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FCC Part 74F Certification Test Report
For the
Broadcast Sports International
HD In-Car Transmitter

FCC ID: KTB-13418-9-001

WLL JOB# **14329-01 Rev 2**
January 05, 2016

Re-Issued
June 7, 2016

Prepared for:

Broadcast Sports International
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Hanover, MD 21076

Prepared By:

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ANAB ACCREDITED ISO/IEC 17025 TESTING LABORATORY

Testing Certificate AT-1448

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FCC Part 74F Certification Test Report
For the
Broadcast Sports International
HD In-Car Transmitter
FCC ID: KTB-13418-9-001

WLL JOB# 14329-01 Rev 2

January 05, 2016

Re-Issued
June 07, 2016

Prepared by:

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Abstract

This report has been prepared on behalf of Broadcast Sports International to support the attached Application for Equipment Authorization. The test report and application are submitted for a Licensed Non-Broadcast Station Transmitter under Part 74 F of the FCC Rules and Regulations. This Federal Communication Commission (FCC) Certification Test Report documents the test configuration and test results for a Broadcast Sports International HD In-Car Transmitter.

Testing was performed on an Open Area Test Site (OATS) of Washington Laboratories, Ltd, 7560 Lindbergh Drive, Gaithersburg, MD 20879. Site description and site attenuation data have been placed on file with the FCC's Sampling and Measurements Branch at the FCC laboratory in Columbia, MD. The Industry Canada OATS numbers are 3035A-1 and 3035A-2 for Washington Laboratories, Ltd. Site 1 and Site 2, respectively. Washington Laboratories, Ltd. has been accepted by the FCC and approved by ANAB under Certificate AT-1448 as an independent FCC test laboratory.

The Broadcast Sports International HD In-Car Transmitter complies with the limits for a Licensed Non-Broadcast Station Transmitter device under Part 74 F of the FCC Rules and Regulations.

Revision History	Reason	Date
Rev 0	Initial Release	January 05, 2016
Rev 1	Updated to reflect correct device name and customer name	May 18, 2016
Rev 2	Update the report to reflect the correct frequency tolerances for the device	June 7, 2016

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1 Introduction

1.1 Compliance Statement

The Broadcast Sports International HD In-Car Transmitter complies with the limits for a Licensed Non-Broadcast Station Transmitter device under Part 74F of the FCC Rules and Regulations.

1.2 Test Scope

Tests for radiated and conducted (at antenna terminal) emissions were performed. All measurements were performed in accordance with the 2014 version of ANSI C63.4 and EIA/TIA 603. The measurement equipment conforms to ANSI C63.2 Specifications for Electromagnetic Noise and Field Strength Instrumentation.

1.3 Contract Information

Customer:	Broadcast Sports International 7455 Race Road Hanover, MD, 21076
Purchase Order Number:	24920
Quotation Number:	68605C

1.4 Test Dates

Testing was performed on the following date(s):	11/11/2015-12/3/2015

1.5 Test and Support Personnel

Washington Laboratories, LTD	John P. Repella
Customer Representative	Dave Starsoneck

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1.6 Abbreviations

A	**A**mpere
ac	**a**lternating **c**urrent
AM	Amplitude Modulation
Amps	**Amp**eres
b/s	**b**its per **s**econd
BW	**B**and**W**idth
CE	**C**onducted **E**mission
cm	**c**enti**m**eter
CW	**C**ontinuous **W**ave
dB	**d**eci**B**el
dc	**d**irect **c**urrent
EMI	**E**lectro**m**agnetic **I**nterference
EUT	**E**quipment **U**nder **T**est
FM	**F**requency **M**odulation
G	**g**iga - prefix for 10^9 multiplier
Hz	**H**ertz
IF	**I**ntermediate **F**requency
k	**k**ilo - prefix for 10^3 multiplier
LISN	**L**ine **I**mpedance **S**tabilization **N**etwork
M	**M**ega - prefix for 10^6 multiplier
m	**m**eter
µ	**m**icro - prefix for 10^{-6} multiplier
NB	**N**arrow**b**and
QP	**Q**uasi-**P**eak
RE	**R**adiated **E**missions
RF	**R**adio **F**requency
rms	**r**oot-**m**ean-**s**quare
SN	**S**erial **N**umber
S/A	**S**pectrum **A**nalyzer
V	**V**olt

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2 Equipment Under Test

2.1 EUT Identification & Description

The HD In-Car Transmitter (TX) is intended to transmit audio and video from remote locations, e.g. mounted in a race car. It can transmit 1 or 2 videos simultaneously.

The TX is designed to accept four pairs of audio and video inputs. The user selects up to 2 A/V inputs upon which the TX performs various processing and modulation functions, and outputs a DVB-T COFDM signal to an external antenna.

The unit's audio inputs are balanced mic-level connectors with T-power. The video inputs can be HD-SDI, SD-SDI, or NTSC, all of which the TX will auto-detect and pre-process appropriately. Once pre-processed, the audio and video are encoded (LPCM, MPEG-2 Layer I&II, or Dolby for audio and H.264 for the video) and mux'ed into a transport stream (TS). The resulting TS is modulated (QPSK, 16QAM, or 64QAM) and output to an attached antenna.

Table 1: Device Summary

ITEM	DESCRIPTION
Manufacturer:	Broadcast Sports International
FCC ID:	KTB-13418-9-001
Model:	HD Mini Transmitter
FCC Rule Parts:	§74 Sub Part F
Industry Canada:	N/A
Frequency Range:	2033 – 2101.5MHz & 2458.5MHz
Maximum Output Power:	(Calibrated & configured by Manufacturer for consumer to be no greater than +25dBm)
Modulation:	QPSK,16QAM, 64QAM
Occupied Bandwidth:	8 MHz
Keying:	Automatic, Manual
Type of Information:	Audio/Video
Number of Channels:	16
Power Output Level	248mW(23.95dBm)
Antenna Connector	SMA
Antenna Type	Multiple up to, Max 5.1 dBi
Frequency Tolerance	2033 - 2067.5MHz >0.005 & 2101.5-2458.5MHz >0.001
Interface Cables:	See Interface Cables
Power Source & Voltage:	12Vdc Nominal

Table 2: Equipment Configuration

Name / Description	Model Number	Part Number	Serial Number	Rev. #
HD In-Car Transmitter	-	13418-9-001	12530	N/A

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2.2 Port and Cabling

The following port and cabling were identified on the EUT

Table 3: Ports & Cabling

Ref. ID	EUT Port	Cable Description or reason for no cable	Qty.	Length (m)	Shielded?
1	V1	7-pin LEMO to BNC	1		Y
2	V2	7-pin LEMO to BNC	1		Y
3	V3	None – 2 video output max	-		N/A
4	V4	None – 2 video output max	-		N/A
5	A1	None – audio not needed	-		N/A
6	A2	None – audio not needed	-		N/A
7	A3	None – audio not needed	-		N/A
8	A4	None – audio not needed	-		N/A
9	RF	SMA-M to SMA-M	1		Y
10	DATA	Configuration Only	-		N/A
11	UHF	5-pin LEMO to DB-9	1		Y
12	PWR	2-pin LEMO to 4-pin XLR	1		Y

2.3 Support Equipment

The following support equipment was used during testing:

Table 4: Support Equipment

Name / Description	Manufacturer	Model Number	*Customer Supplied Calibration Data
Video Generator	Leader	LT 443D	N/A
Down Converter	BSI	-	N/A
Receiver/Decoder	BSI	-	N/A
SDI Monitor	Marshall	V-R10420P-TE4U	N/A
RS232-RS485 Converter	B&B	485SD9R	N/A
Laptop	Dell	E4310	N/A
USB-RS232 Converter	Assmann	Digitus	N/A

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2.4 Test Configuration

With all equipment connected as shown in Figure 1 and the HD In-Car TX transmitting. With all equipment connected as shown in the block diagram and the TX transmitting, the decoder status "GOOD" LED should be green and the monitor should display the test pattern being fed to the TX.

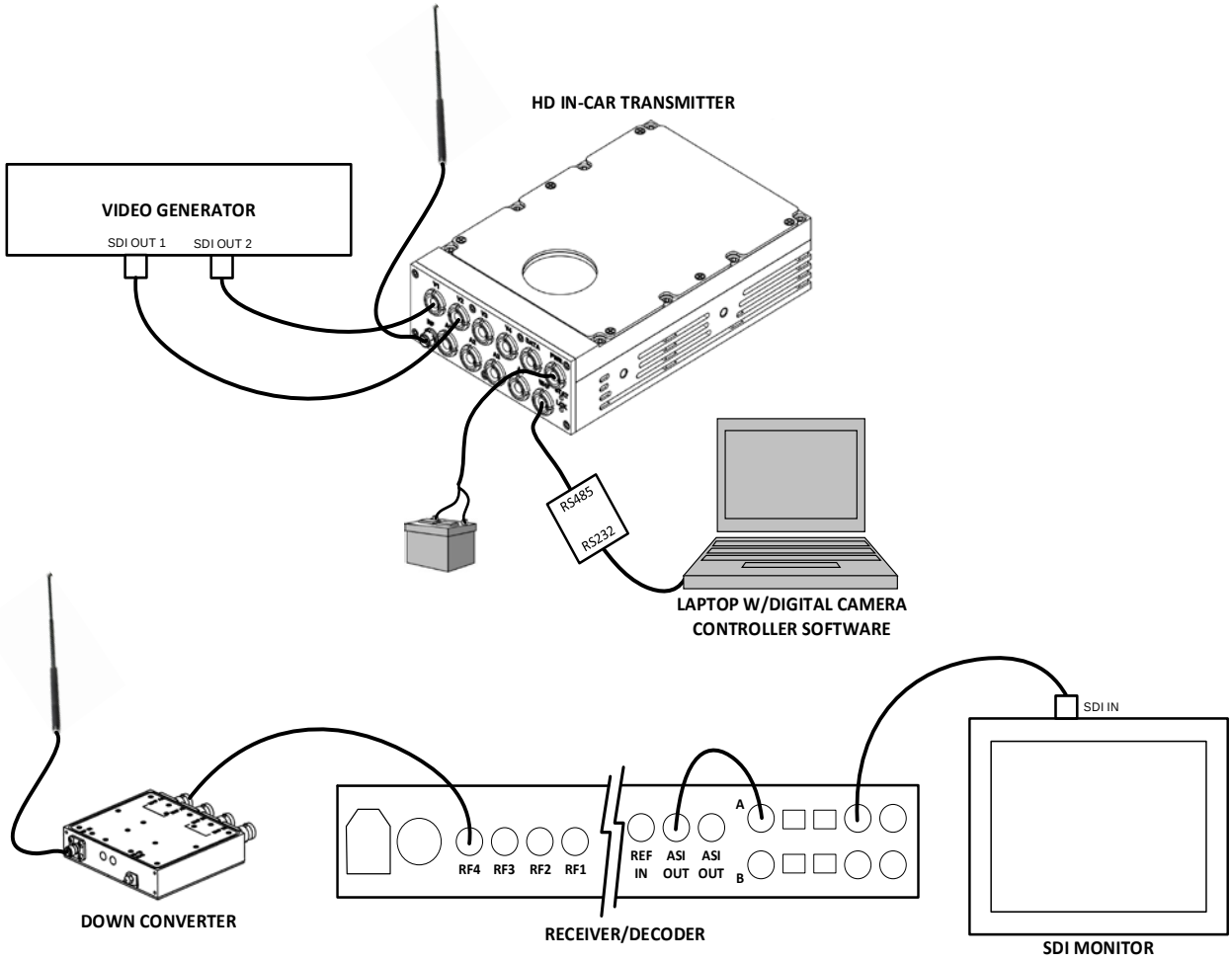

Figure 1: Test Configuration

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2.5 Testing Algorithm

The HD In-Car TX will auto-detect input video the following formats – HD-SDI, SD-SDI, and NTSC. The carrier is selectable in 250 kHz increments, from 1435MHz to 2600MHz. The frequency range is restricted to the applicable requirements for the region that it is distributed. The FEC rate is selectable (1⁄2, 2⁄3, 3⁄4, 5⁄6, 7⁄8) as is the modulation scheme (QPSK or QAM16). In dual stream mode, the two videos are modulated onto two adjacent COFDM pedestals.

2.6 Test Location

All measurements herein were performed at Washington Laboratories, Ltd. test center in Gaithersburg, MD. Site description and site attenuation data have been placed on file with the FCC's Sampling and Measurements Branch at the FCC laboratory in Columbia, MD. The Industry Canada OATS numbers are 3035A-1 and 3035A-2 for Washington Laboratories, Ltd. Site 1 and Site 2, respectively. Washington Laboratories, Ltd. has been accepted by the FCC and approved by ANAB under Certificate AT-1448 as an independent FCC test laboratory.

2.7 Measurements

2.7.1 References

ANSI/TIA/EIA-603 Land Mobile FM or PM Communications Equipment Measurement and Performance Standards

ANSI C63.2 Specifications for Electromagnetic Noise and Field Strength Instrumentation

ANSI C63.4 American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz

2.8 Measurement Uncertainty

All results reported herein relate only to the equipment tested. The basis for uncertainty calculation uses ANSI/NCSL Z540-2-1997 (2002) with a type B evaluation of the standard uncertainty. Elements contributing to the standard uncertainty are combined using the method described in Equation 1 to arrive at the total standard uncertainty. The standard uncertainty is multiplied by the coverage factor to determine the expanded uncertainty which is generally accepted for use in commercial, industrial, and regulatory applications and when health and safety are concerned (see Equation1 and Equation 2). A coverage factor was selected to yield a 95% confidence in the uncertainty estimation.

Equation 1: Standard Uncertainty

$$u_c = \pm\sqrt{\frac{a^2}{div_a{}^2} + \frac{b^2}{div_b{}^2} + \frac{c^2}{div_c{}^2} + ...}$$

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Where uc = standard uncertainty

a, b, c,.. = individual uncertainty elements

diva, b, c = the individual uncertainty element divisor based on the probability distribution

Divisor = 1.732 for rectangular distribution

Divisor = 2 for normal distribution

Divisor = 1.414 for trapezoid distribution

Equation 2: Expanded Uncertainty

$$U = ku_c$$

Where U = expanded uncertainty

k = coverage factor

$k \leq 2$ for 95% coverage (ANSI/NCSL Z540-2 Annex G)

uc = standard uncertainty

The measurement uncertainty complies with the maximum allowed uncertainty from CISPR 16-4-2. Measurement uncertainty is not used to adjust the measurements to determine compliance. The expanded uncertainty values for the various scopes in the WLL accreditation are provided in Table 5.

Table 5: Expanded Uncertainty List

Scope	Standard(s)	Expanded Uncertainty
Bench Conducted Emissions	ANSI/NCSL Z540-2/CISPR 16-4-2	±2.30 dB
Radiated Emissions	ANSI/NCSL Z540-2/CISPR 16-4-2	+4.55 dB

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3 Test Equipment

The test equipment used for test measurements along with the calibration information is shown in Table 6 below.

Table 6: Test Equipment List

Test Name:	**Radiated Emissions**	Test Date:	**11/15/2015**
Asset #	**Manufacturer/Model**	**Description**	**Cal. Due**
382	SUNOL SCIENCES CORPORATION - JB1	ANTENNA BICONLOG	8/31/2017
644	SUNOL SCIENCES CORPORATION - JB1 925-833-9936	BICONALOG ANTENNA	8/14/2017
849	AH SYSTEMS - SAC-18G-16	16 METER CABLE	8/22/2016
528	AGILENT - E4446A	3HZ - 44GHZ ANALYZER SPECTRUM	7/15/2016
522	HP - 8449B	PRE-AMPLIFIER 1-26.5GHZ	12/24/2015
4	ARA - DRG-118/A	ANTENNA DRG 1-18GHZ	10/8/2016
425	ARA - DRG-118/A	ANTENNA DRG 1-18GHZ	11/23/2017
803	R&S - SMR 40	SIGNAL GENERATOR 1 - 40GHZ	7/15/2017
558	HP - 8447D	AMPLIFIER	2/20/2016
558	HP - 8447D	AMPLIFIER	2/20/2016

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4 Test Results

4.1 RF Power Output (FCC Part §2.1046 & §74.636)

The output from the transmitter was connected to a broadband power meter and the output power was measured.

The output power shall be measured when the transmitter is operating at the manufacturer's rated power and modulated with signals representative (i.e. typical) of those encountered in a real system operation.

Table 7: RF Power Output (QPSK Modulation)

Channel/TX Frequency (MHz)	Measured Level (dBm)	Measured Level (Watts)	Limit (Watts)
2033.0	23.20	0.209	12
2067.5	23.05	0.202	12
2101.5	23.81	0.240	12
2458.5	23.06	0.202	12

Table 8: RF Power Output (16QAM Modulation)

Channel/TX Frequency (MHz)	Measured Level (dBm)	Measured Level (Watts)	Limit (Watts)
2033.0	23.25	0.211	12
2067.5	23.05	0.202	12
2101.5	23.87	0.244	12
2458.5	23.10	0.204	12

Table 9: RF Power Output (64QAM Modulation)

Channel/TX Frequency (MHz)	Measured Level (dBm)	Measured Level (Watts)	Limit (Watts)
2033.0	23.23	0.210	12
2067.5	23.04	0.201	12
2101.5	23.95	0.248	12
2458.5	23.06	0.202	12

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4.2 Occupied Bandwidth: (FCC Part §2.1049 & §74.637)

Occupied bandwidth was performed by coupling the output of the EUT via cable to the input of a spectrum analyzer.

At full modulation, the occupied bandwidth was measured as shown:

Table 10: Occupied Bandwidth Results (QPSK)

Frequency(MHz)	Bandwidth(MHz)	Limit	Pass/Fail
2033.0	8.053	18 MHz	Pass
2067.5	8.003	18 MHz	Pass
2101.5	8.034	18 MHz	Pass
2458.5	8.142	18 MHz	Pass

Table 11: Occupied Bandwidth Results (16QAM)

Frequency(MHz)	Bandwidth(MHz)	Limit	Pass/Fail
2033.0	8.062	18 MHz	Pass
2067.5	8.038	18 MHz	Pass
2101.5	8.021	18 MHz	Pass
2458.5	8.101	18 MHz	Pass

Table 12: Occupied Bandwidth Results (64QAM)

Frequency(MHz)	Bandwidth(MHz)	Limit	Pass/Fail
2033.0	8.069	18 MHz	Pass
2067.5	8.134	18 MHz	Pass
2101.5	8.123	18 MHz	Pass
2458.5	8.089	18 MHz	Pass

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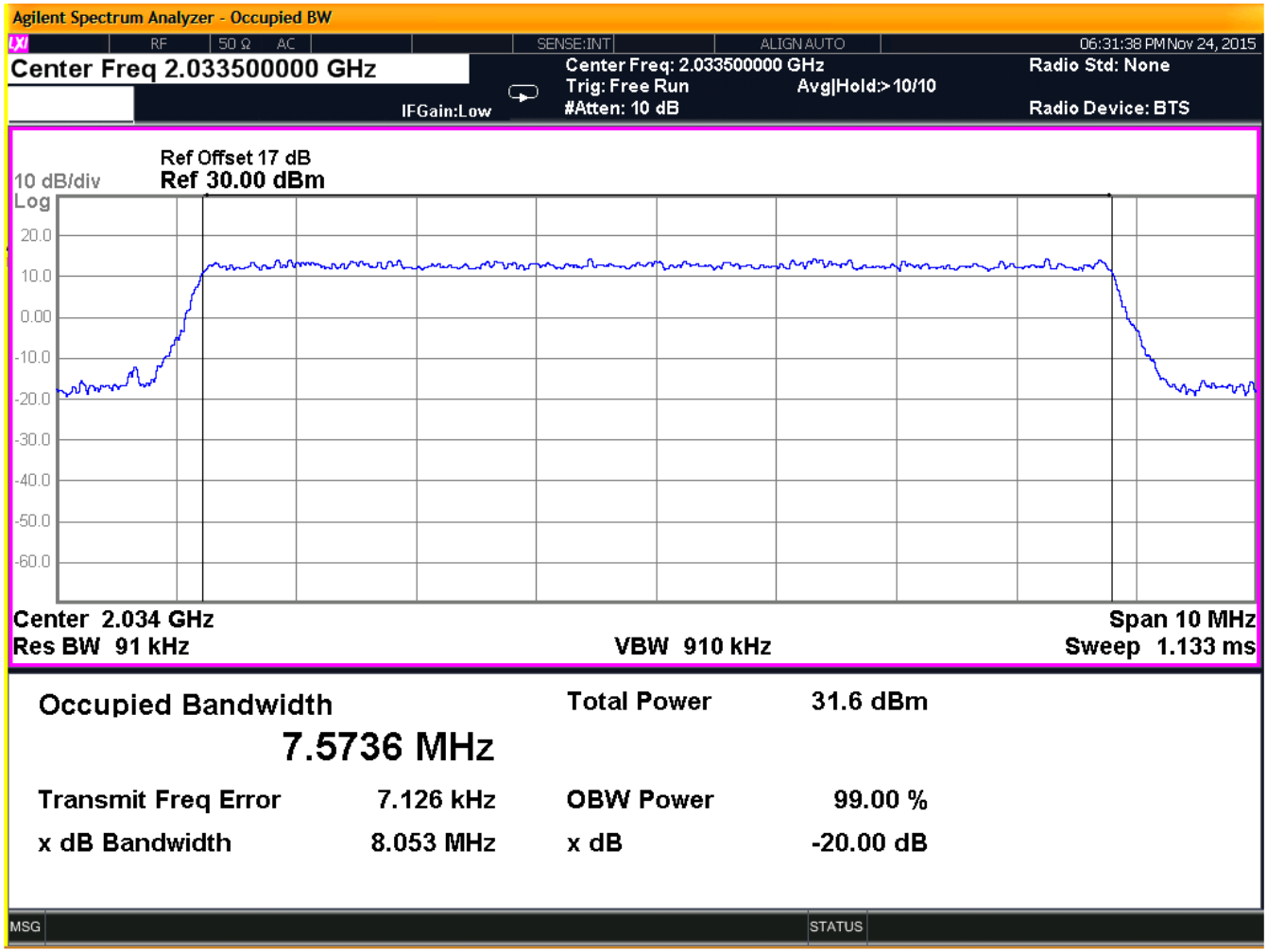

Figure 1: Occupied Bandwidth, QPSK Modulation, TX @ 2033MHz

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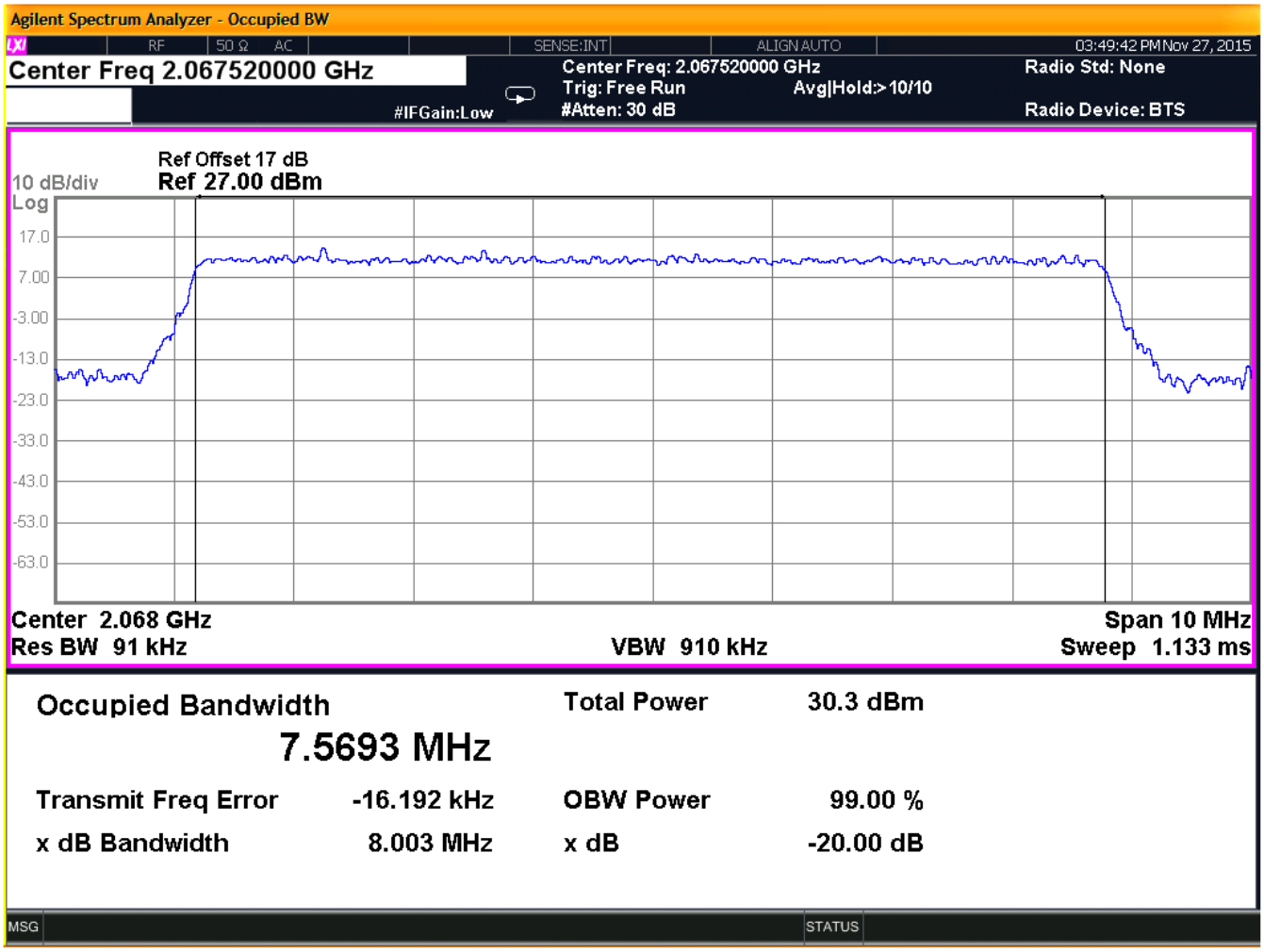

