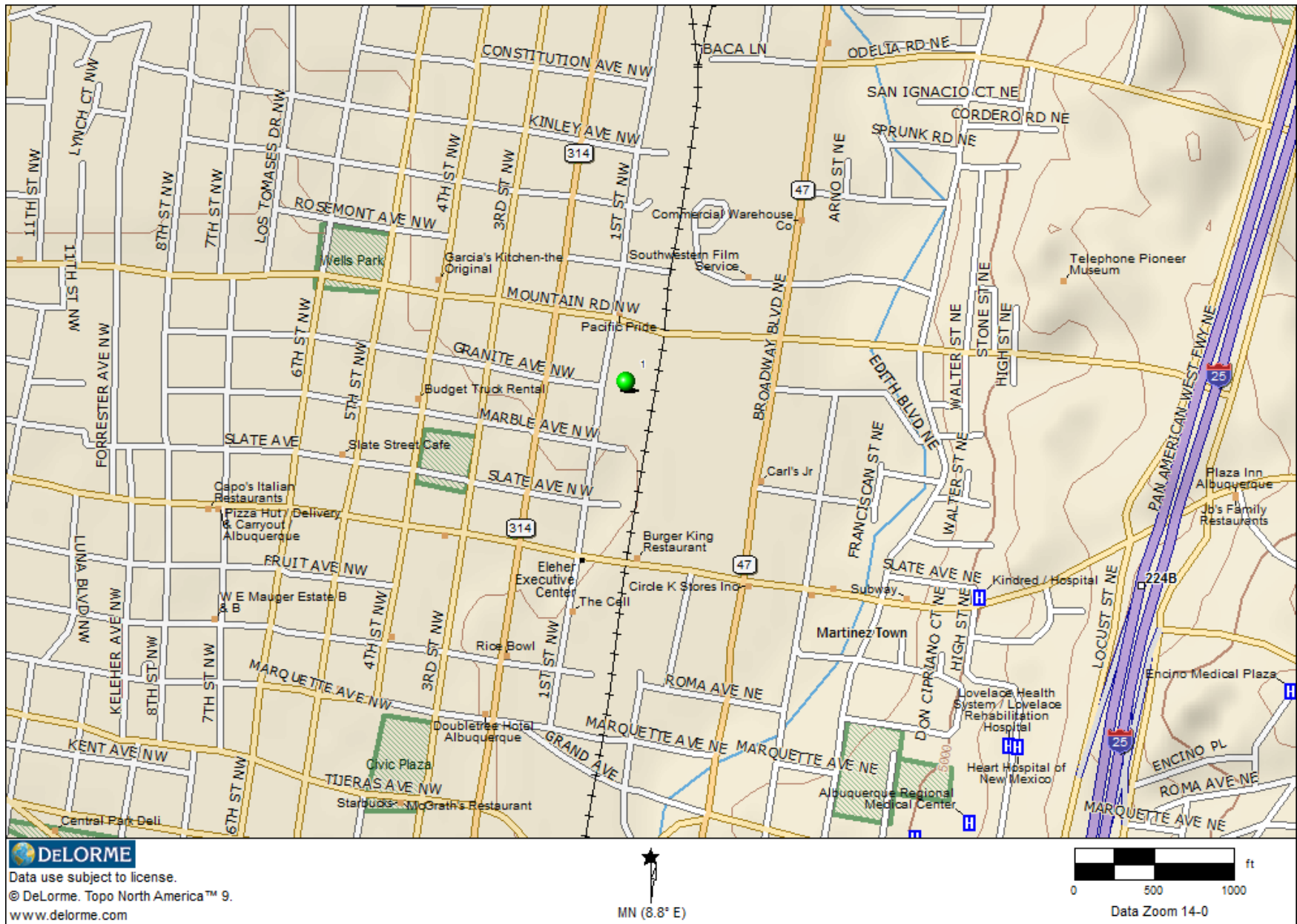


Figure 1.2-1 – Topographic Map





Figure 1.2-2 – Aerial Photograph





**Figure 1.2-3 – GPS Photograph**

***SECTION***

***TWO***

## SECTION 2

### TEST PROCEDURE

#### 2.1 Calibration

Figure 2.1-1 is the block diagram of the test set for all bands to be tested. All test equipment used was allowed a proper warm-up period prior to calibration. The test set was calibrated by the signal substitution method, as recommended by NSMA, utilizing a synthesized signal generator. The reference signal from the signal generator was adjusted for the center frequency of each band to be tested and measured with a thermal power meter for calibrated reference test level (-60 dBm). This calibrated reference signal from the signal generator was then injected into the end of the coaxial cable of the test set at the point, which normally connects to the test antenna. A spectrum analyzer then measured the reference test signal level after passing through the test set. At this point, the spectrum analyzer was calibrated such that the top graticule of the spectrum analyzer display (-60 dBm) corresponded to the injected reference signal (-60 dBm) by utilizing the reference level offset function of the Anritsu – MS2720T spectrum analyzer. Upon completion of the calibration process, a known reference level was obtained for the measurements that correspond to a given set of spectrum analyzer display readings.

The following formula is used to transform the measured signal level as read on the spectrum analyzer display (dBm) to an isotropic reference signal level (dBW<sub>I</sub>) as seen at the point of test:

$$\text{dBW}_I = \text{LI} - \text{GA} - 30$$

Where:      dBW<sub>I</sub> = Isotropic level in dBW

LI = Level (dBm) of injected signal

GA = Test antenna gain

-30 = Conversion factor from dBm to dBW

$$\begin{aligned} \text{at 19.5 GHz: } \quad \text{dBW}_I &= -60 \text{ dBm} - 30 \text{ dB} - 30 \text{ dB} \\ &= -120 \text{ dBW}_I \end{aligned}$$

In this instance, the spectrum analyzer displayed measured signal level of -60 dBm equates to an isotropic signal level of -120 dBW<sub>I</sub>.

Figures 2.1-2(A-H) displays the spectrum photographs of the described calibration procedure employed during these measurements.

# Test Set Equipment Diagram

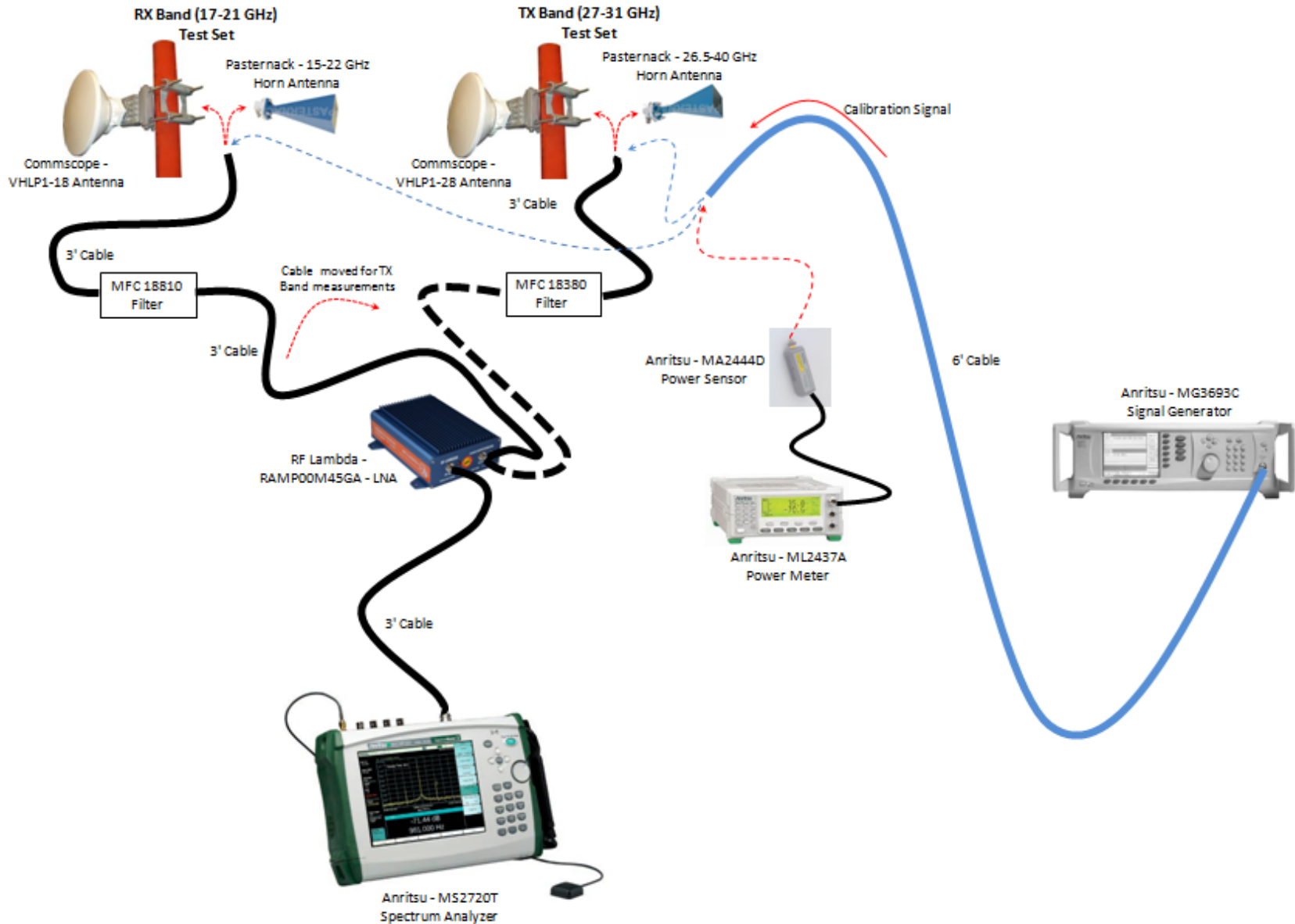
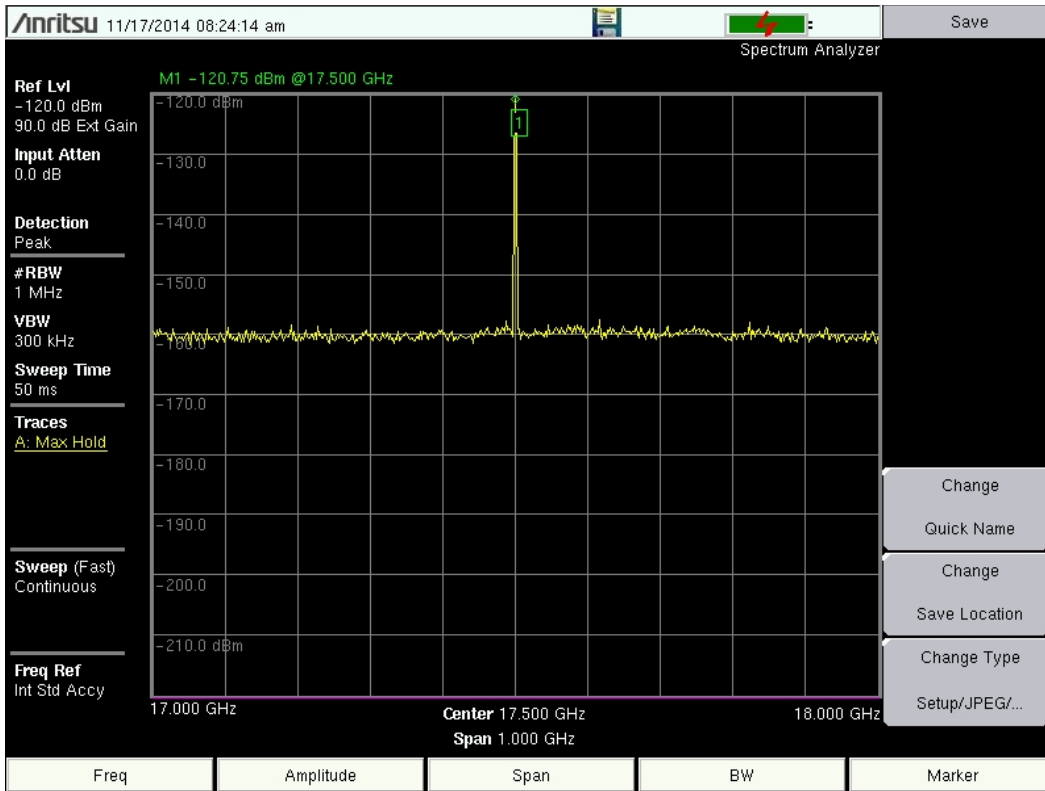
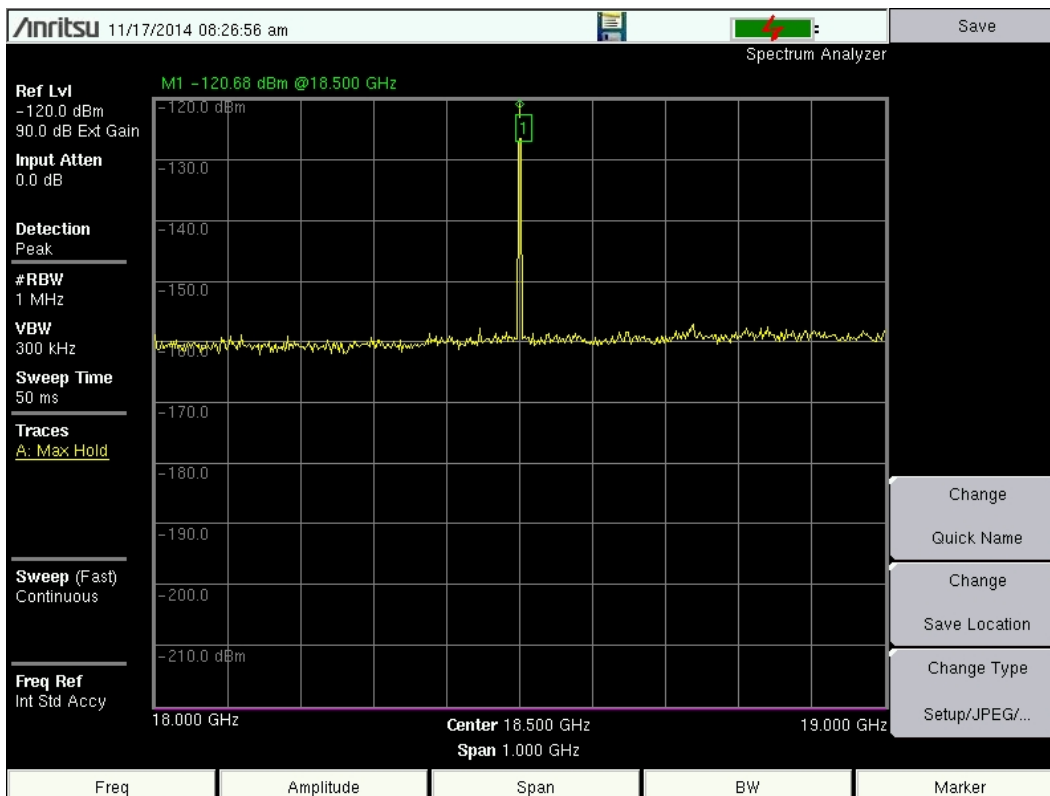


Figure 2.1-1 Receive Test Equipment Block



**Figure 2.1-2 (A) Calibration Spectrum Photo 17.5 GHz**



**Figure 2.1-2 (B) Calibration Spectrum Photo 18.5 GHz**



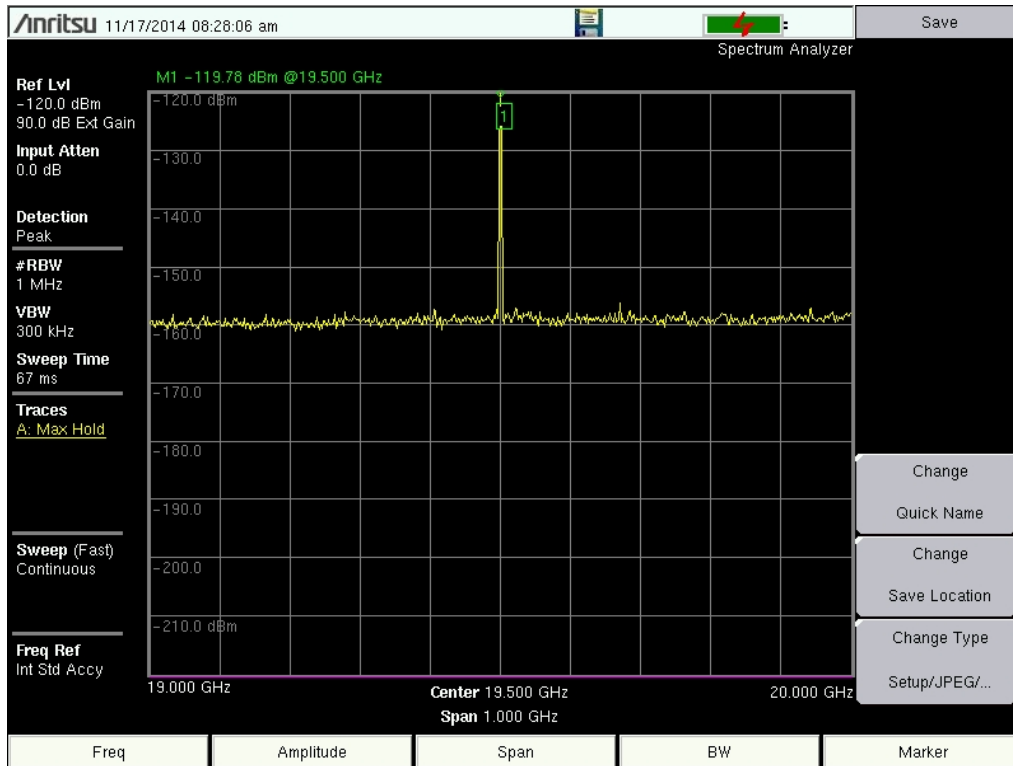


Figure 2.1-2 (C) Calibration Spectrum Photo 19.5 GHz

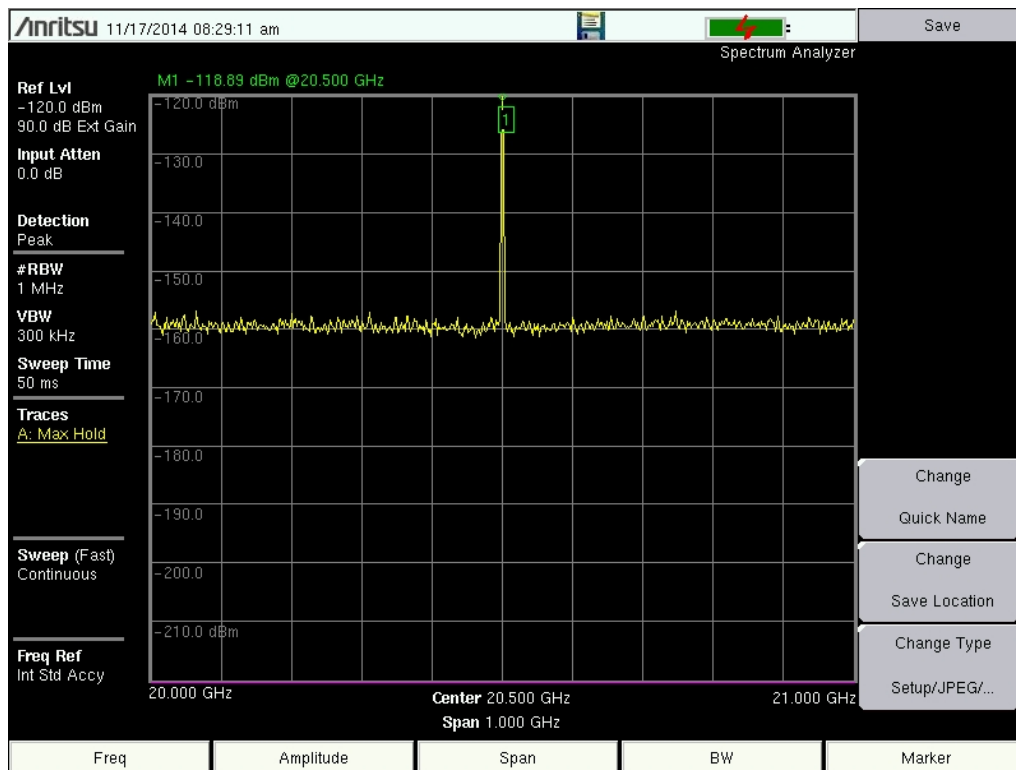
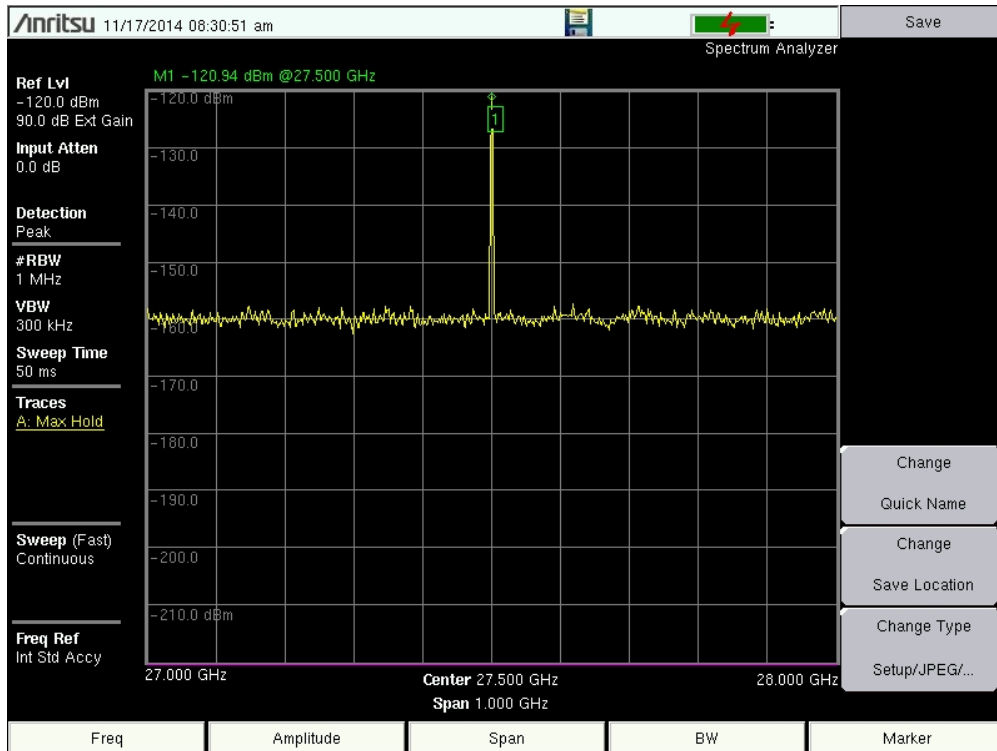
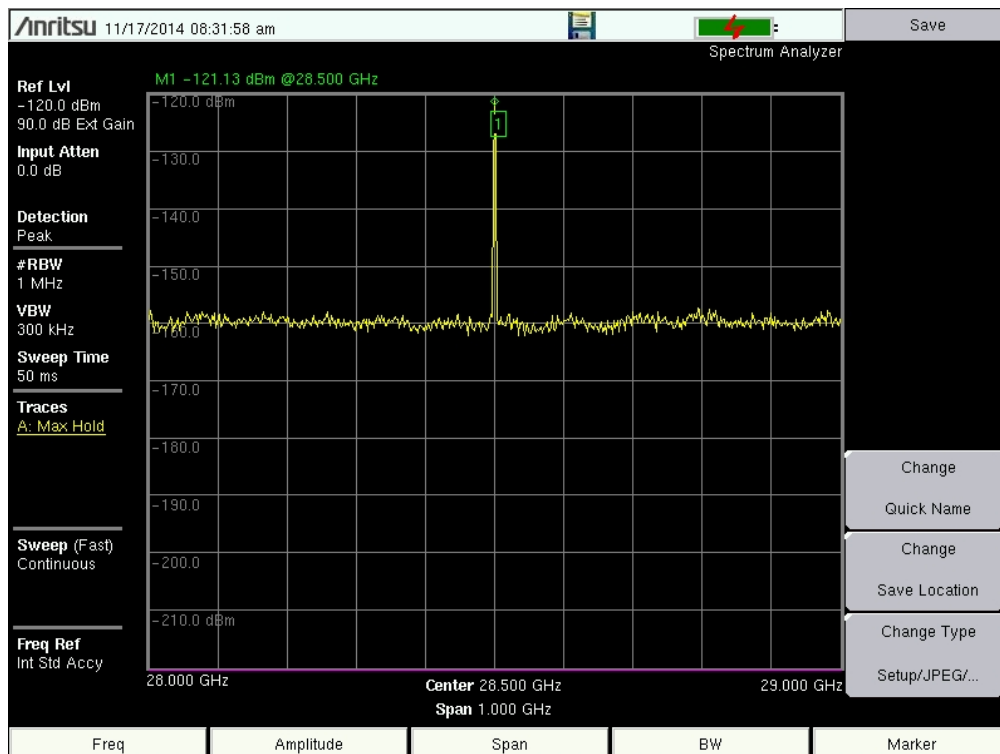


