

MICROWAVE PATH SURVEY REPORT

RADIO FREQUENCY INTERFERENCE (RFI) MEASUREMENT REPORT

Prepared For

ViaSat

Detroit, MI

Transmit and Receive Earth Station 17-21 GHz and 27-31 GHz

April 29, 2015

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ONE

INTRODUCTION AND BACKGROUND

1.1 Introduction

On-site Radio Frequency interference (RFI) measurements were performed on behalf of ViaSat, Inc. on April 29, 2015, at their proposed site in Detroit, MI. 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:

- Andrew 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

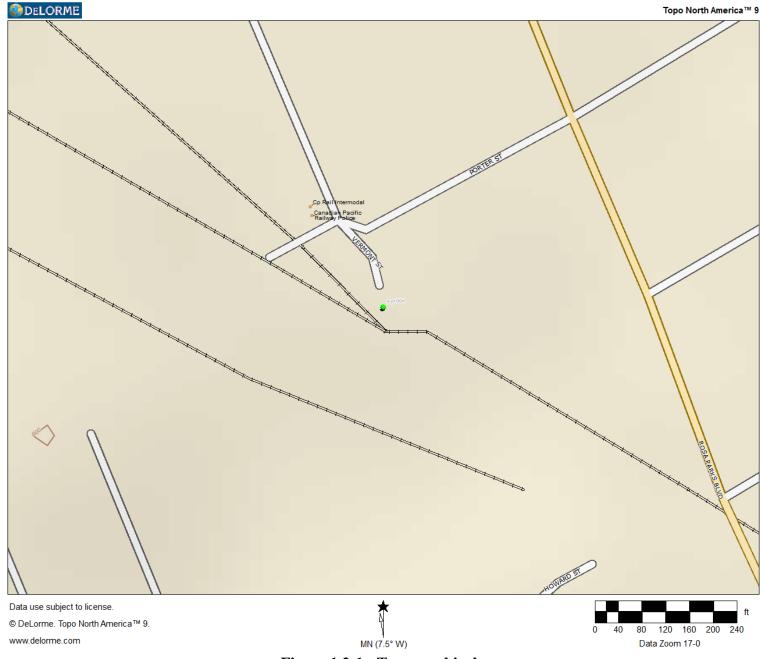
ViaSat, Inc is proposing to locate a new transmit/receive antenna at a new location of 42° 19' 30.1" N 083° 04' 11.7" ViaSat, Inc had requested that Comsearch conduct RFI measurements at the facility to assess the interference potential. This facility is currently nonoperational and measurements were done at a point near the proposed antenna locations.

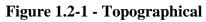
The measured site is identified on a portion of a topographic map shown in Figure 1.2-1. An aerial photo of the site location is shown in Figure 1.2-2. A photo of the measurement using a GPS is shown in Figure 1.2-3. A photo of the surrounding cellular/PCS coverage is shown in Figure 1.2-4.

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 θ 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.





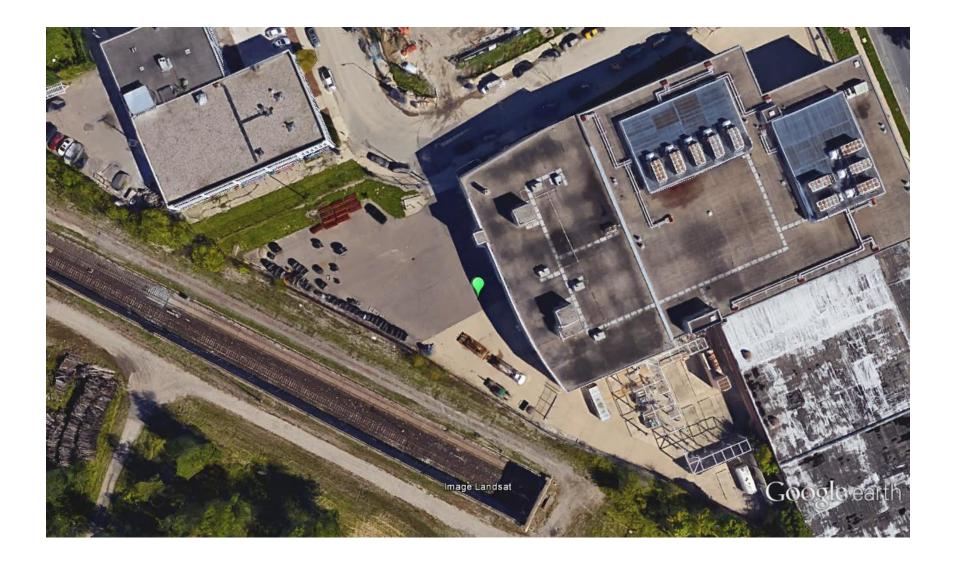
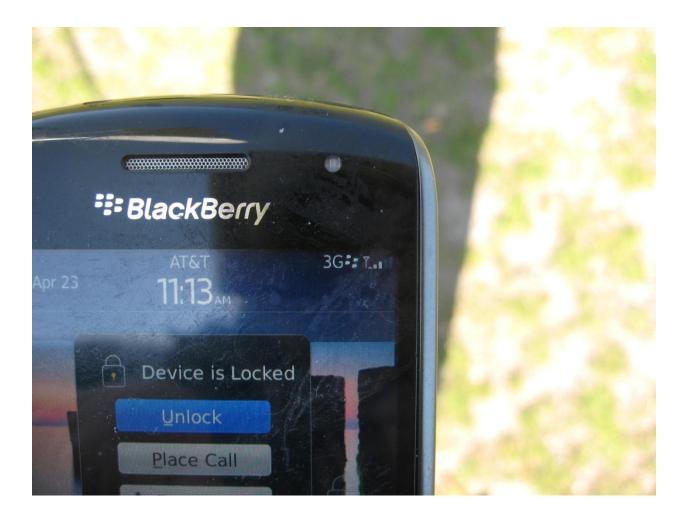






Figure 1.2-3 – GPS Photograph



TWO

TEST PROCEDURE

2.1 Calibration

Where:

Figures 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 reference signal (-60 dBm) by utilizing the reference level offset function of the Anritsu –M52720T spectrum analyzer. Upon completion of the calibration process, a known reference level was obtained for the measured in 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_I) as seen at the point of test:

 $dBW_I = LI - GA - 30$ $dBW_I = Isotropic level in dBW$

LI = Level (dBm) of injected signal

GA = Test antenna gain

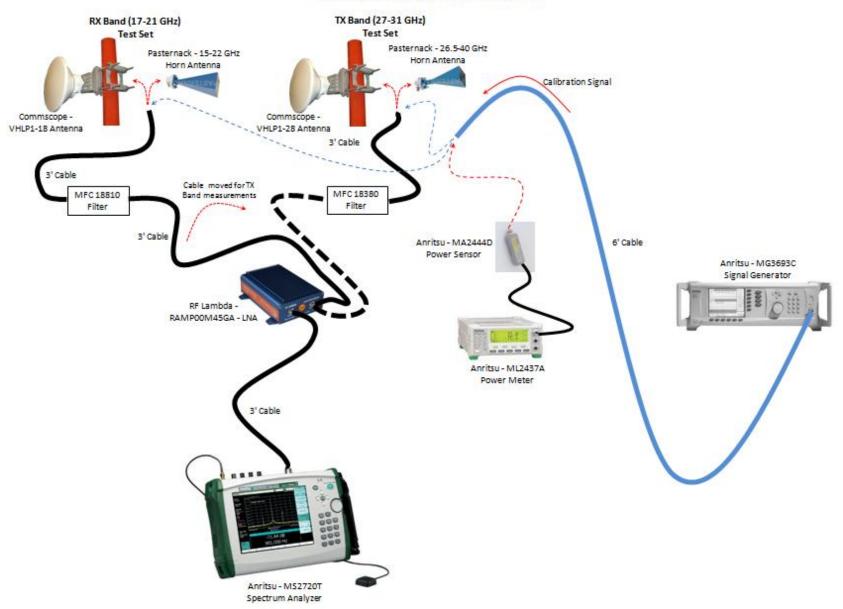
-30 = Conversion factor from dBm to dBW

at 19.5 GHz: $dBW_I = -60 dBm - 30 dB - 30 dB$

 $= -120 \text{ dBW}_{\text{I}}$

In this instance, the spectrum analyzer displayed measured signal level of -60 dBm equates to an isotropic signal level of -120 dBW_I.