Figure 2: Occupied Bandwidth, QPSK Modulation, TX @ 2067.5MHz

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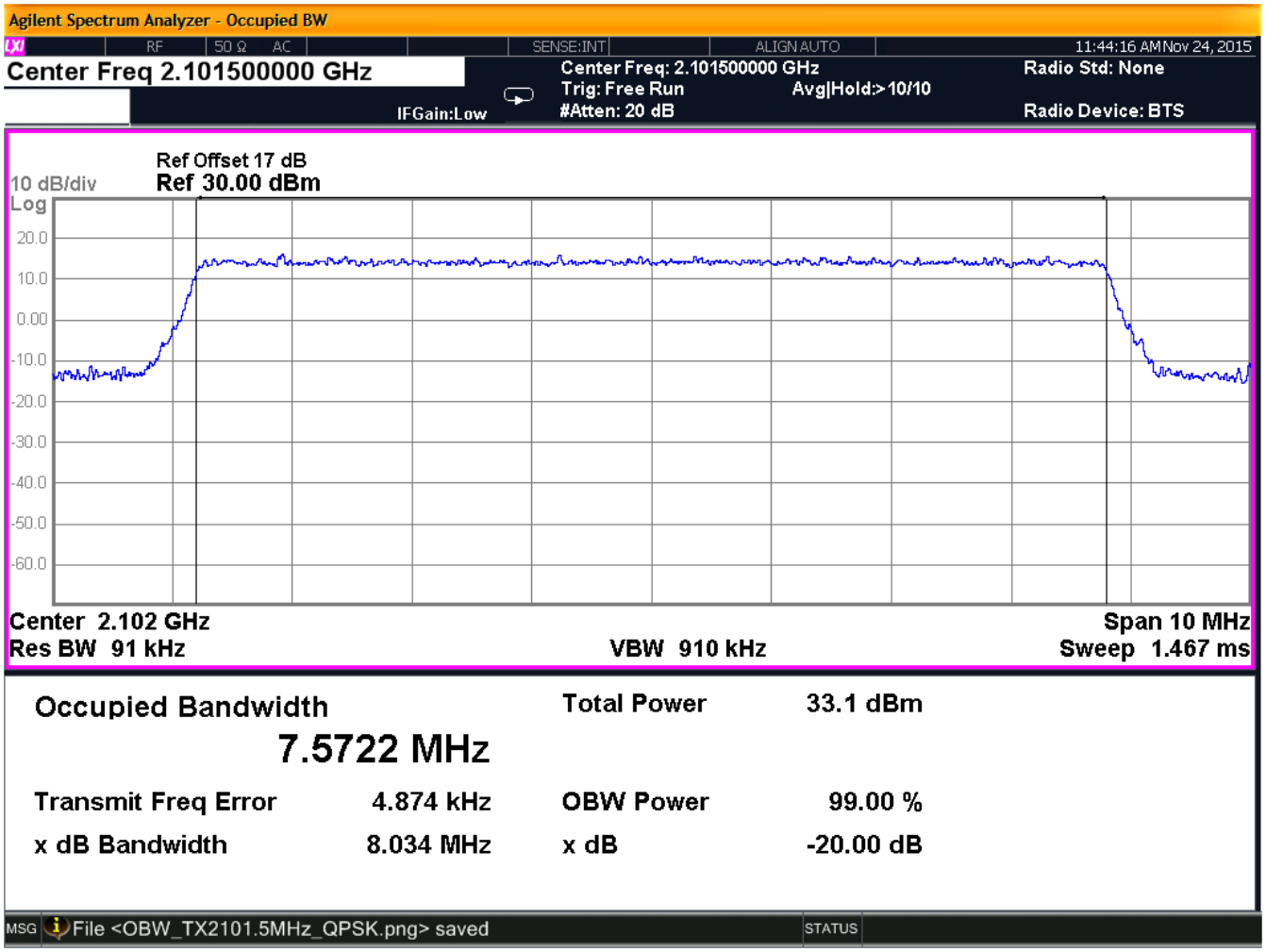

Figure 3: Occupied Bandwidth, QPSK Modulation, TX @ 2101.5MHz

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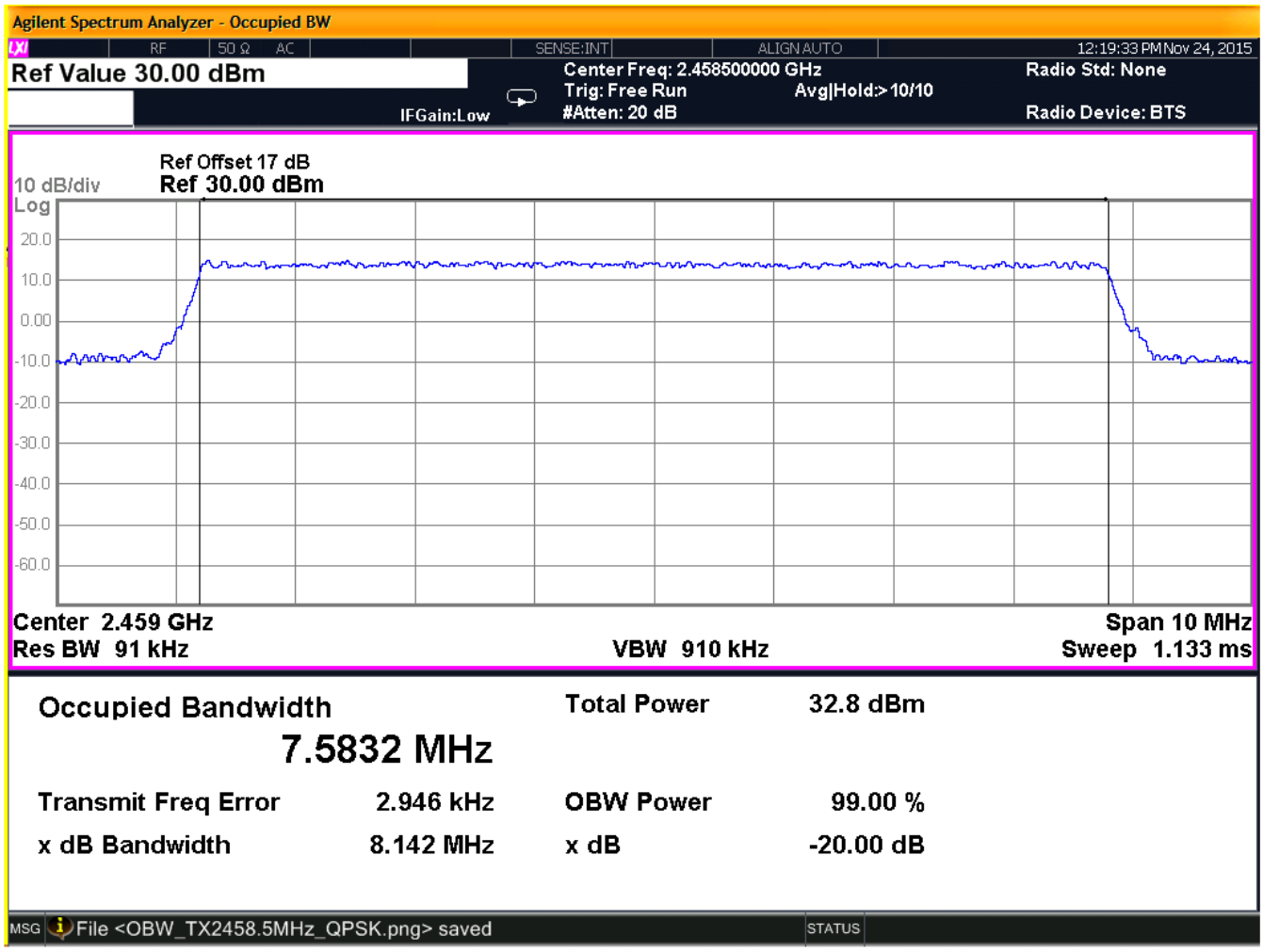

Figure 4: Occupied Bandwidth, QPSK Modulation, TX @ 2458.5MHz

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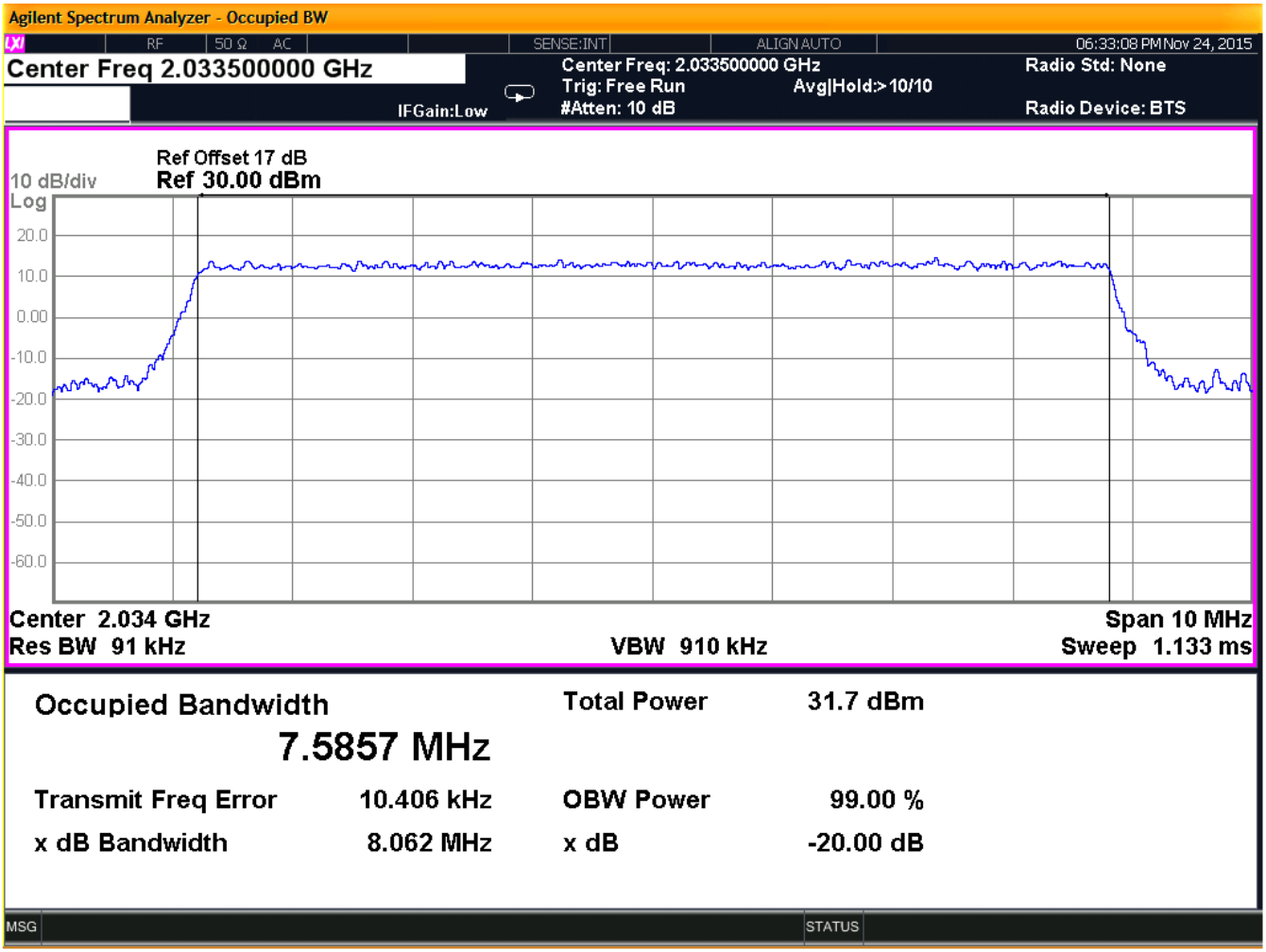

Figure 5: Occupied Bandwidth, 16QAM Modulation, TX @ 2033MHz

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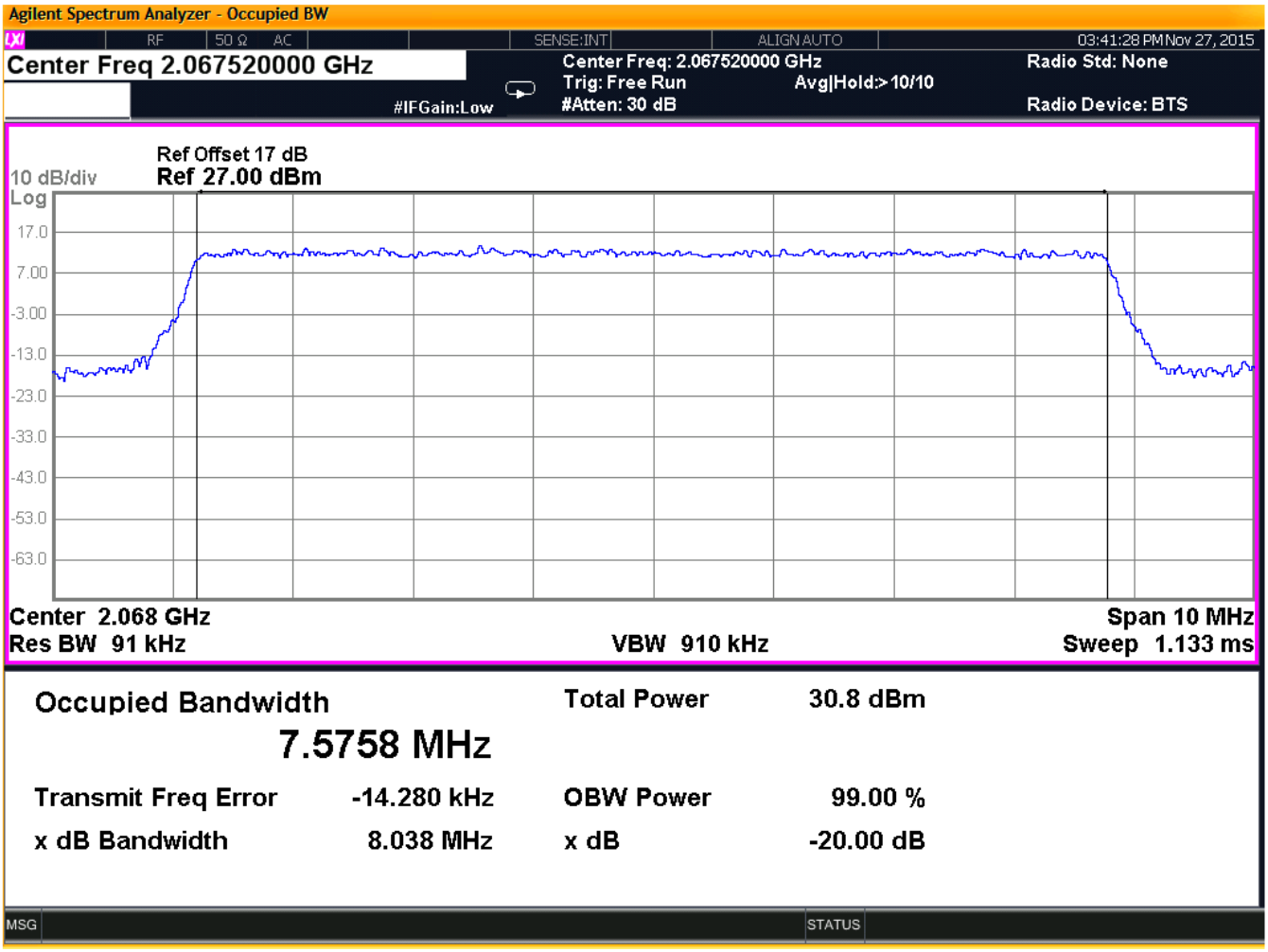

Figure 6: Occupied Bandwidth, 16QAM Modulation, TX @ 2067.5MHz

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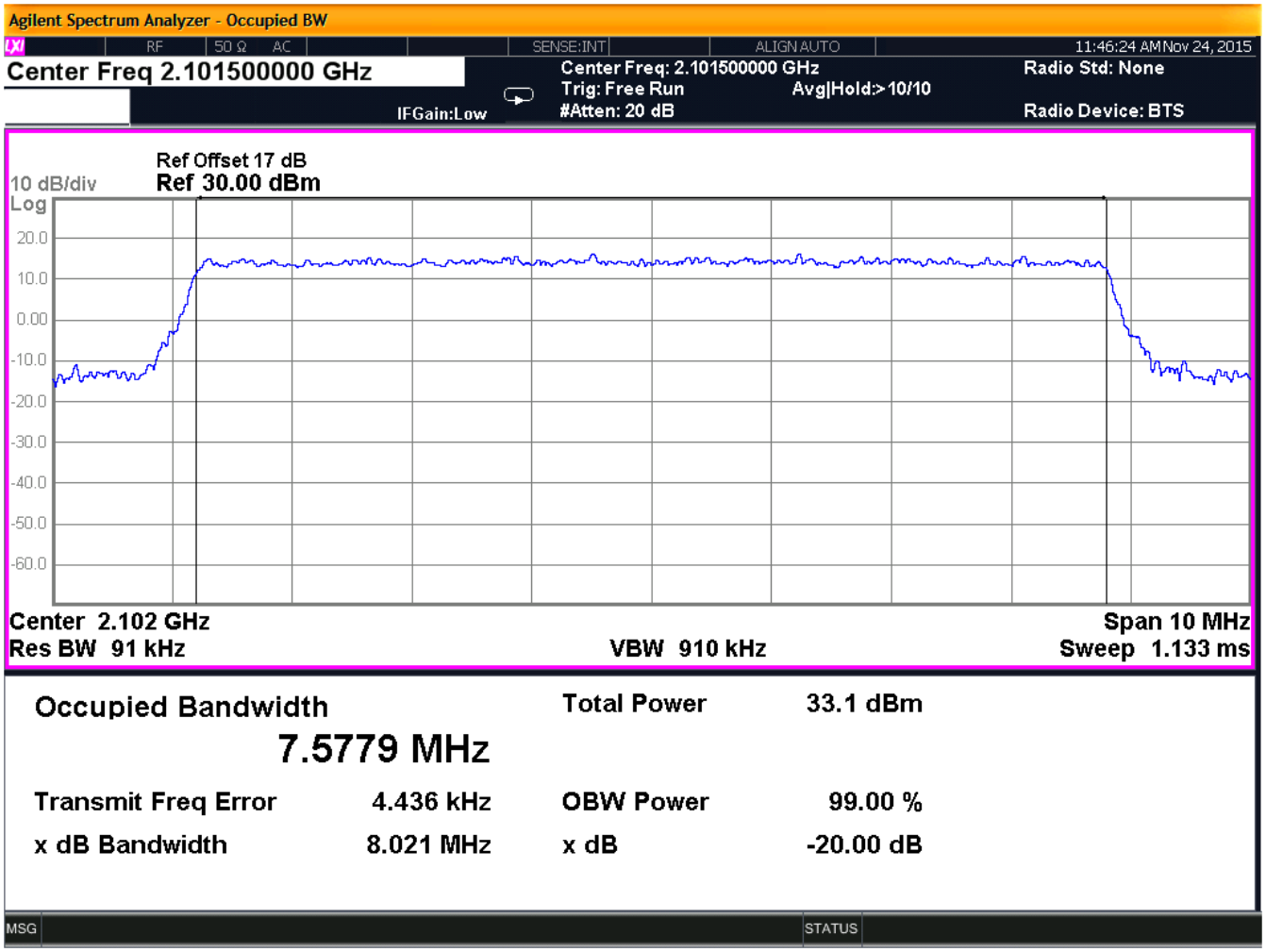

Figure 7: Occupied Bandwidth, 16QAM Modulation, TX @ 2101.5MHz

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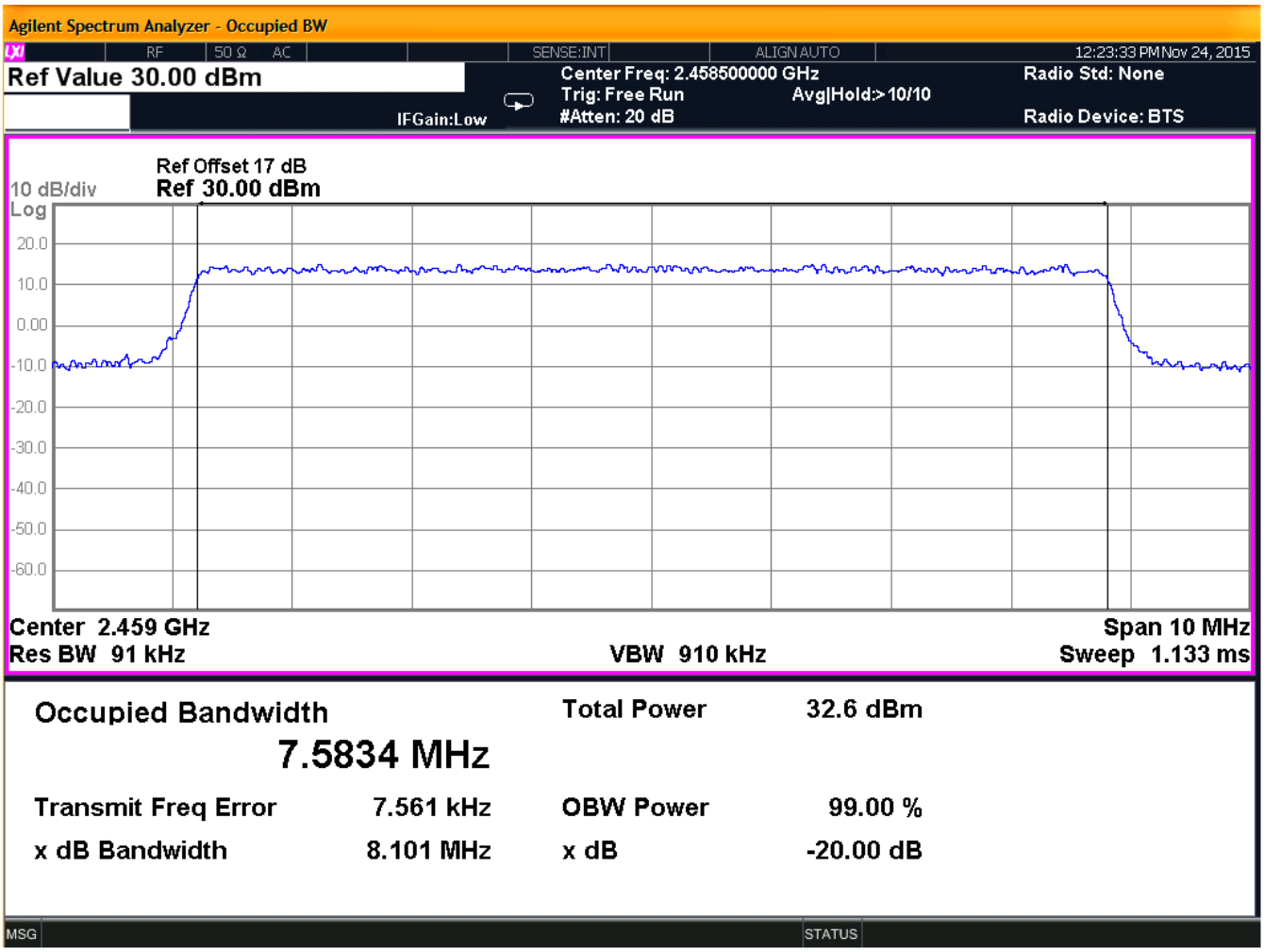

Figure 8: Occupied Bandwidth, 16QAM Modulation, TX @ 2458.5MHz

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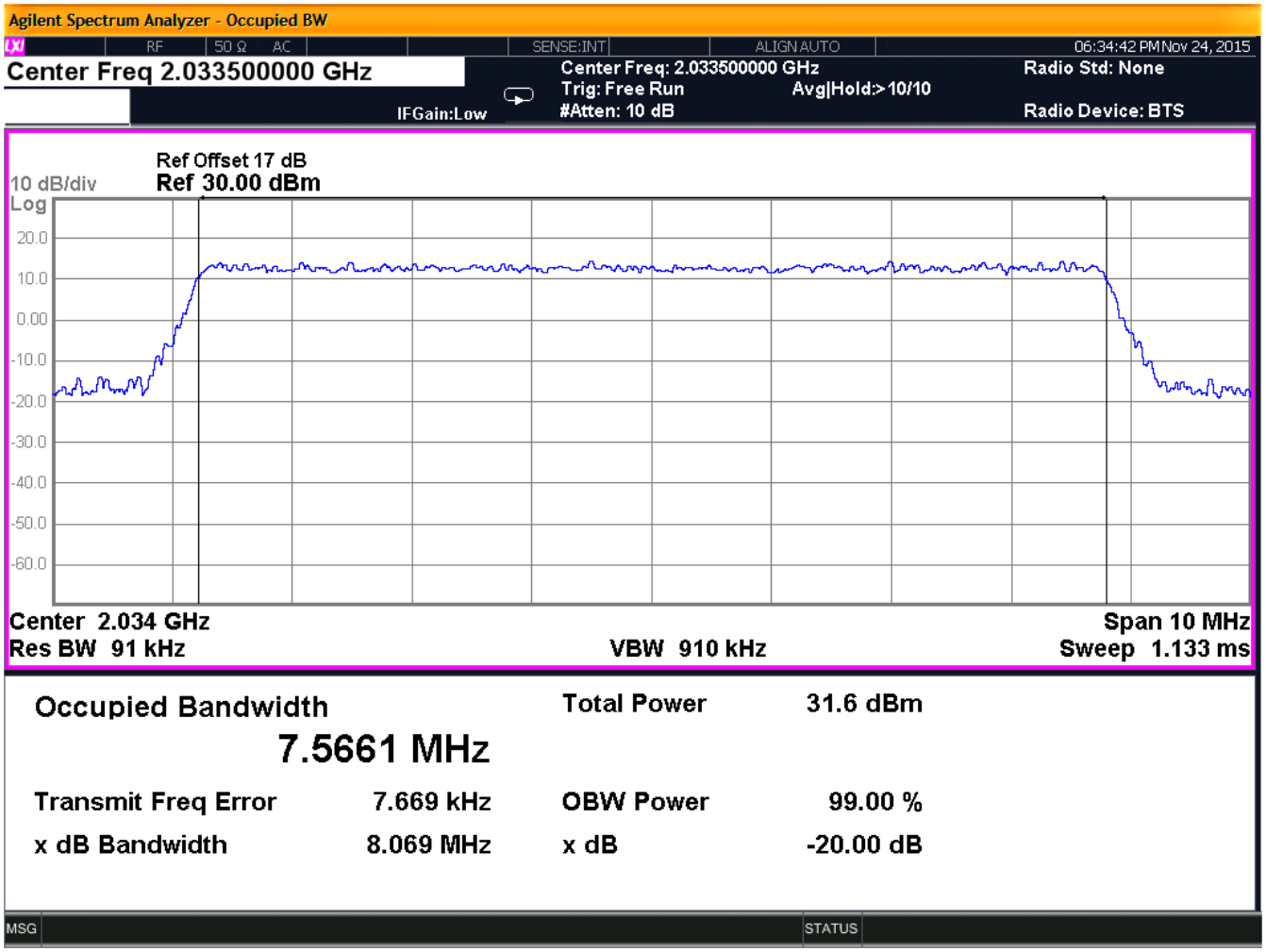

Figure 9: Occupied Bandwidth, 64QAM Modulation, TX @ 2033MHz

 © 2016 Washington Laboratories, Ltd.