Figure 2.1-2 (D) Calibration Spectrum Photo 20.5 GHz



**Figure 2.1-2 (E) Calibration Spectrum Photo 27.5 GHz**



**Figure 2.1-2 (F) Calibration Spectrum Photo 28.5 GHz**

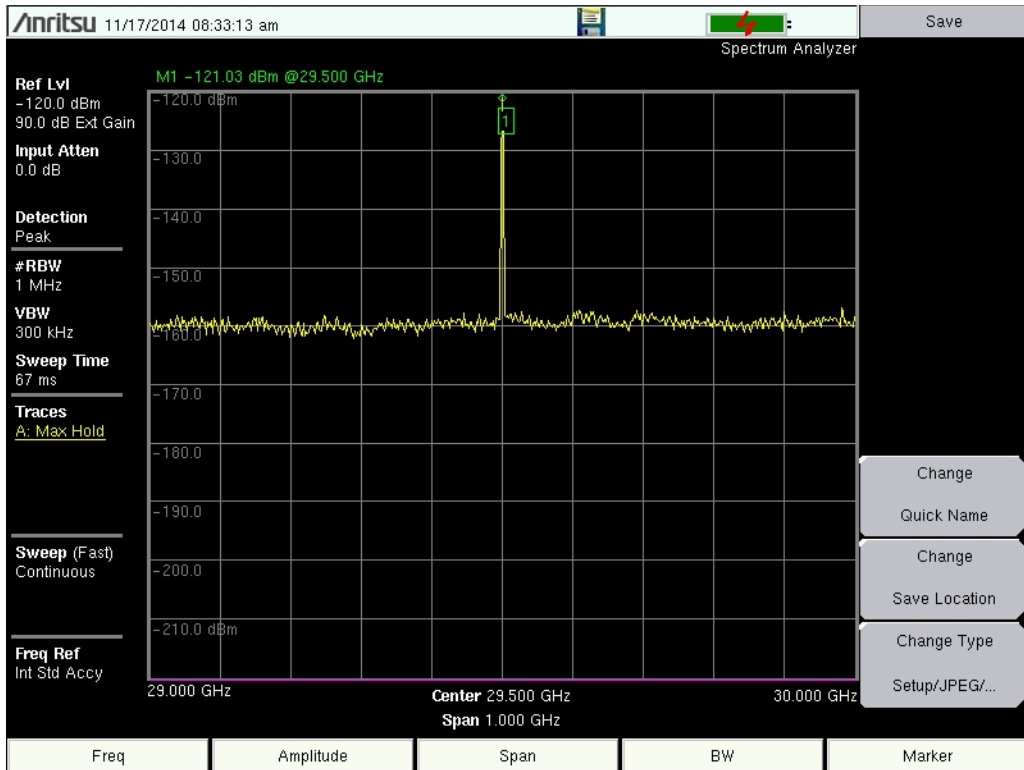


Figure 2.1-2 (G) Calibration Spectrum Photo 29.5 GHz

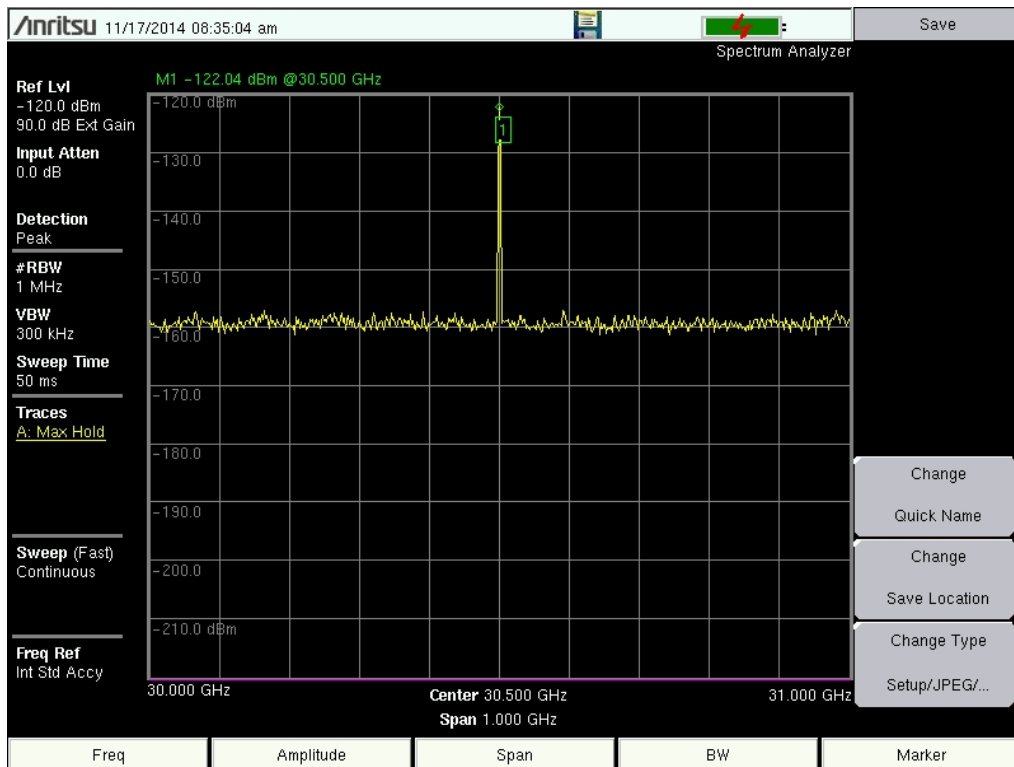


Figure 2.1-2 (H) Calibration Spectrum Photo 30.5 GHz

## **2.2 Methodology**

Upon arriving at the existing earth station site, azimuth and horizon elevation measurements were performed to evaluate if any satellite arc obstructions exist. The coordinates of the existing earth station site were verified on the DeLorme topographic map. Photographs were taken to document the satellite arc (clearance) and are included in this report.

After site coordinates and horizon elevations were verified, the test equipment was set up and calibrated to measure the RF environment. Measurements were conducted at the proposed earth station location for the 17-21 and 27-31 GHz band. After the equipment calibration was completed, the test antenna was mounted on an extendable tower and elevated to a height of 6.5 feet. This height is greater than the centerline of the earth station antenna. The antenna was rotated 360 degrees (scanning), once in each polarization, while activating the peak hold function of the spectrum analyzer. This enabled the analyzer to maintain and display the maximum signal level received for all frequencies under consideration. After the initial documentation of interference, all interference conflicts if observed were peaked on to determine the azimuth and the level of the interference source.

Upon completion of the RF testing, the measured signal levels were transposed to earth station interference levels after accounting for the addition of the corresponding earth station antenna gain.

***SECTION***

***THREE***

## **SECTION 3**

### **DATA PRESENTATION**

The following section contains the tables and spectrum photos pertaining to the site location measured.

#### **3.1 Albuquerque, NM**

- Table 3.1-1 presents a site data sheet including all pertinent site information.
- Figures 3.1-1 and 3.1-2 are the photographs depicting the existing earth station site and satellite arc.
- Figures 3.1-3 through 3.1-10 are the RF spectrum photographs depicting the interference environment at the test site.

**TABLE 3.1-1**

**MEASUREMENT SITE DATA SHEET**

- |   |   |
|---|---|
| 1. SYSTEM NAME:   | ViaSat, Inc   |
| 2. CITY AND STATE:  | Albuquerque, NM   |
| 3. SITE IDENTIFICATION:   | Albuquerque   |
| 4. COORDINATES:<br>(NAD 1983)   | LATITUDE: 35° 5' 37.1" N<br>LONGITUDE: 106° 38' 44.8" W |
| 5. GROUND ELEVATION:  | 4961 feet AMSL  |
| 6. MEASUREMENT DATE AND TIMES:  | November 17, 2014                                       |
| 7. GEOSTATIONARY ARC RANGE:<br>SATELLITE POSITIONS:<br>AZIMUTH:<br>ELEVATION: | 55W – 115W<br>114.5° – 194.3°<br>22.5° / 48.3           |
| 8. GEOSTATIONARY ARC VISIBILITY:  | Satellite arc has no blockage at this time              |



**North**



**East**

Figure 3.1-1 Earth Station Site Photographs





**South**



**West**

**Figure 3.1-1 (cont.) Earth Station Site Photographs**

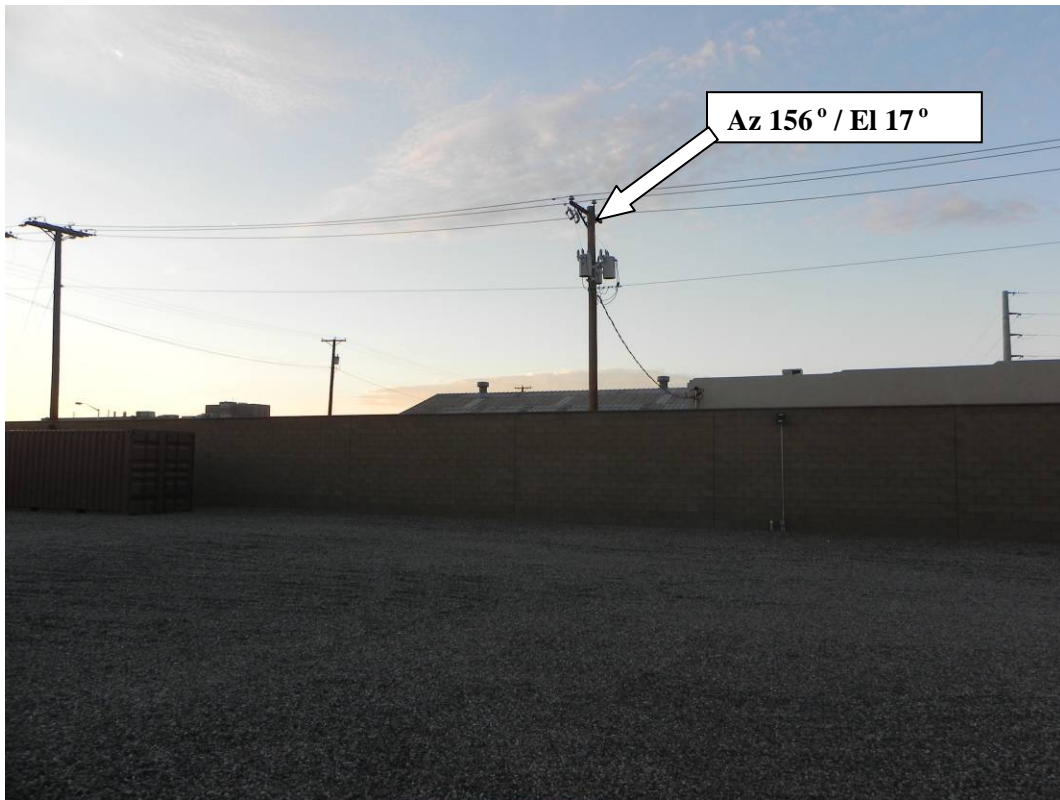


Figure 3.1-2 Horizon Photographs of Earth Station Site

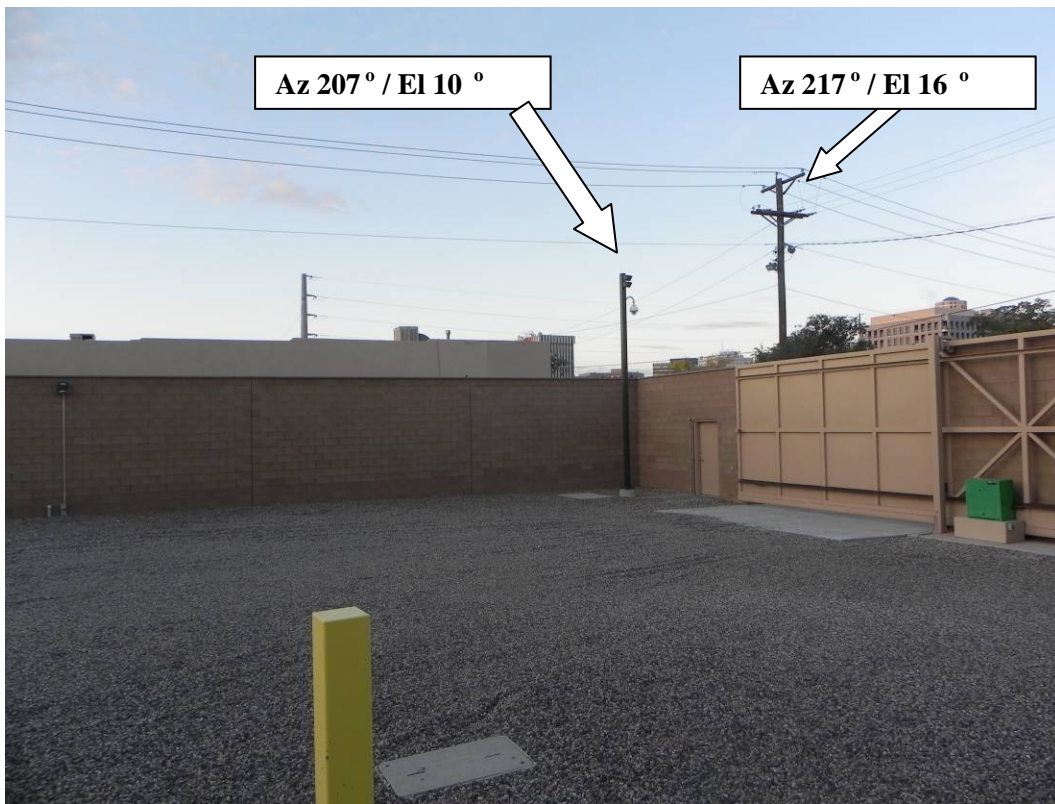
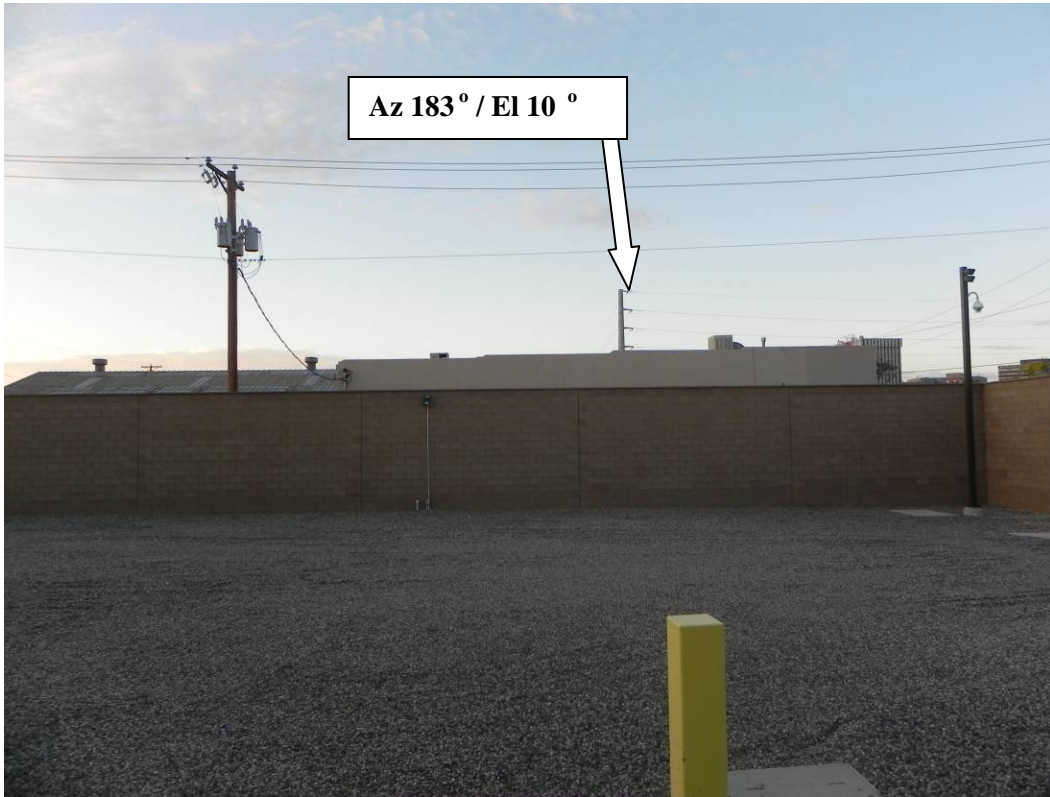


Figure 3.1-2 (cont.) Horizon Photographs of Earth Station Site





Figure 3.1-2 (cont.) Horizon Photographs of Earth Station Site

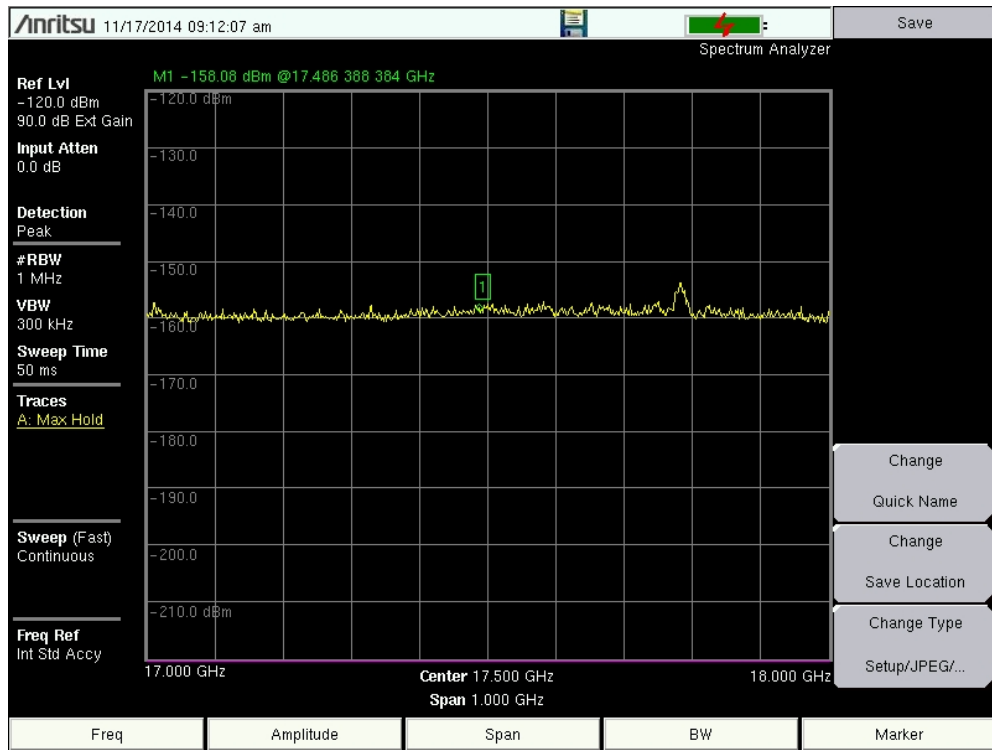


Figure 3.1-3 (A) Spectrum Photos 17-18 GHz 1MHz Res BW Horizontal Pol 360<sup>0</sup>