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



Test Set Equipment Diagram

Figure 2.1-1 Receive Test Equipment Block

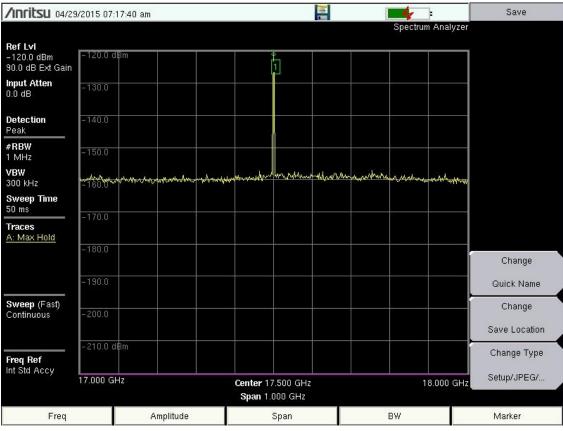


Figure 2.1-2 (A) Calibration Spectrum Photo 17.5 GHz

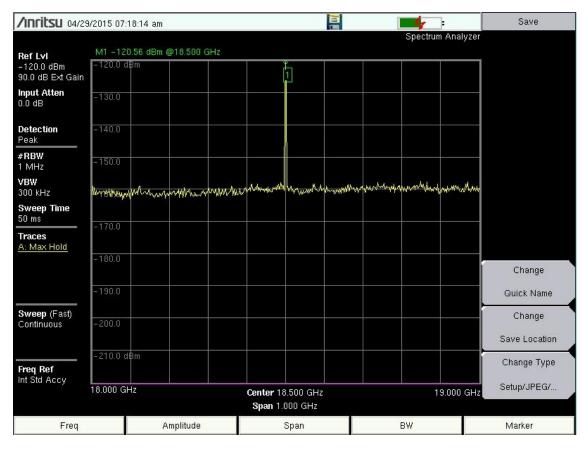


Figure 2.1-2 (B) Calibration Spectrum Photo 18.5 GHz

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put Atten 0 dB	-130.0								
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races :: Max Hold									
	-180.0								Change
	-190.0								Quick Name
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ontinuous	-200.0								Save Location
req Ref	-210.0 dBm								Change Type
it Std Accy	19.000 GHz			 19.500 GHz 1.000 GHz			2	0.000 GHz	Setup/JPEG/
Freq		Amplitude		Span		В	W		Marker



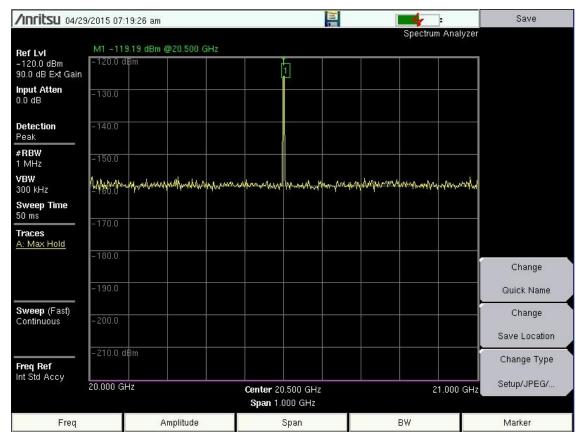


Figure 2.1-2 (D) Calibration Spectrum Photo 20.5 GHz

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					Spectr	um Analyzer	
lef Lvl	M1 -122.49 dBm	@27.500 GHz					
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etection 'eak	-140.0						
RBW MHz	-150.0				9. <u></u>	<u> </u>	
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Sweep Time 50 ms	=170.0						
Fraces A: Max Hold	-1,20.0						
	-180.0						Change
	-190.0				·		Quick Name
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Continuous	-200.0						Save Location
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nt Std Accy							Setup/JPEG/
	27.000 GHz		Center 27.500 Span 1.000 G			28.000 GHz	Setup/JPEG/

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

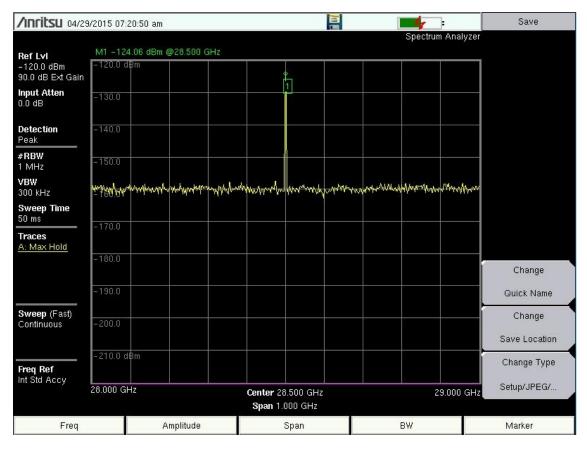


Figure 2.1-2 (F) Calibration Spectrum Photo 28.5 GHz

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					Spectru	ım Analyzer	
lef Lvl		dBm @29.500 GHz					
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races : Max Hold	- 120.0					s .	
	-180.0						Change
	-190.0						Quick Name
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it Std Accy	29.000 GHz						Setup/JPEG/
	23.000 GHZ		Center 29.50 Span 1.000			30.000 GHz	
Freq		Amplitude	Sp	an	BW		Marker

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

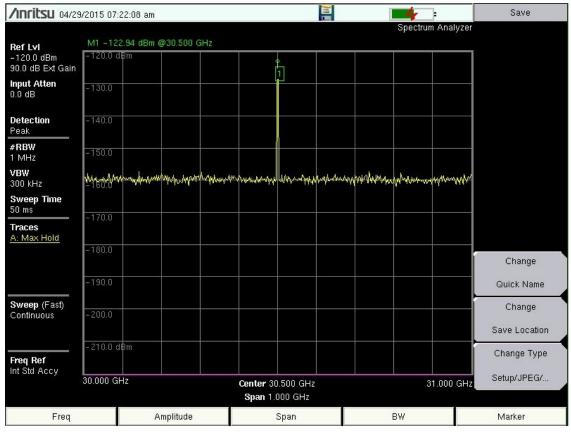


Figure 2.1-2 (H) Calibration Spectrum Photo 30.5 GHz

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.