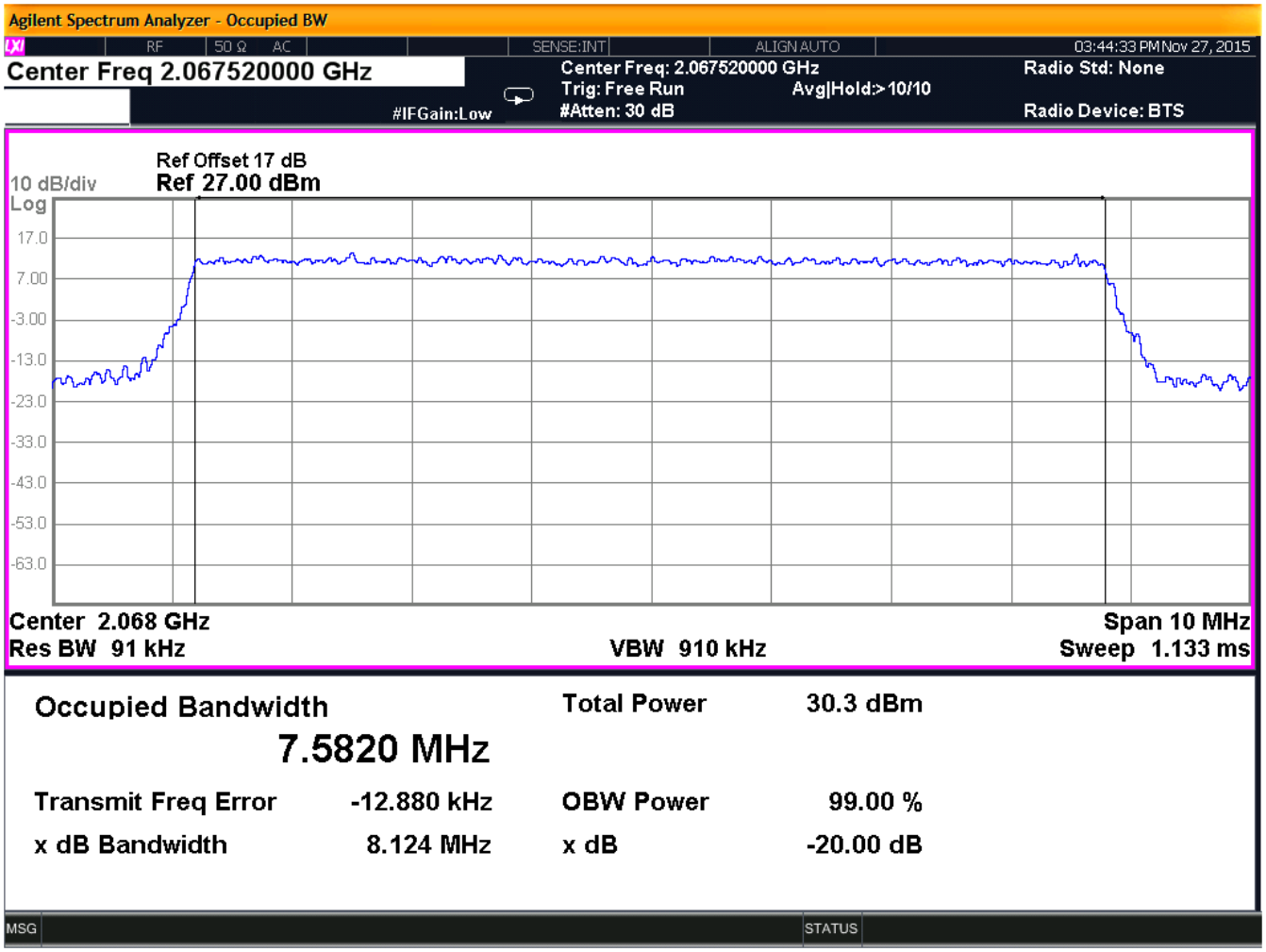

Figure 10: Occupied Bandwidth, 64QAM Modulation, TX @ 2067.5MHz

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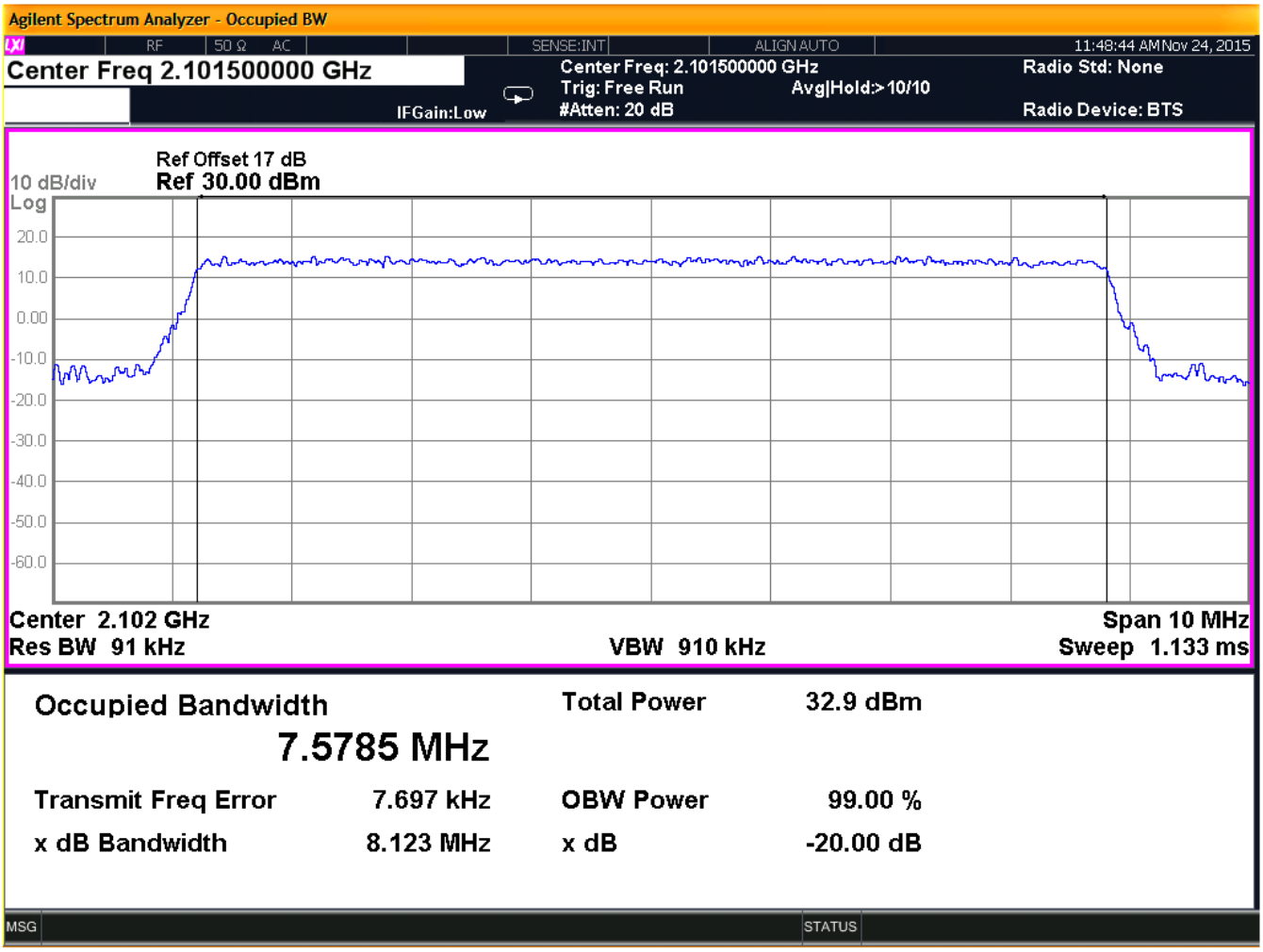

Figure 11: Occupied Bandwidth, 64QAM Modulation, TX @ 2101.5MHz

 © 2016 Washington Laboratories, Ltd.

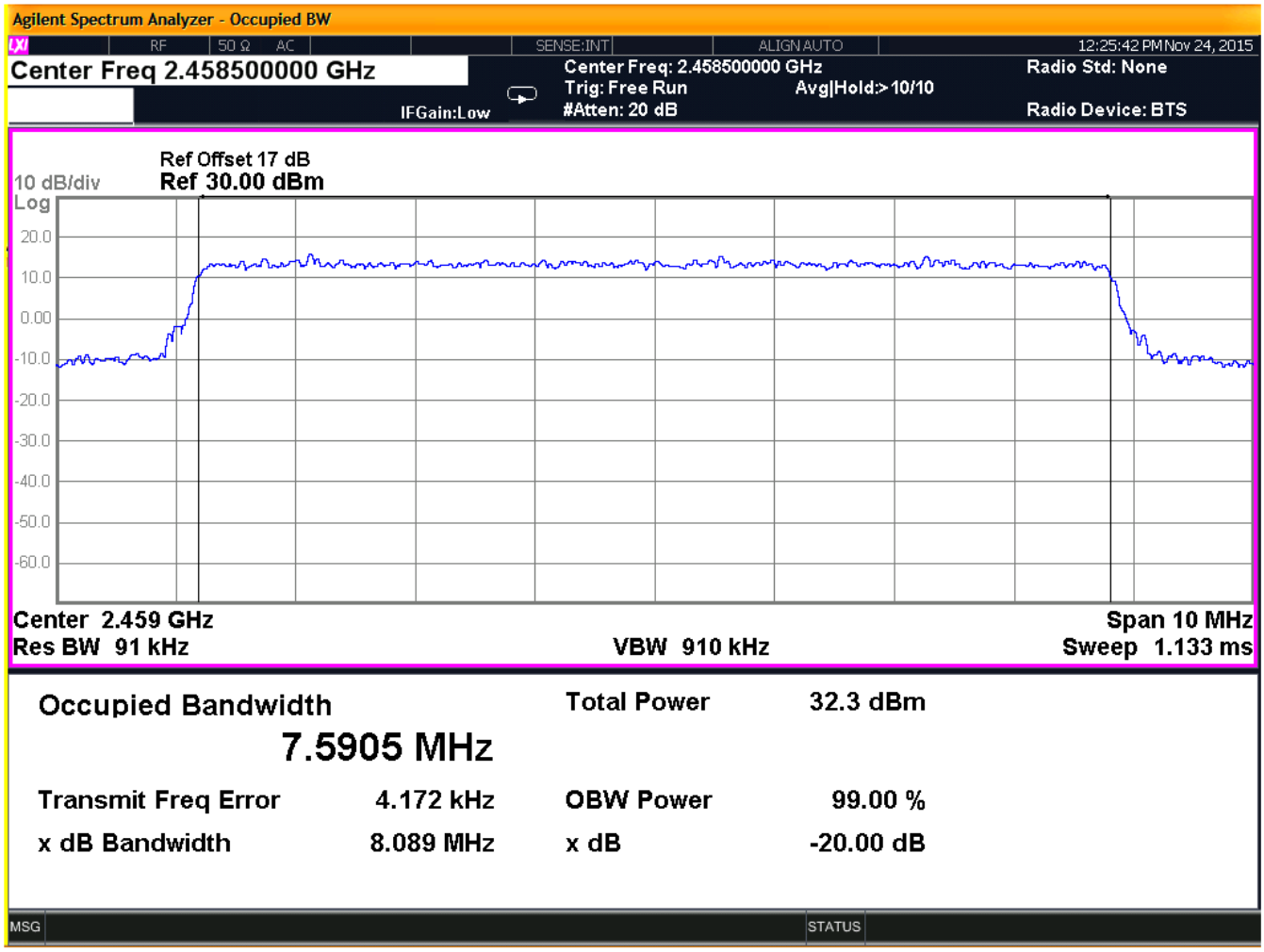

Figure 12: Occupied Bandwidth, 64QAM Modulation, TX @ 2458.5MHz

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4.3 Emission Limitations per FCC Part § 74.637 (Emission Masks & Spurious Emissions)

Emissions limitations are specified in §74.637 (a) 2 (i) for digitally modulated transmissions.

4.3.1 Test Procedure

The emissions from 30 MHz to the tenth harmonic of the operating frequency were measured. The EUT antenna was removed and the cable was connected directly into a spectrum analyzer through a 10 dB attenuator. An offset was programmed into the spectrum analyzer to compensate for the loss of the external attenuator. The spectrum analyzer resolution bandwidth was set to 100 kHz and the video bandwidth was set to 3MHz. The amplitude of the EUT carrier frequency was measured to determine the emissions limit (20 dB below the carrier frequency amplitude). The emissions outside of the allocated frequency band were then scanned from 30 MHz up to the tenth harmonic of the carrier. Each of the available modulation schemes was tested.

4.3.2 Test Results

The following plots detail the emissions measured.

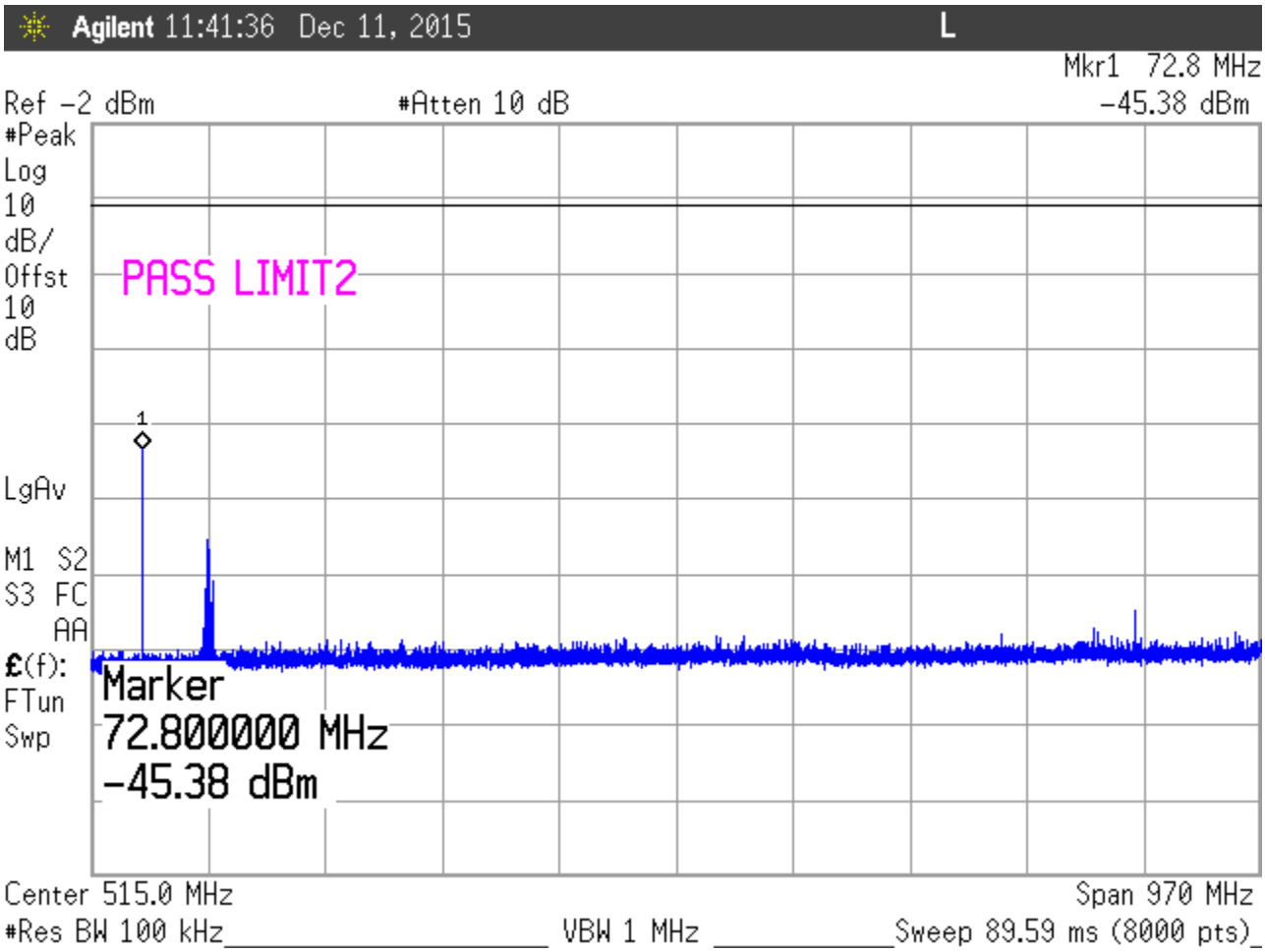

Figure 13: Spurious Emissions, QPSK Modulation, TX @ 2033MHz, 30MHz-1000MHz

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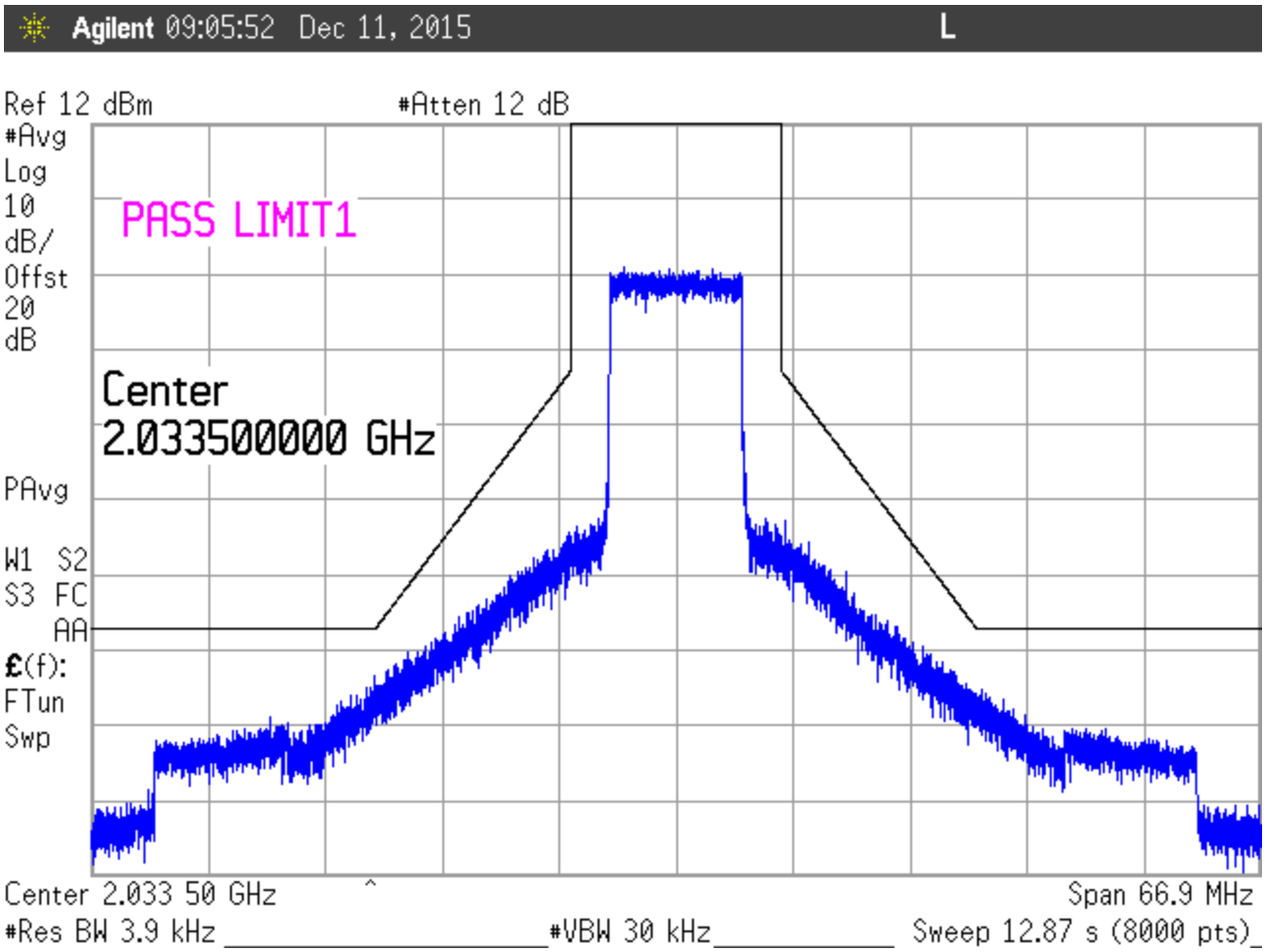

Figure 14: Spurious Emissions, QPSK Modulation, TX @ 2033MHz, Emission Mask

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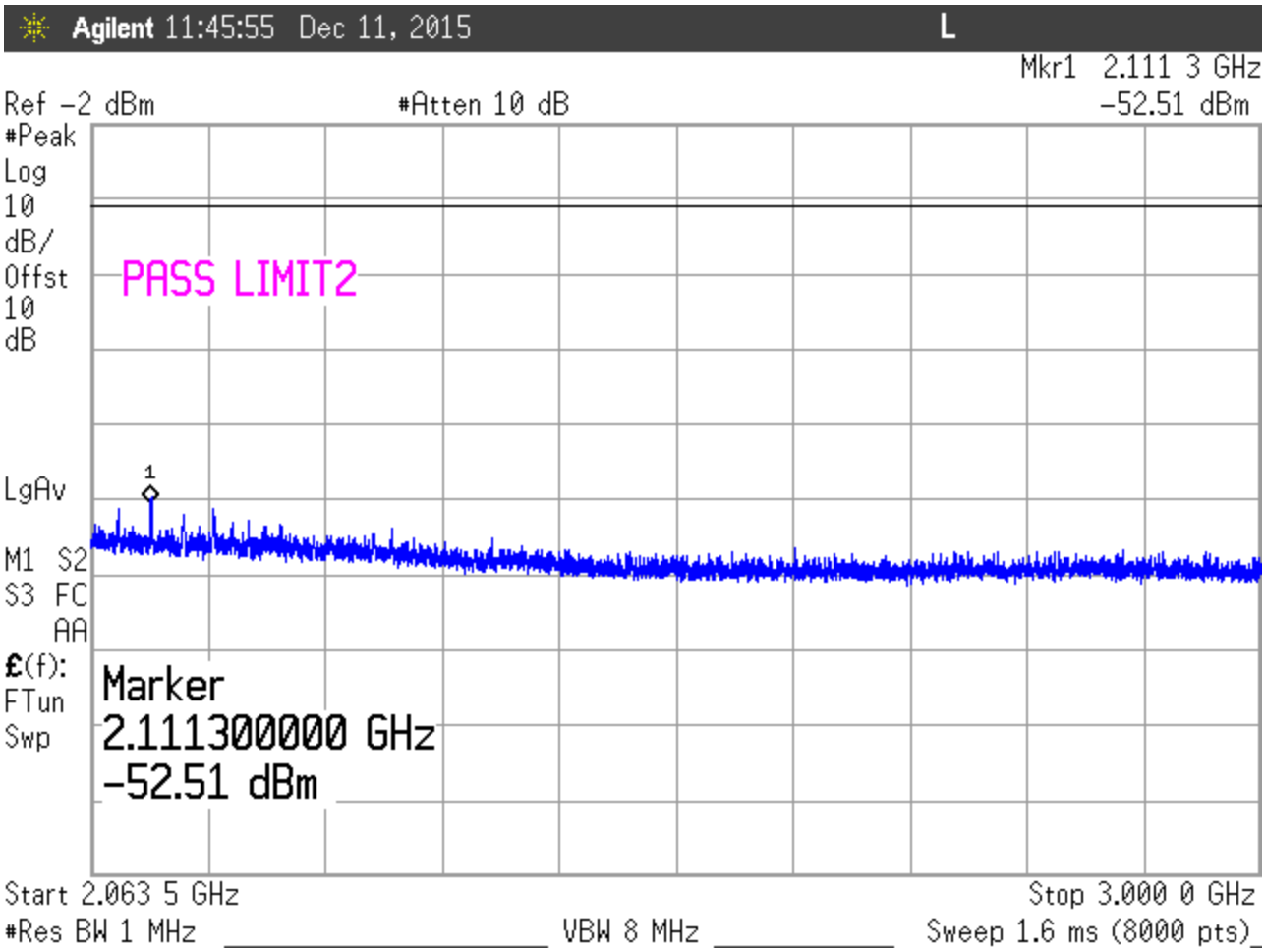

Figure 15: Spurious Emissions, QPSK Modulation, TX @ 2033MHz, 2063MHz-3000MHz

 © 2016 Washington Laboratories, Ltd.

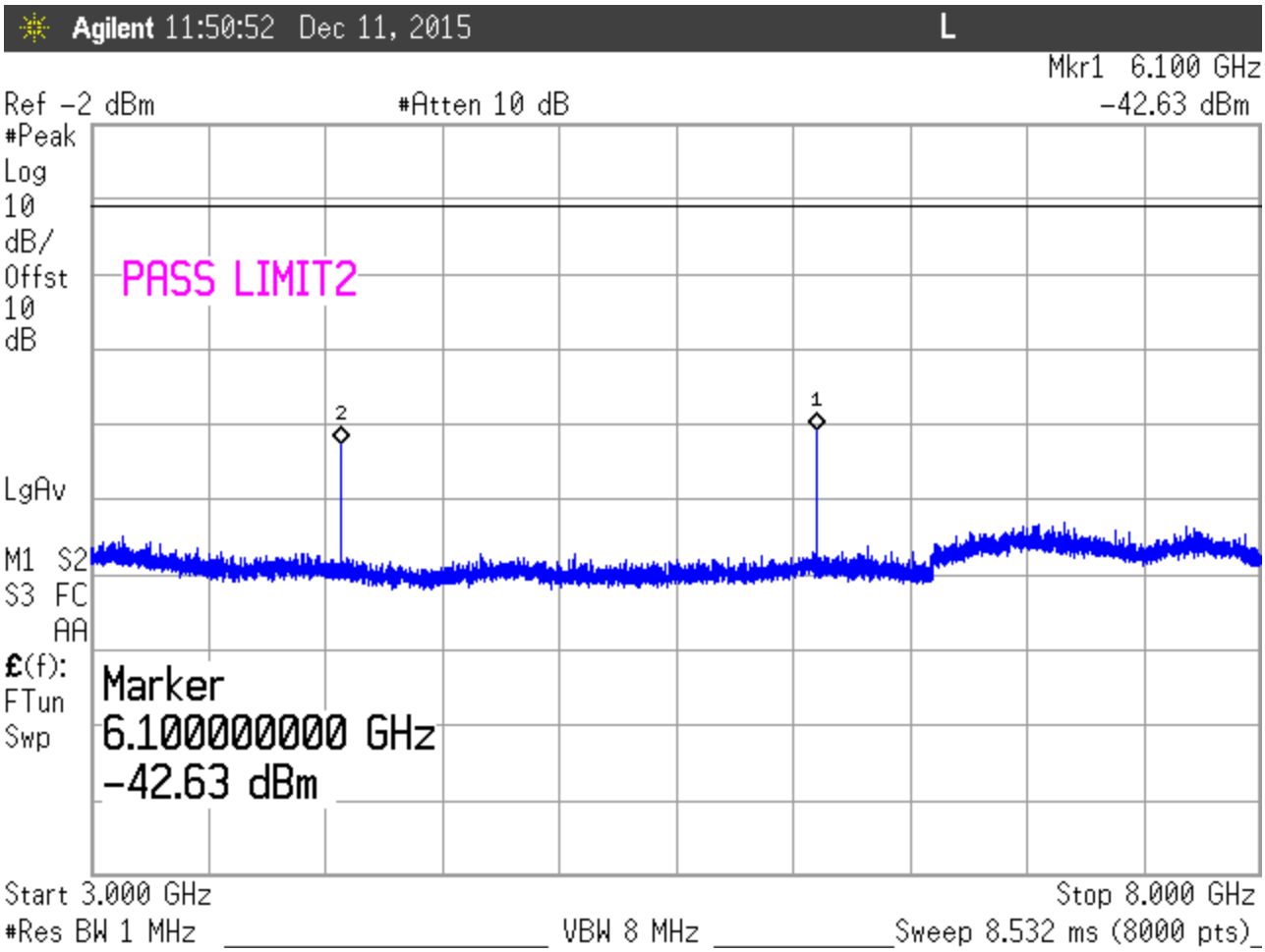

Figure 16: Spurious Emissions, QPSK Modulation, TX @ 2033MHz, 3GHz-8GHz

 © 2016 Washington Laboratories, Ltd.