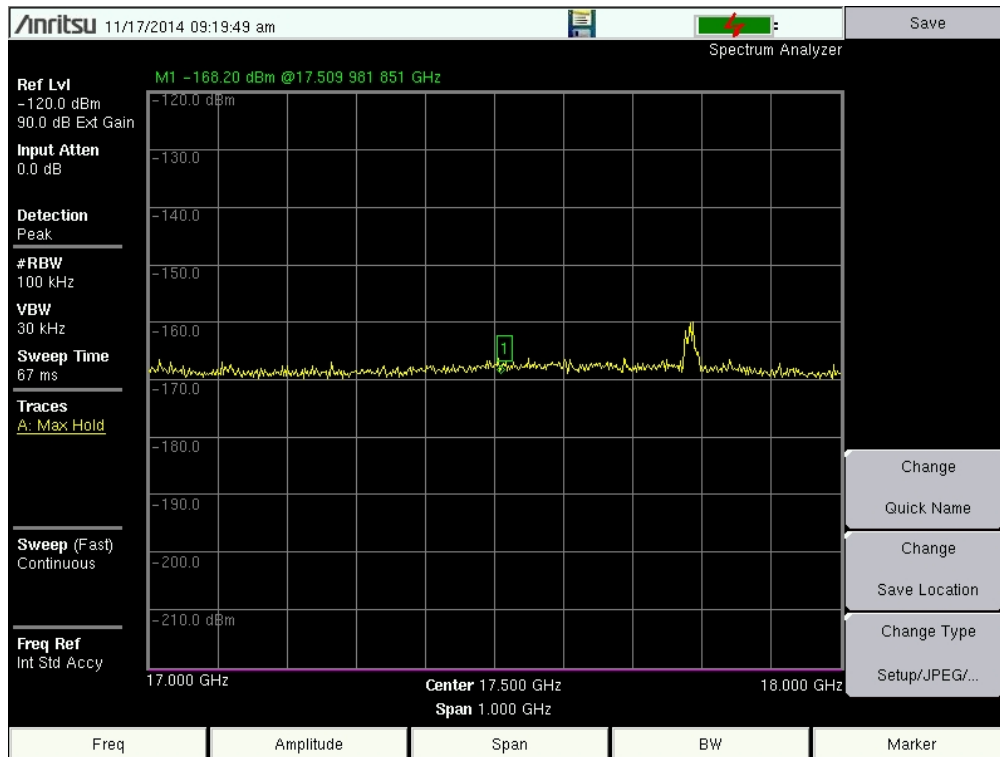


Figure 3.1-3 (B) Spectrum Photos 17-18 GHz 100 KHz Res BW Horizontal Pol 360<sup>0</sup>

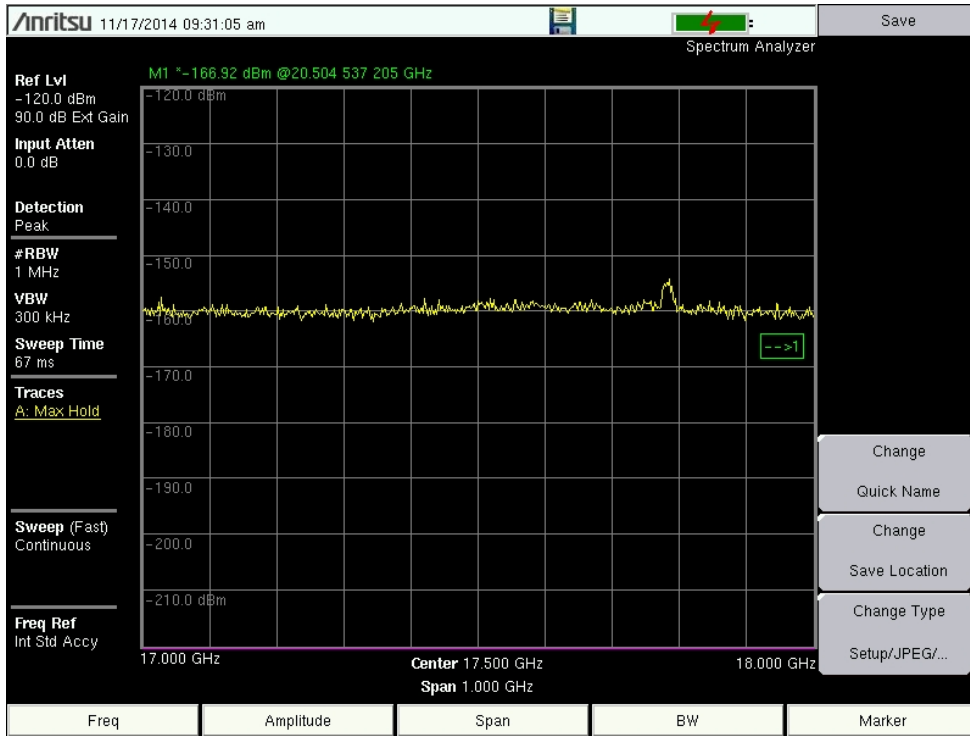


Figure 3.1-3 (C) Spectrum Photos 17-18 GHz 1 MHz Res BW Horizontal Pol Worst Case

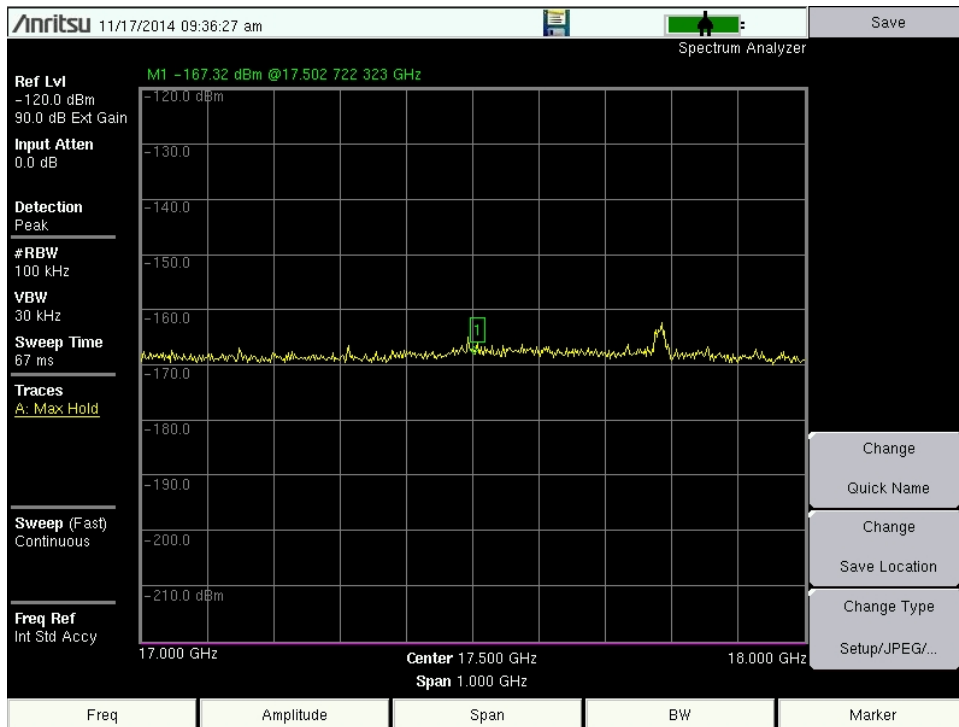


Figure 3.1-3 (D) Spectrum Photos 17-18 GHz 100 KHz Res BW Horizontal Pol Worst Case

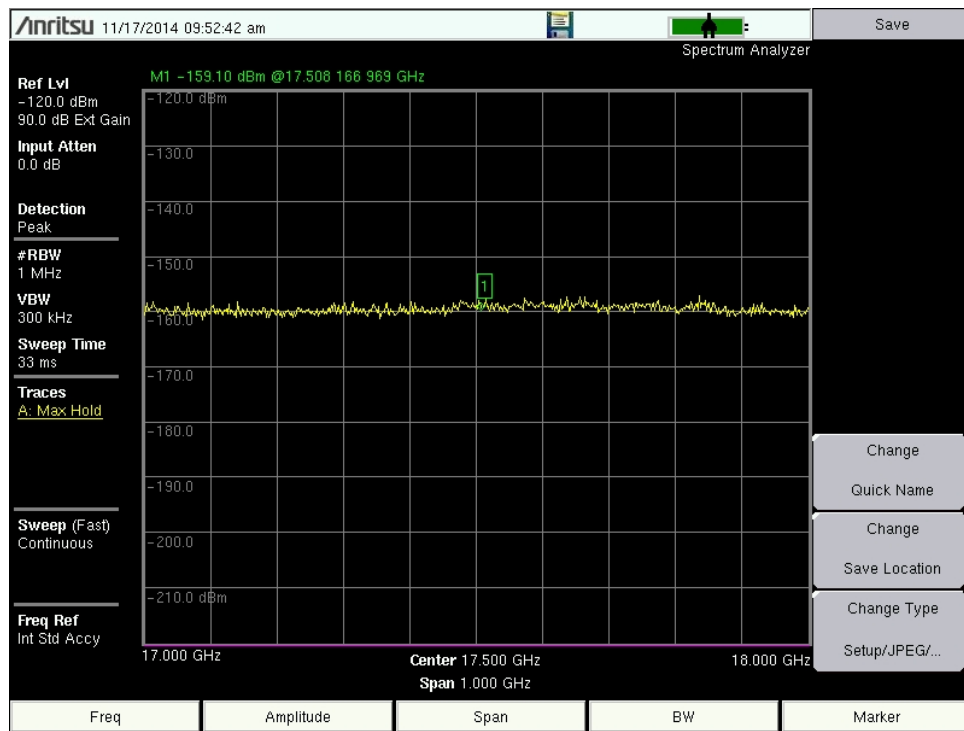


Figure 3.1-3 (E) Spectrum Photos 17-18 GHz 1MHz Res BW Vertical Pol 360<sup>0</sup>

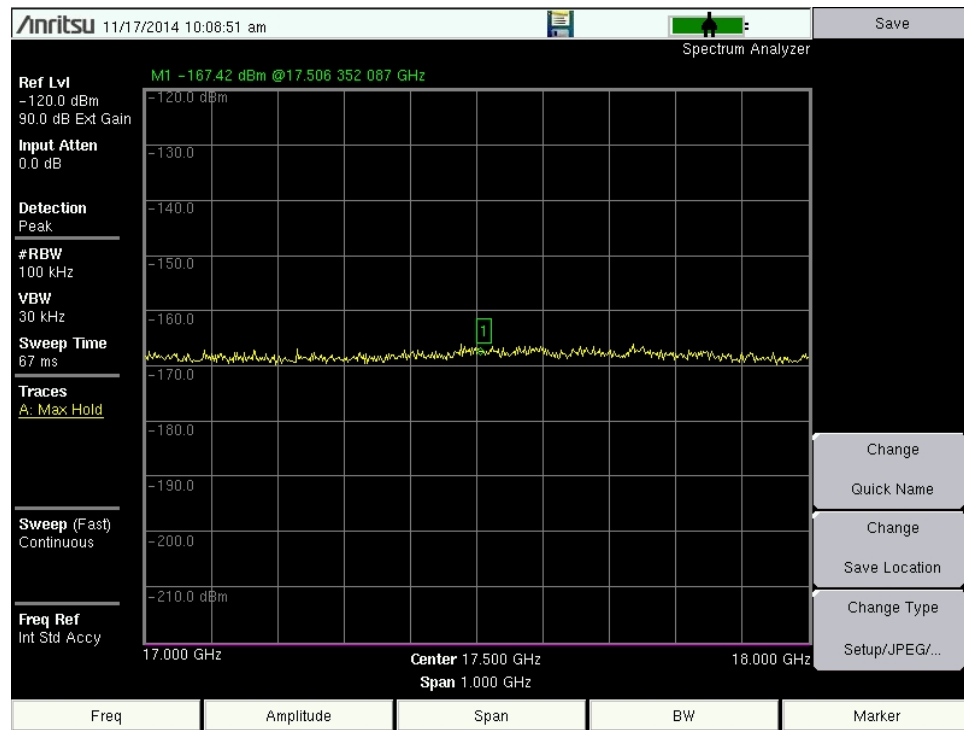


Figure 3.1-3 (F) Spectrum Photos 17-18 GHz 100 KHz Res BW Vertical Pol 360<sup>0</sup>

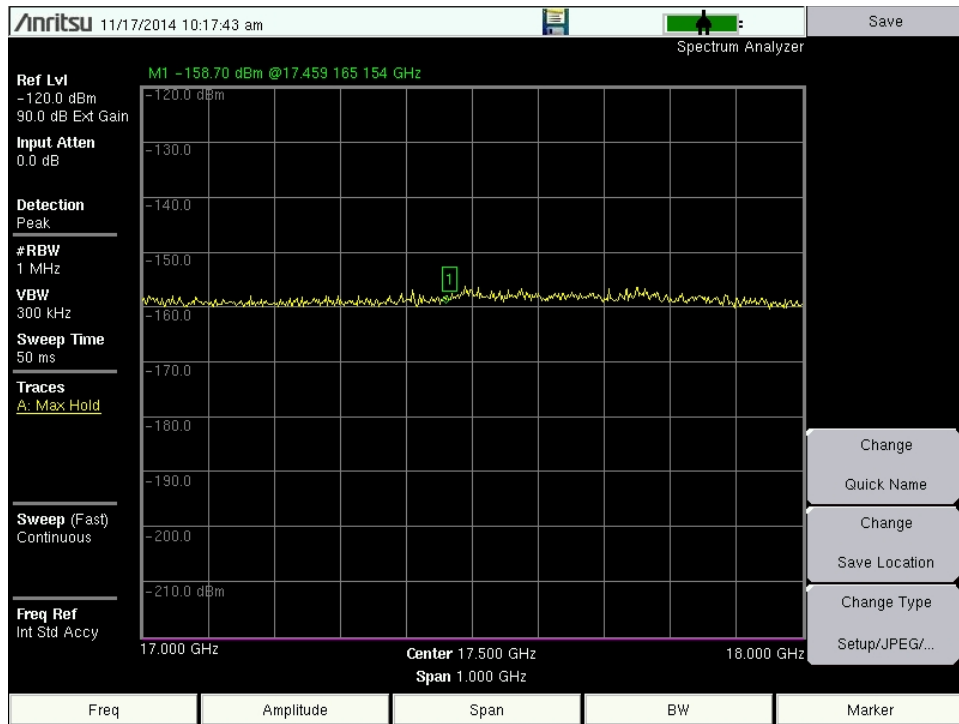


Figure 3.1-3 (G) Spectrum Photos 17-18 GHz 1 MHz Res BW Vertical Pol Worst Case

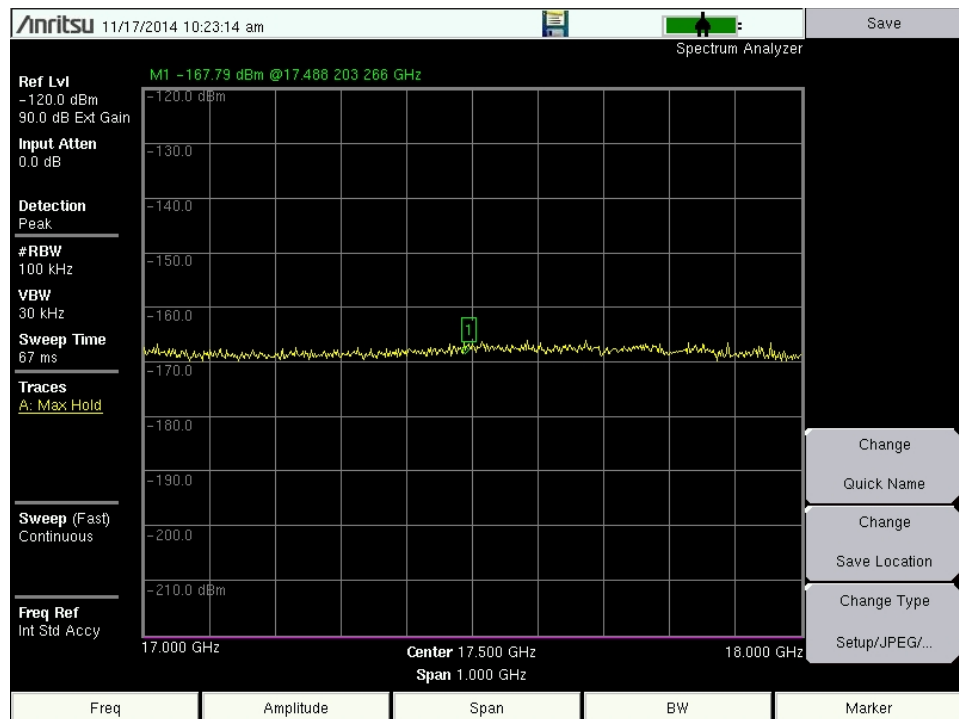


Figure 3.1-3 (H) Spectrum Photos 17-18 GHz 100 KHz Res BW Vertical Pol Worst Case



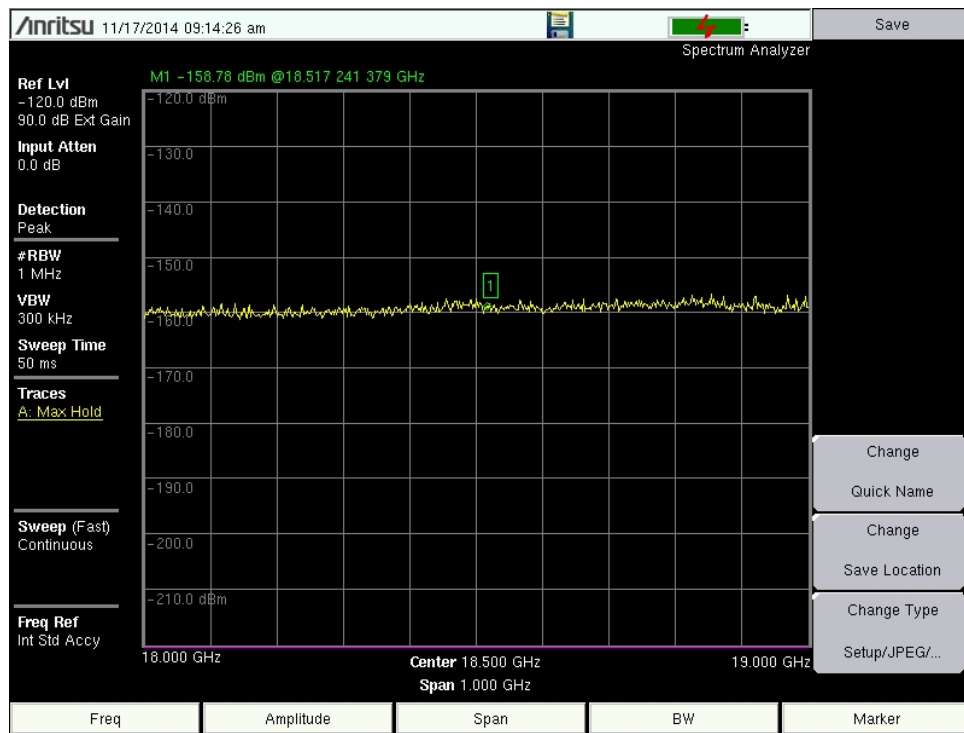


Figure 3.1-4 (A) Spectrum Photos 18-19 GHz 1 MHz Res BW Horizontal Pol 360<sup>0</sup>

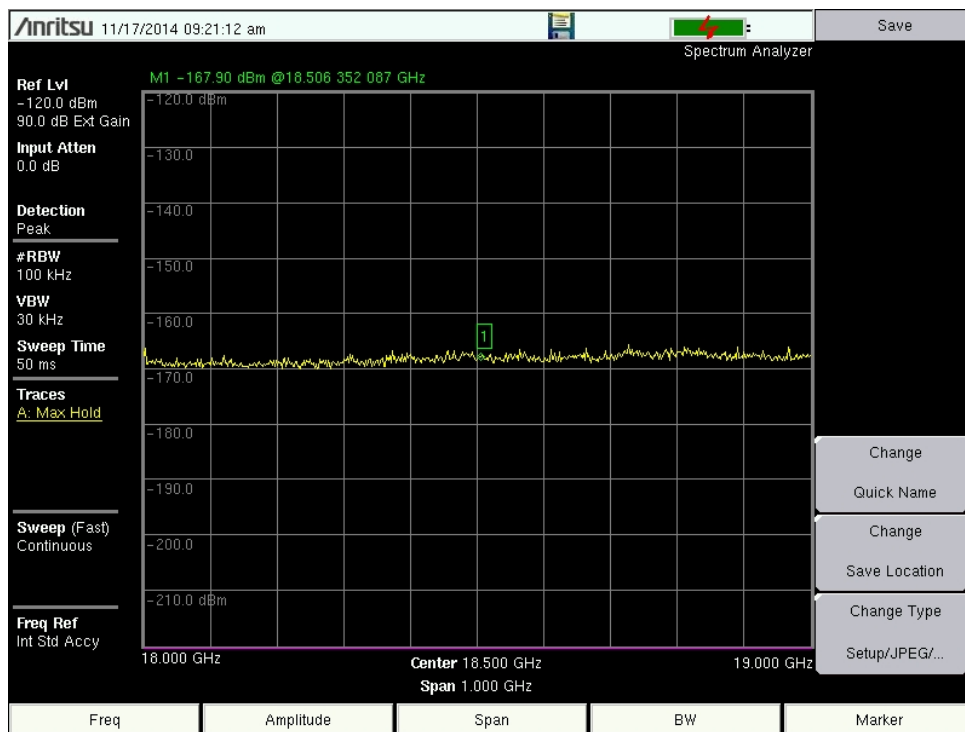


Figure 3.1-4 (B) Spectrum Photos 18-19 GHz 100 KHz Res BW Horizontal Pol 360<sup>0</sup>