THREE

DATA PRESENTATION

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

3.1 Detroit, MI

- 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:	Detroit, MI	
3.	SITE IDENTIFICATION:	Detroit	
4.	COORDINATES: (NAD 1983)	LATITUDE: 42° 19' 30.1" N LONGITUDE: 083° 04' 11.7" W	
5.	GROUND ELEVATION:	598 feet AMSL	
6.	MEASUREMENT DATE AND TIMES:	April 29, 2015	
7.	GEOSTATIONARY ARC RANGE: SATELLITE POSITIONS: AZIMUTH: ELEVATION:	55W – 115W 141.6° – 222.8° 33.5° / 31.5°	
8.	GEOSTATIONARY ARC VISIBILITY:	Satellite arc has no blockage at this time	e

/Inritsu 04/29	9/2015 07:39:0	1 am				Save
ef Lvl	M1 -158.02	dBm @17.506 352 ()87 GHz		Spectrum A	nalyzer
120.0 dBm 0.0 dB Ext Gain	–120.0 dBm					
put Atten 0 dB	-130.0					
e tection eak	-140.0					
RBW MHz	-150.0		1		c 9	
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veep Time 'ms	-170.0					
aces Max Hold					e 5	
	-180.0					Change
	-190.0					Quick Name
veep (Fast) intinuous	-200.0					Change Save Location
eq Ref	-210.0 dBm					Change Type
Std Accy	17.000 GHz		Center 17.500 G Span 1.000 GF		18.0	00 GHz Setup/JPEG/
Freq		Amplitude	Span		BW	Marker



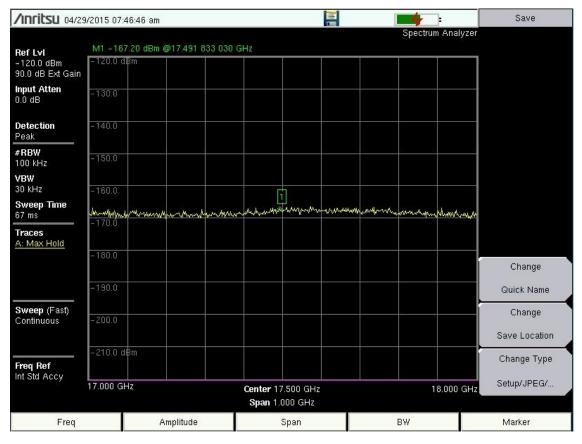


Figure 3.1-3 (B) Spectrum Photos 17-18 GHz 100 kHz Res BW Horizontal Pol 360⁰

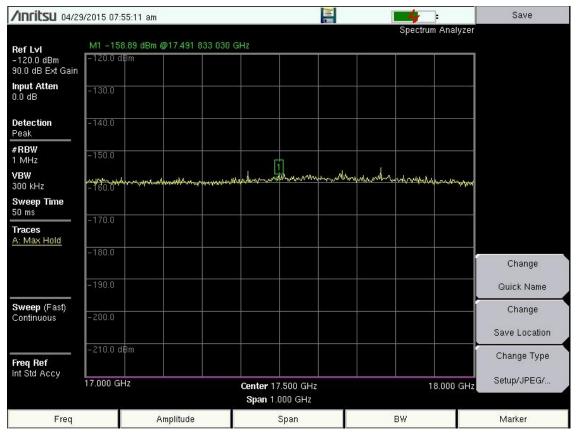


Figure 3.1-3 (C) Spectrum Photos 17-18 GHz 1MHz Res BW Horizontal Pol Worst Case

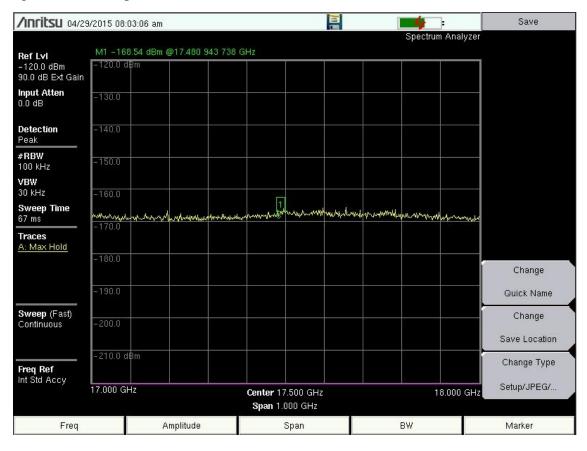


Figure 3.1-3 (D) Spectrum Photos 17-18 GHz 100 KHz Res BW Horizontal Pol Worst Case

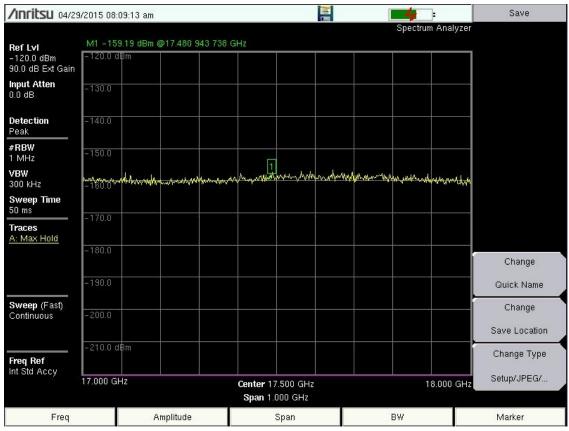


Figure 3.1-3 (E) Spectrum Photos 17-18 GHz 1MHz Res BW Vertical Pol 360⁰

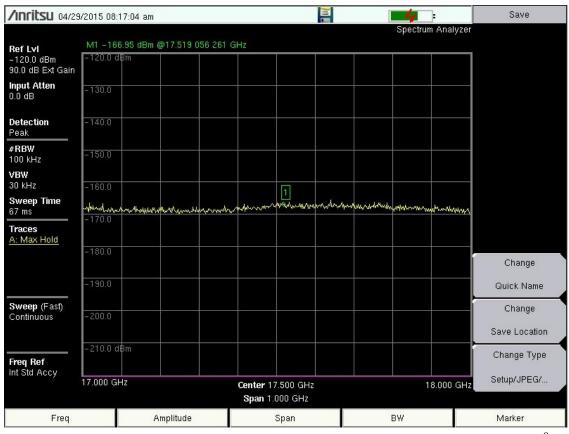


Figure 3.1-3 (F) Spectrum Photos 17-18 GHz 100 kHz Res BW Vertical Pol 360⁰

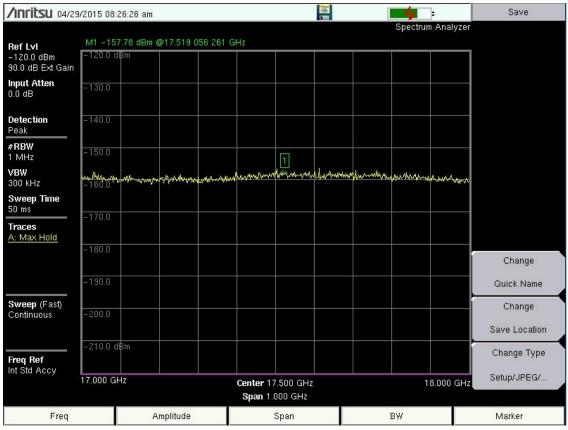


Figure 3.1-3 (G) Spectrum Photos 17-18 GHz 1 MHz Res BW Vertical Pol Worst Case

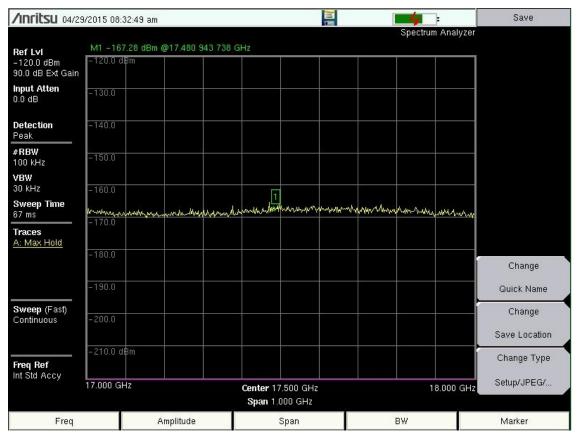


Figure 3.1-3 (H) Spectrum Photos 17-18 GHz 100 kHz Res BW Vertical Pol Worst Case