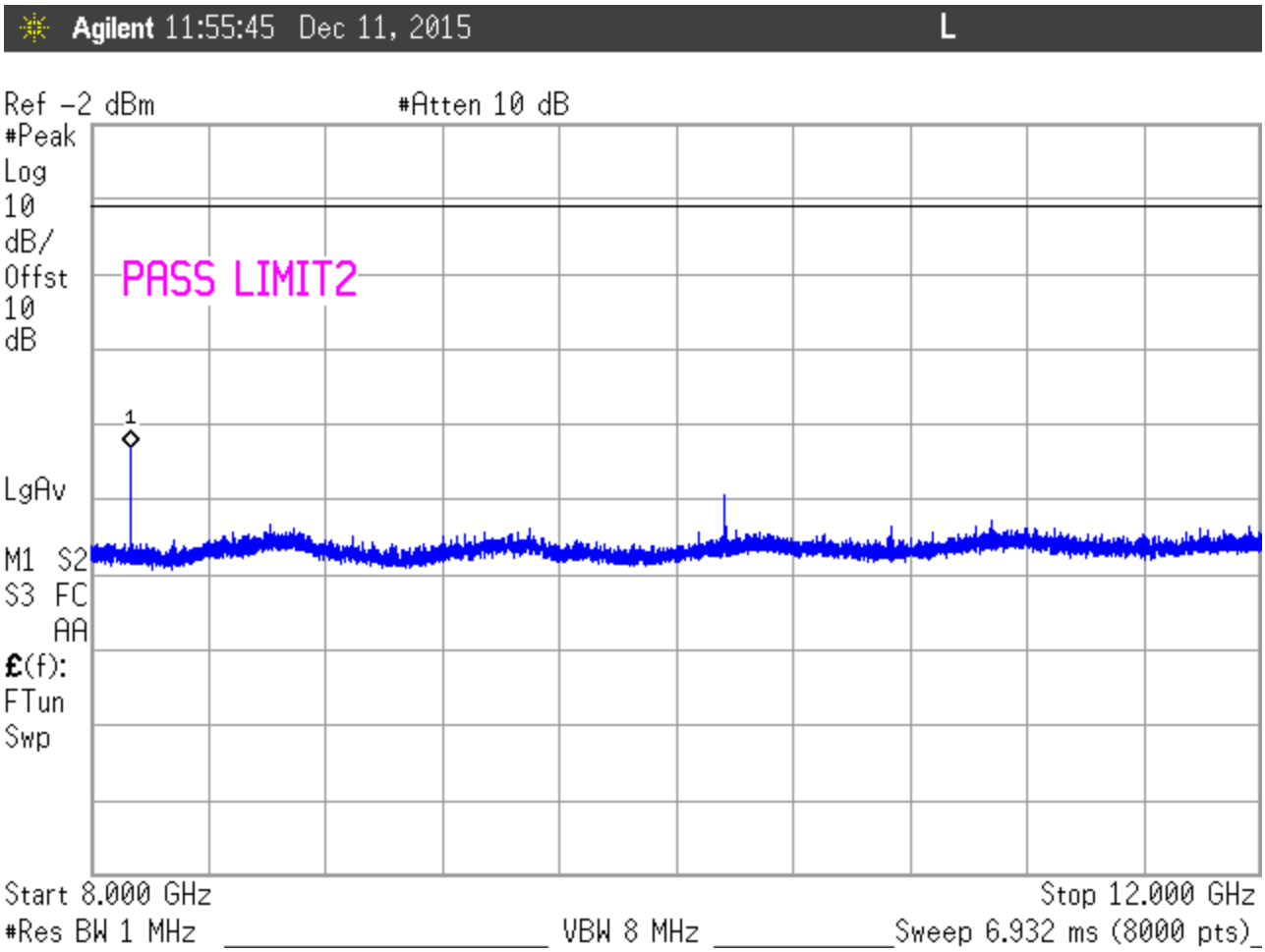

Figure 17: Spurious Emissions, QPSK Modulation, TX @ 2033MHz, 8GHz-12GHz

 © 2016 Washington Laboratories, Ltd.

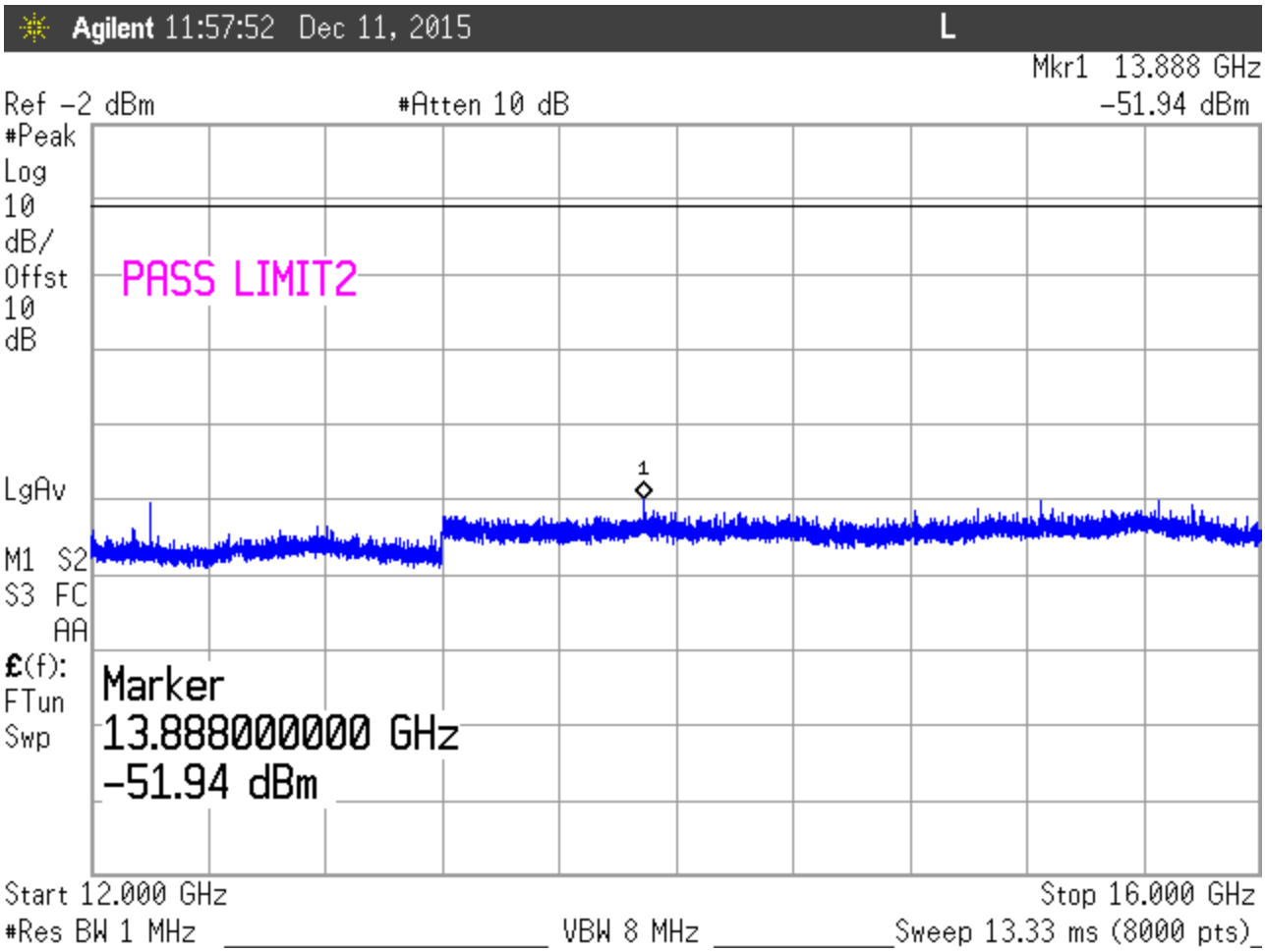

Figure 18: Spurious Emissions, QPSK Modulation, TX @ 2033MHz, 12GHz-16GHz

 © 2016 Washington Laboratories, Ltd.

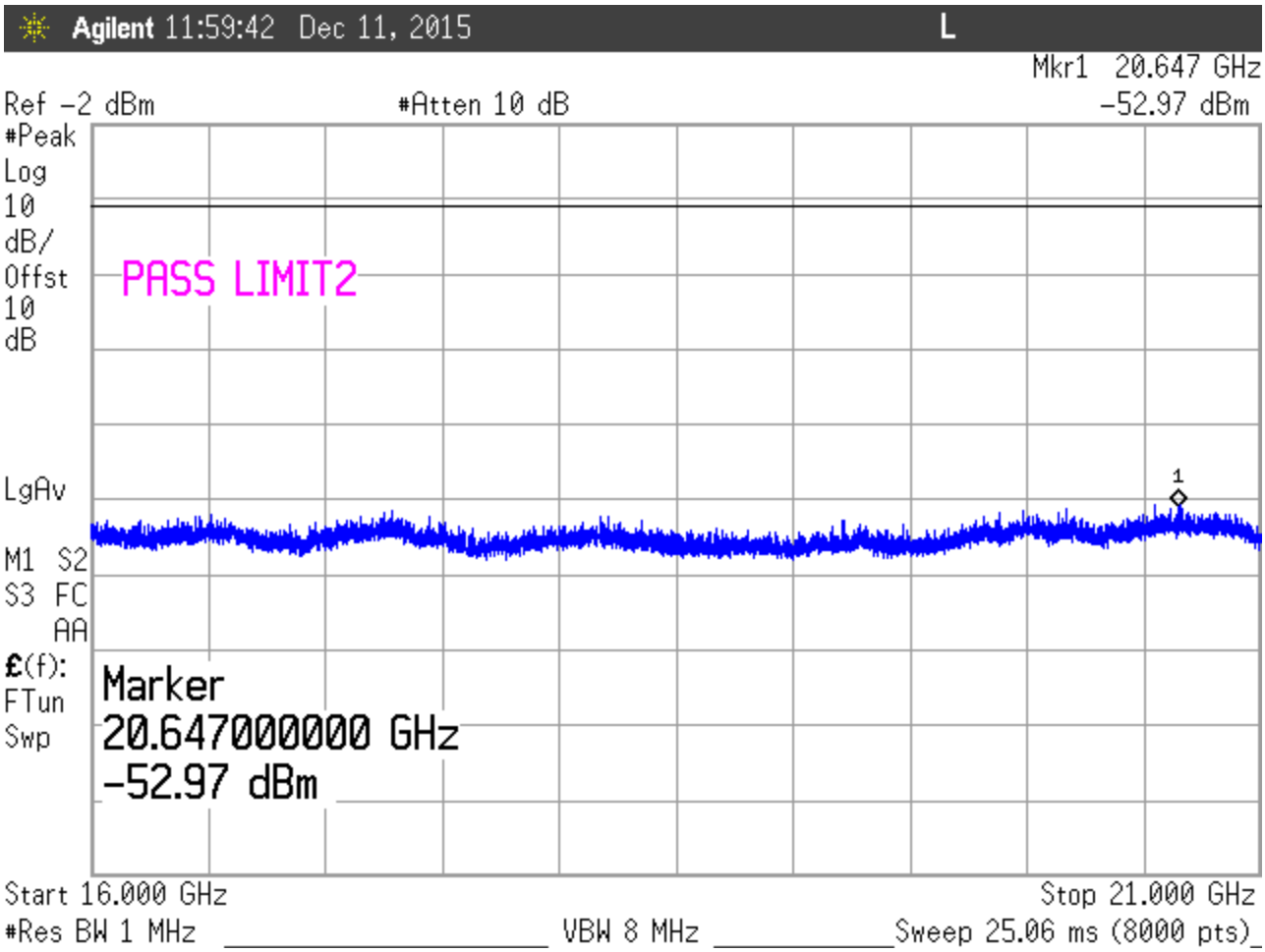

Figure 19: Spurious Emissions, QPSK Modulation, TX @ 2033MHz, 16GHz-21GHz

 © 2016 Washington Laboratories, Ltd.

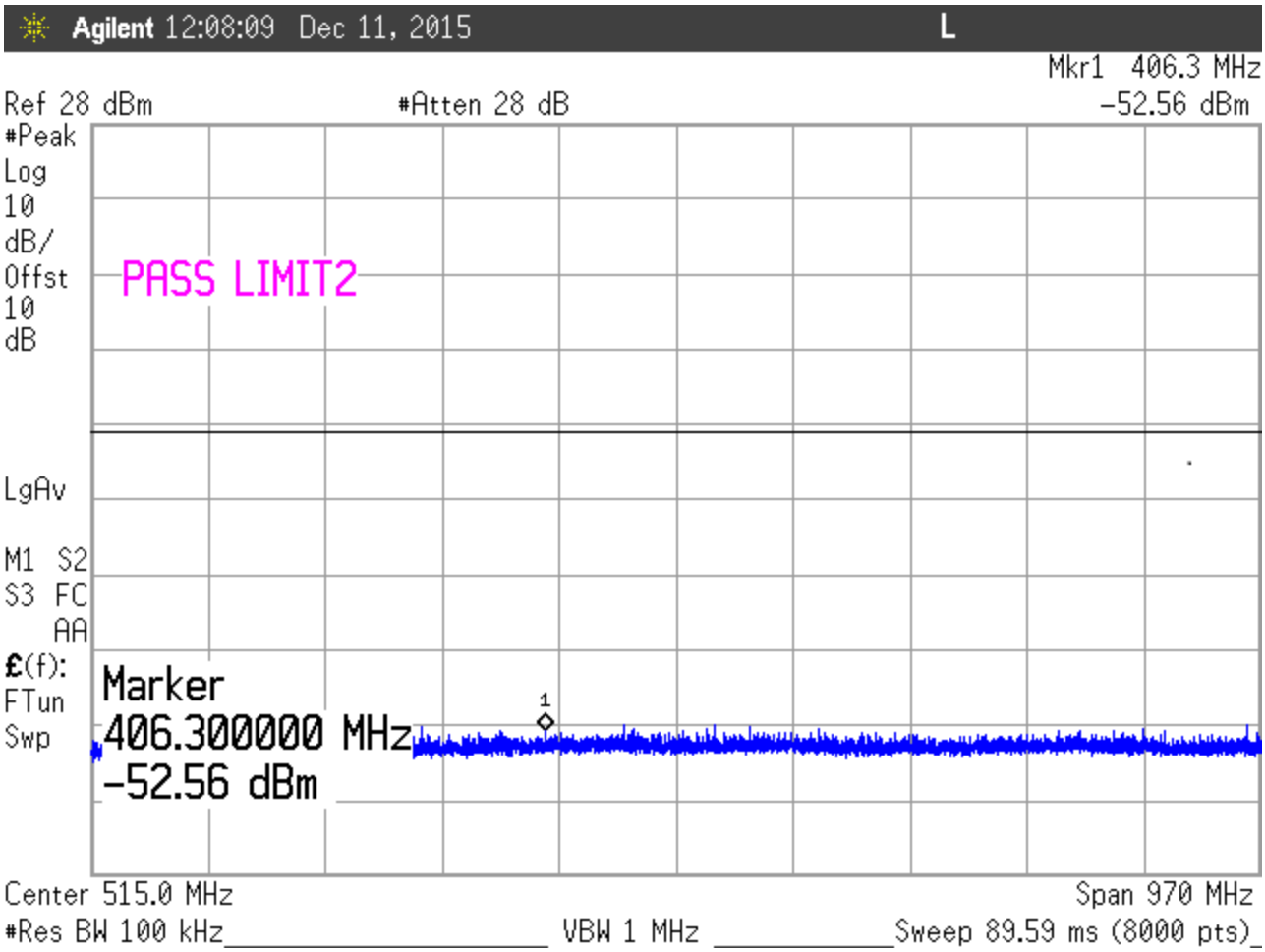

Figure 20: Spurious Emissions, 16QAM Modulation, TX @ 2033MHz, 30MHz-1000MHz

 © 2016 Washington Laboratories, Ltd.

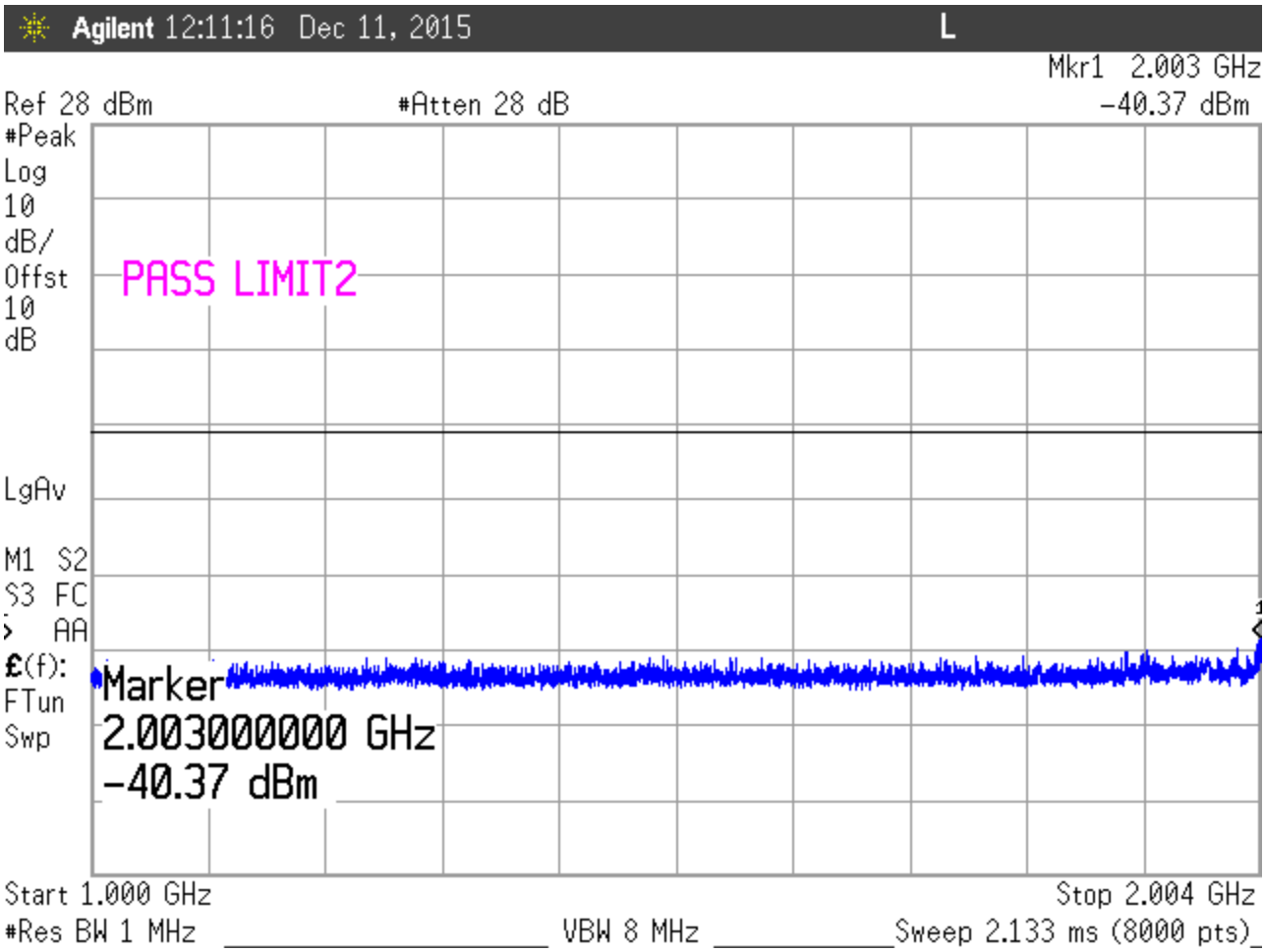

Figure 21: Spurious Emissions, 16QAM Modulation, TX @ 2033MHz, 1000MHz-2004MHz

 © 2016 Washington Laboratories, Ltd.

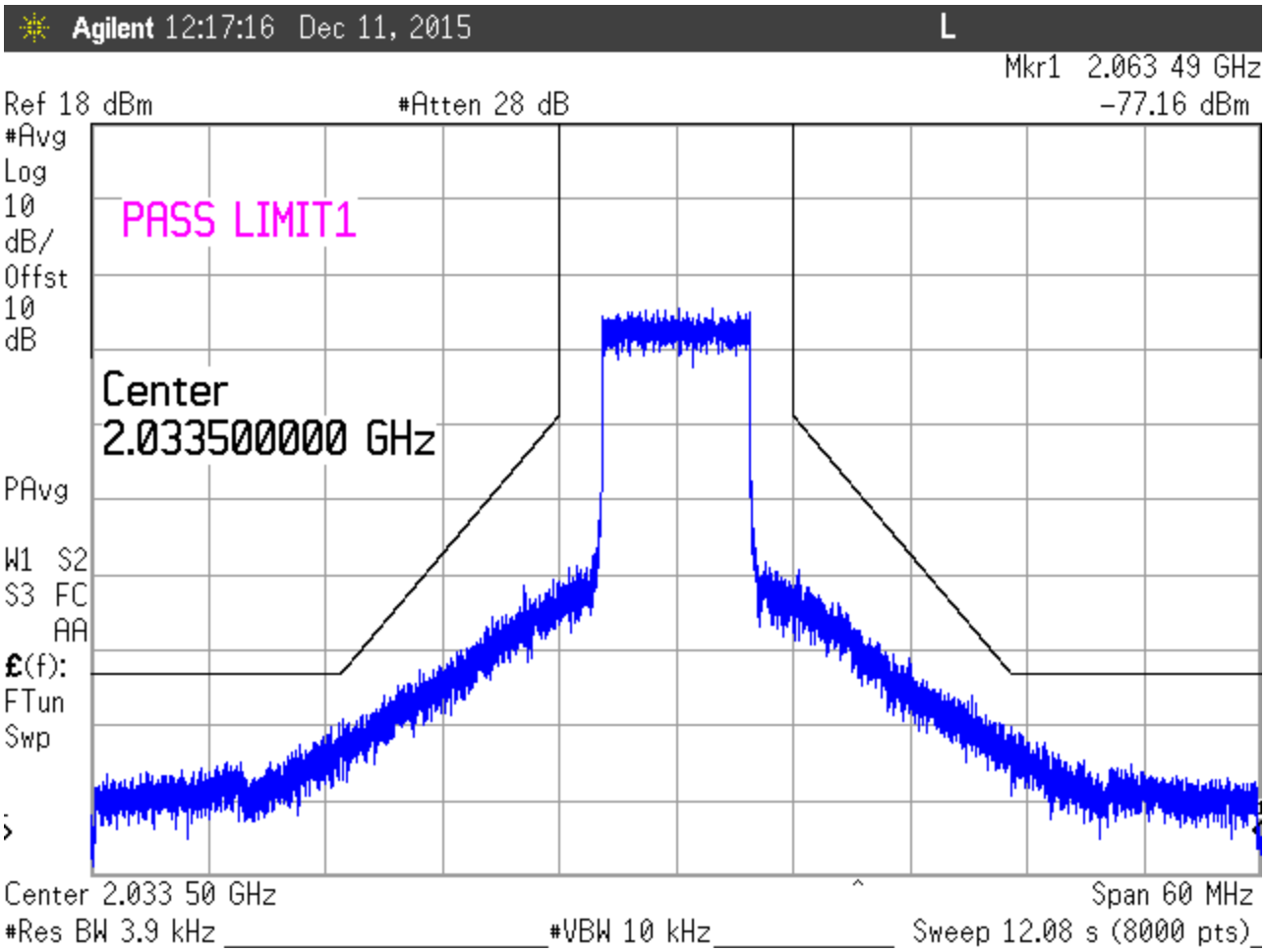

Figure 22: Spurious Emissions, 16QAM Modulation, TX @ 2033MHz, Emission Mask

 © 2016 Washington Laboratories, Ltd.

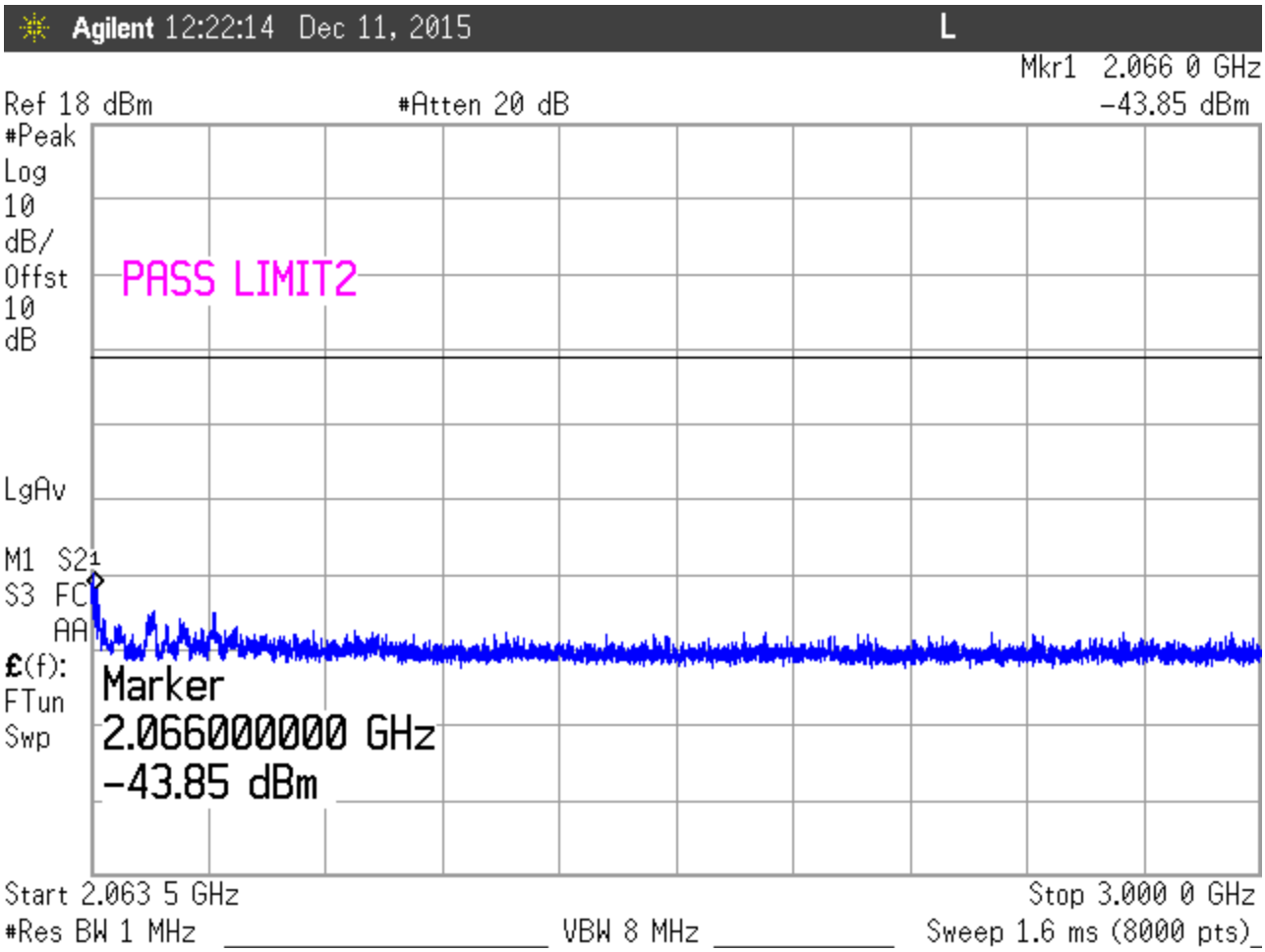

Figure 23: Spurious Emissions, 16QAM Modulation, TX @ 2033MHz, 2063.5MHz-3GHz

 © 2016 Washington Laboratories, Ltd.