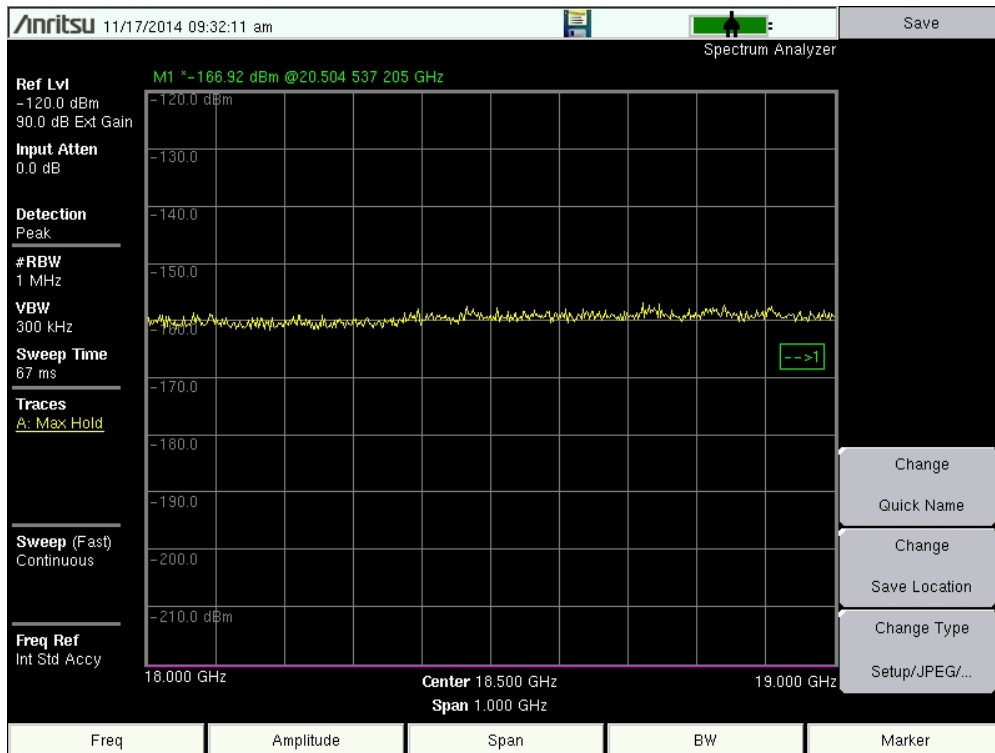


Figure 3.1-4 (C) Spectrum Photos 18-19 GHz 1 MHz Res BW Horizontal Pol Worst Case

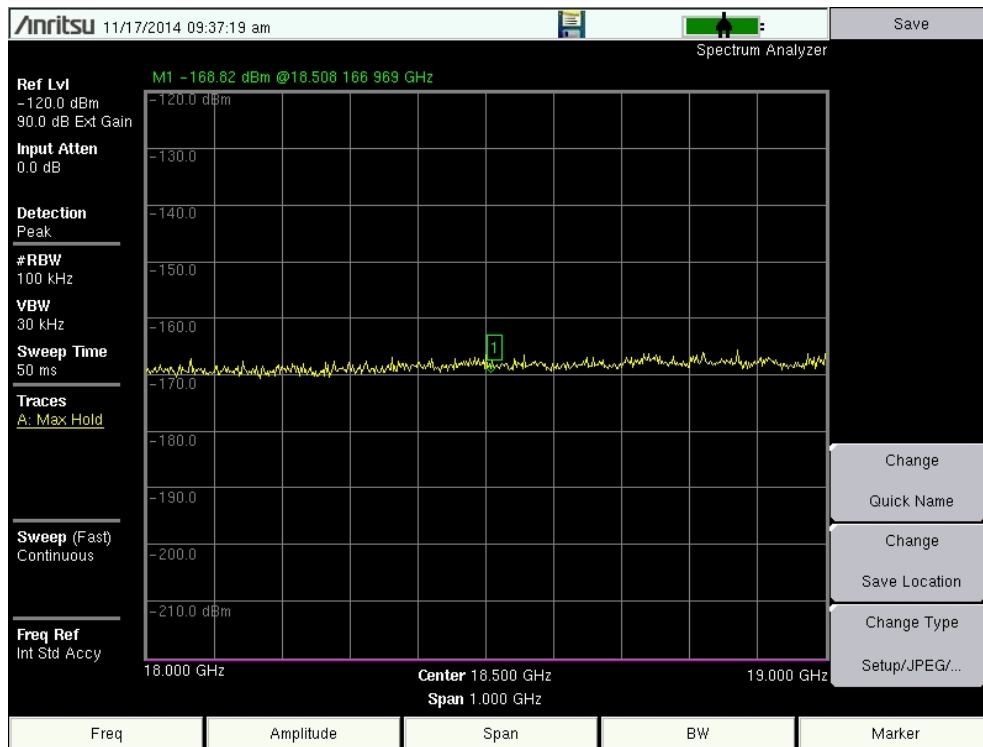


Figure 3.1-4 (D) Spectrum Photos 18-19 GHz 100 KHz Res BW Horizontal Pol Worst Case

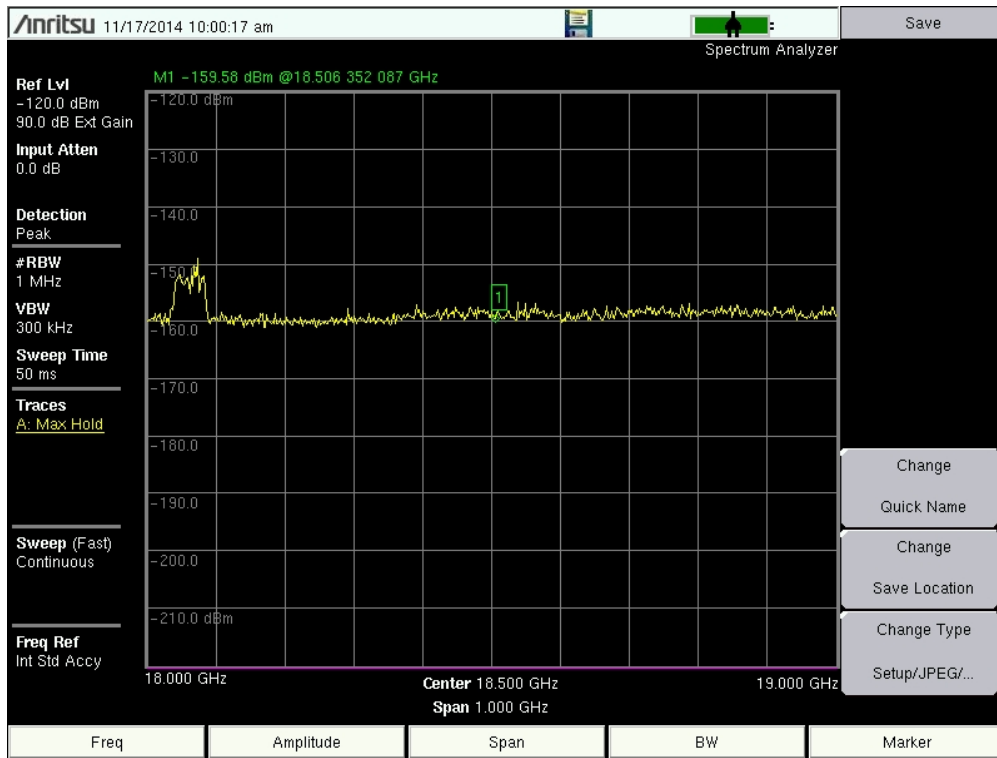


Figure 3.1-4 (E) Spectrum Photos 18-19 GHz 1 MHz Res BW Vertical Pol 360<sup>0</sup>

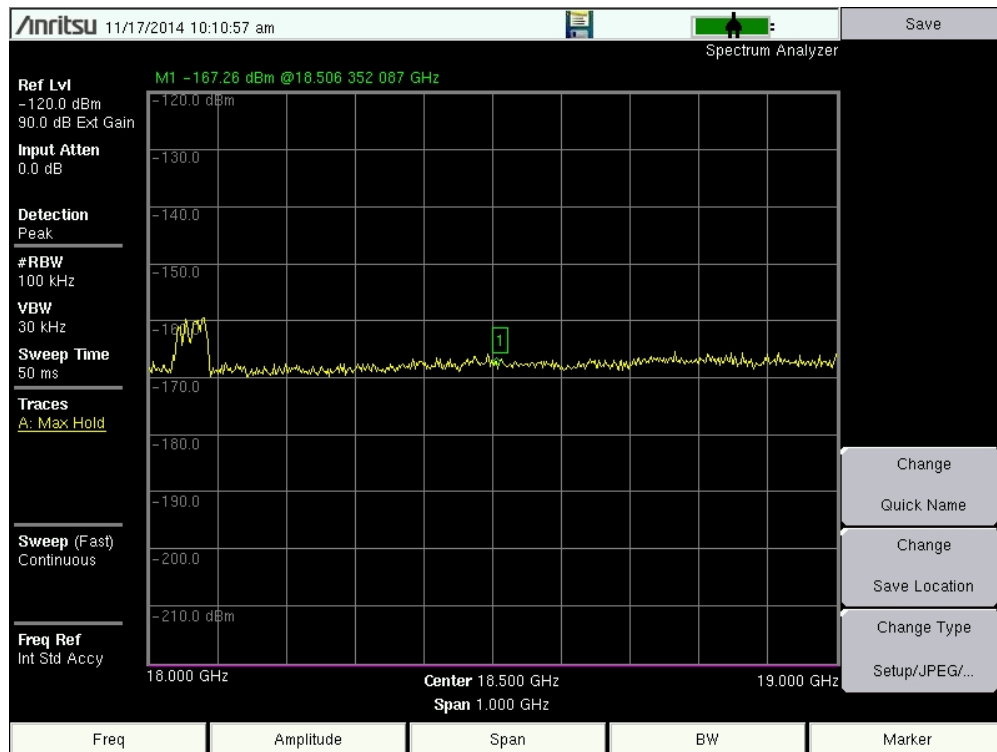


Figure 3.1-4 (F) Spectrum Photos 18-19 GHz 100 KHz Res BW Vertical Pol 360<sup>0</sup>

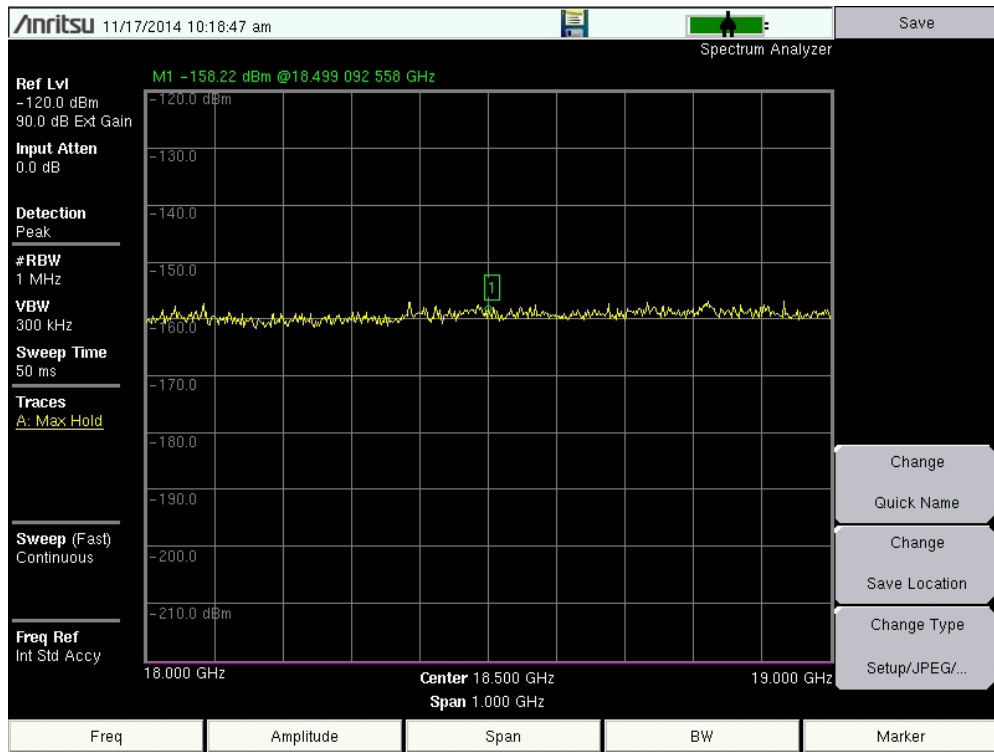


Figure 3.1-5 (G) Spectrum Photos 18-19 GHz 1 MHz Res BW Vertical Pol Worst Case

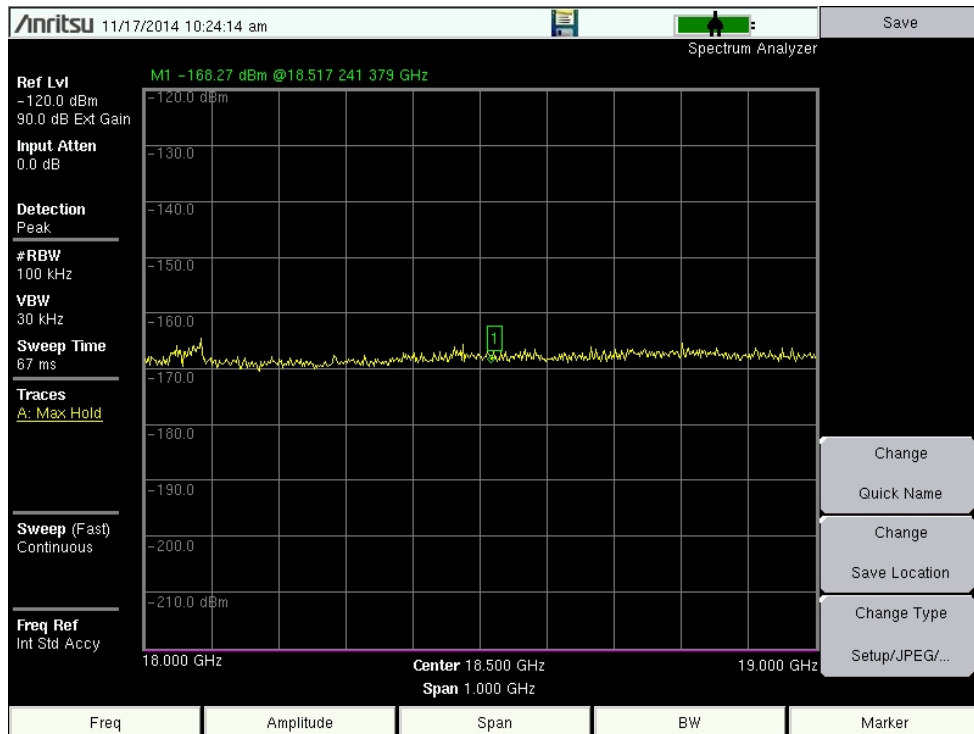


Figure 3.1-4 (H) Spectrum Photos 18-19 GHz 100 KHz Res BW Vertical Worst Case

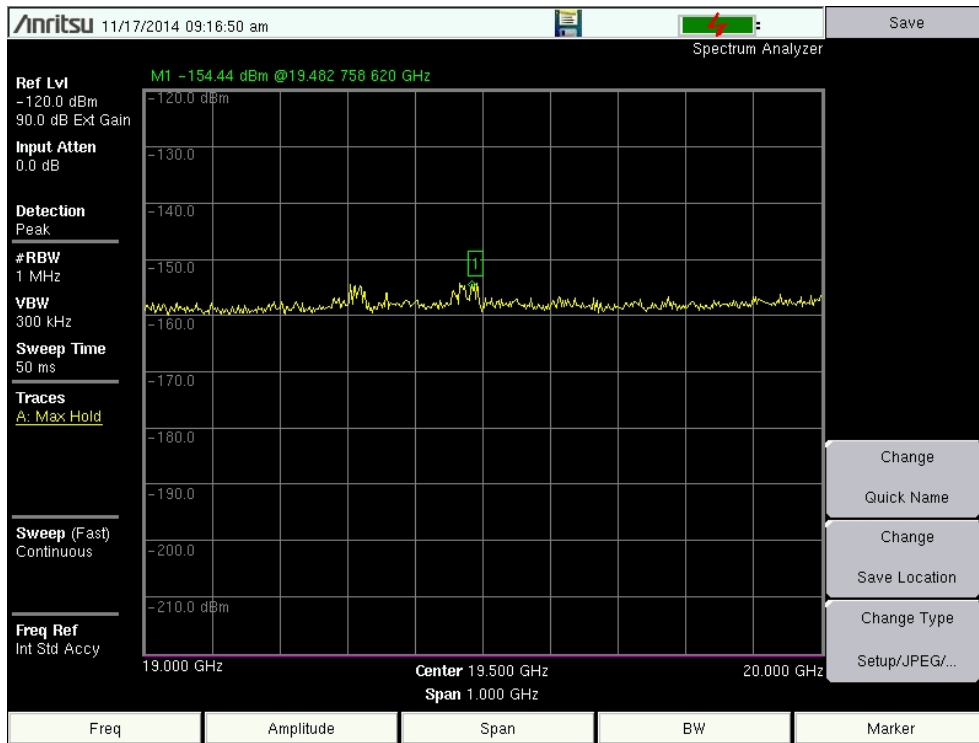


Figure 3.1-5 (A) Spectrum Photos 19-20 GHz 100 KHz Res BW Vertical Pol 360<sup>0</sup>

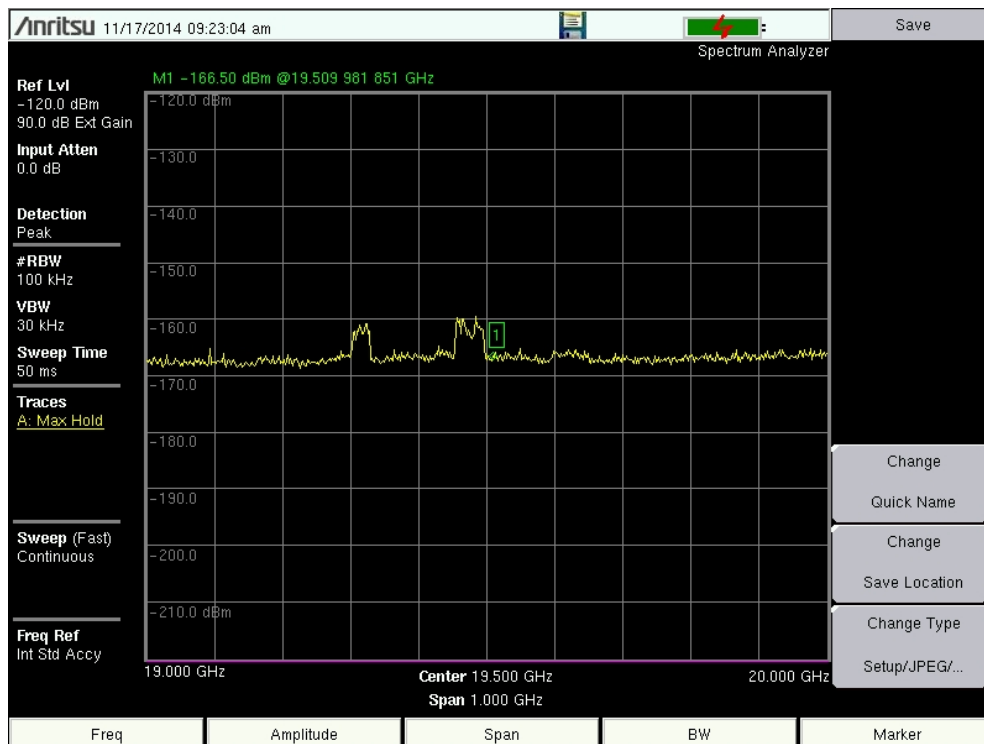


Figure 3.1-5 (B) Spectrum Photos 19-20 GHz 100 KHz Res BW Horizontal Pol 360<sup>0</sup>

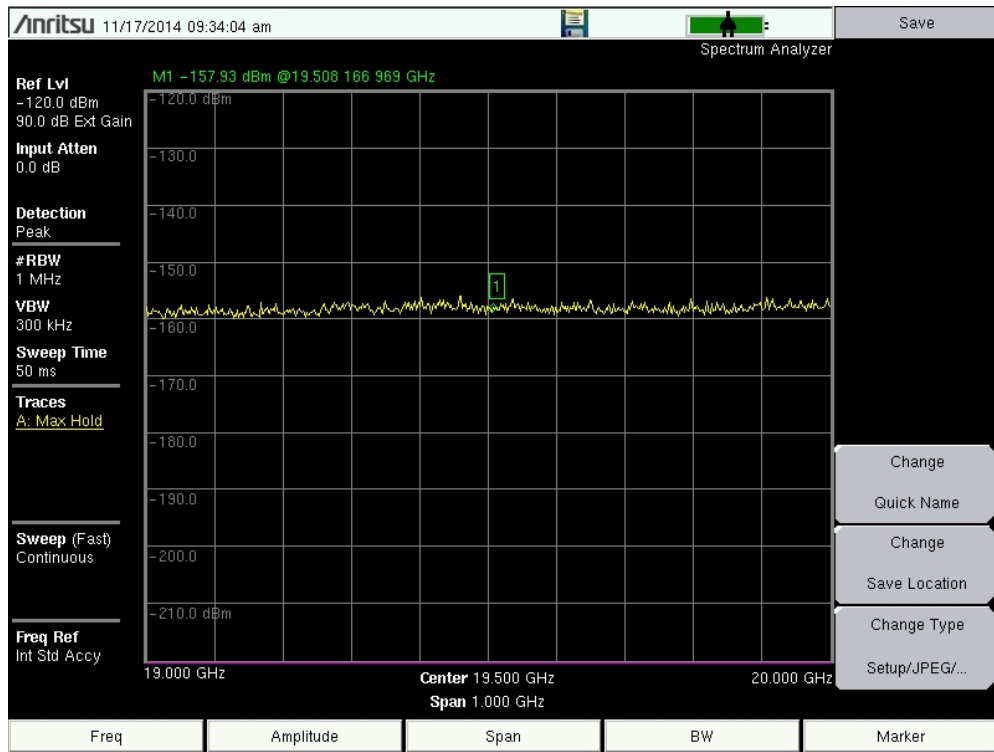


Figure 3.1-5 (C) Spectrum Photos 19-20 GHz 1 MHz Res BW Horizontal Pol Worst Case