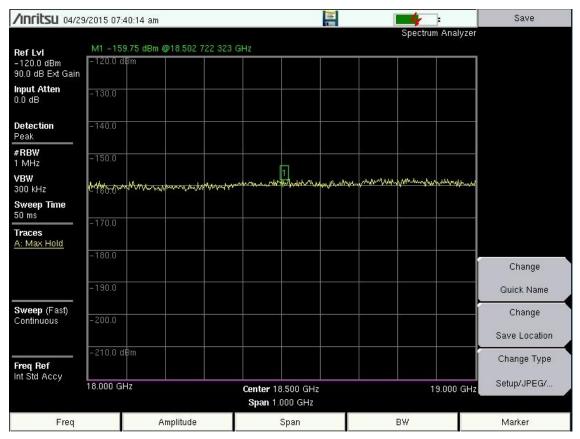


Figure 3.1-4 (A) Spectrum Photos 18-19 GHz 1MHz Res BW Horizontal Pol 360⁰

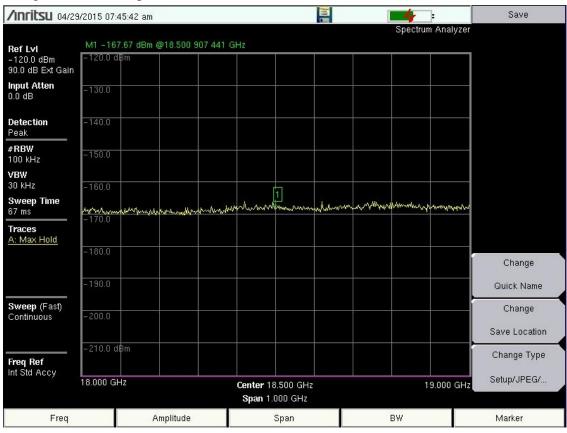


Figure 3.1-4 (B) Spectrum Photos 18-19 GHz 100 kHz Res BW Horizontal Pol 360⁰

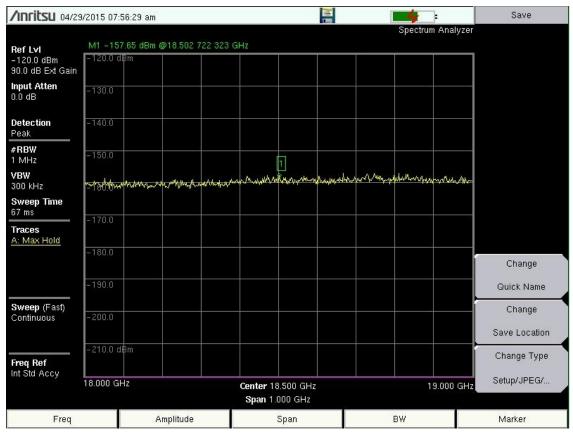


Figure 3.1-4 (C) Spectrum Photos 18-19 GHz 1MHz Res BW Horizontal Pol Worst Case

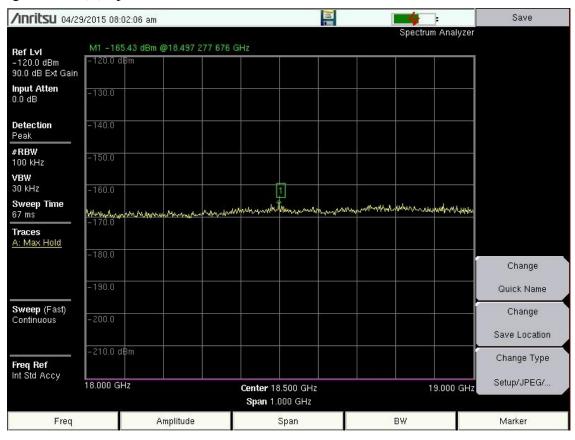


Figure 3.1-4 (D) Spectrum Photos 18-19 GHz 100 kHz Res BW Horizontal Pol Worst Case

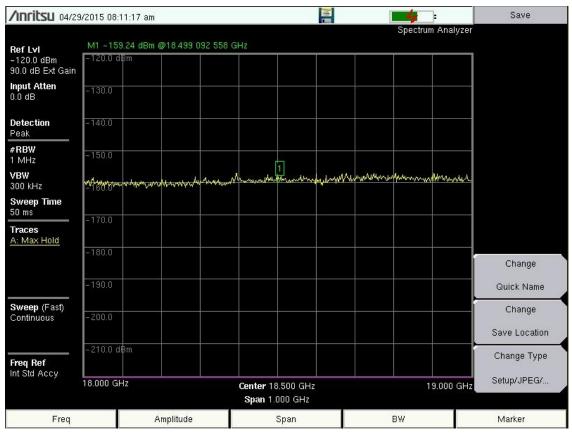


Figure 3.1-4 (E) Spectrum Photos 18-19 GHz 1MHz Res BW Vertical Pol 360⁰

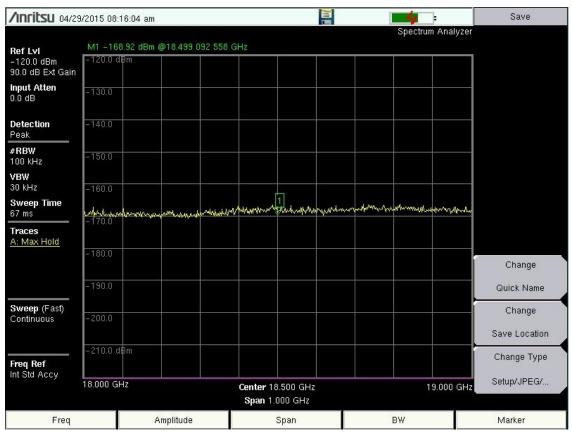


Figure 3.1-4 (F) Spectrum Photos 18-19 GHz 100 kHz Res BW Vertical Pol 360⁰

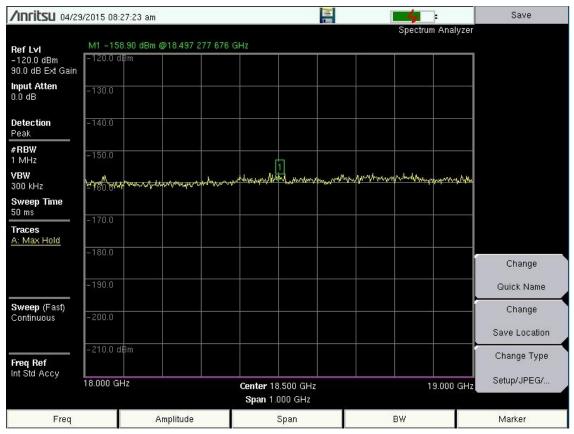


Figure 3.1-4 (G) Spectrum Photos 18-19 GHz 1 MHz Res BW Vertical Pol Worst Case

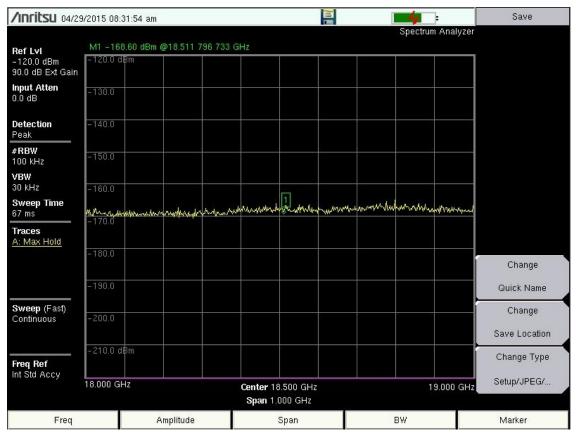


Figure 3.1-4 (H) Spectrum Photos 18-19 GHz 100 kHz Res BW Vertical Pol Worst Case