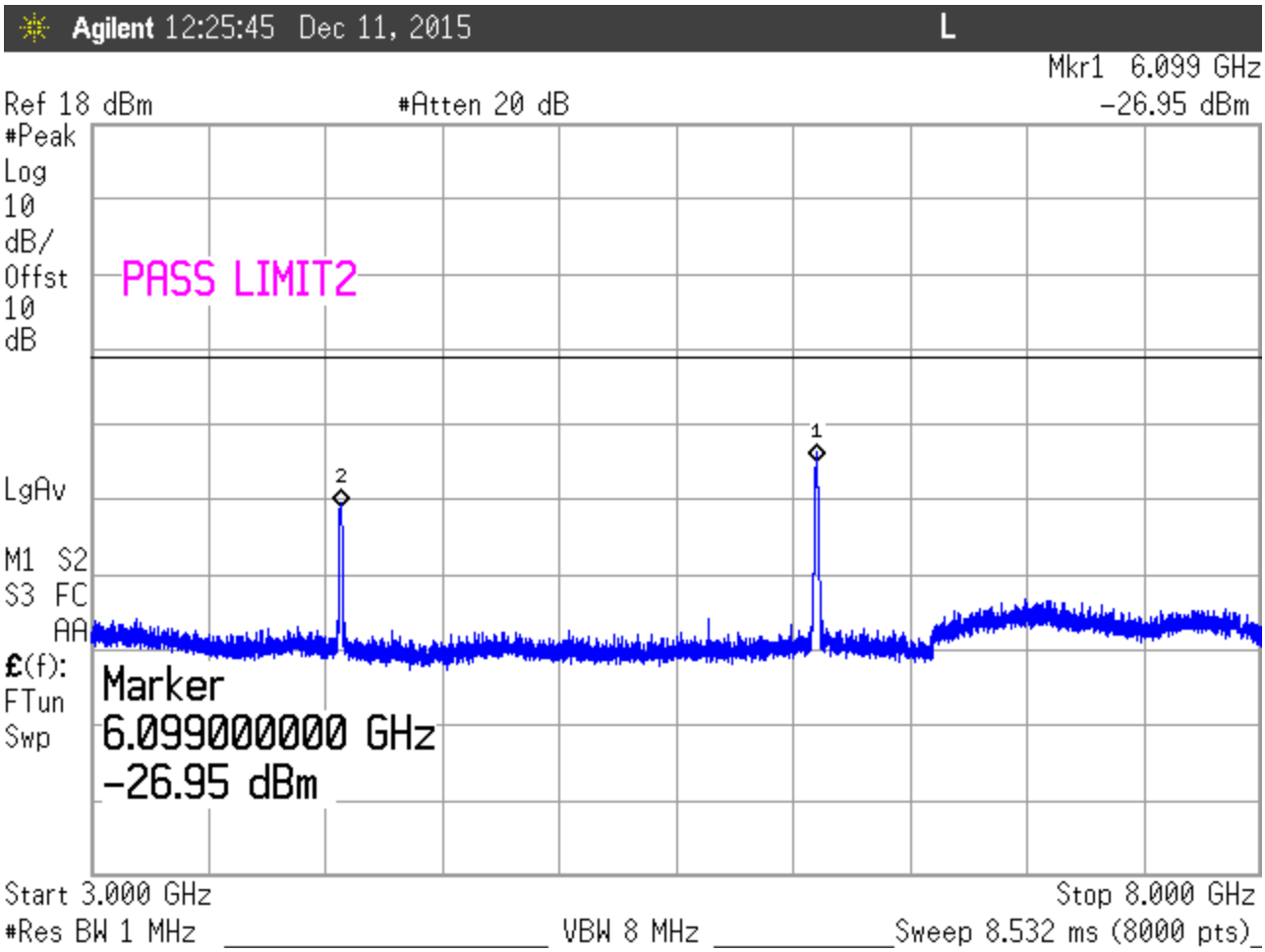

Figure 24: Spurious Emissions, 16QAM Modulation, TX @ 2033MHz, 3GHz-8GHz

 © 2016 Washington Laboratories, Ltd.

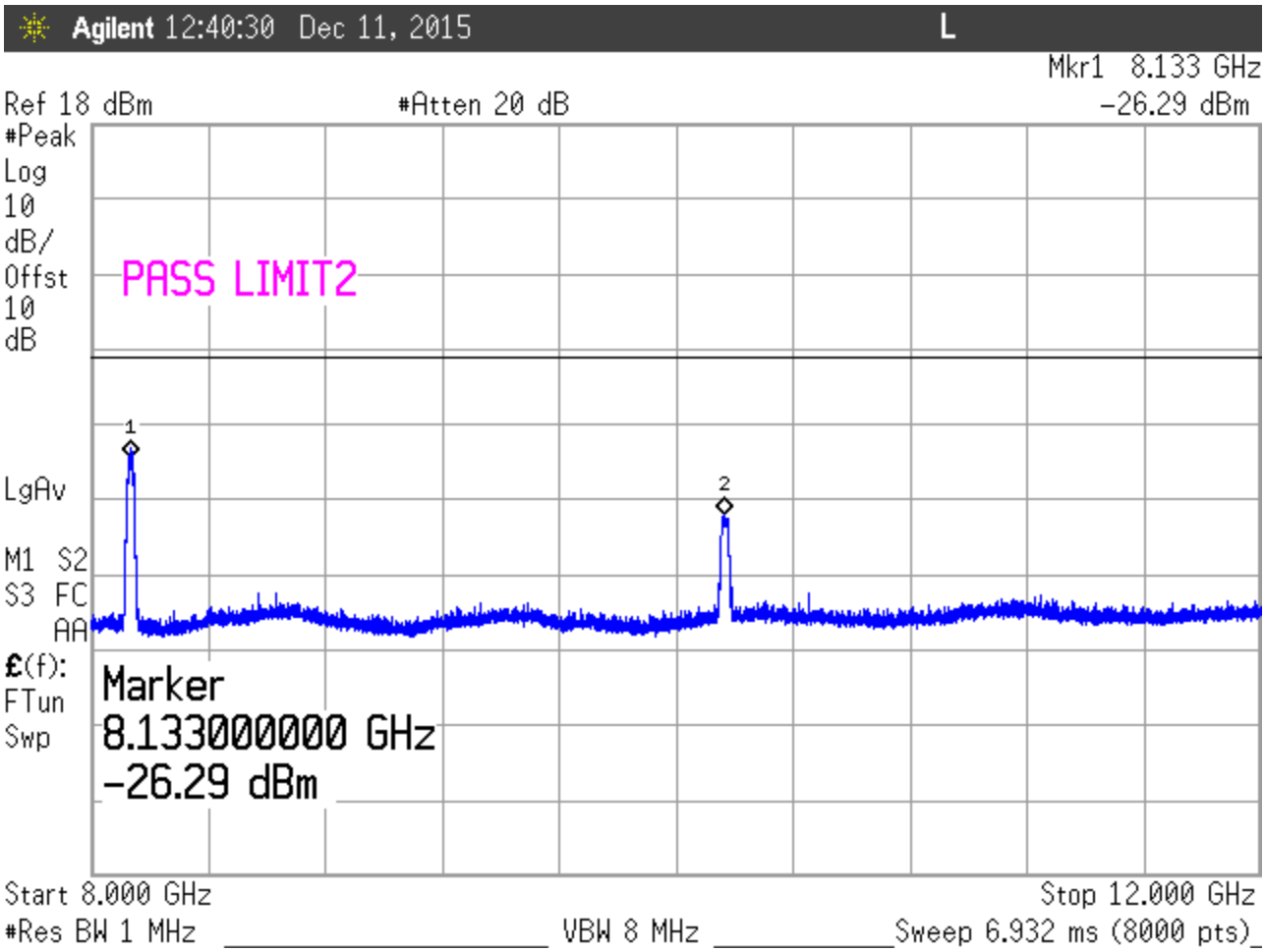

Figure 25: Spurious Emissions, 16QAM Modulation, TX @ 2033MHz, 8GHz-12GHz

 © 2016 Washington Laboratories, Ltd.

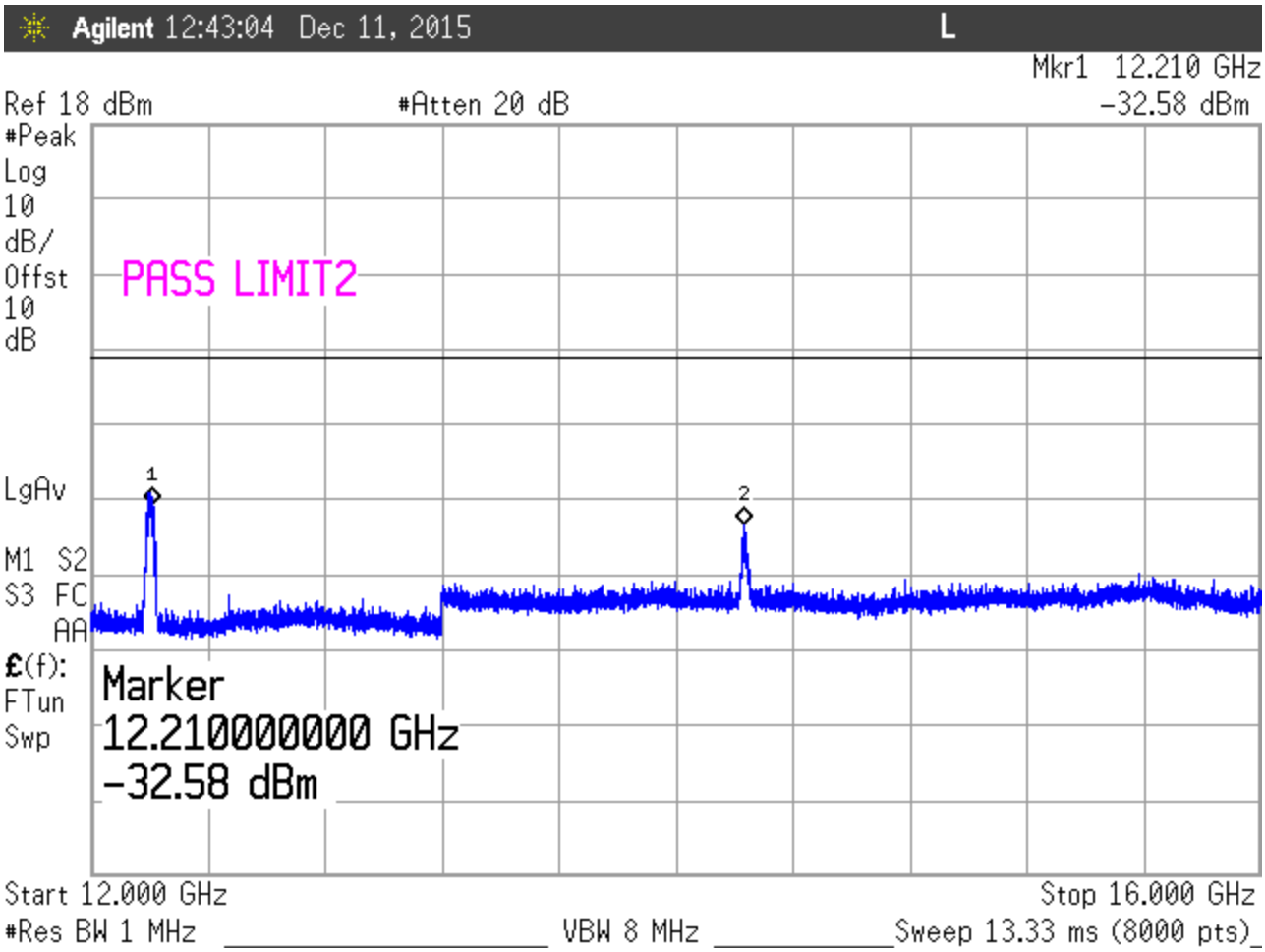

Figure 26: Spurious Emissions, 16QAM Modulation, TX @ 2033MHz, 12GHz-16GHz

 © 2016 Washington Laboratories, Ltd.

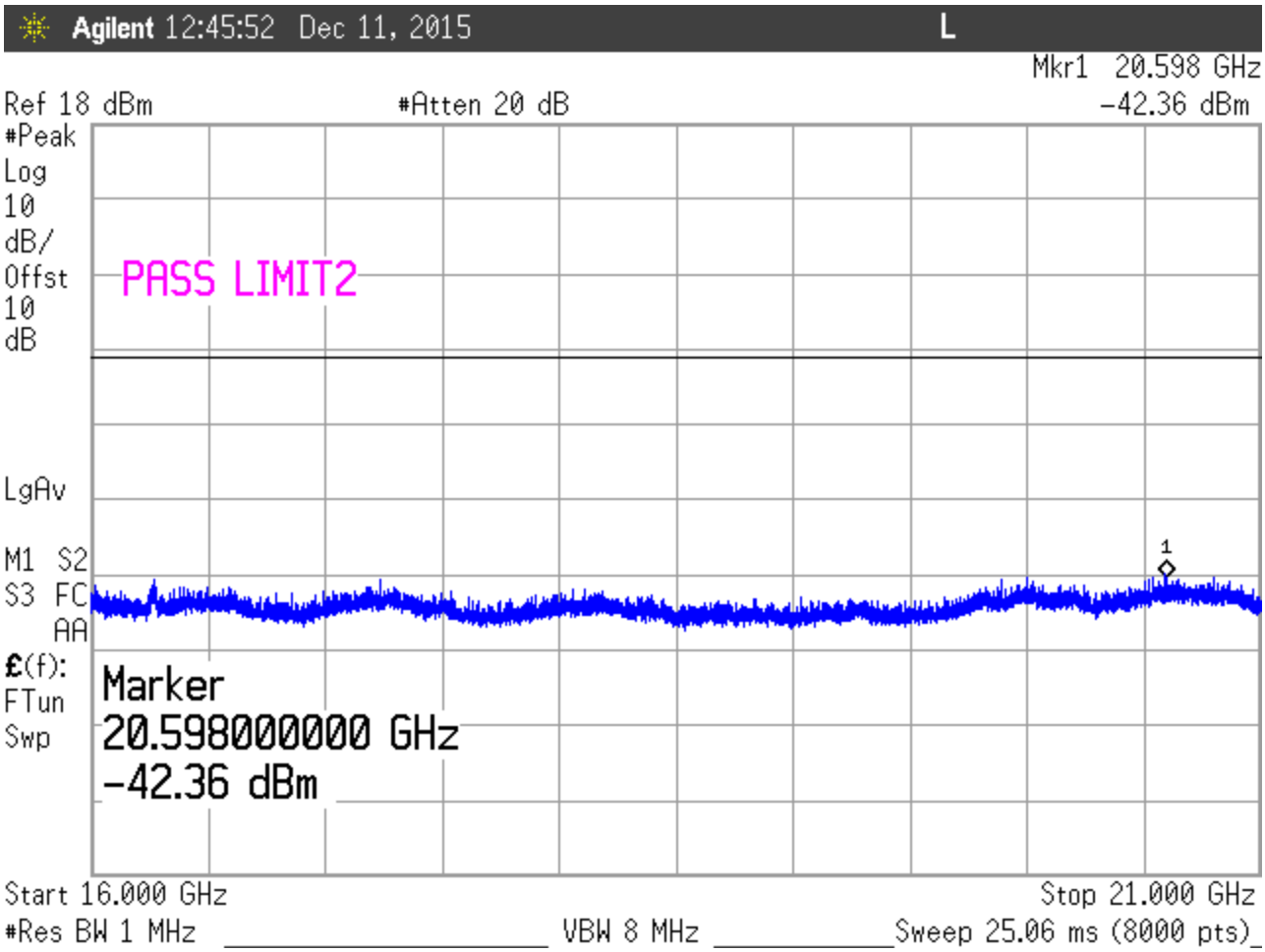

Figure 27: Spurious Emissions, 16QAM Modulation, TX @ 2033MHz, 16GHz-21GHz

 © 2016 Washington Laboratories, Ltd.

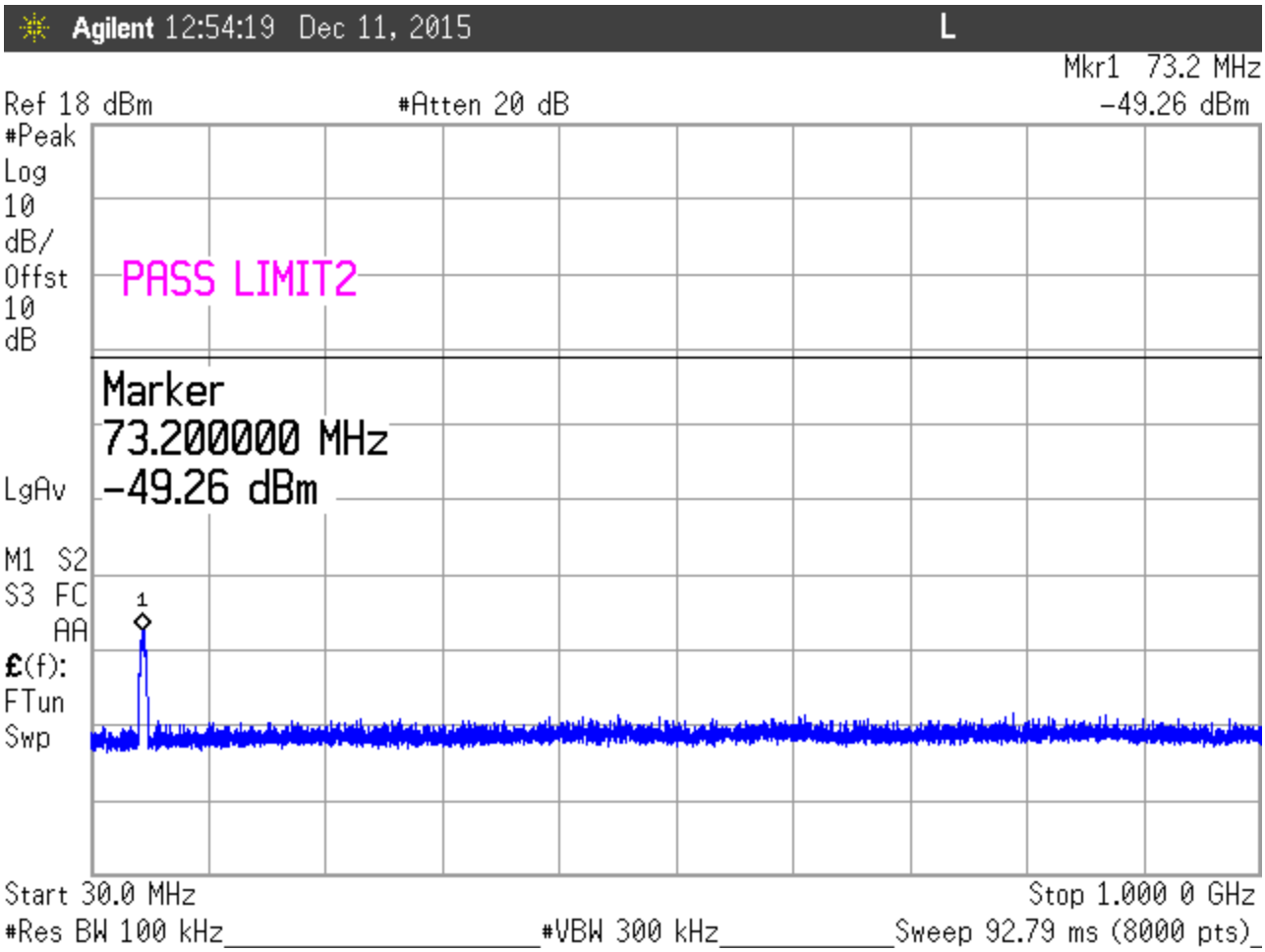

Figure 28: Spurious Emissions, 64QAM Modulation, TX @ 2033MHz, 30MHz-1000MHz

 © 2016 Washington Laboratories, Ltd.

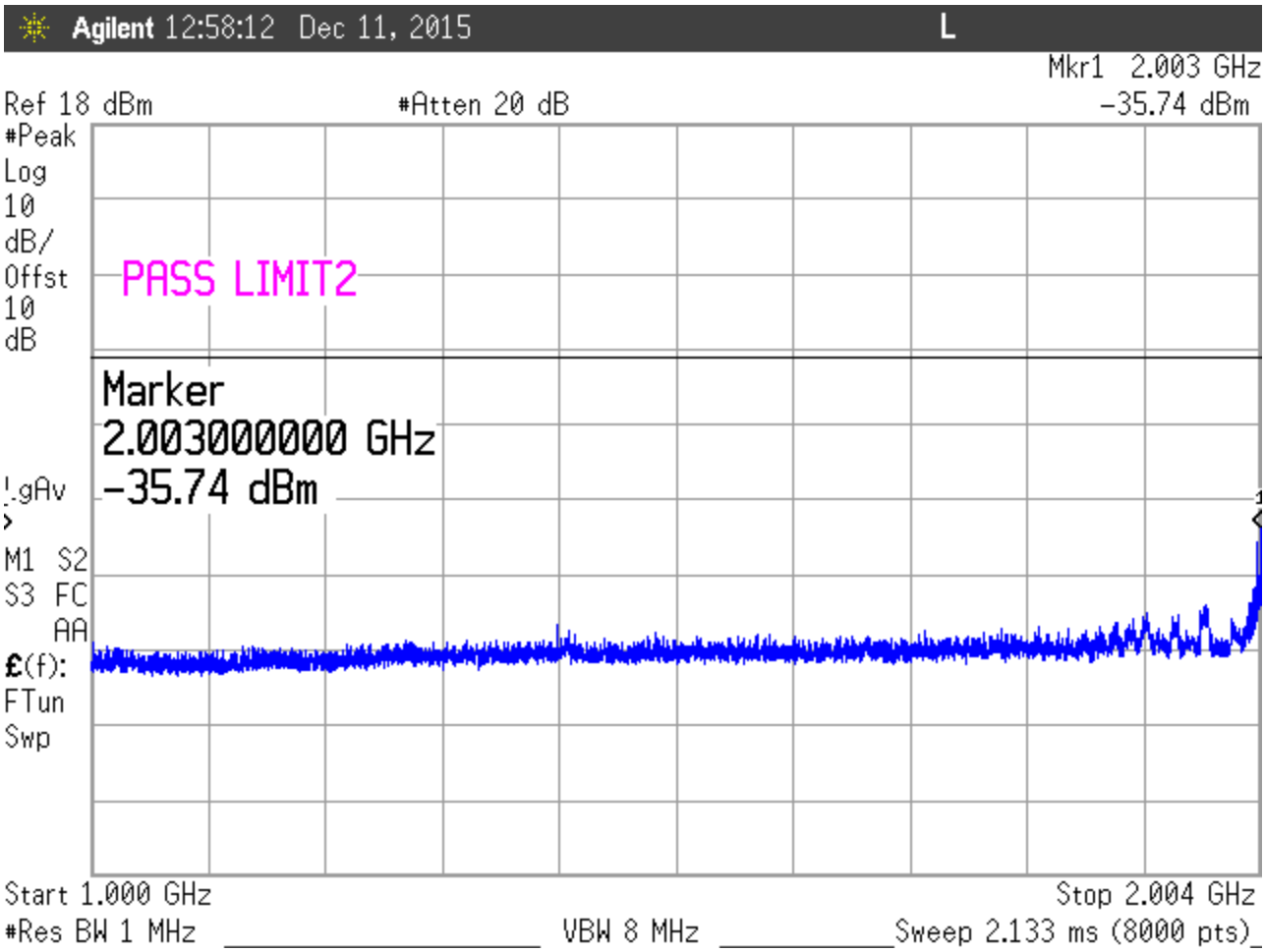

Figure 29: Spurious Emissions, 64QAM Modulation, TX @ 2033MHz, 1000MHz-2004MHz

 © 2016 Washington Laboratories, Ltd.

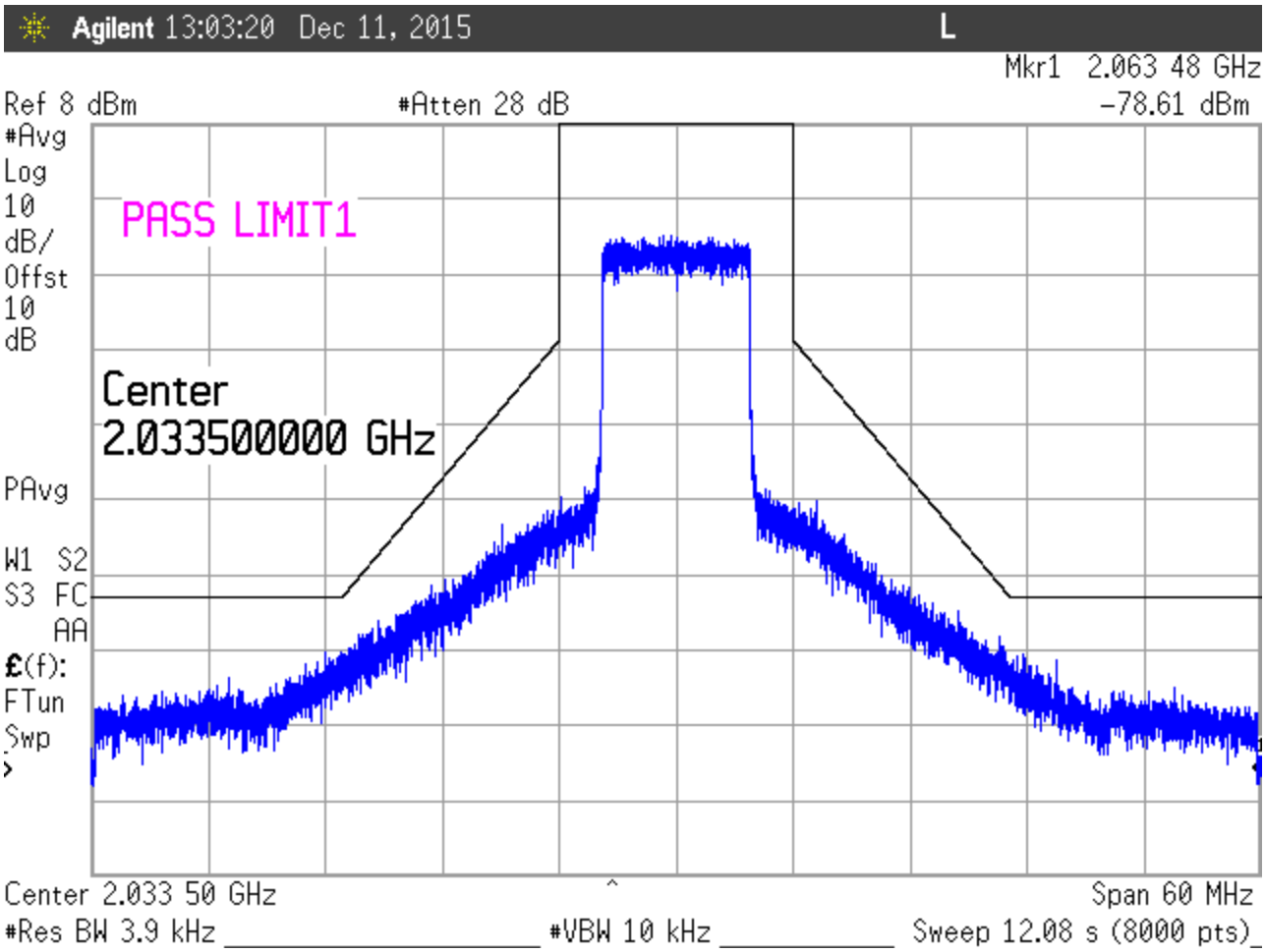

Figure 30: Spurious Emissions, 64QAM Modulation, TX @ 2033MHz, Emission Mask

 © 2016 Washington Laboratories, Ltd.