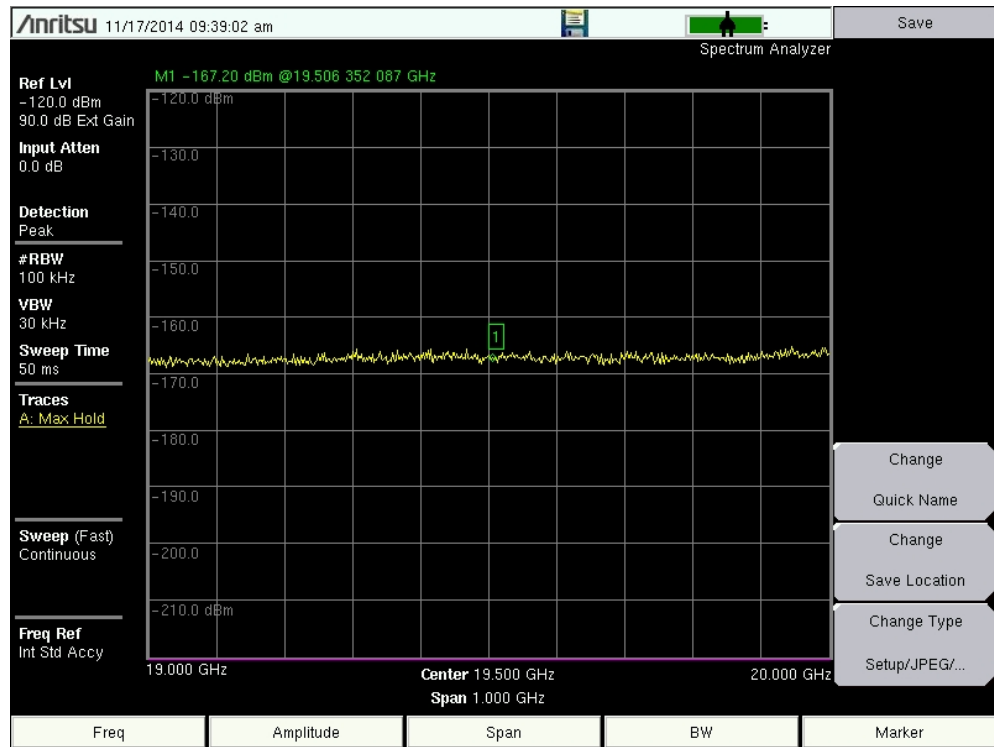


Figure 3.1-5 (D) Spectrum Photos 19-20 GHz 100 kHz Res BW Horizontal Pol Worst Case

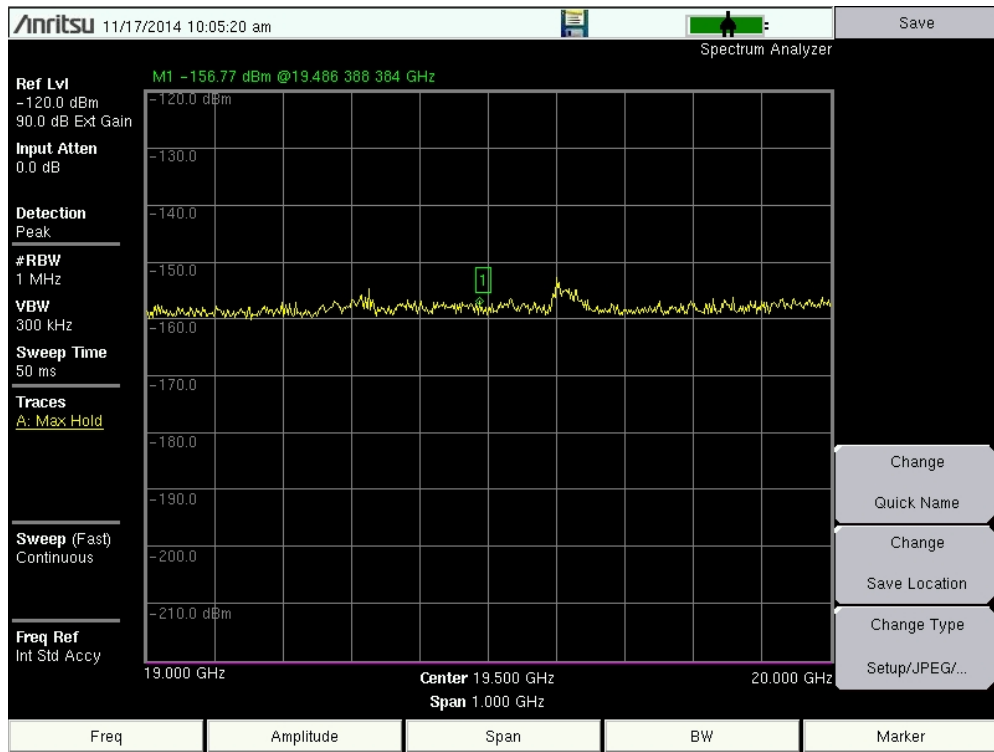


Figure 3.1-5 (E) Spectrum Photos 19-20 GHz 1MHz Res BW Vertical Pol 360<sup>0</sup>

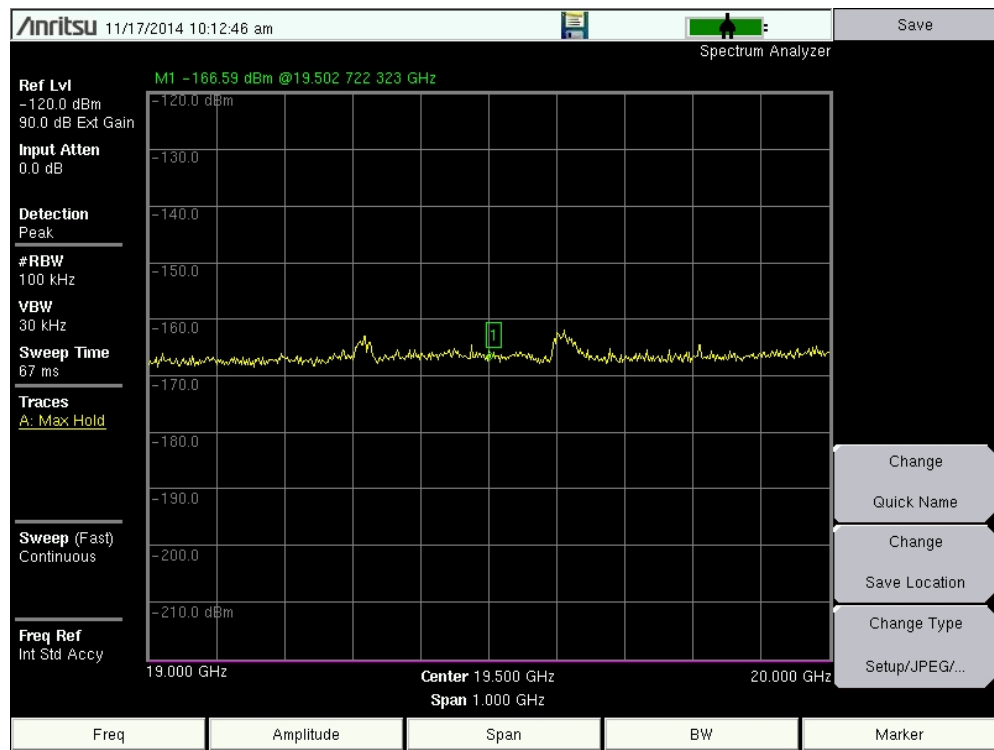


Figure 3.1-5 (F) Spectrum Photos 19-20 GHz 100 KHz Res BW Vertical Pol 360<sup>0</sup>

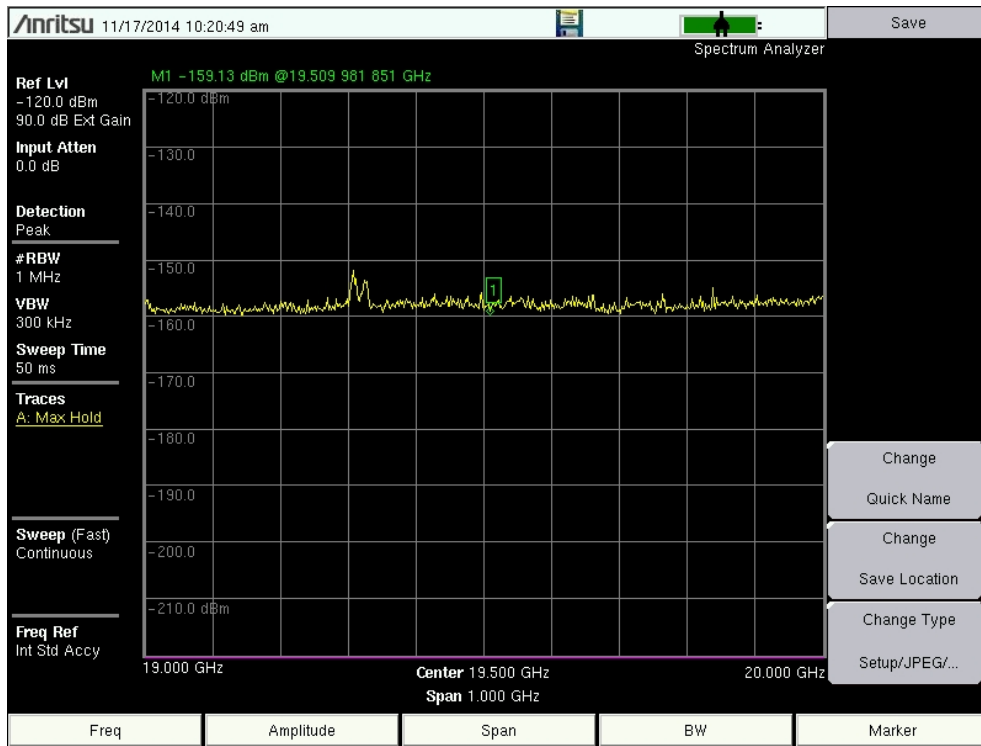


Figure 3.1-5 (G) Spectrum Photos 19-20 GHz 1MHz Res BW Vertical Pol Worst Case

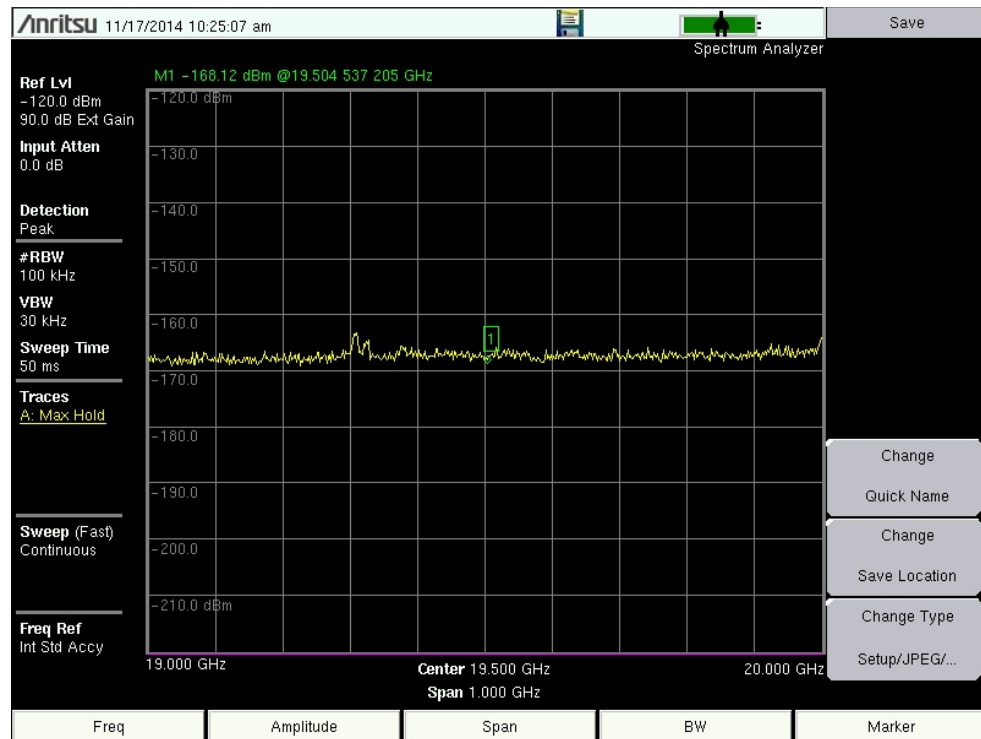


Figure 3.1-5 (H) Spectrum Photos 19-20 GHz 100 KHz Res BW Vertical Pol Worst Case



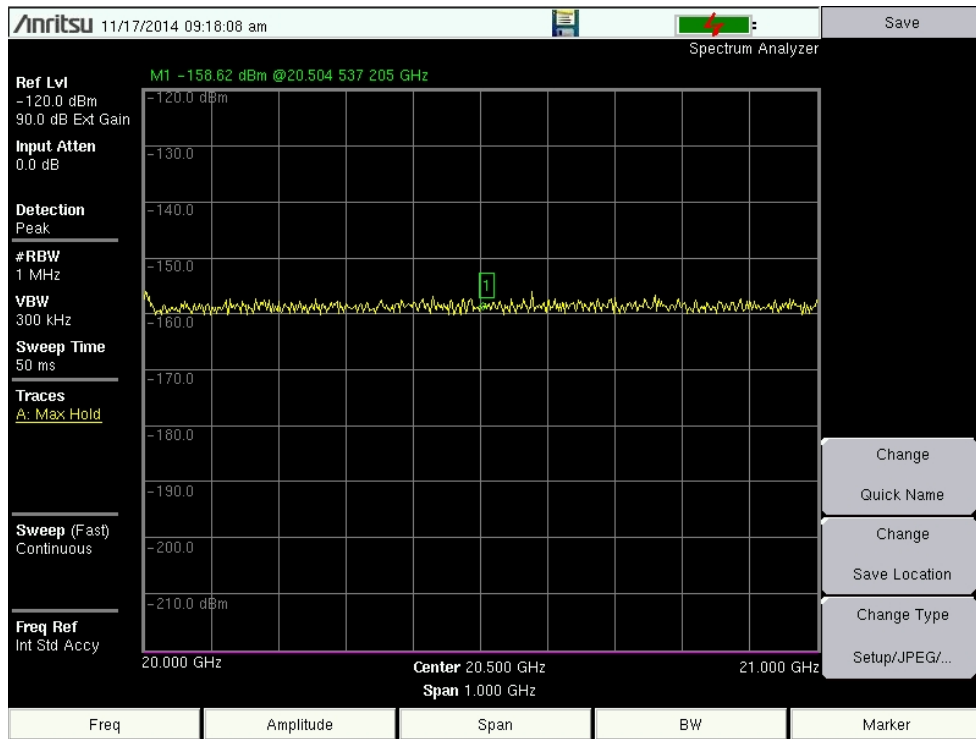


Figure 3.1-6 (A) Spectrum Photos 20-21 GHz 1MHz Res BW Horizontal Pol 360<sup>0</sup>

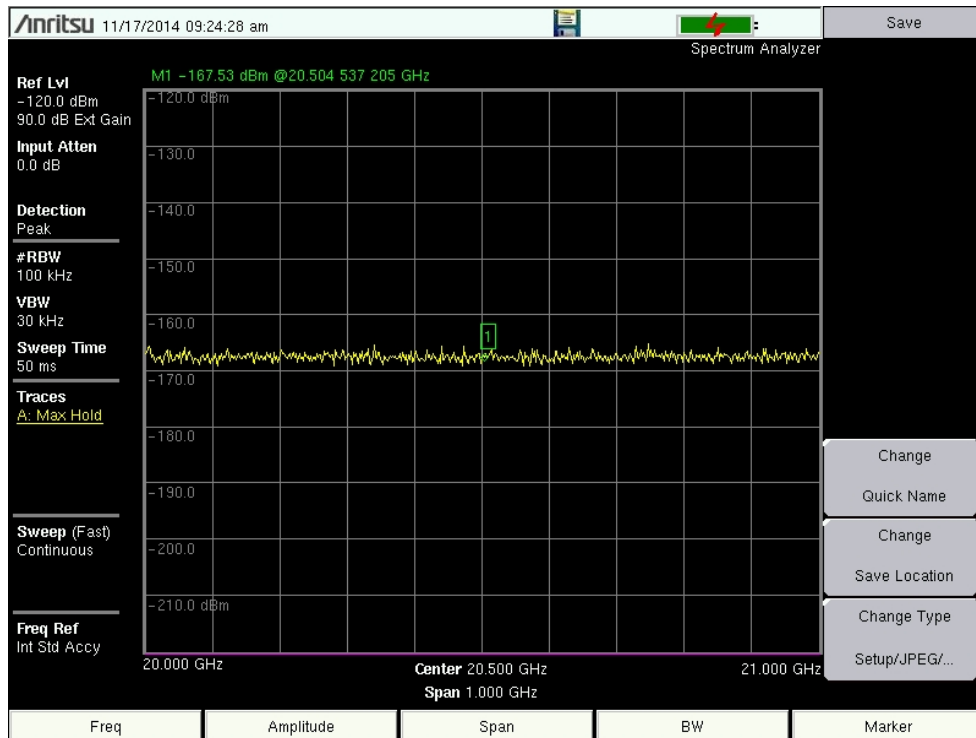


Figure 3.1-6 (B) Spectrum Photos 20-21 GHz 100 KHz Res BW Horizontal Pol 360<sup>0</sup>

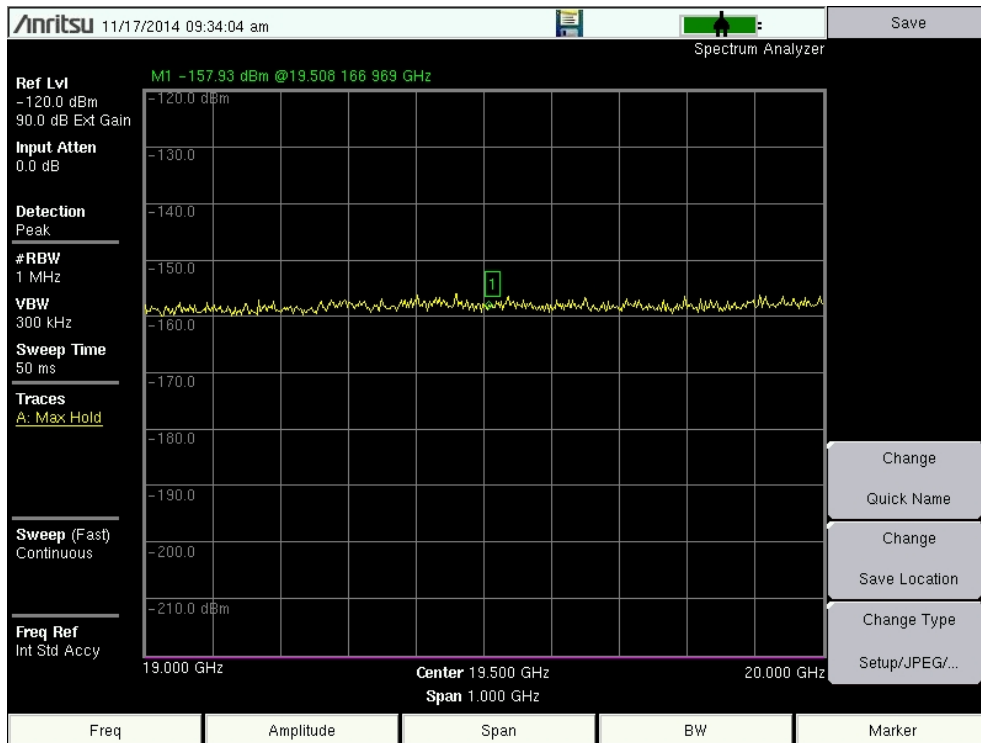


Figure 3.1-6 (C) Spectrum Photos 20-21 GHz 1 MHz Res BW Horizontal Pol Worst Case

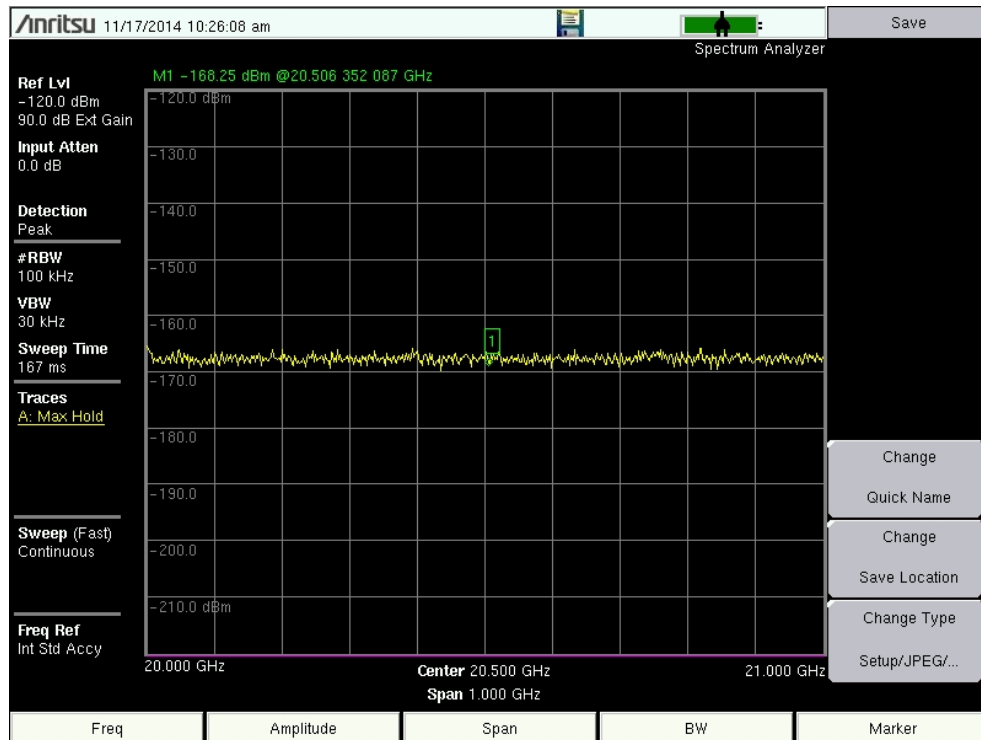


Figure 3.1-6 (D) Spectrum Photos 20-21 GHz 100 KHz Res BW Horizontal Pol Worst Case