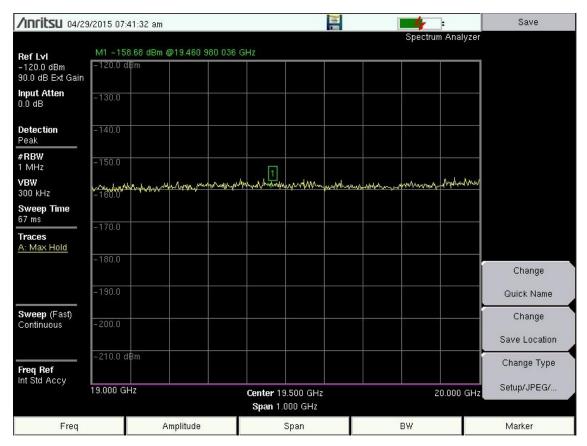


Figure 3.1-5 (A) Spectrum Photos 19-20 GHz 1MHz Res BW Horizontal Pol 360⁰

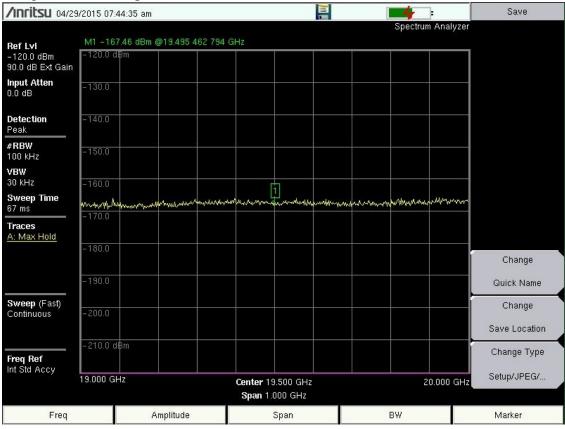


Figure 3.1-5 (B) Spectrum Photos 19-20 GHz 100 kHz Res BW Horizontal Pol 360⁰

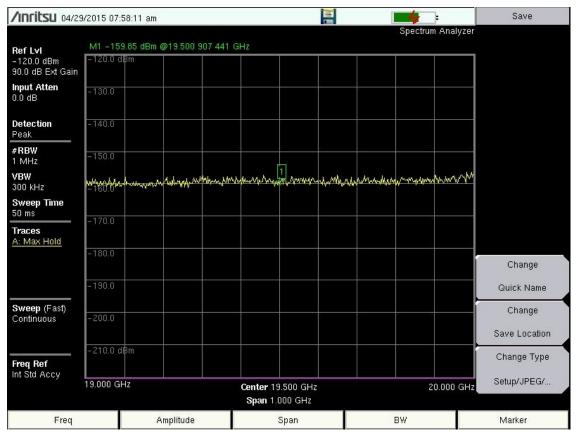


Figure 3.1-5 (C) Spectrum Photos 19-20 GHz 1MHz Res BW Horizontal Pol Worst Case

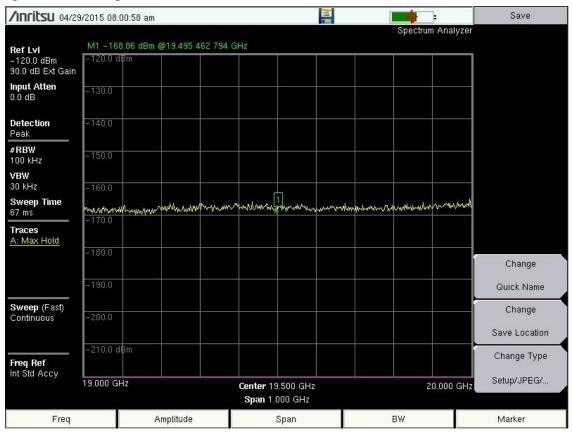


Figure 3.1-5 (D) Spectrum Photos 19-20 GHz 100 kHz Res BW Horizontal Pol Worst Case

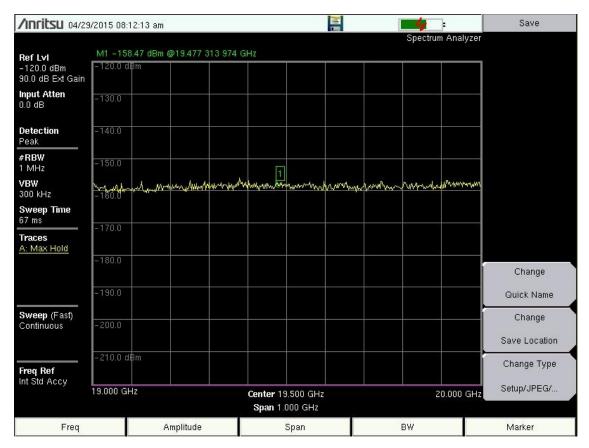


Figure 3.1-5 (E) Spectrum Photos 19-20 GHz 1MHz Res BW Vertical Pol 360⁰

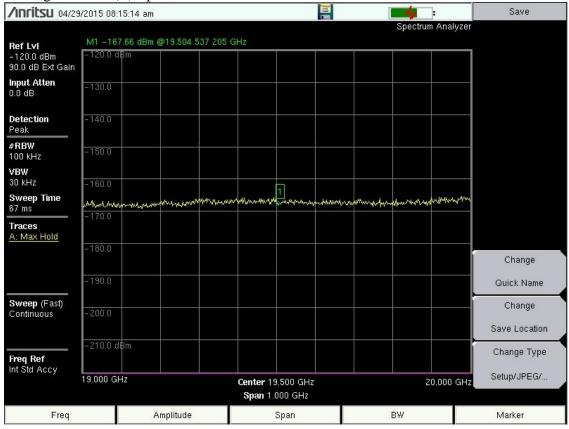


Figure 3.1-5 (F) Spectrum Photos 19-20 GHz 100 kHz Res BW Vertical Pol 360⁰

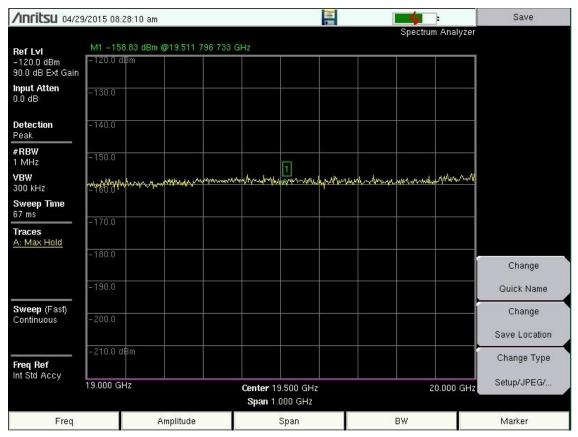


Figure 3.1-5 (G) Spectrum Photos 19-20 GHz 1 MHz Res BW Vertical Pol Worst Case

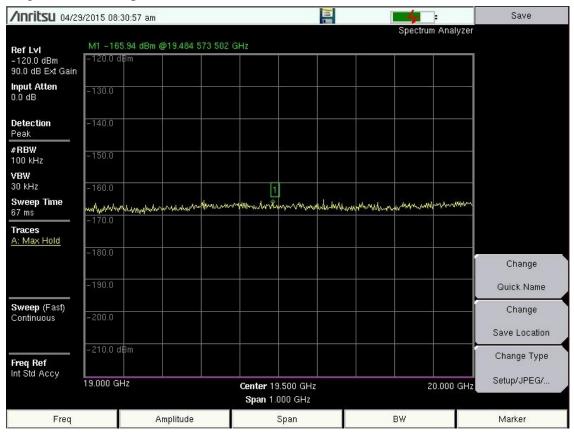


Figure 3.1-5 (H) Spectrum Photos 19-20 GHz 100 kHz Res BW Vertical Pol Worst Case