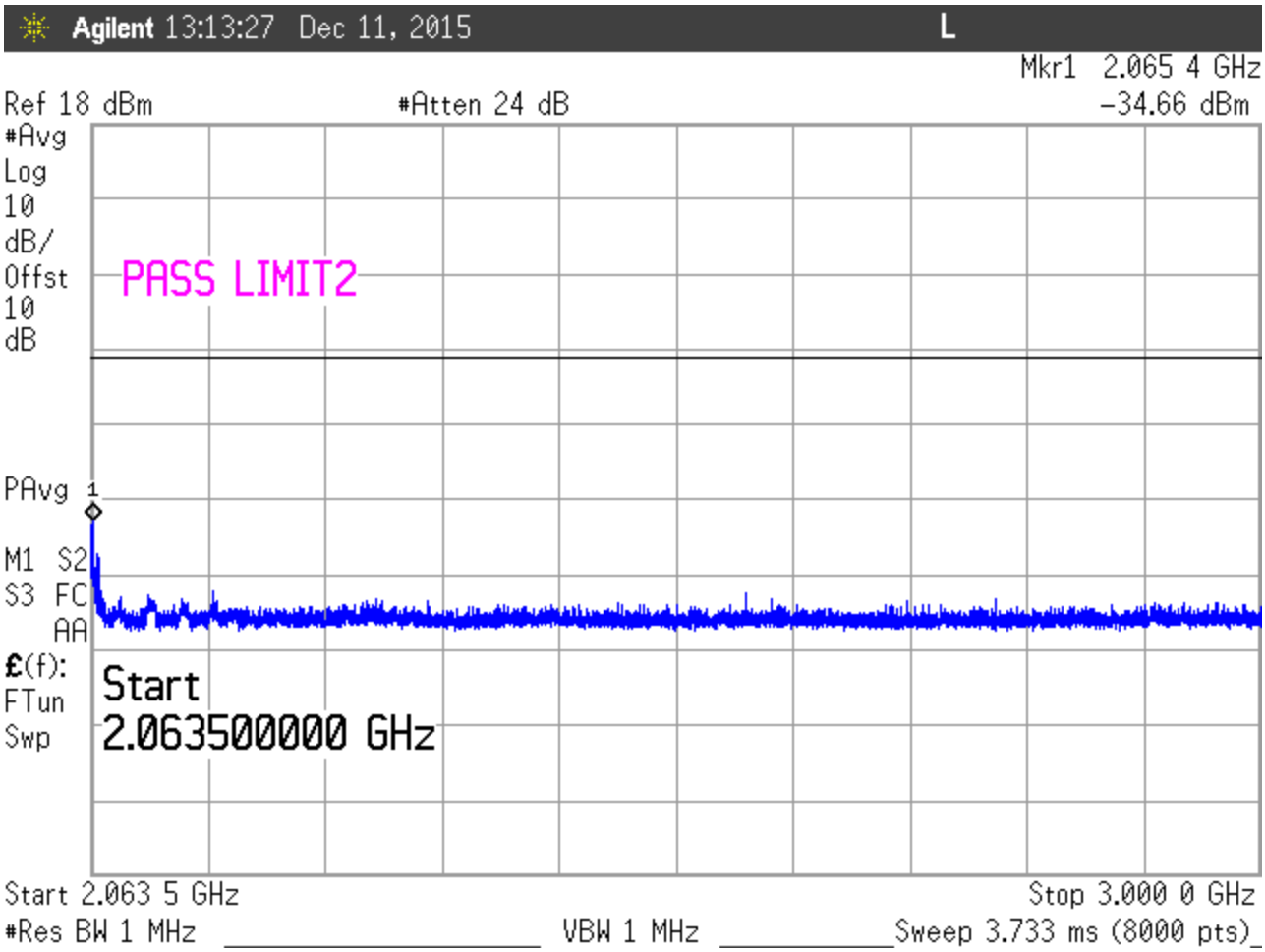

Figure 31: Spurious Emissions, 64QAM Modulation, TX @ 2033MHz, 2063.5MHz-3GHz

 © 2016 Washington Laboratories, Ltd.

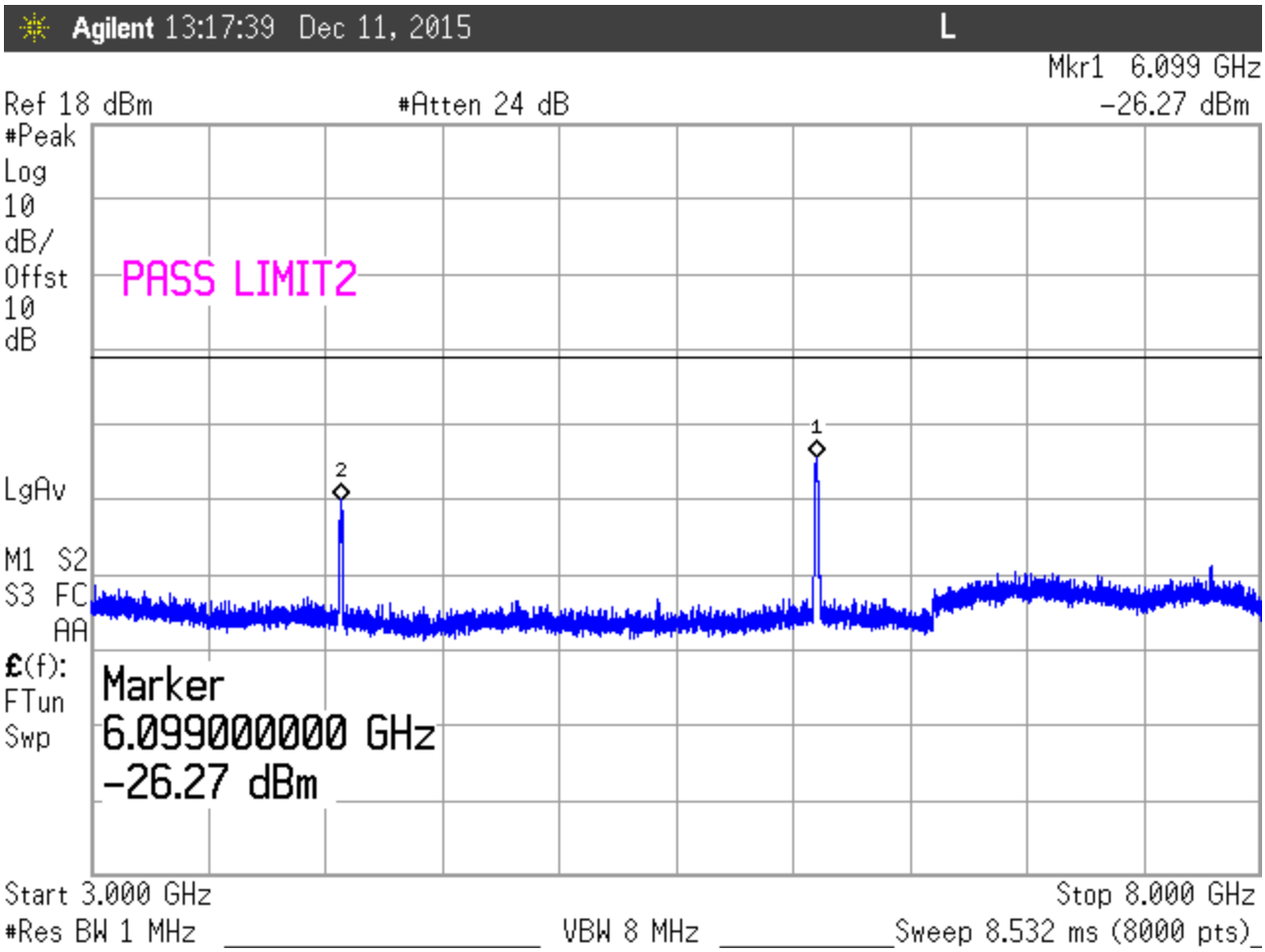

Figure 32: Spurious Emissions, 64QAM Modulation, TX @ 2033MHz, 3GHz-8GHz

 © 2016 Washington Laboratories, Ltd.

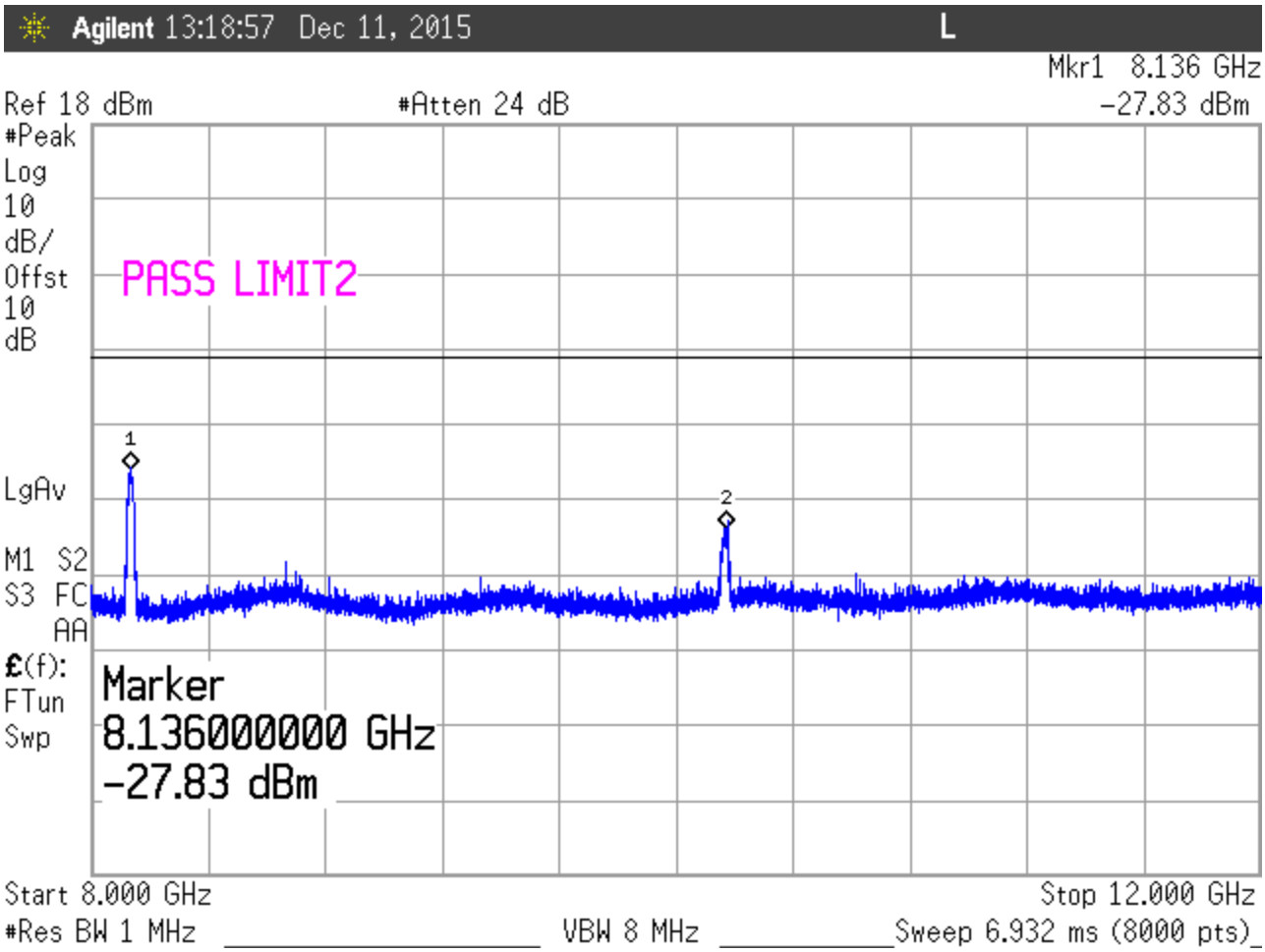

Figure 33: Spurious Emissions, 64QAM Modulation, TX @ 2033MHz, 8GHz-12GHz

 © 2016 Washington Laboratories, Ltd.

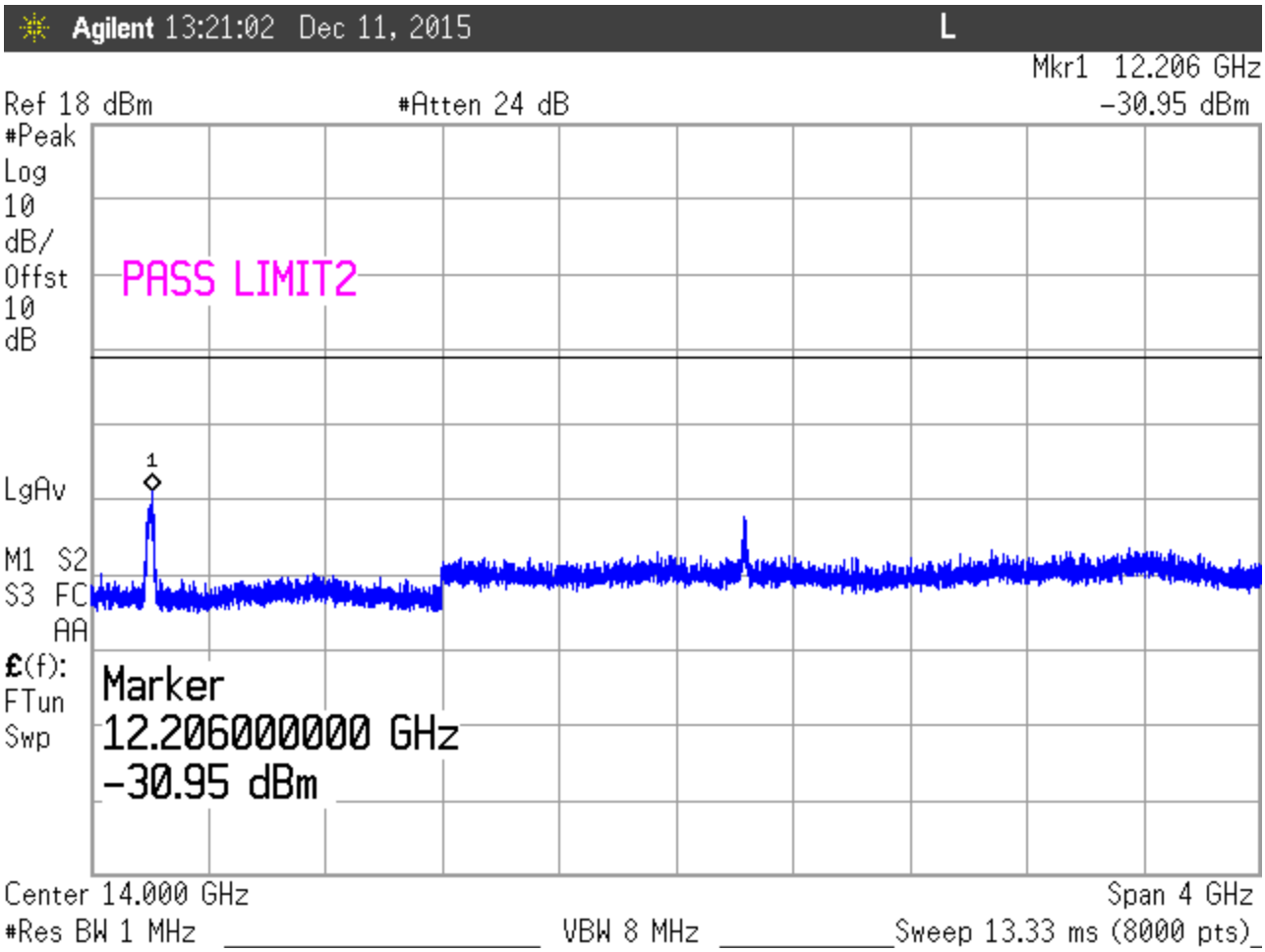

Figure 34: Spurious Emissions, 64QAM Modulation, TX @ 2033MHz, 12GHz-16GHz

 © 2016 Washington Laboratories, Ltd.

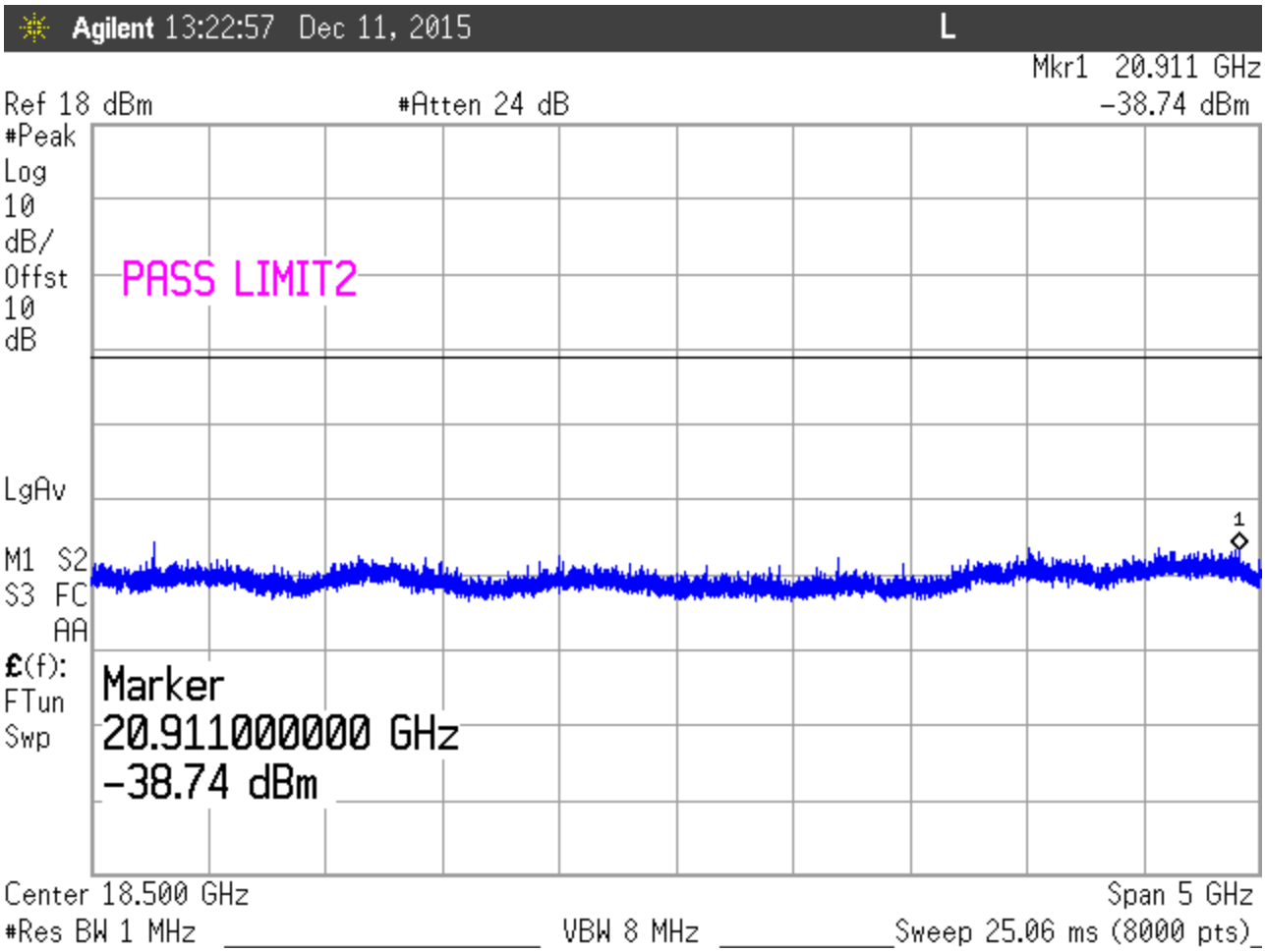

Figure 35: Spurious Emissions, 64QAM Modulation, TX @ 2033MHz, 16GHz-21GHz

 © 2016 Washington Laboratories, Ltd.

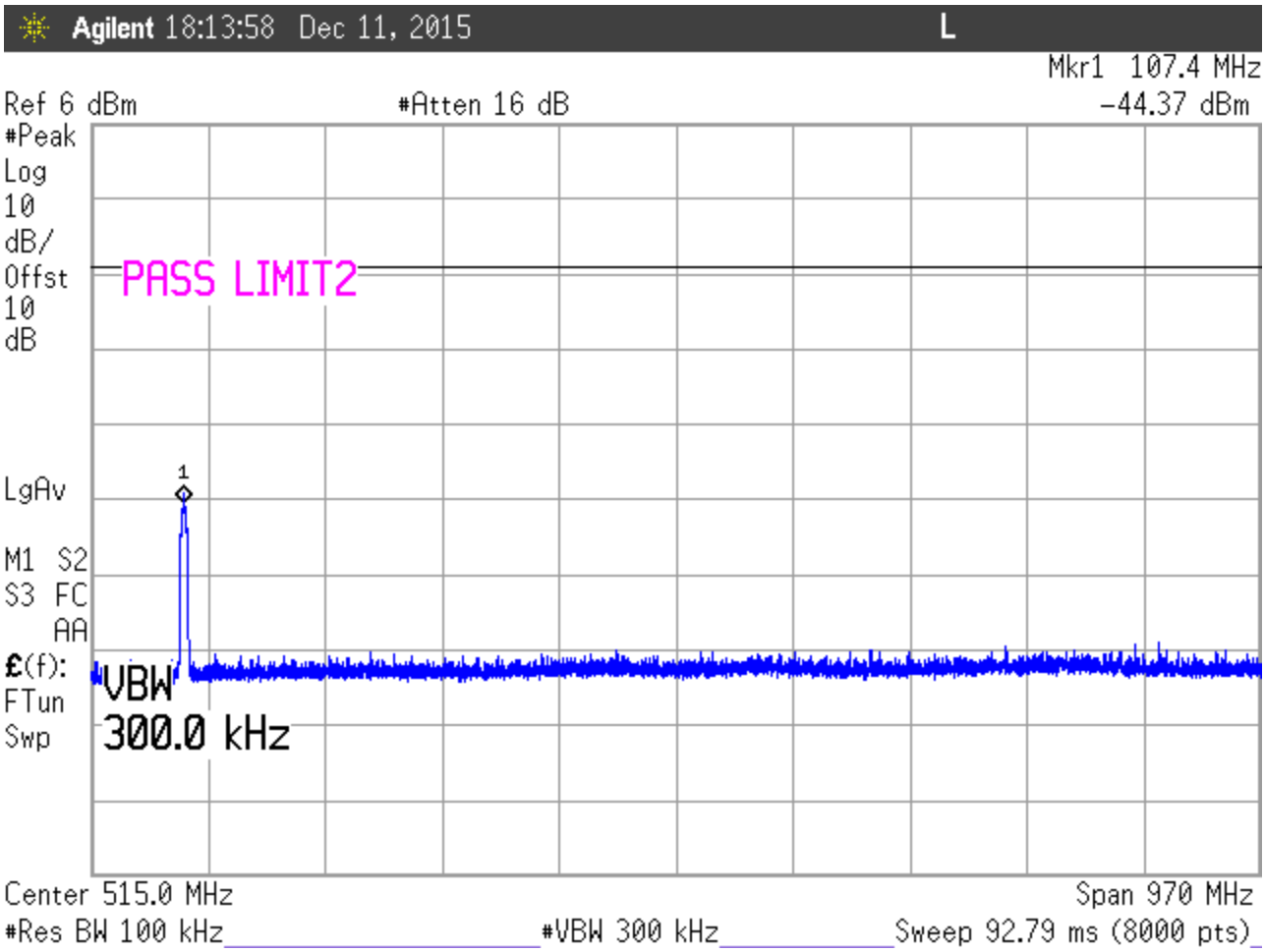

Figure 36: Spurious Emissions, QPSK Modulation, TX @ 2067.5MHz, 30MHz-1000MHz

 © 2016 Washington Laboratories, Ltd.

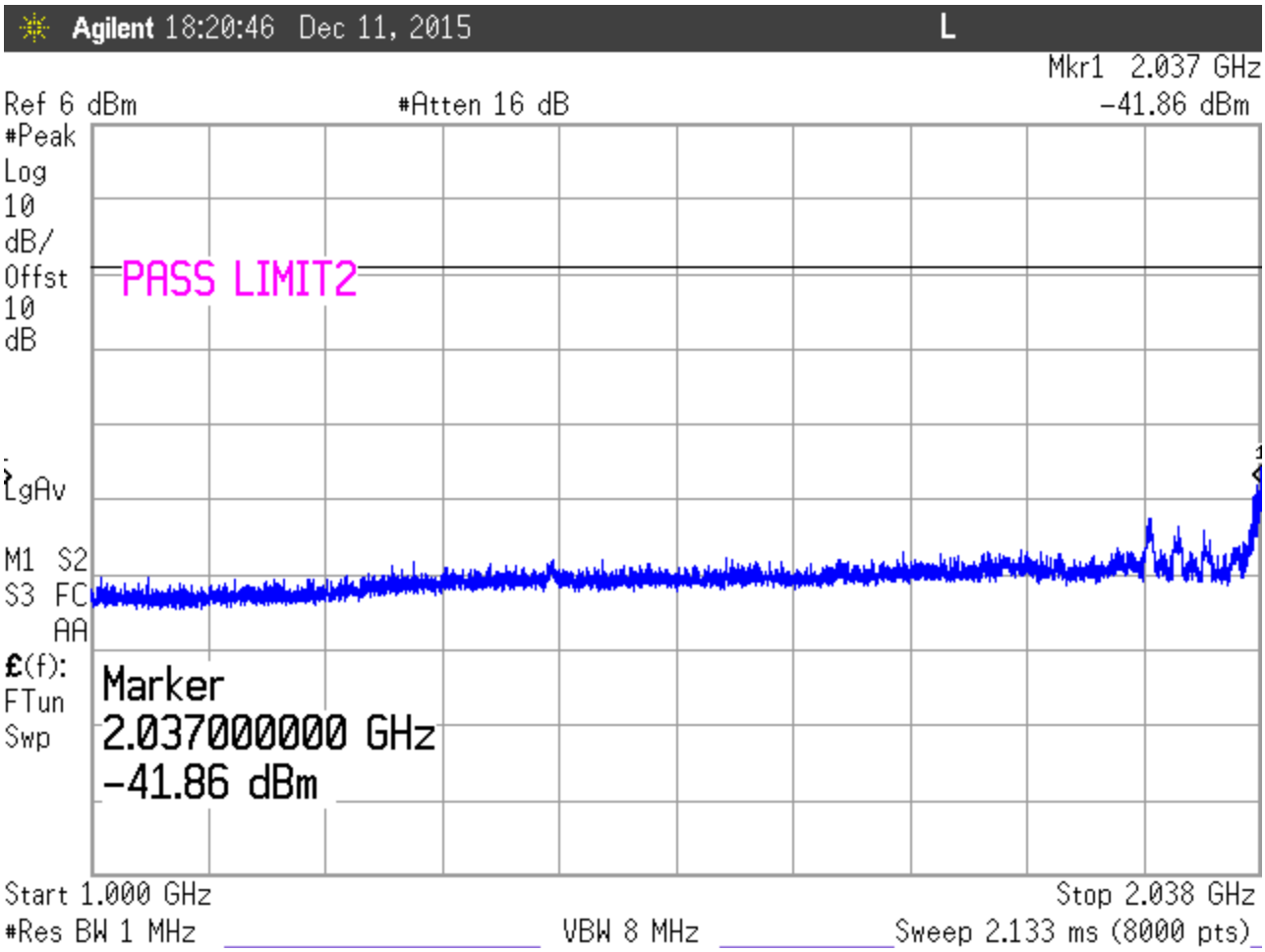

Figure 37: Spurious Emissions, QPSK Modulation, TX @ 2067.5MHz, 1000MHz -2038MHz

 © 2016 Washington Laboratories, Ltd.