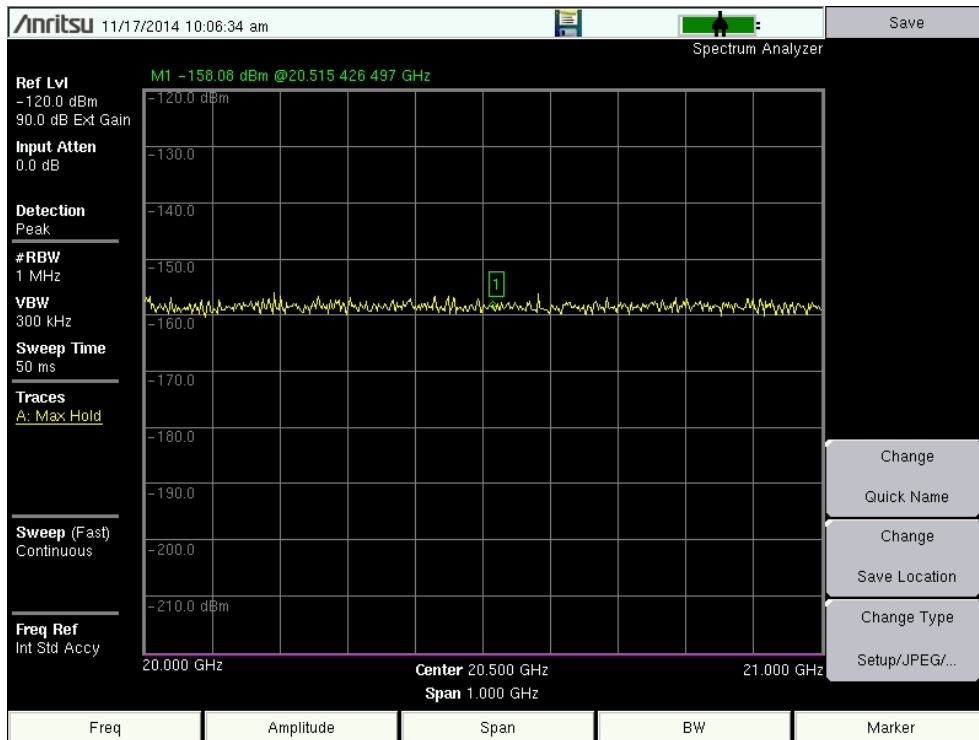


Figure 3.1-6 (E) Spectrum Photos 20-21 GHz 1MHz Res BW Vertical Pol 360<sup>0</sup>

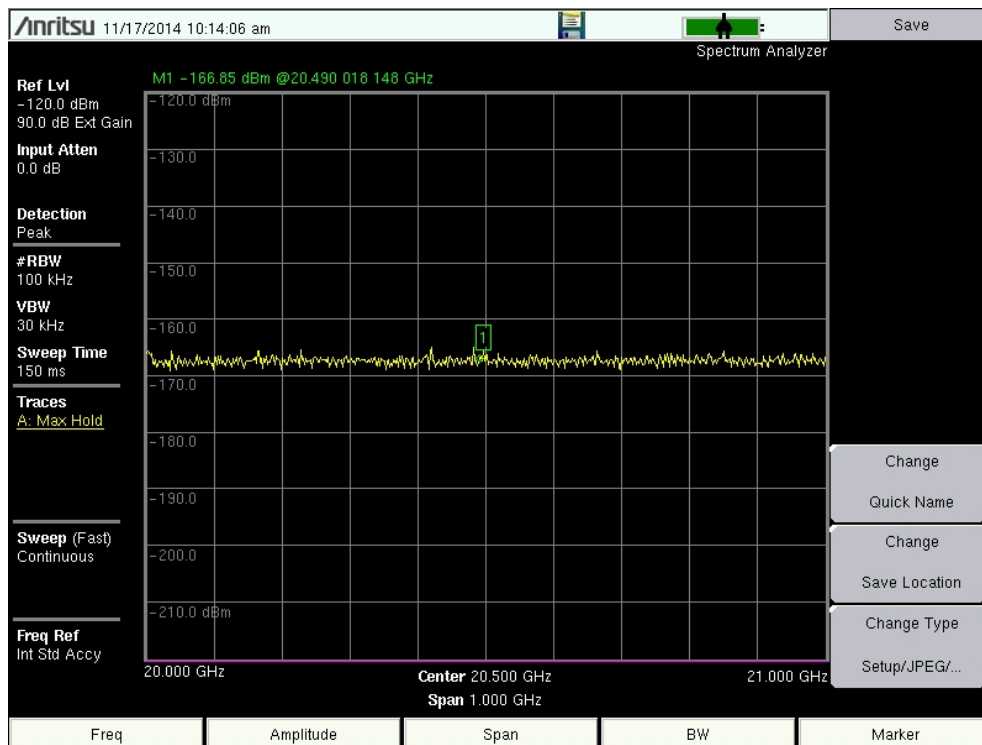


Figure 3.1-6 (F) Spectrum Photos 20-21 GHz 100 KHz Res BW Vertical Pol 360<sup>0</sup>

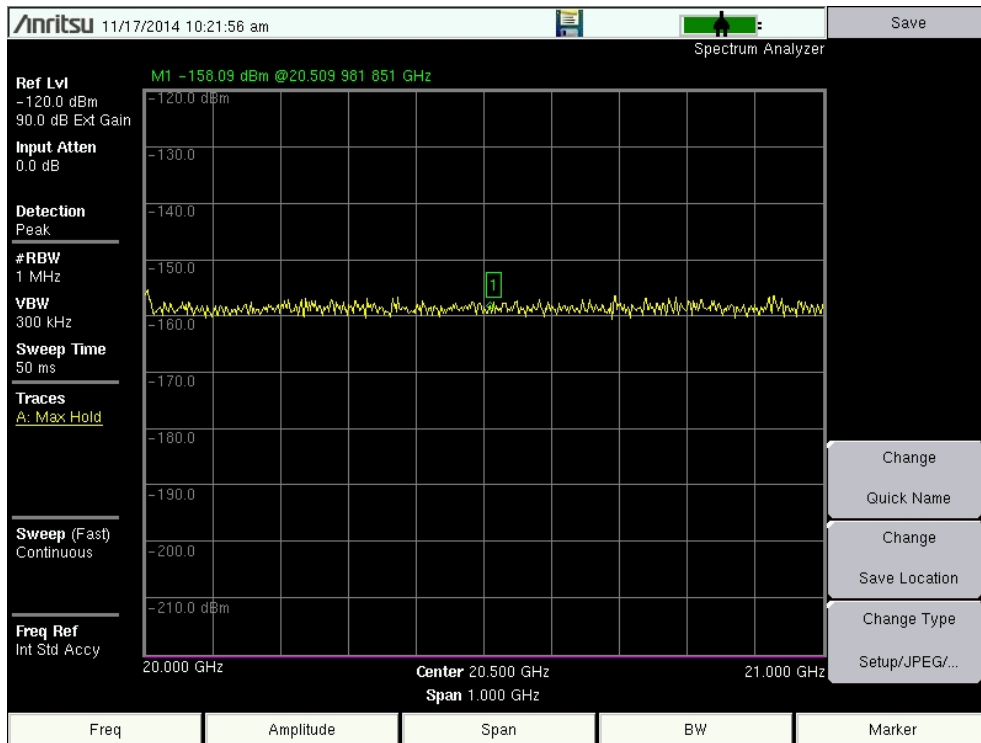


Figure 3.1-6 (G) Spectrum Photos 20-21 GHz 1MHz Res BW Vertical Pol Worst Case

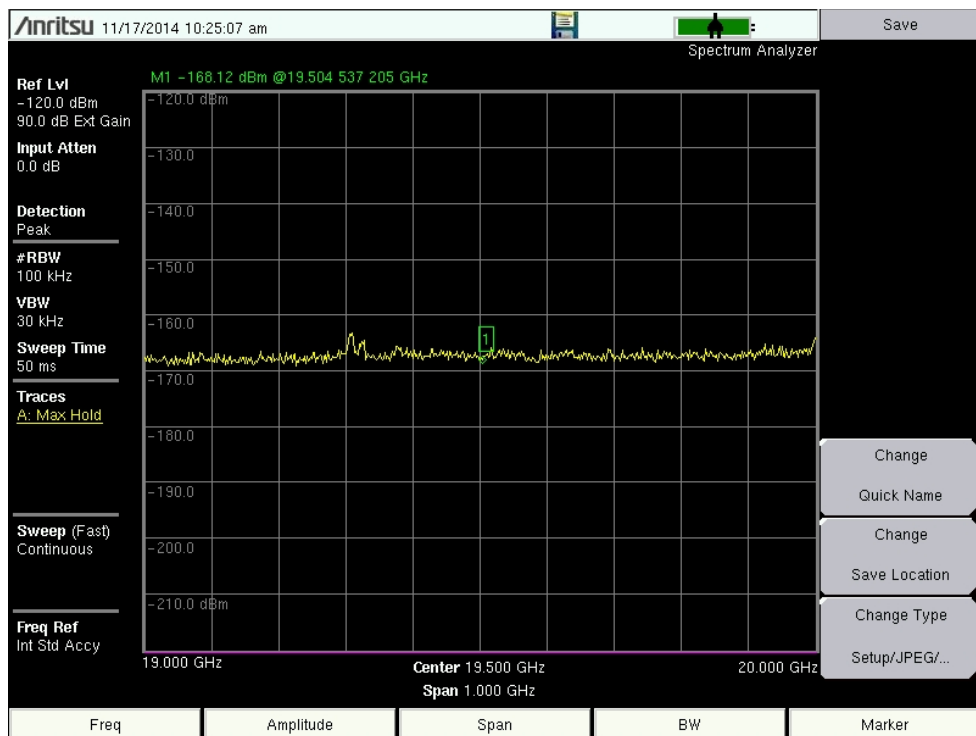


Figure 3.1-6 (H) Spectrum Photos 20-21 GHz 100 KHz Res BW Vertical Pol Worst Case

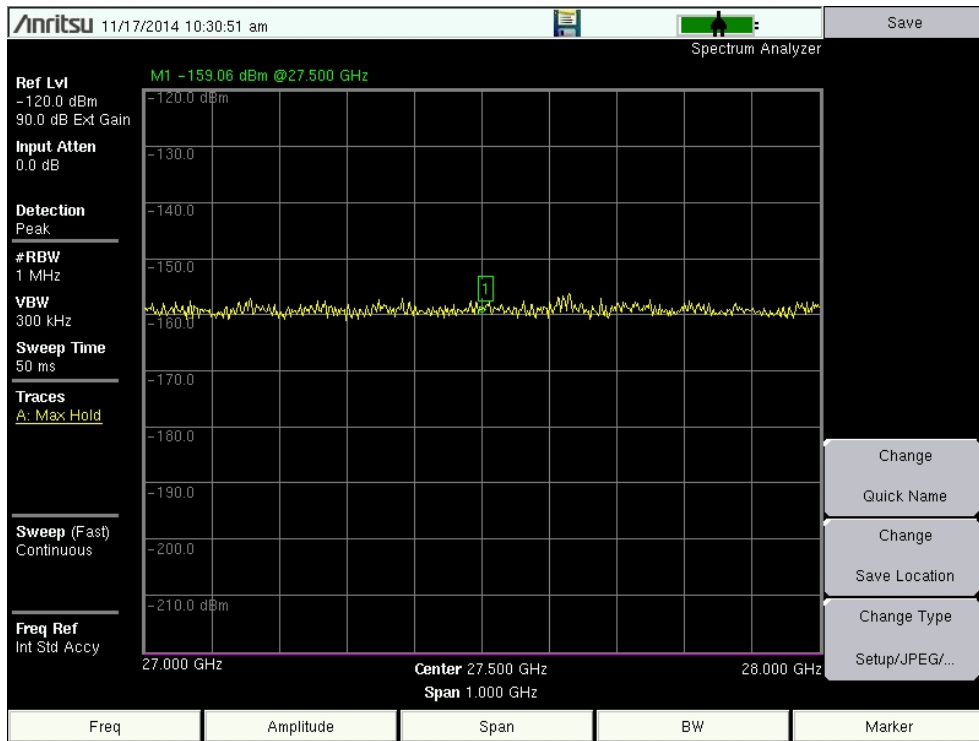


Figure 3.1-7 (A) Spectrum Photos 27-28 GHz 1MHz Res BW Horizontal Pol 360<sup>0</sup>

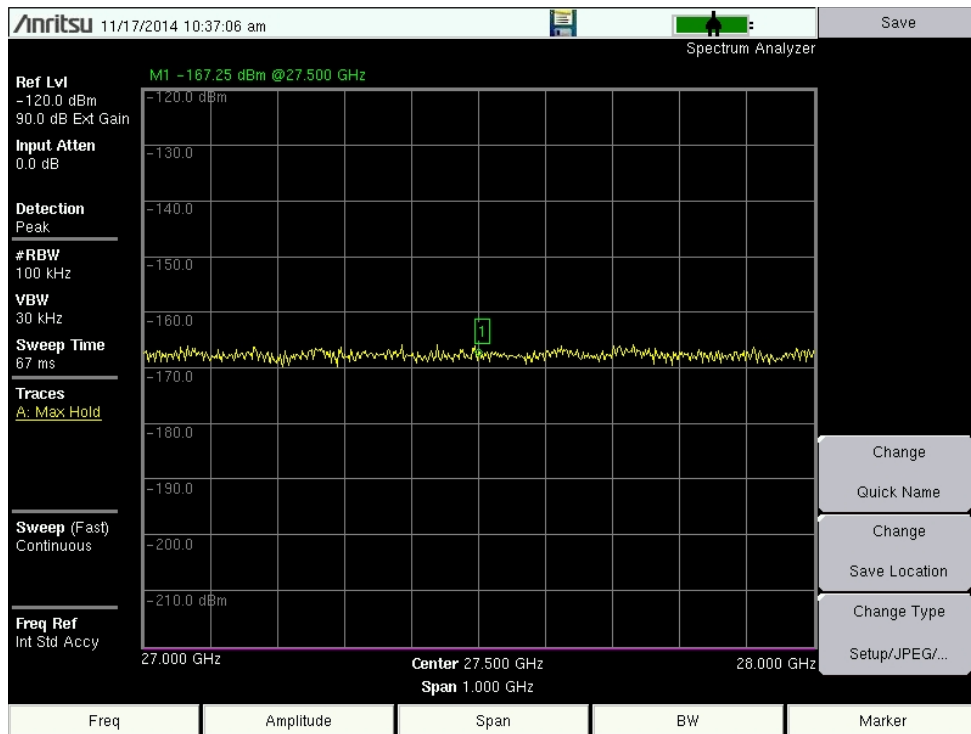


Figure 3.1-7 (B) Spectrum Photos 27-28 GHz 100 KHz Res BW Horizontal Pol 360<sup>0</sup>

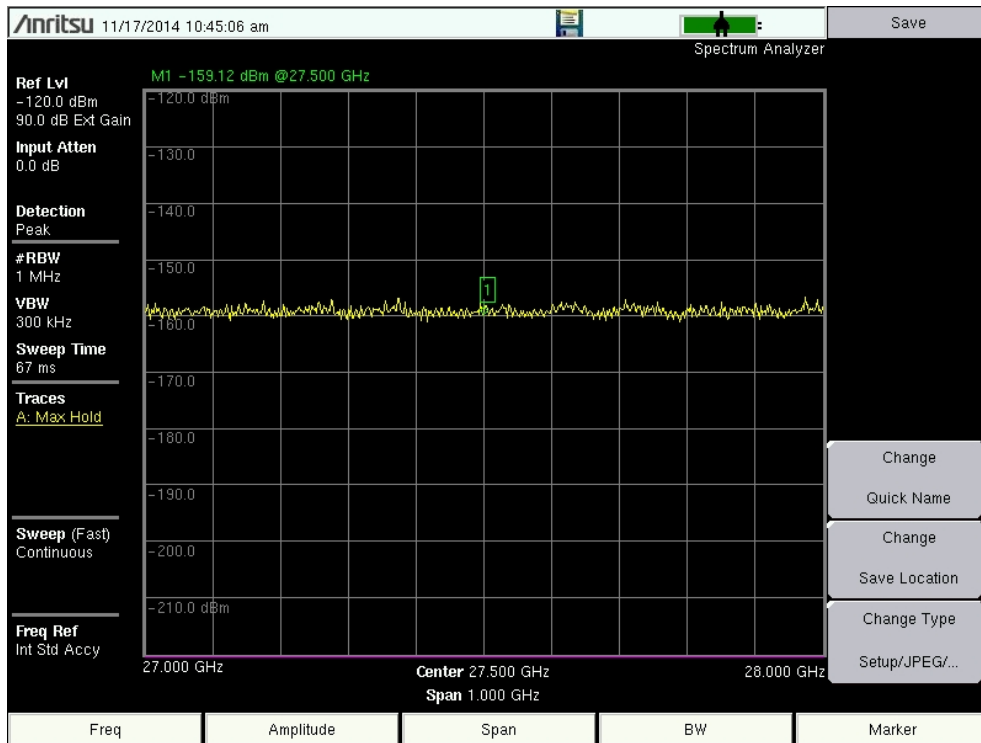


Figure 3.1-7 (C) Spectrum Photos 27-28 GHz 1MHz Res BW Vertical Pol 360<sup>0</sup>

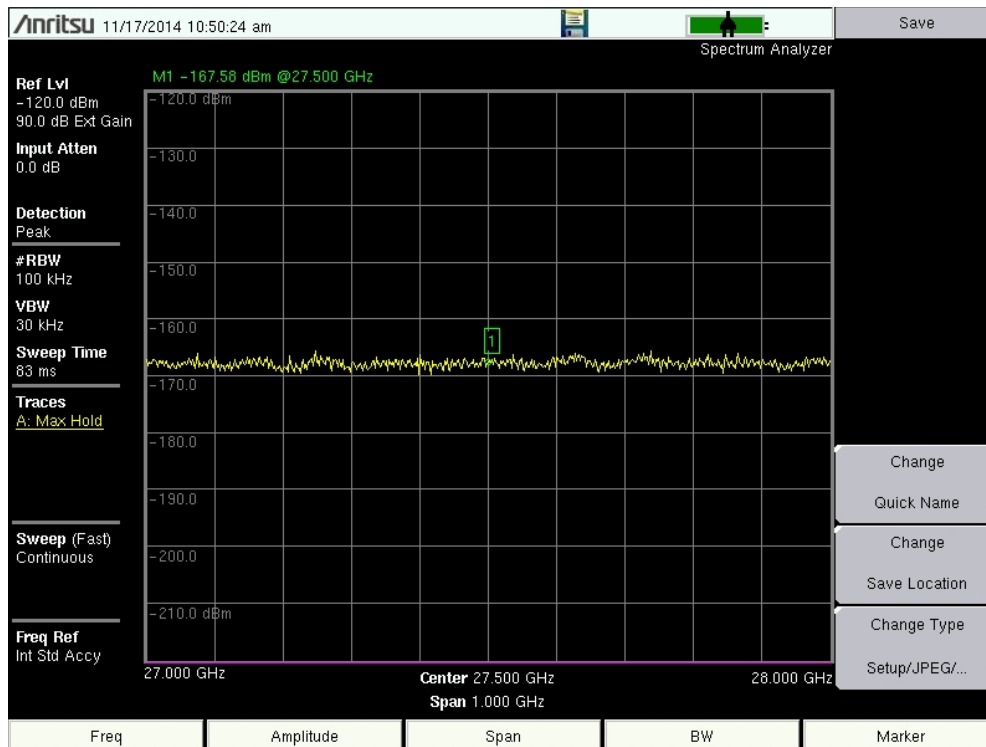


Figure 3.1-7 (D) Spectrum Photos 27-28 GHz 100 KHz Res BW Vertical Pol 360<sup>0</sup>

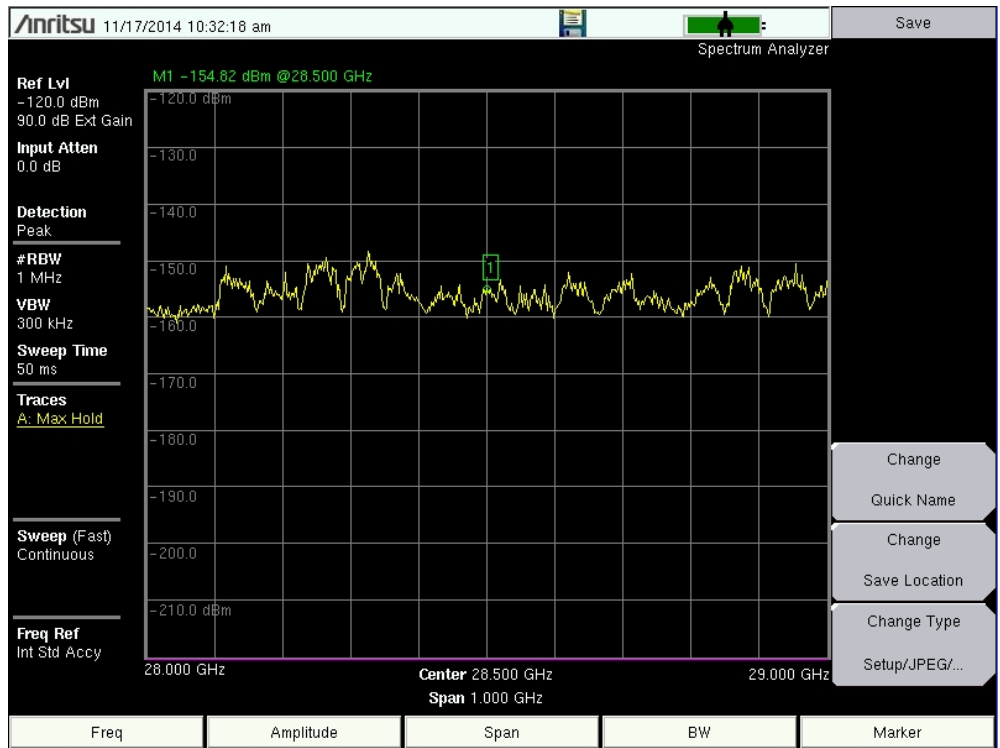


Figure 3.1-8 (A) Spectrum Photos 28-29 GHz 1MHz Res BW Horizontal Pol 360<sup>0</sup>