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Detection Peak	-140.0			
#RBW 1 MHz	-150.0			
VBW 300 kHz	Jan Lanan al warman and march and all they	walking have an	warman and a second and a second	
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Traces A: Max Hold				
	-180.0			Change
	-190.0			Quick Name
Sweep (Fast) Continuous	-200.0			Change Save Location
Freq Ref Int Std Accy	–210.0 d₿m			Change Type
in old Heey	20.000 GHz	Center 20.500 GHz Span 1.000 GHz	21.000 GHz	Setup/JPEG/
Freq	Amplitude	Span	BW	Marker

Figure 3.1-6 (A) Spectrum Photos 20-21 GHz 1MHz Res BW Horizontal Pol 360°

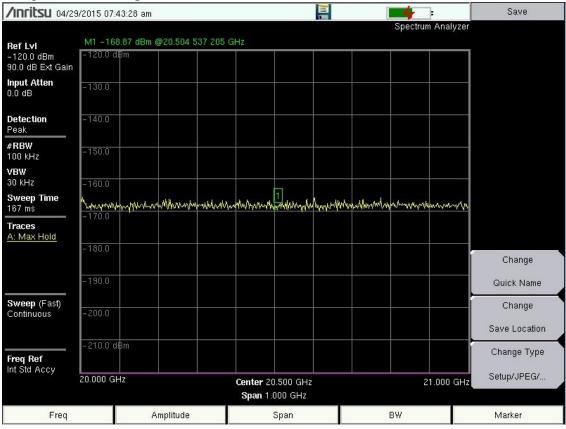


Figure 3.1-6 (B) Spectrum Photos 20-21 GHz 100 kHz Res BW Horizontal Pol 360°

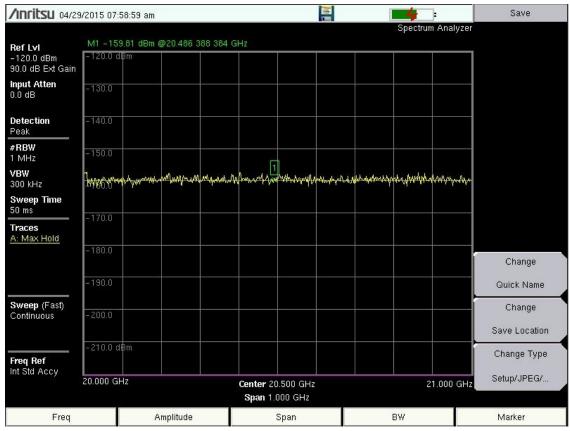


Figure 3.1-6 (C) Spectrum Photos 20-21 GHz 1MHz Res BW Horizontal Pol Worst Case

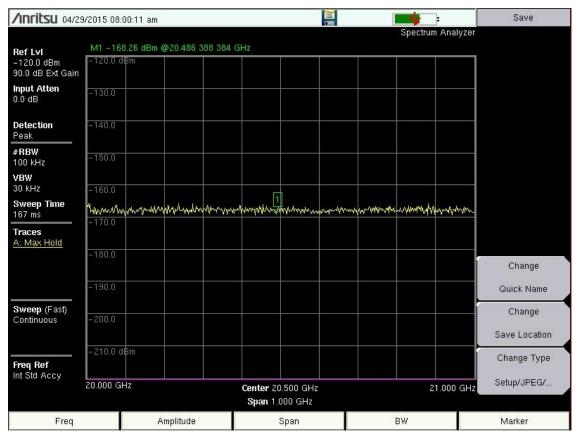


Figure 3.1-6 (D) Spectrum Photos 20-21 GHz 100 kHz Res BW Horizontal Pol Worst Case

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-120.0 dBm 90.0 dB Ext Gain	–120.0 d₿m			
Input Atten 0.0 dB	-130.0			
Detection Peak	-140.0			
#RBW 1 MHz	-150.0			
VBW 300 kHz	Japanen Million and Million and Market	and market and the second	manantantantanatanatanatanatanatan	
Sweep Time 50 ms	-170.0			
Traces <u>A: Max Hold</u>				
	-180.0			Change
. <u> </u>	-190.0			Quick Name
Sweep (Fast) Continuous	-200.0			Change Save Location
Freq Ref Int Std Accy	-210.0 dBm			Change Type Setup/JPEG/
	20.000 GHz	Center 20.500 GHz Span 1.000 GHz	21.000 GHz	Gerapion Edv
Freq	Amplitude	Span	BW	Marker

Figure 3.1-6 (E) Spectrum Photos 20-21 GHz 1MHz Res BW Vertical Pol 360⁰

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nput Atten).0 dB	-130.0				
Detection Peak	-140.0				
≭RBW 100 kHz	-150.0				
/BW 30 kHz	-160.0				
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	-180.0				Change
	-190.0				Quick Name
Sweep (Fast) Continuous	-200.0				Change
					Save Location
req Ref	–210.0 d₿m				Change Type
nt Std Accy					Setup/JPEG/
nt Std Accy	20.000 GHz		r 20.500 GHz 1.000 GHz	21.00	00 GHz

Figure 3.1-6 (F) Spectrum Photos 20-21 GHz 100 kHz Res BW Vertical Pol 360°

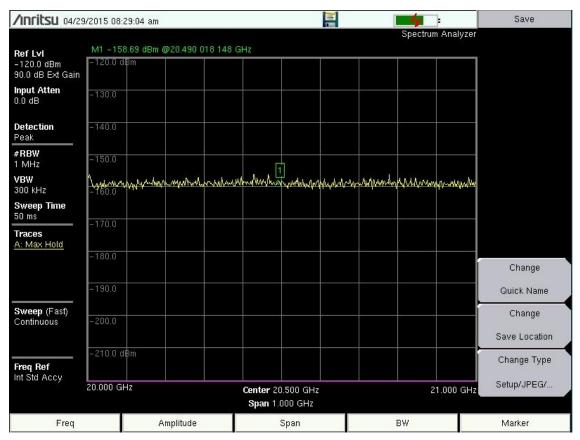


Figure 3.1-6 (G) Spectrum Photos 20-21 GHz 1 MHz Res BW Vertical Pol Worst Case

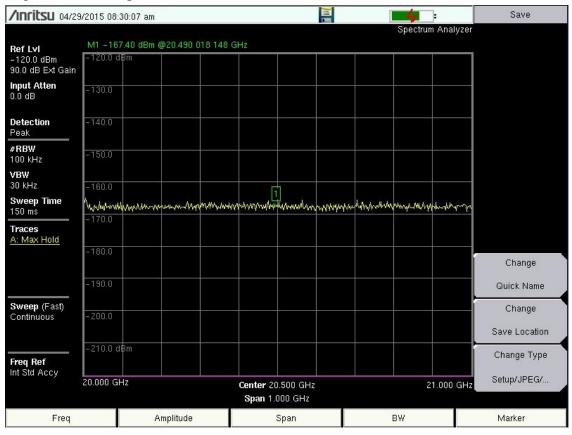


Figure 3.1-6 (H) Spectrum Photos 20-21 GHz 100 kHz Res BW Vertical Pol Worst Case