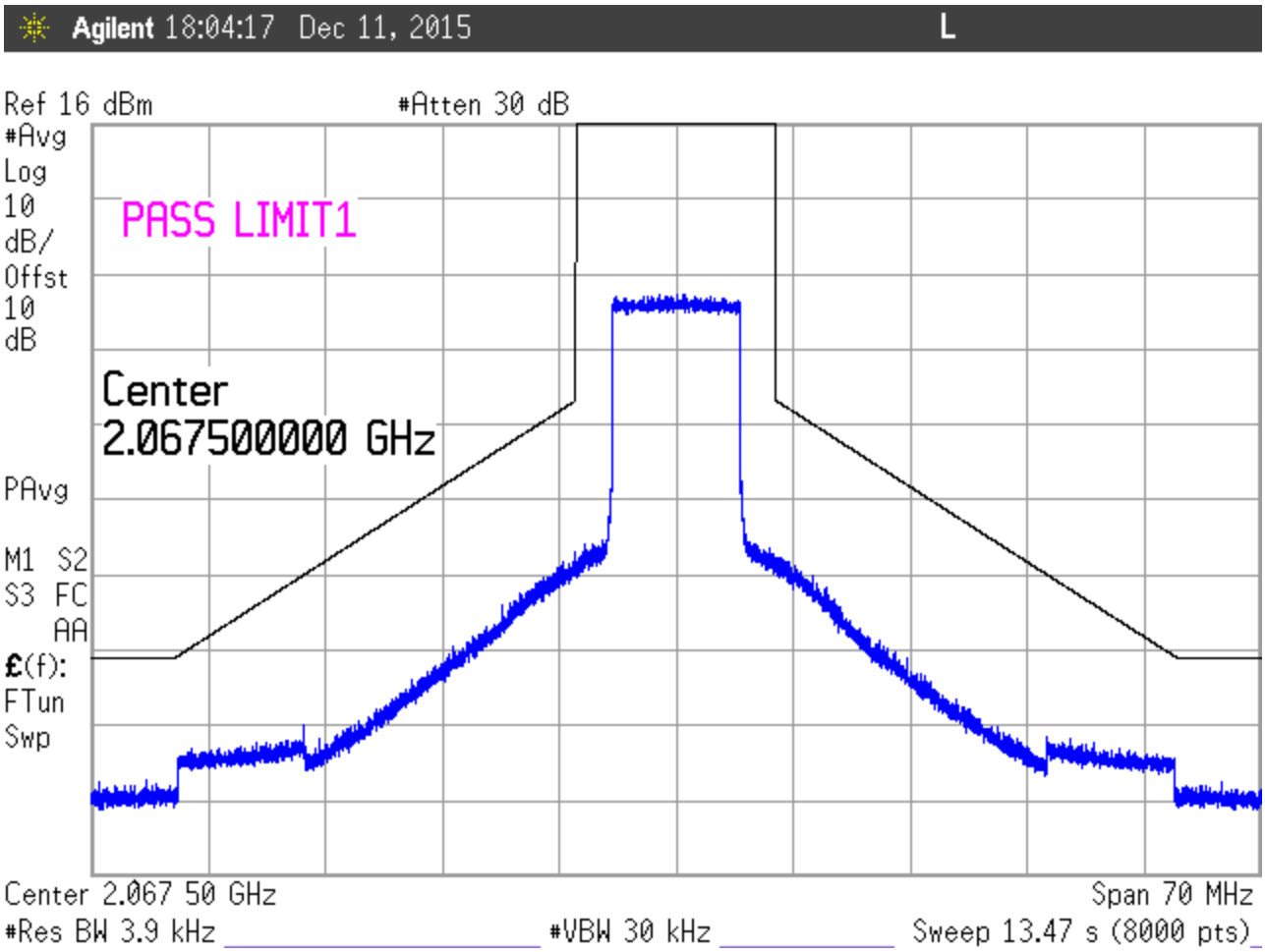

Figure 38: Spurious Emissions, QPSK Modulation, TX @ 2067.5MHz, Emission Mask

 © 2016 Washington Laboratories, Ltd.

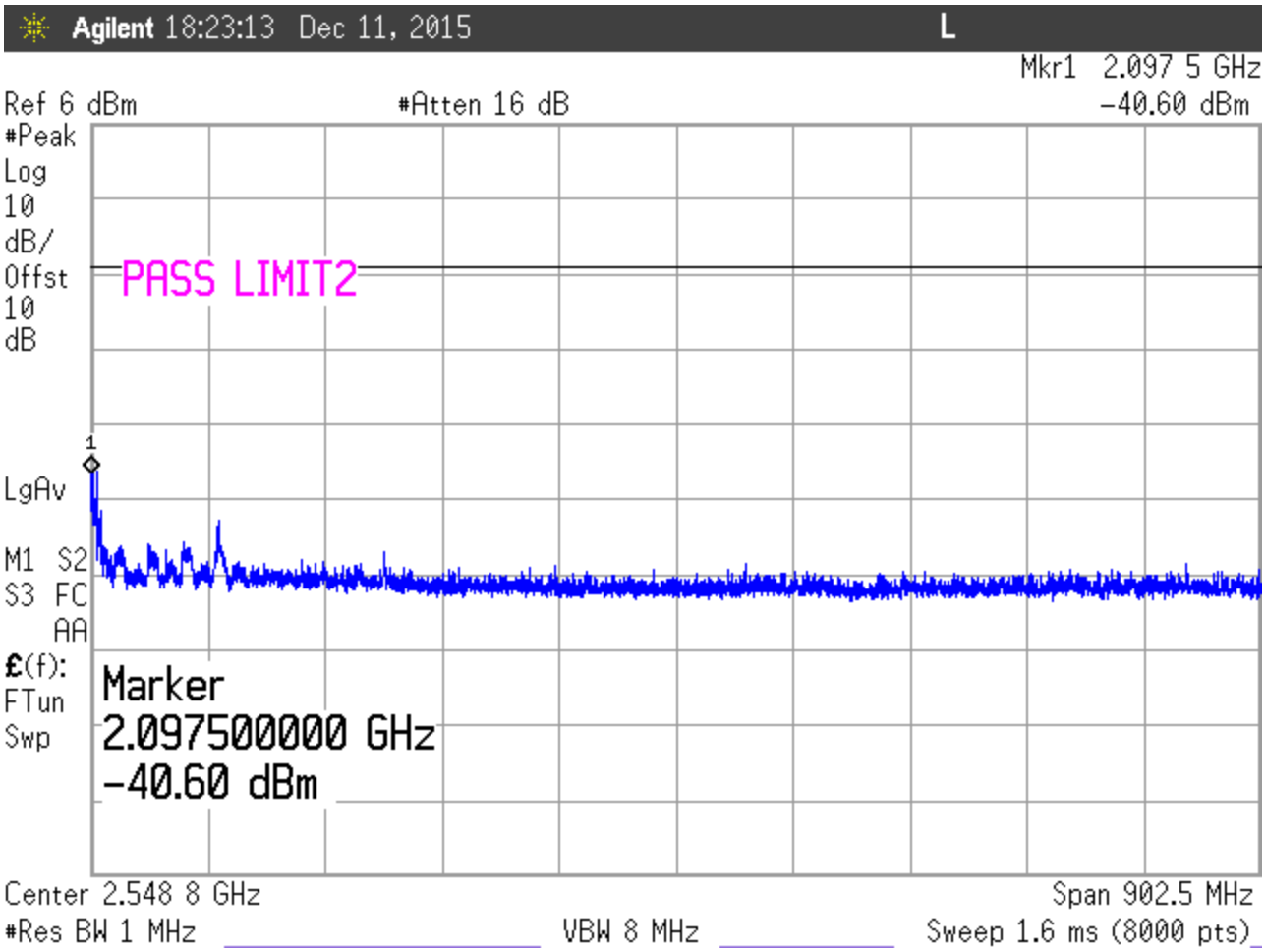

Figure 39: Spurious Emissions, QPSK Modulation, TX @ 2067.5MHz, 2140MHz-10GHz

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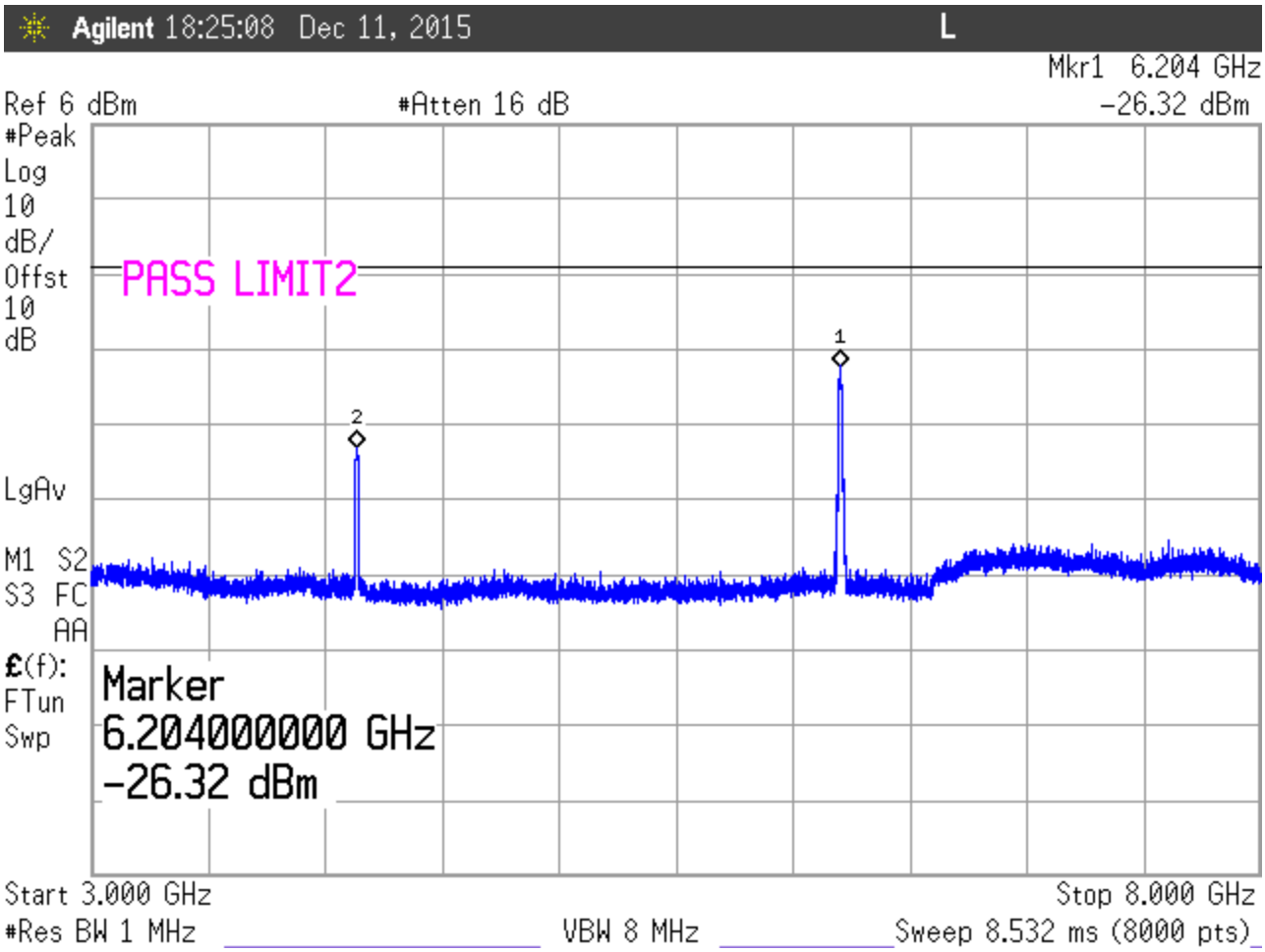

Figure 40: Spurious Emissions, QPSK Modulation, TX @ 2067.5MHz, 3GHz-8GHz

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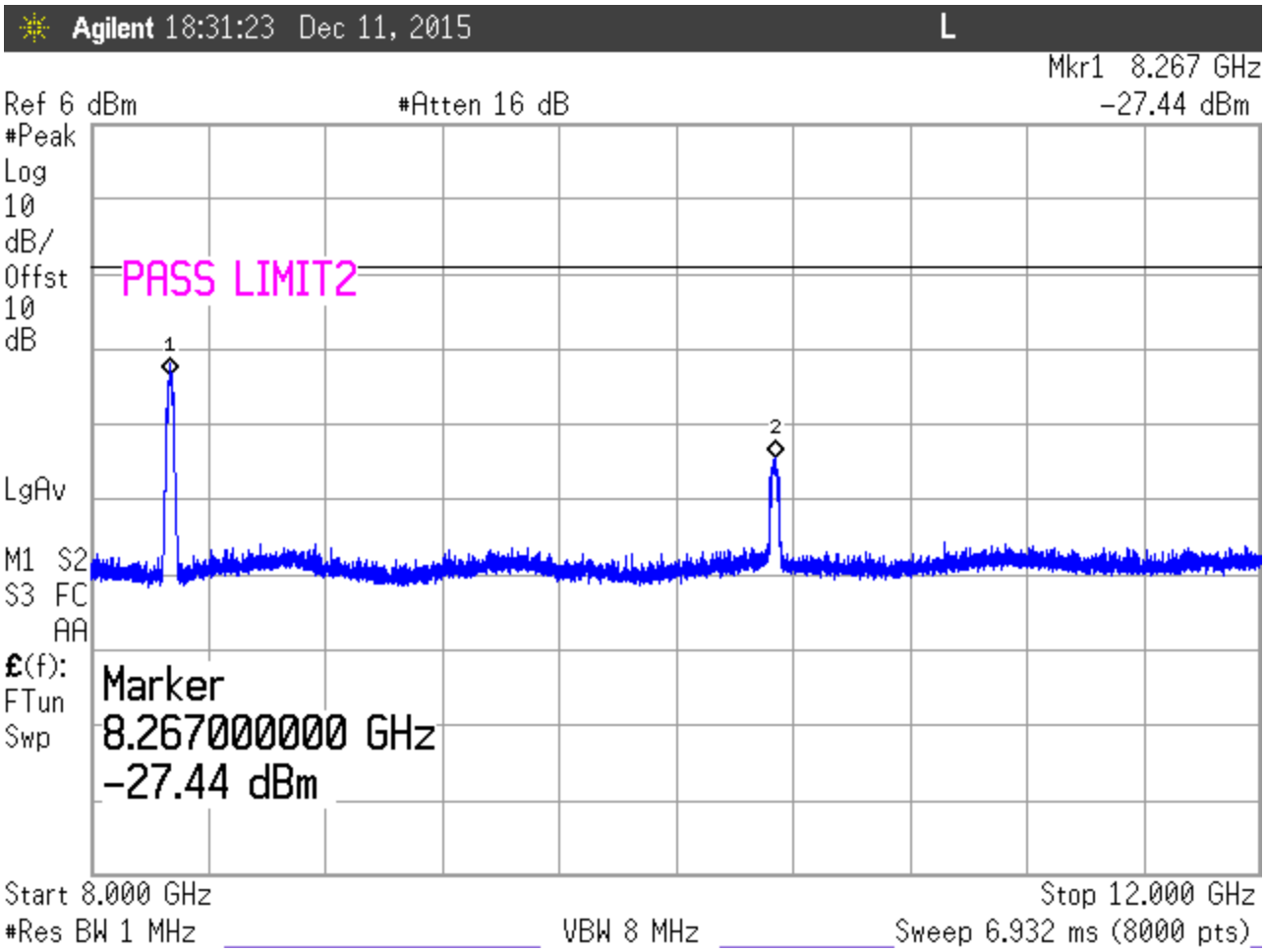

Figure 41: Spurious Emissions, QPSK Modulation, TX @ 2067.5MHz, 8GHz-12GHz

 © 2016 Washington Laboratories, Ltd.

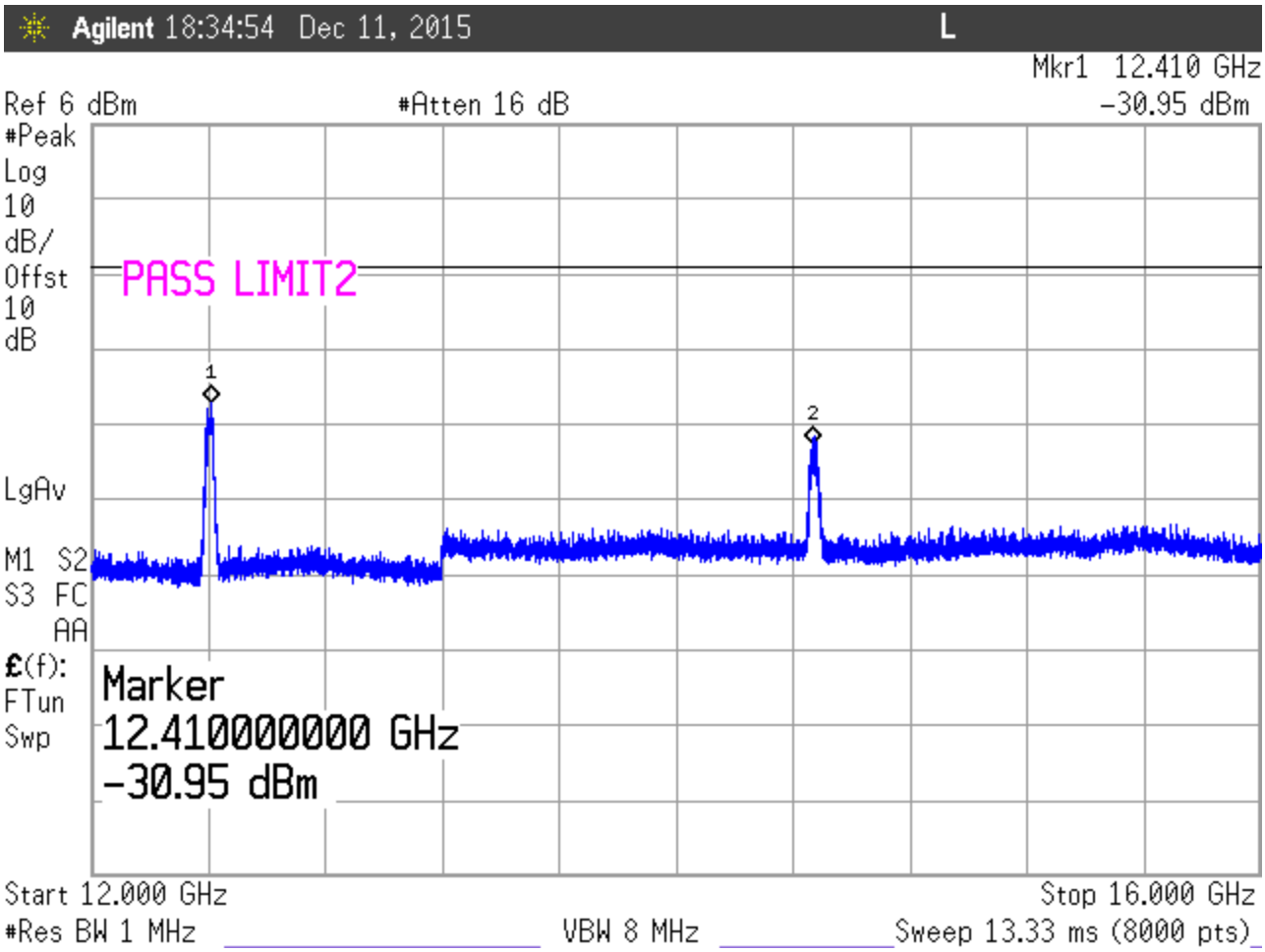

Figure 42: Spurious Emissions, QPSK Modulation, TX @ 2067.5MHz, 12GHz-16GHz

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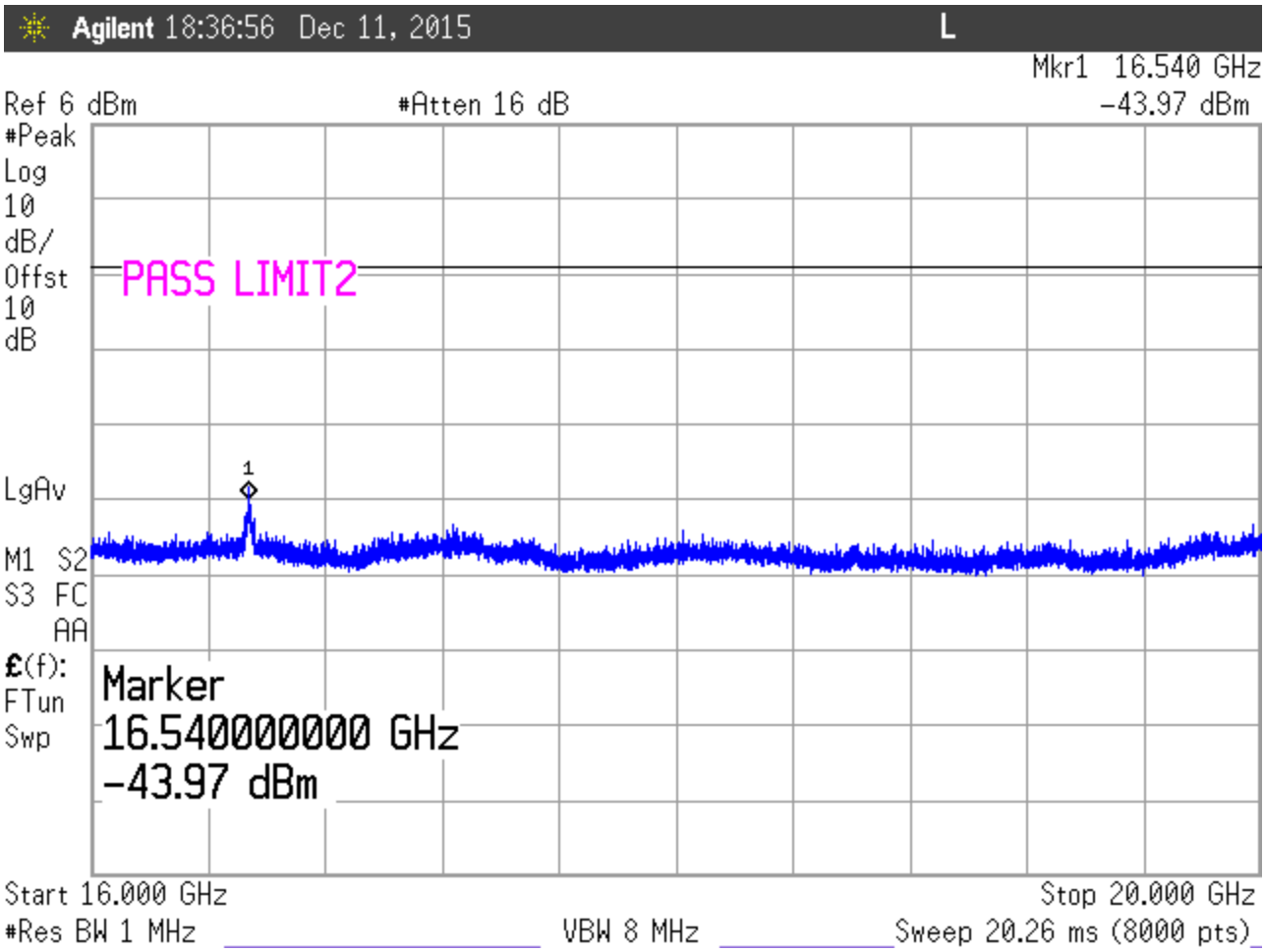

Figure 43: Spurious Emissions, QPSK Modulation, TX @ 2067.5MHz, 16GHz-20GHz

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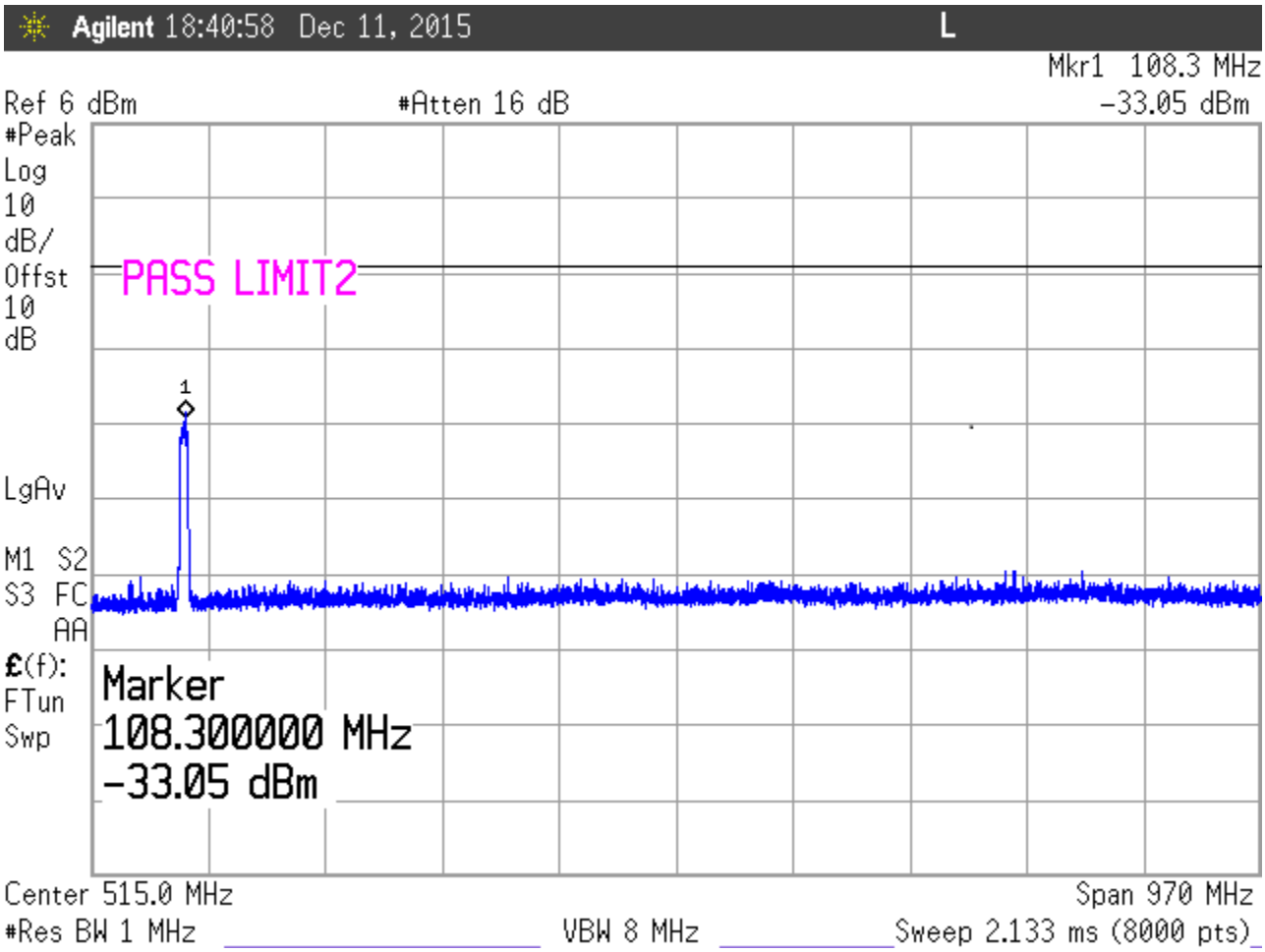