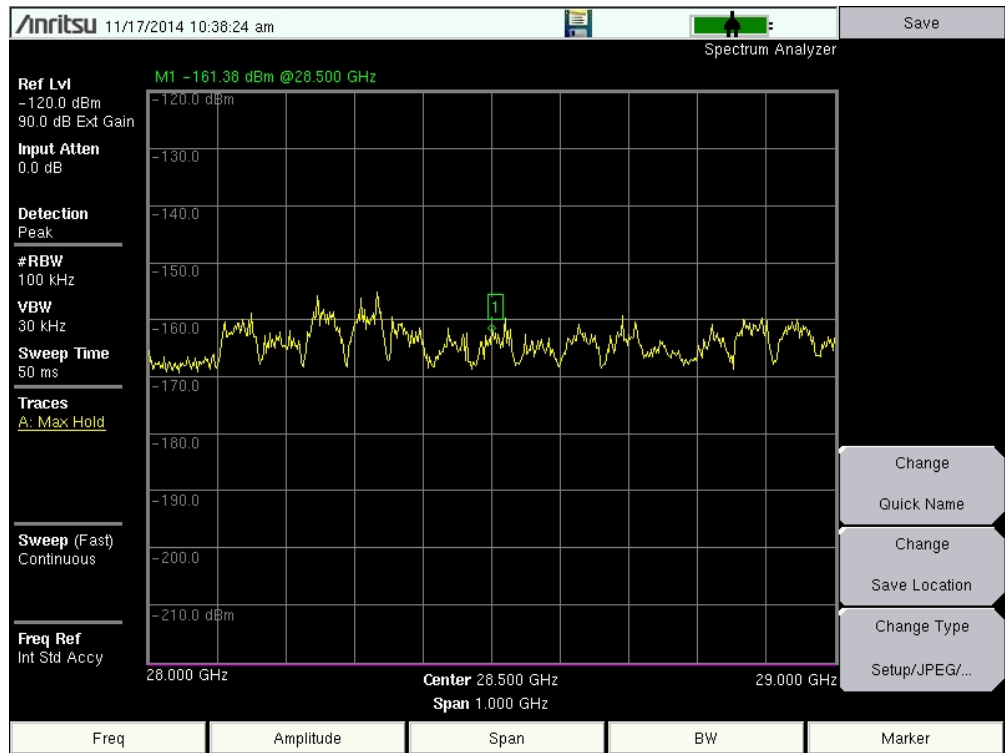


Figure 3.1-8 (B) Spectrum Photos 28-29 GHz 100 KHz Res BW Horizontal Pol 360<sup>0</sup>



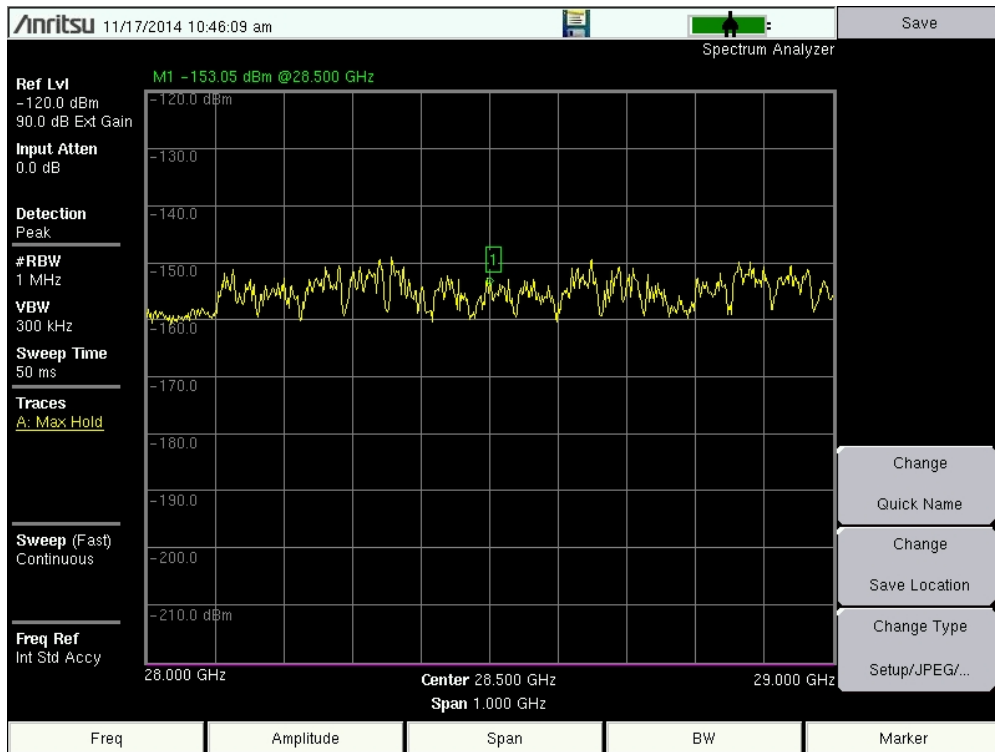


Figure 3.1-8 (C) Spectrum Photos 28-29 GHz 1MHz Res BW Vertical Pol 360<sup>0</sup>

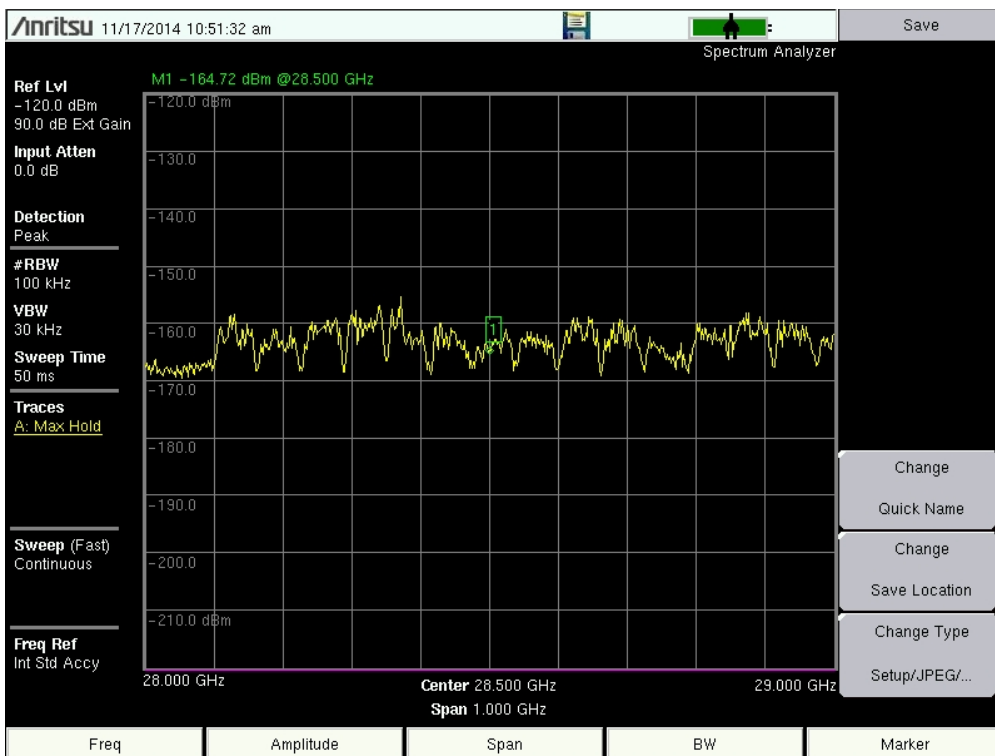


Figure 3.1-8 (D) Spectrum Photos 28-29 GHz 100 KHz Res BW Vertical Pol 360<sup>0</sup>

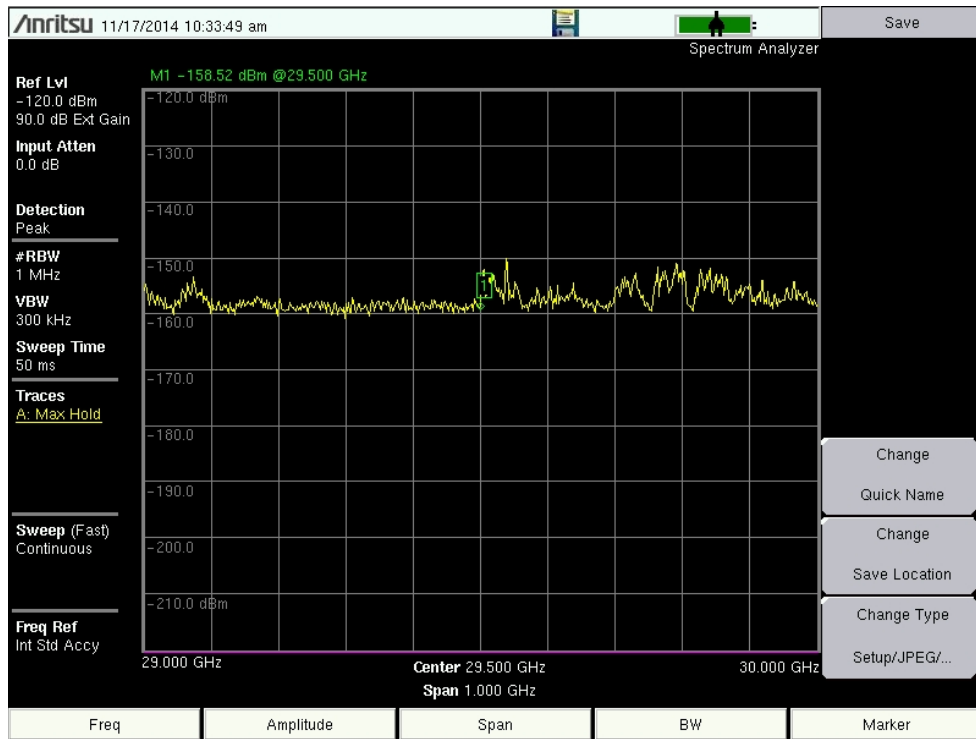


Figure 3.1-9 (A) Spectrum Photos 29-30 GHz 1MHz Res BW Horizontal Pol 360<sup>0</sup>

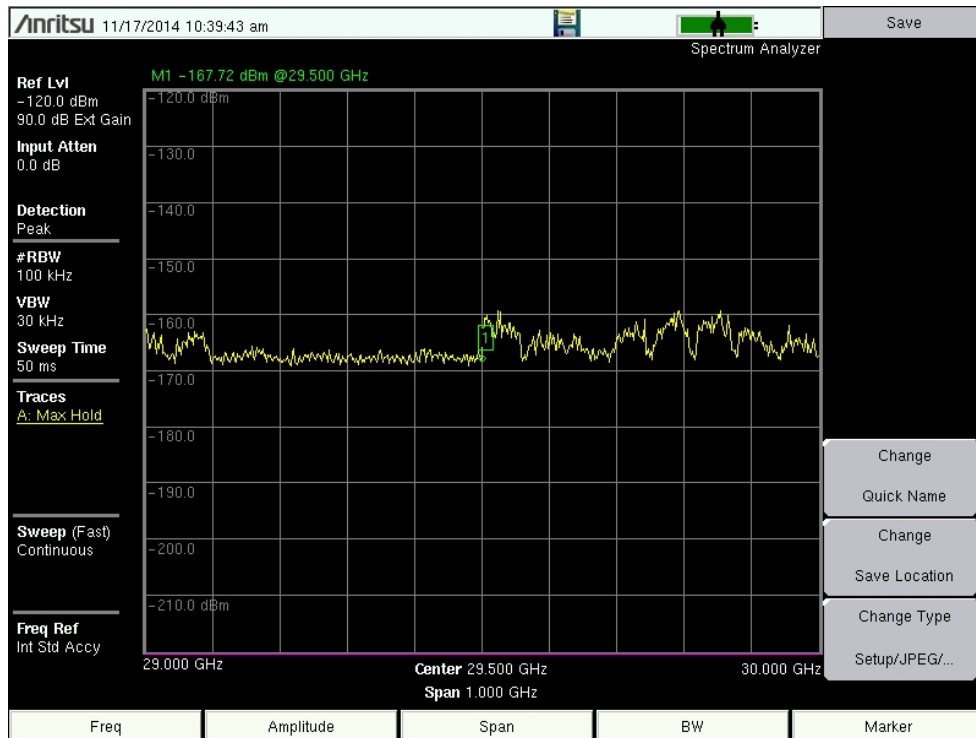


Figure 3.1-9 (B) Spectrum Photos 29-30 GHz 100 KHz Res BW Horizontal Pol 360<sup>0</sup>

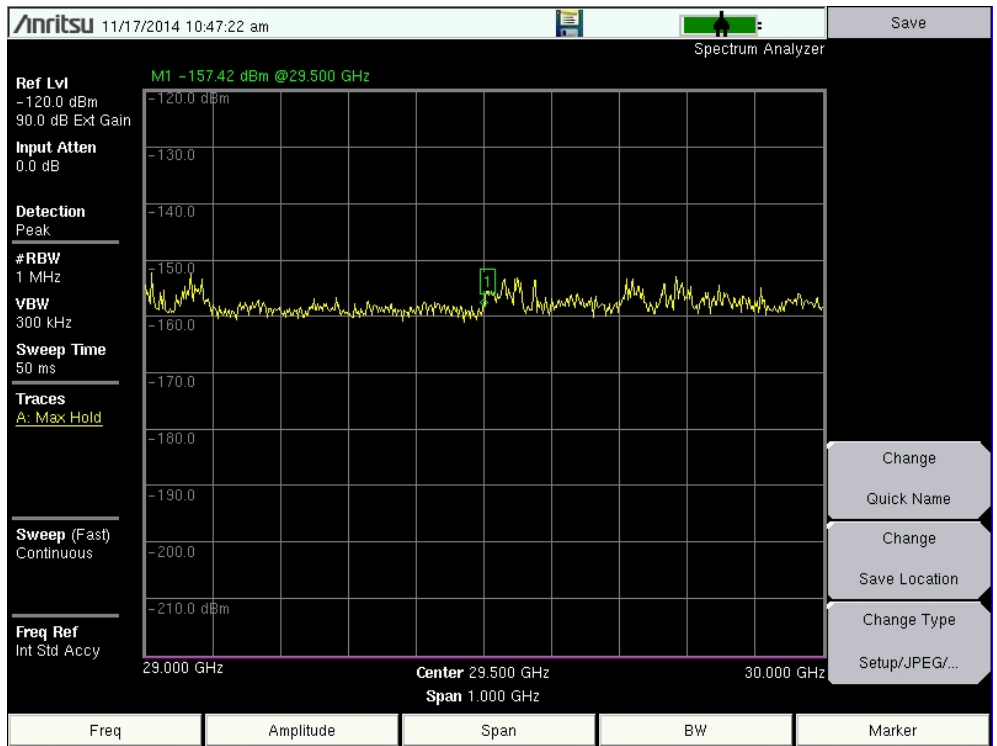


Figure 3.1-9 (C) Spectrum Photos 29-30 GHz 1MHz Res BW Vertical Pol 360<sup>0</sup>

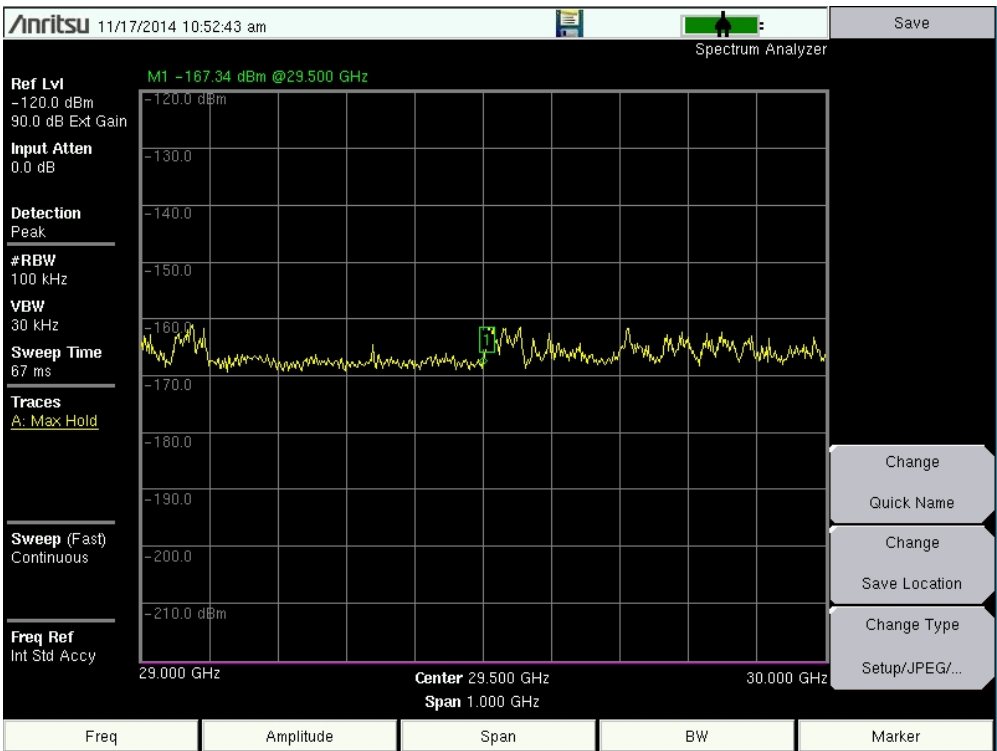


Figure 3.1-9 (D) Spectrum Photos 29-30 GHz 100 KHz Res BW Vertical Pol 360<sup>0</sup>

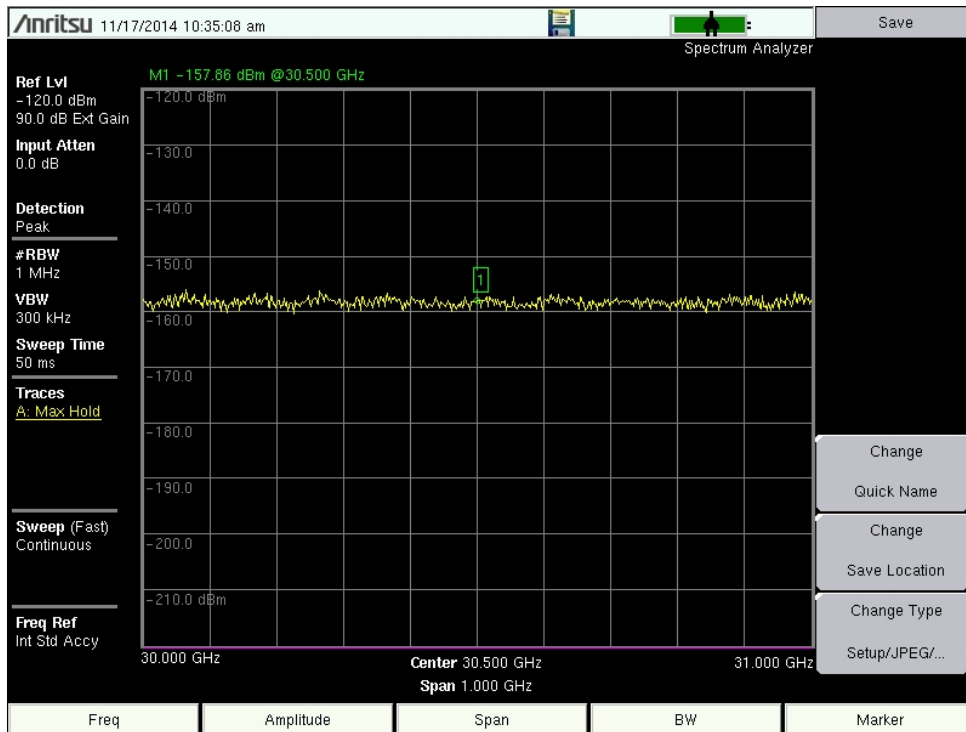


Figure 3.1-10 (A) Spectrum Photos 30-31 GHz 1MHz Res BW Horizontal Pol 360<sup>0</sup>

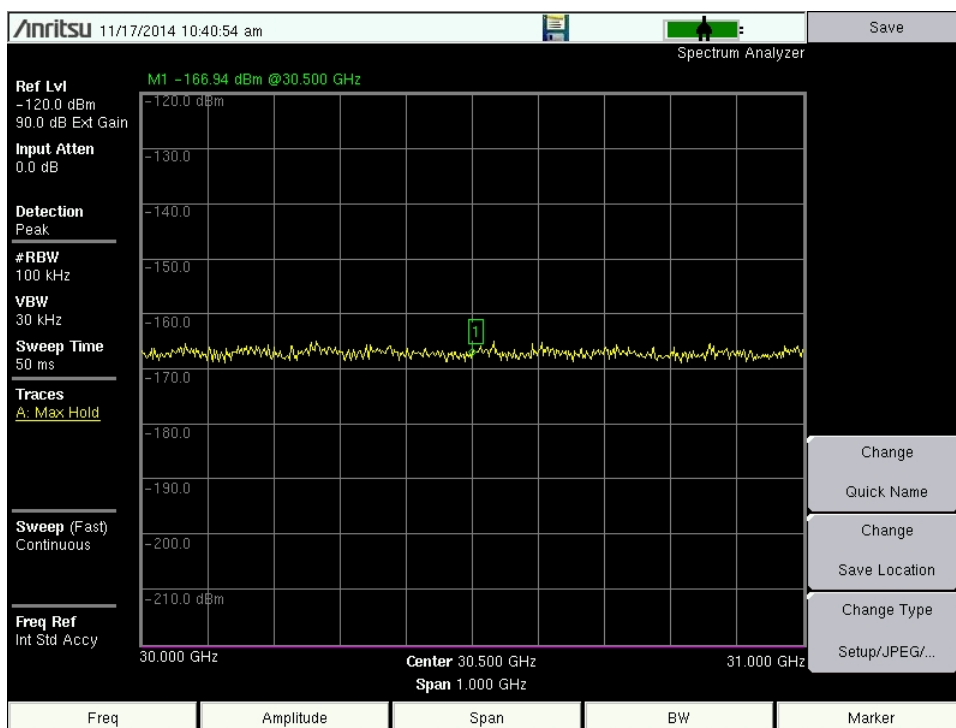


Figure 3.1-10 (B) Spectrum Photos 30-31 GHz 100 KHz Res BW Horizontal Pol 360<sup>0</sup>