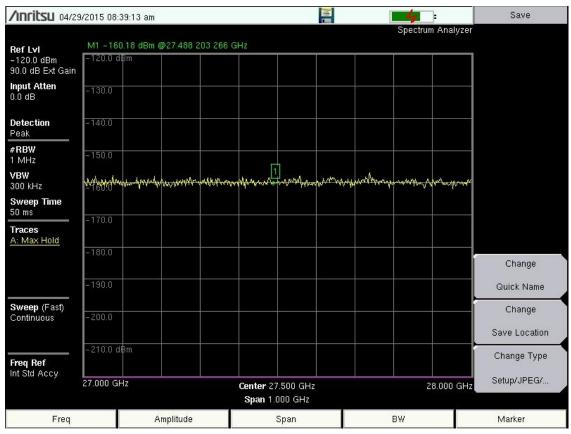


Figure 3.1-7 (A) Spectrum Photos 27-28 GHz 1MHz Res BW Horizontal Pol 360⁰

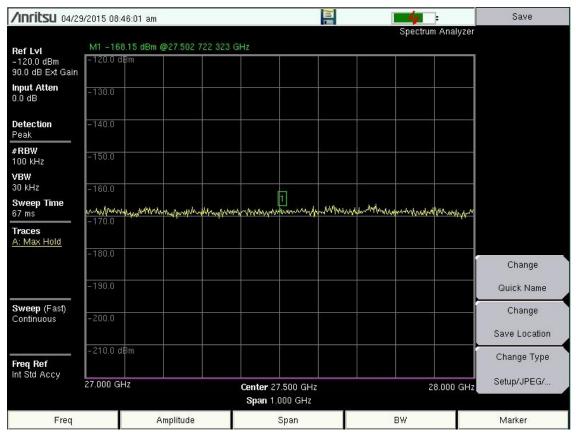


Figure 3.1-7 (B) Spectrum Photos 27-28 GHz 100 kHz Res BW Horizontal Pol 360⁰

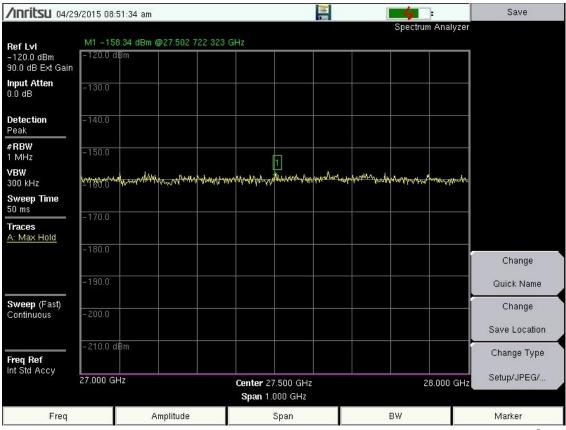


Figure 3.1-7 (C) Spectrum Photos 27-28 GHz 1MHz Res BW Vertical Pol $\overline{360^0}$

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			10.00		Spec	trum Analyzer	
Ref Lvi -120.0 dBm 30.0 dB Ext Gain	M1 -169.08 dE -120.0 dBm	m @27.500 907 4	41 GHz				
nput Atten 1.0 dB	-130.0						
Detection Peak	-140.0			2	i. O.		
#RBW 100 kHz	-150.0			: <u> </u>	- 62 	<u>.</u>	
VBW 30 kHz	-160.0						
Sweep Time 33 ms	170.0	munantur	www.	1 anthrong with the	when my many	WWWWWWWWW	
Fraces A: Max Hold						o	
	-180.0						Change
-0	-190.0						Quick Name
Sweep (Fast) Continuous	-200.0						Change
							Save Location
F req Ref nt Std Accy	–210.0 d₿m						Change Type Setup/JPEG/
	27.000 GHz			Center 27.500 GHz Span 1.000 GHz		28.000 GHz	
Freq		Amplitude		Span	BW		Marker

Figure 3.1-7 (D) Spectrum Photos 27-28 GHz 100 kHz Res BW Vertical Pol 360⁰

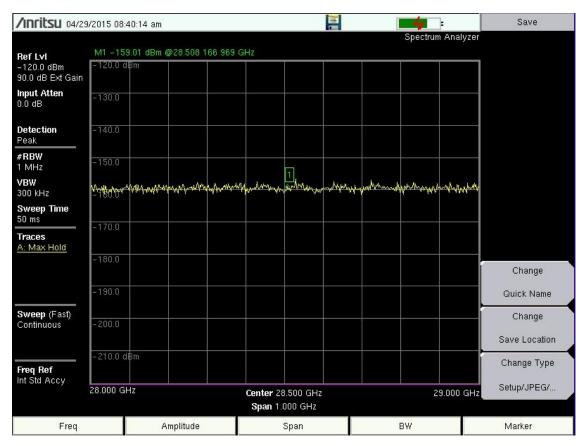


Figure 3.1-8 (A) Spectrum Photos 28-29 GHz 1MHz Res BW Horizontal Pol 360⁰

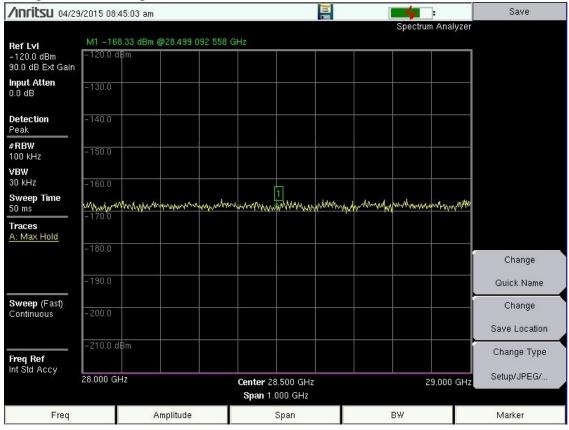


Figure 3.1-8 (B) Spectrum Photos 28-29 GHz 100 kHz Res BW Horizontal Pol 360⁰

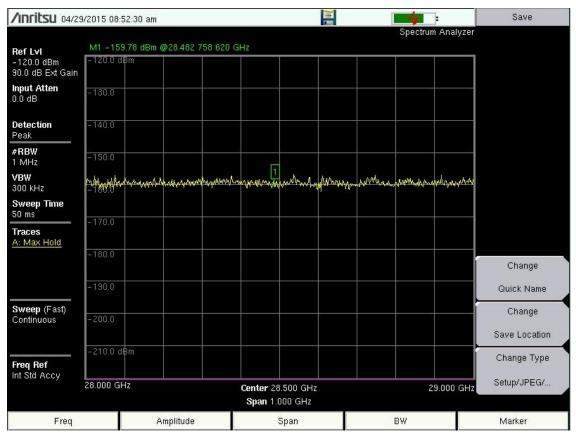


Figure 3.1-8 (C) Spectrum Photos 28-29 GHz 1MHz Res BW Vertical Pol 360⁰

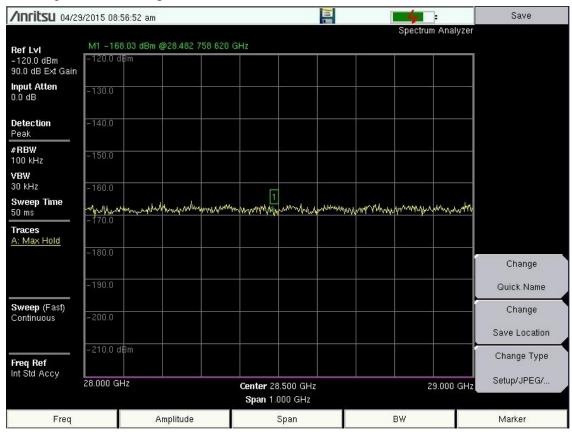


Figure 3.1-8 (D) Spectrum Photos 28-29 GHz 100 kHz Res BW Vertical Pol 360⁰

/nritsu 04/29/2015 08:41:11 am				Save
			Spectrum Analyzer	
Ref Lvl -120.0 dBm 90.0 dB Ext Gain	M1 -161.25 dBm @29.517 241 379 -120.0 dBm	GHz		
Input Atten 0.0 dB	-130.0			
Detection Peak	-140.0			
#RBW 1 MHz	-150.0			
VBW 300 kHz	-160.0	and a section of the second and a second	manythingation and the second	
Sweep Time 50 ms	217000			
Traces <u>A: Max Hold</u>	-170.0			
	-180.0			Change
	-190.0			Quick Name
Sweep (Fast) Continuous	-200.0			Change Save Location
Freq Ref Int Std Accy	–210.0 dBm			Change Type
	29.000 GHz	Setup/JPEG/		
Freq	Amplitude	Span	BW	Marker