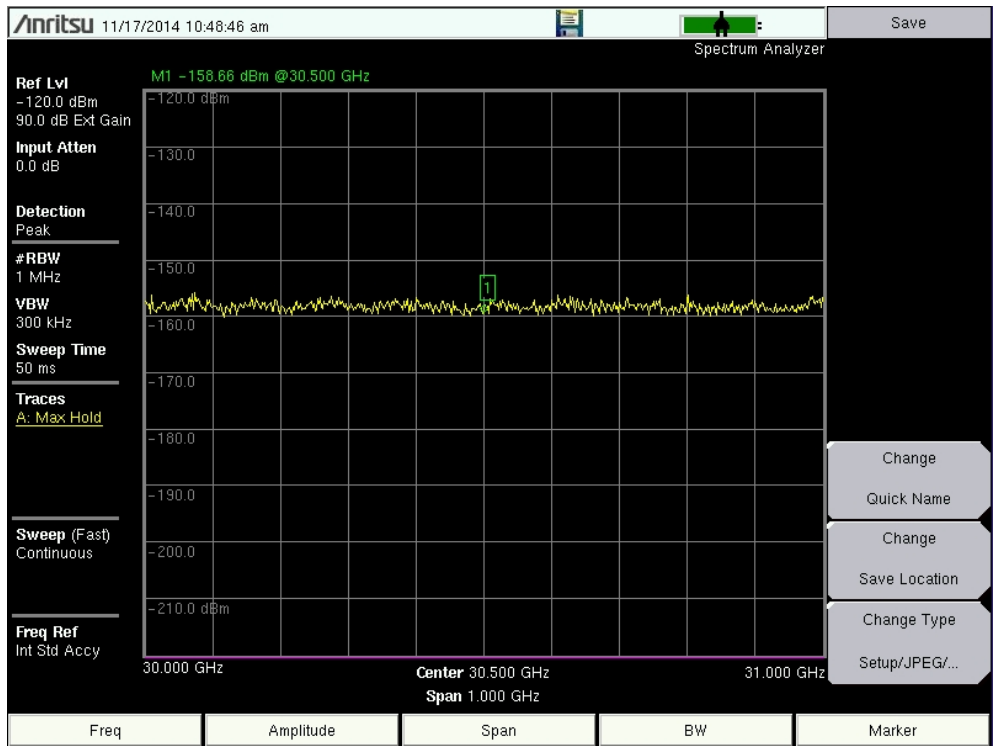


Figure 3.1-10 (C) Spectrum Photos 30-31 GHz 1 GHz Res BW Vertical Pol 360<sup>0</sup>

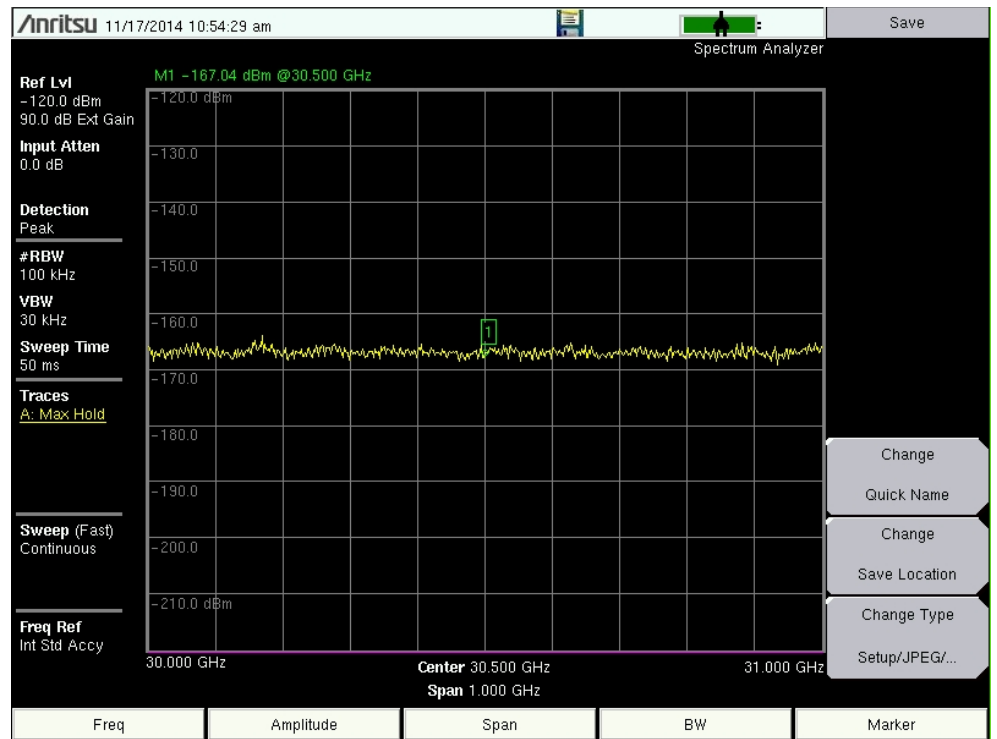


Figure 3.1-10 (D) Spectrum Photos 30-31 GHz 100 KHz Res BW Vertical Pol 360<sup>0</sup>

***SECTION***

***FOUR***

## SECTION 4

### SUMMARY OF RESULTS

The results of the measurements conducted at the proposed ViaSat, Inc site in Albuquerque, NM are presented in this section.

#### **Arc Clearance:**

There is no potential satellite arc blockage at this site. Final arc clearance will depend on antenna placement.

#### **Ka-Band Measurements:**

There was six (6) radio frequency interference cases measured at this site above the noise floor of the test equipment. Fifteen (15) cases were predicted but only six (6) were observed during the measurement period (See Addendum 1).



***SECTION***

***FIVE***

## SECTION 5

### CONCLUSIONS AND RECOMMENDATIONS

#### 5.1 Conclusions

There were signals measured above the  $-156$  dBW/ 1 MHz interference objective for digital reception at this site. Please see ADDENDUM 1 for detail on the cases as seen.

The satellite arc has no potential blockage from 55W through 115W.

#### 5.2 Recommendations

ViaSat, Inc should review the system parameters for this down-link in order to verify the viability of this objective. It is recommended that frequency coordination of this site be initiated to protect this location at the more stringent digital receive interference objective.

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## **ADDENDUM 1**

### **INTRODUCTION AND BACKGROUND**

#### **A1.1 Introduction**

Based on the Detailed Interference Analysis Report conducted by Comsearch Engineering there were cases that could not be cleared by the analysis and were specifically tested in the field during the On-Site Radio Frequency Interference (RFI) measurement. Below is the result of that On-Site measurement.

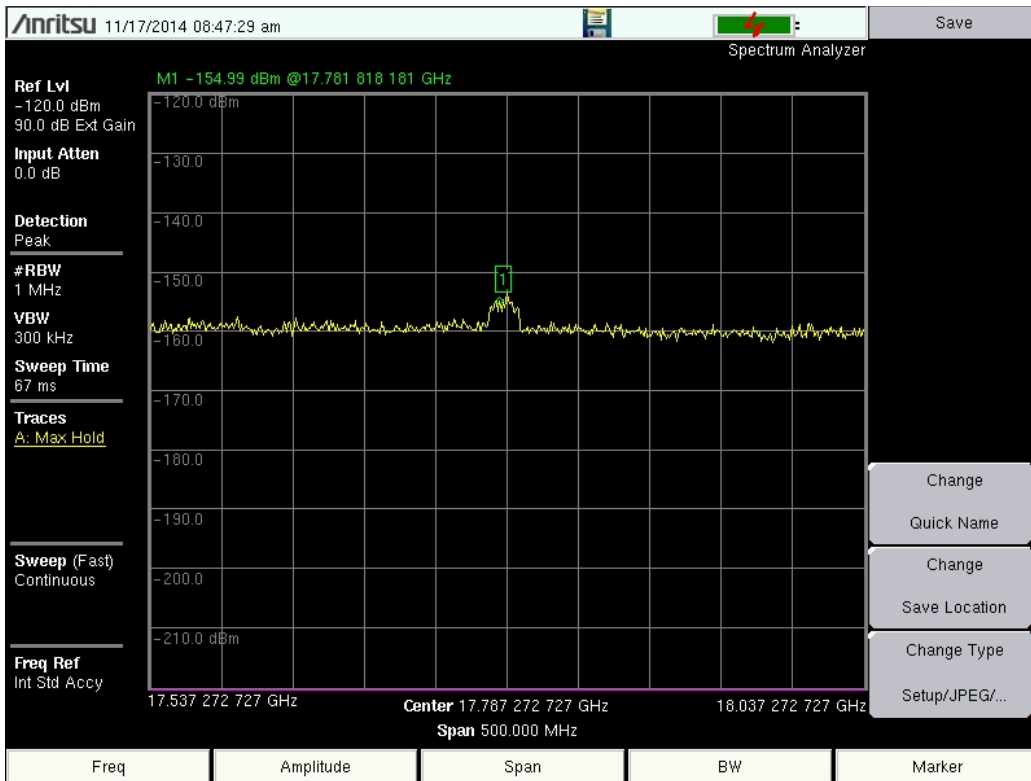
#### **The results in this report is based upon the following:**

- The Analysis was unable to clear 6 of 15 cases of possible interference conflicts
- Satellite Arc: 55 to 115 Degrees West Longitude
- Frequency Range Considered: 17 to 21 GHz
- Interference Objective: -156 dBW/1 MHz
- Type of Reception: Digital
- Measured Antenna Center Line: 6.5 Feet Above Ground Level

#### **A1.2 Background**

Based on actual On-Site measurements at the Albuquerque ViaSat location of the 15 possible interference cases there were five (5) signals detected of known licensed broadcasts in the Receive bands. This Addendum contains the spectral photo of the received carrier as well as the direction and possible transmit site for each.

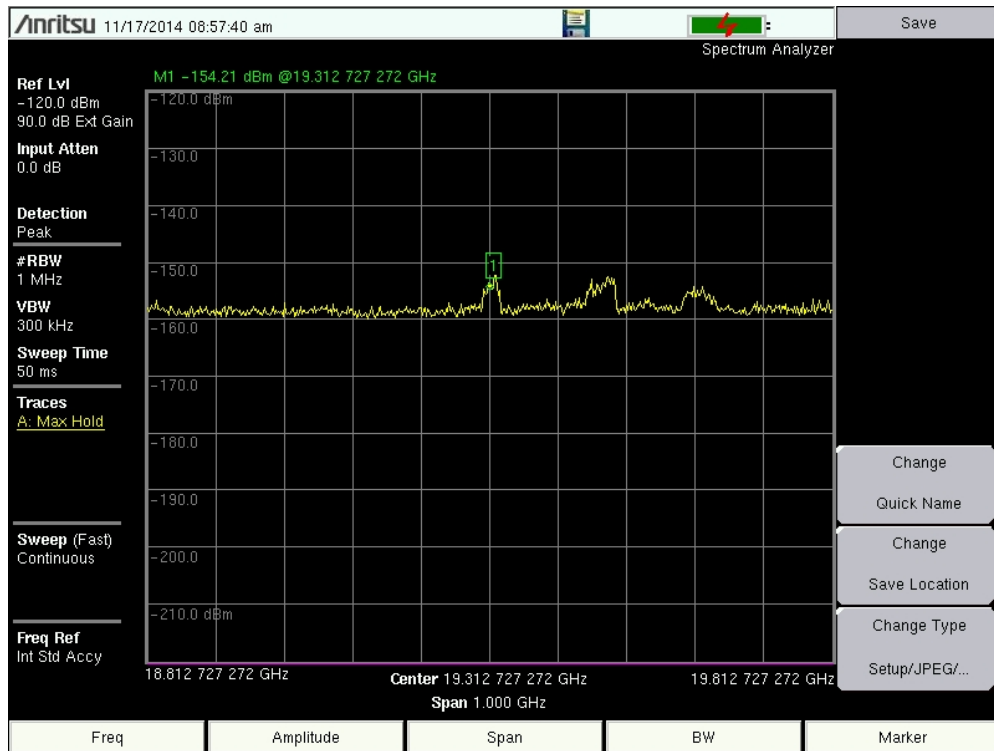
There was also one signal detected from an unknown source apparently transmitting from an adjacent building just outside the proposed arc, at approximately  $222^{\circ}$ . Photos are shown below in Figures A1.2.1- A1.2.6. The licensed site name is in parenthesis after the figure number.



**FIGURE A1.2.1-A (4 – Crest Site)**



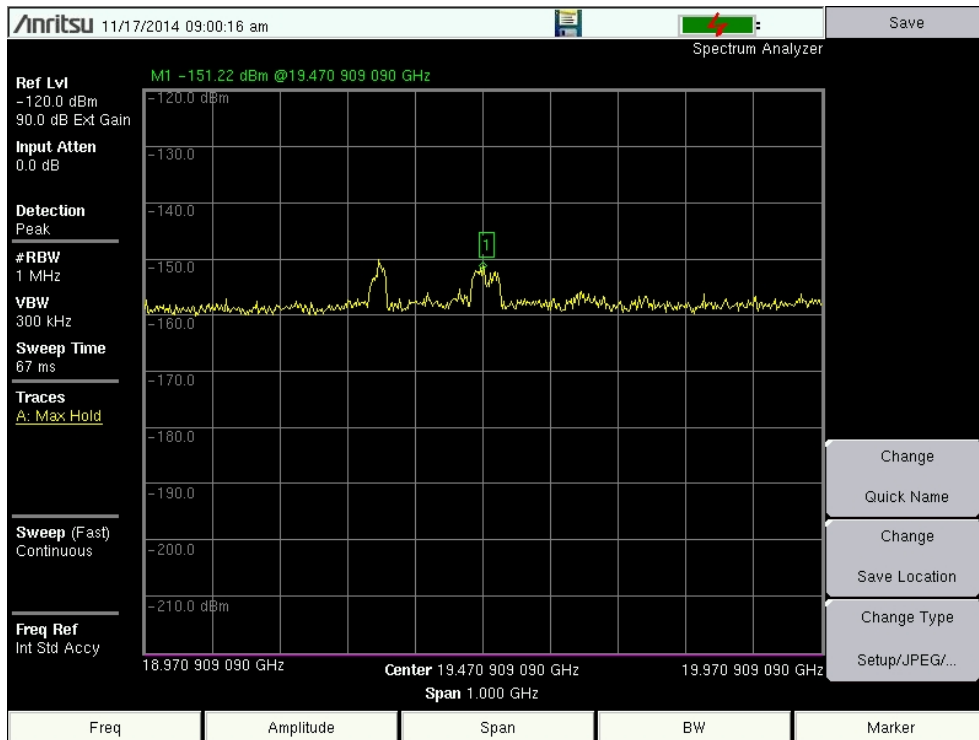
**FIGURE A1.2.1-B (4 – Crest Site)**



**FIGURE A1.2.2-A (13 – CO)**



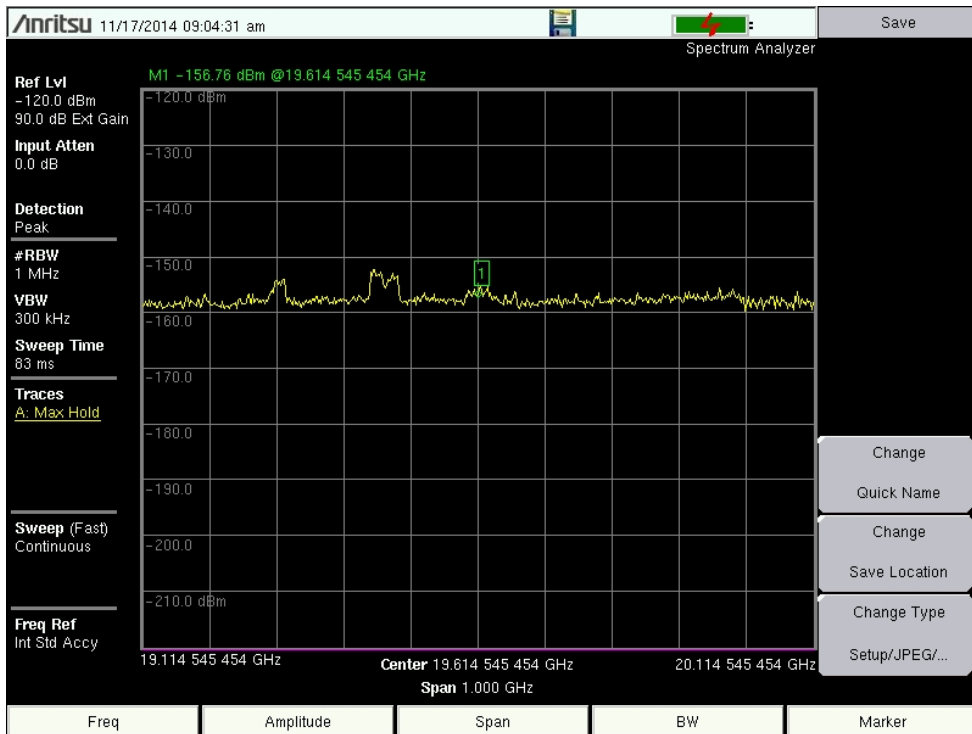
**FIGURE A1.2.2-B (13 – CO)**



**FIGURE A1.2.3-A (23 – Sandia Cres)**



**FIGURE A1.2.3-B (23 – Sandia Cres)**

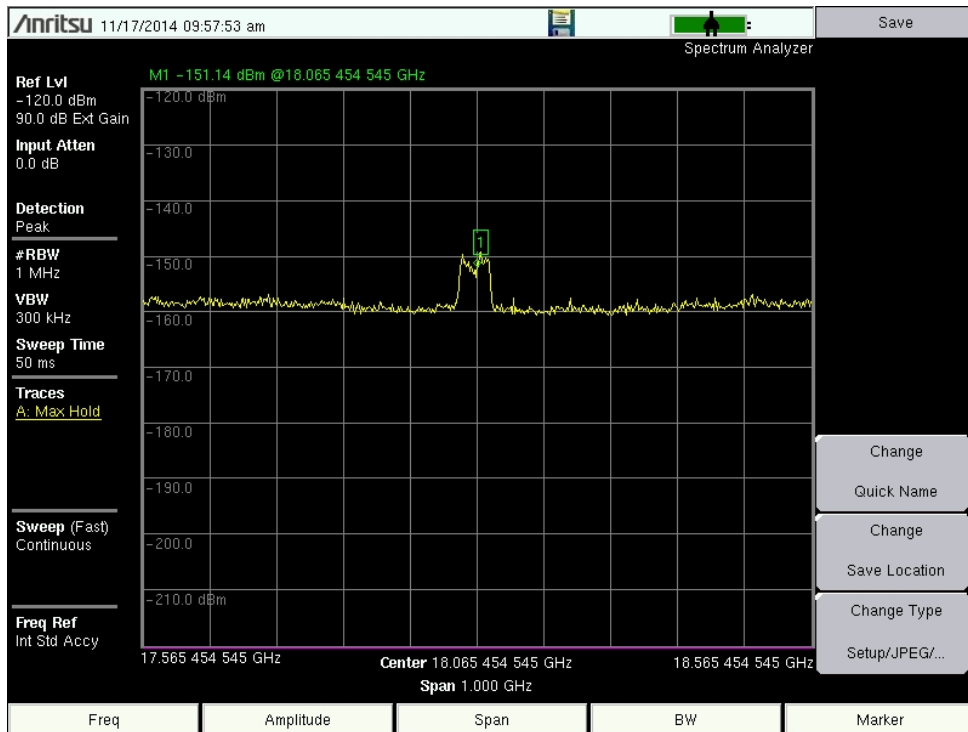


**FIGURE A1.2.4-A (Unknown)**



**FIGURE A1.2.4-B (Unknown)**

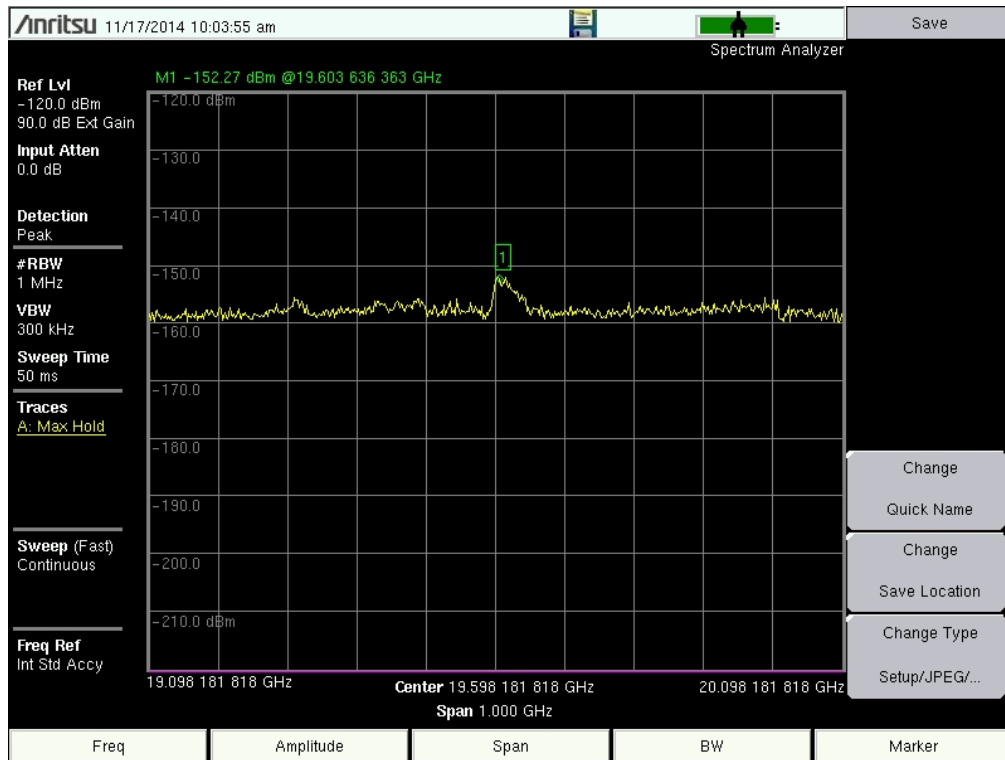




**FIGURE A1.2.5-A (5-Sandia Crest)**



**FIGURE A1.2.5-B (5 – Sandia Crest)**



**FIGURE A1.2.6-A ( 21-ABQCOORS)**



**FIGURE A1.2.6-B ( 21-ABQCOORS)**