Figure 3.1-9 (A) Spectrum Photos 29-30 GHz 1MHz Res BW Horizontal Pol 360⁰

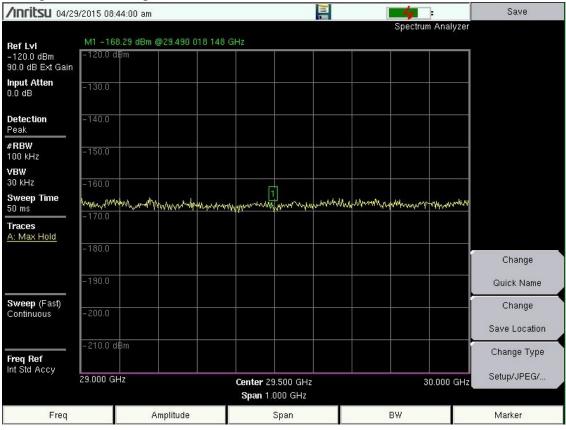


Figure 3.1-9 (B) Spectrum Photos 29-30 GHz 100 kHz Res BW Horizontal Pol 360°

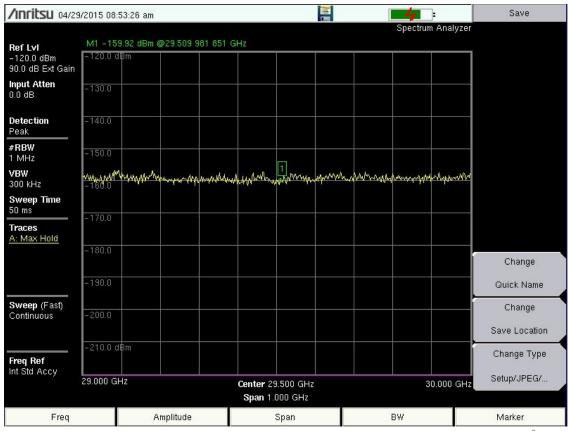


Figure 3.1-9 (C) Spectrum Photos 29-30 GHz 1MHz Res BW Vertical Pol 360⁰

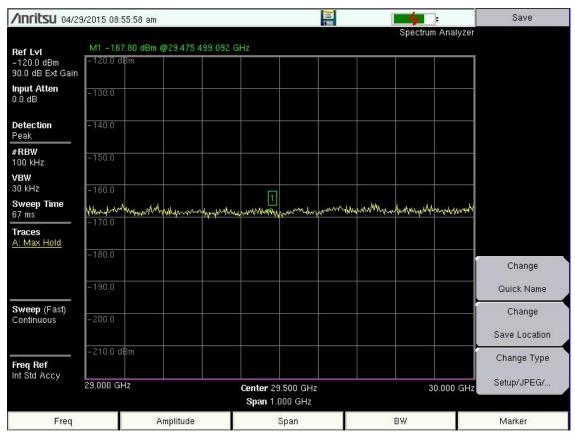


Figure 3.1-9 (D) Spectrum Photos 29-30 GHz 100 kHz Res BW Vertical Pol 360⁰

/Inritsu 04/29	/2015 08:42:13 am			Save			
			Spectrum Analyzer				
RefLvi -120.0 dBm	M1 -159.50 dBm @30.528 130 671 -120.0 dBm	GHz					
90.0 dB Ext Gain							
Input Atten 0.0 dB	-130.0						
Detection Peak	-140.0						
#RBW 1 MHz	-150.0						
VBW 300 kHz	nanwalkanawanananakanananakana	way water have the water and	and again and the second s				
Sweep Time 50 ms							
Traces <u>A: Max Hold</u>	-170.0						
	-180.0			Change			
	-190.0			Quick Name			
Sweep (Fast) Continuous	-200.0			Change Save Location			
Freq Ref	-210.0 d8m			Change Type			
Int Std Accy 30.000 GHz Center 30.500 GHz 31.000 GHz Setup Span 1.000 GHz							
Freq	Amplitude	Span	BW	Marker			

Figure 3.1-10 (A) Spectrum Photos 30-31 GHz 1MHz Res BW Horizontal Pol 360°

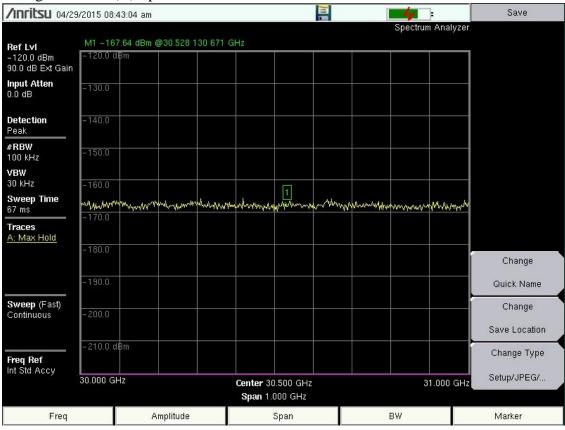


Figure 3.1-10 (B) Spectrum Photos 30-31 GHz 100 kHz Res BW Horizontal Pol 360⁰

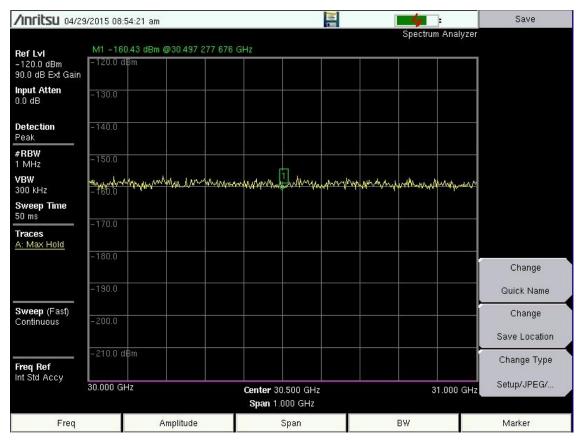


Figure 3.1-10 (C) Spectrum Photos 30-31 GHz 1MHz Res BW Vertical Pol 360⁰

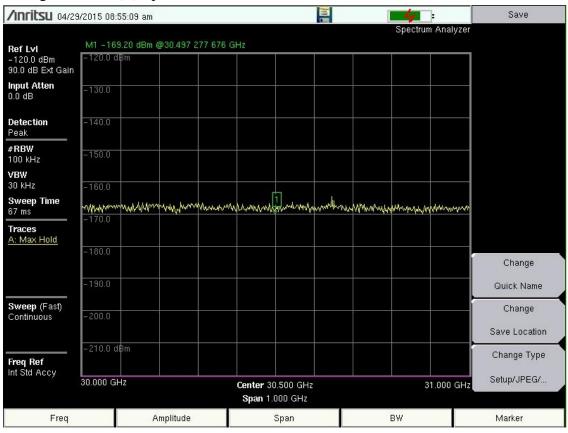


Figure 3.1-10 (D) Spectrum Photos 30-31 GHz 100 kHz Res BW Vertical Pol 360⁰

FOUR

SUMMARY OF RESULTS

The results of the measurements conducted at the proposed ViaSat, Inc site in Detroit, MI 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.

Ku-Band Measurements:

There was no radio frequency interference cases measured at this site above the noise floor of the test equipment. Five conflicts were projected with six possible frequencies. These were not found.

FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 <u>Conclusions</u>

There were no signals measured above the -156 dBW/ 1 MHz interference objective for digital reception at this site.

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

Special note: The RF measurements were performed approx 100 feet from the actual prospective site. The parking area is a very active staging area and as such the area of interest was not accessible and an area was created for testing.

5.2 <u>Recommendations</u>

It is recommended that frequency coordination of this site be initiated to protect this location at the more stringent digital receive interference objective.