Figure 44: Spurious Emissions, 16QAM Modulation, TX @ 2067.5MHz, 30MHz-1000MHz

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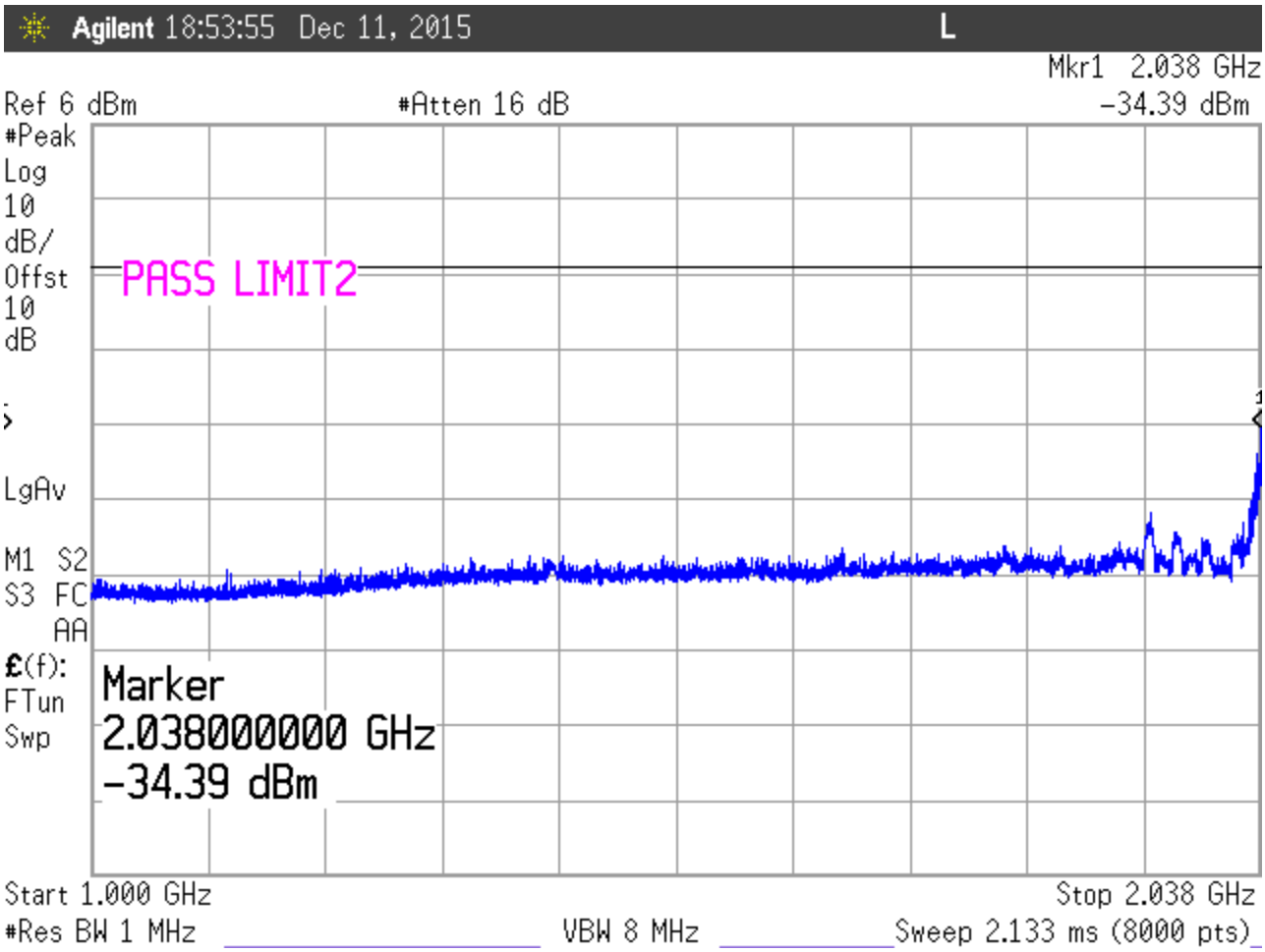

Figure 45: Spurious Emissions, 16QAM Modulation, TX @ 2067.5MHz, 1000MHz-2038MHz

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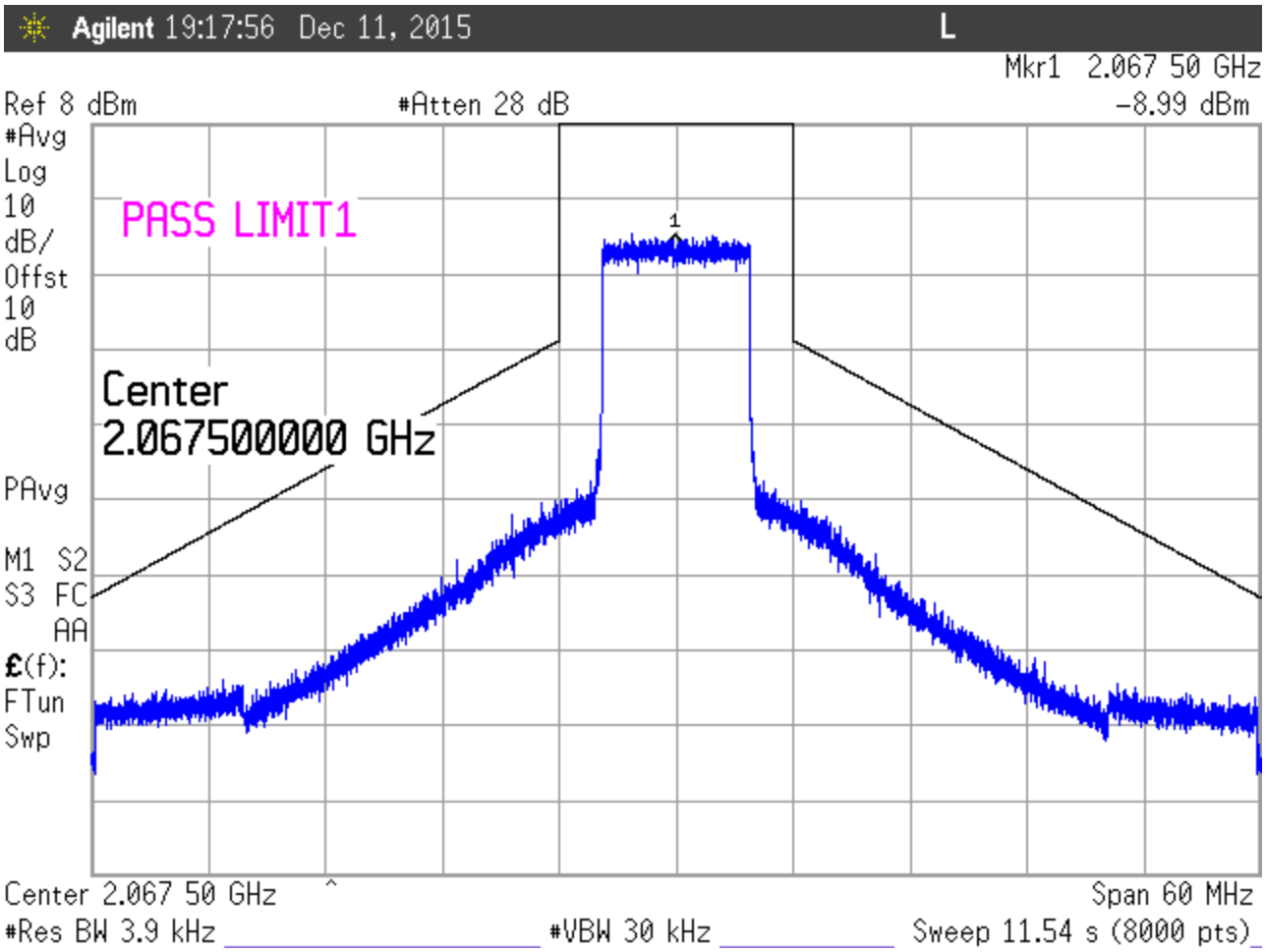

Figure 46: Spurious Emissions, 16QAM Modulation, TX @ 2067.5MHz, Emission Mask

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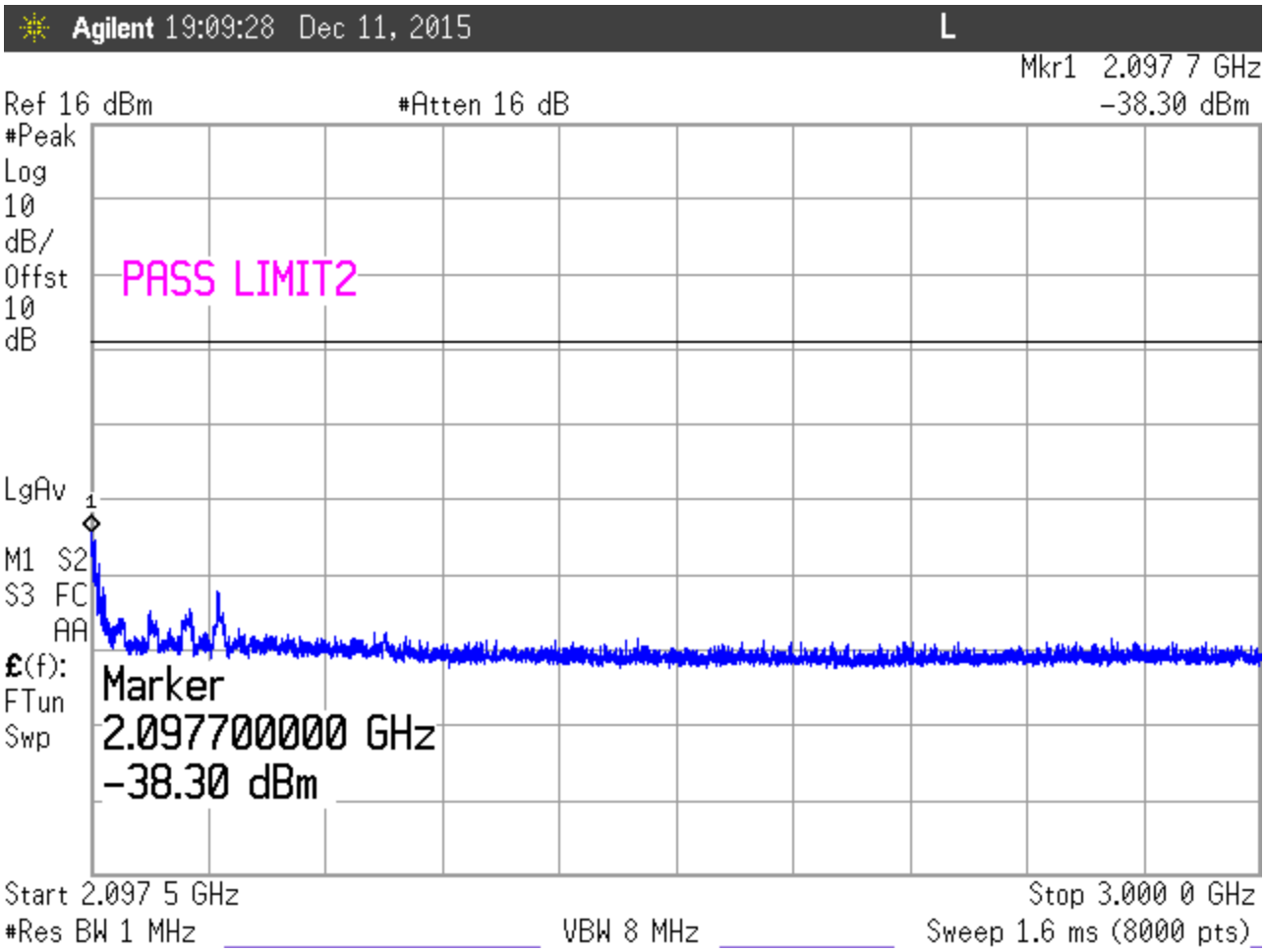

Figure 47: Spurious Emissions, 16QAM Modulation, TX @ 2067.5MHz, 2097.5MHz-3GHz

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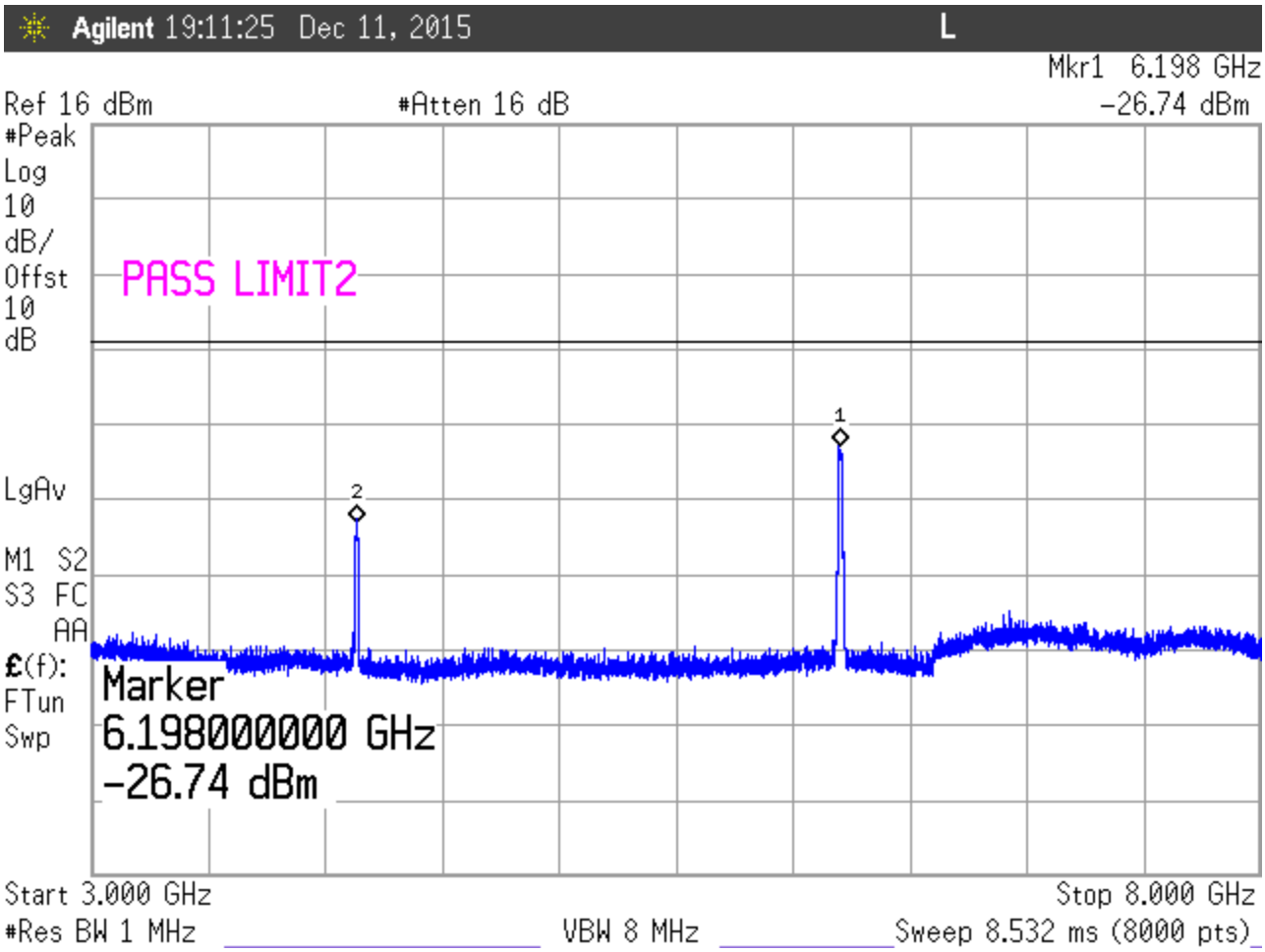

Figure 48: Spurious Emissions, 16QAM Modulation, TX @ 2067.5MHz, 3GHz-8GHz

 © 2016 Washington Laboratories, Ltd.

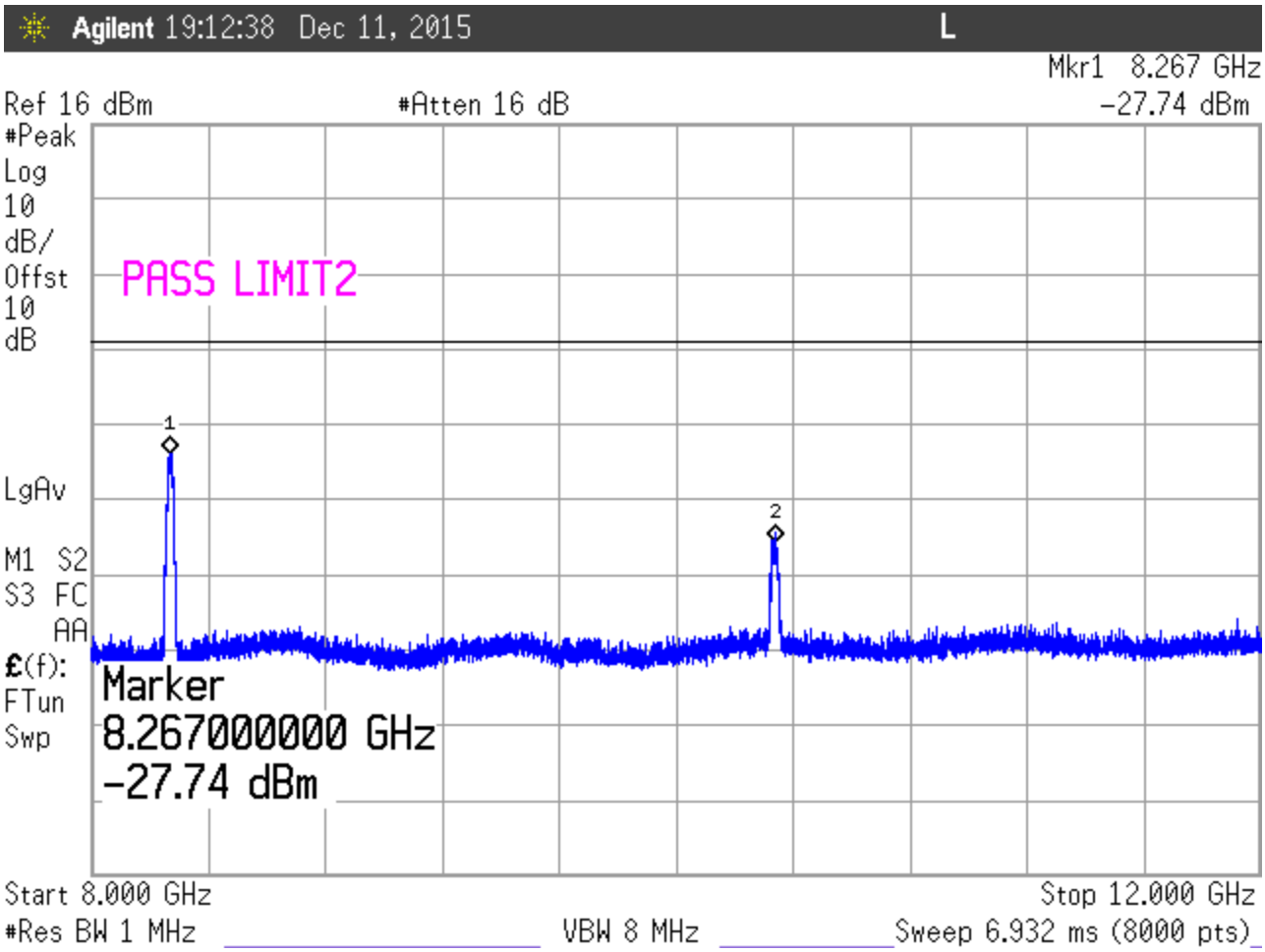

Figure 49: Spurious Emissions, 16QAM Modulation, TX @ 2067.5MHz, 8GHz-12GHz

 © 2016 Washington Laboratories, Ltd.

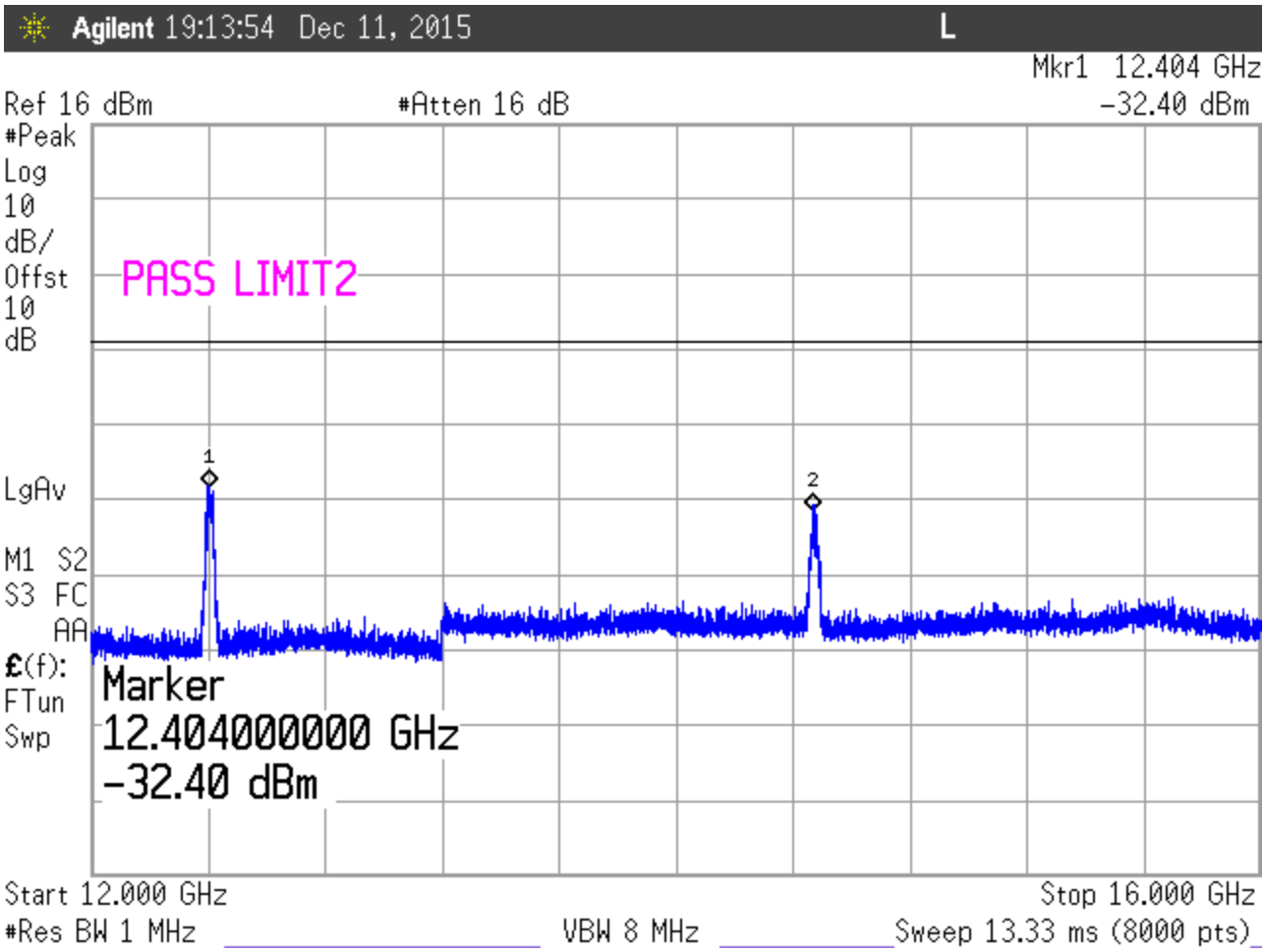

Figure 50: Spurious Emissions, 16QAM Modulation, TX @ 2067.5MHz, 12GHz-16GHz

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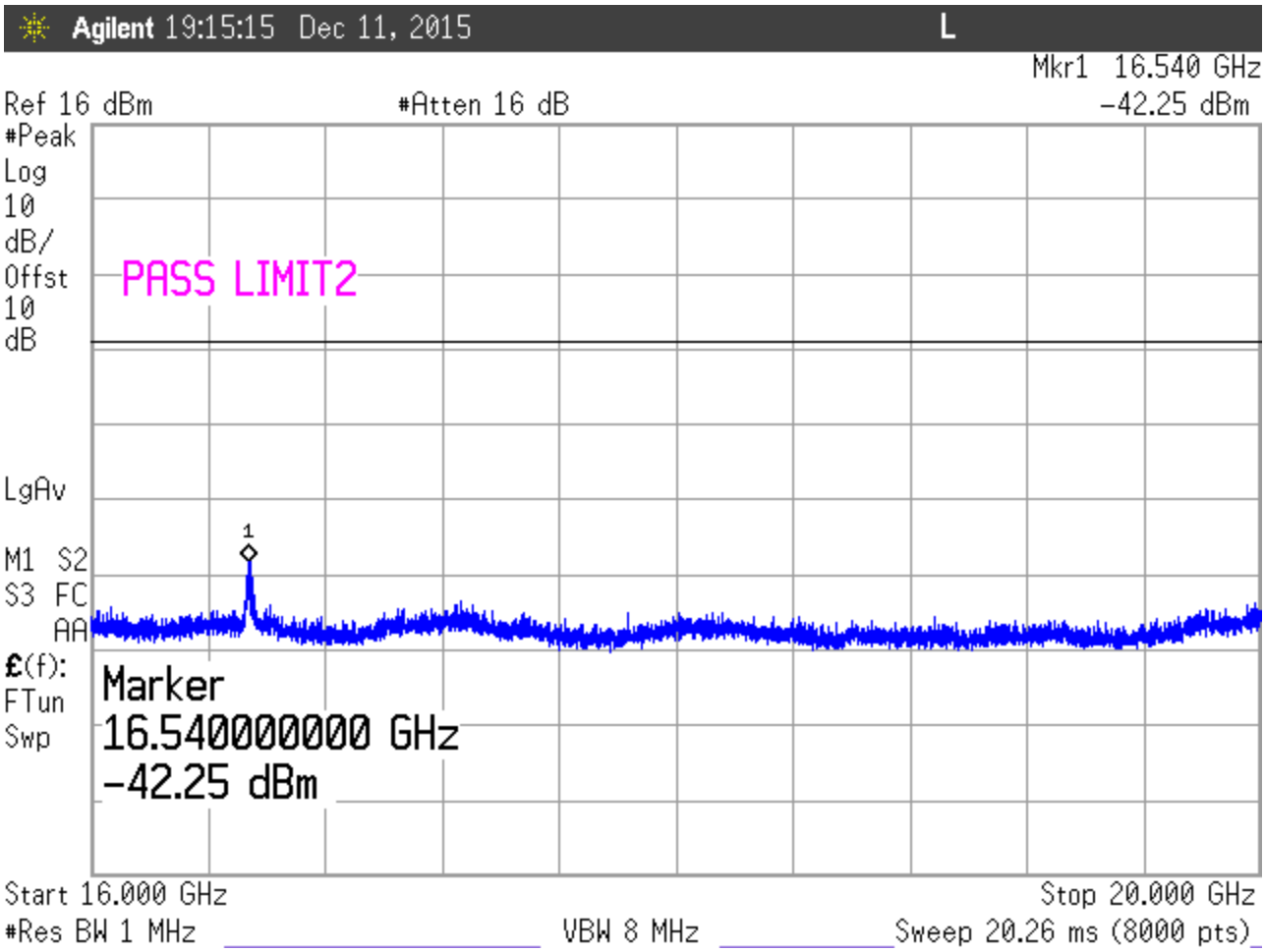

Figure 51: Spurious Emissions, 16QAM Modulation, TX @ 2067.5MHz, 16GHz-20GHz

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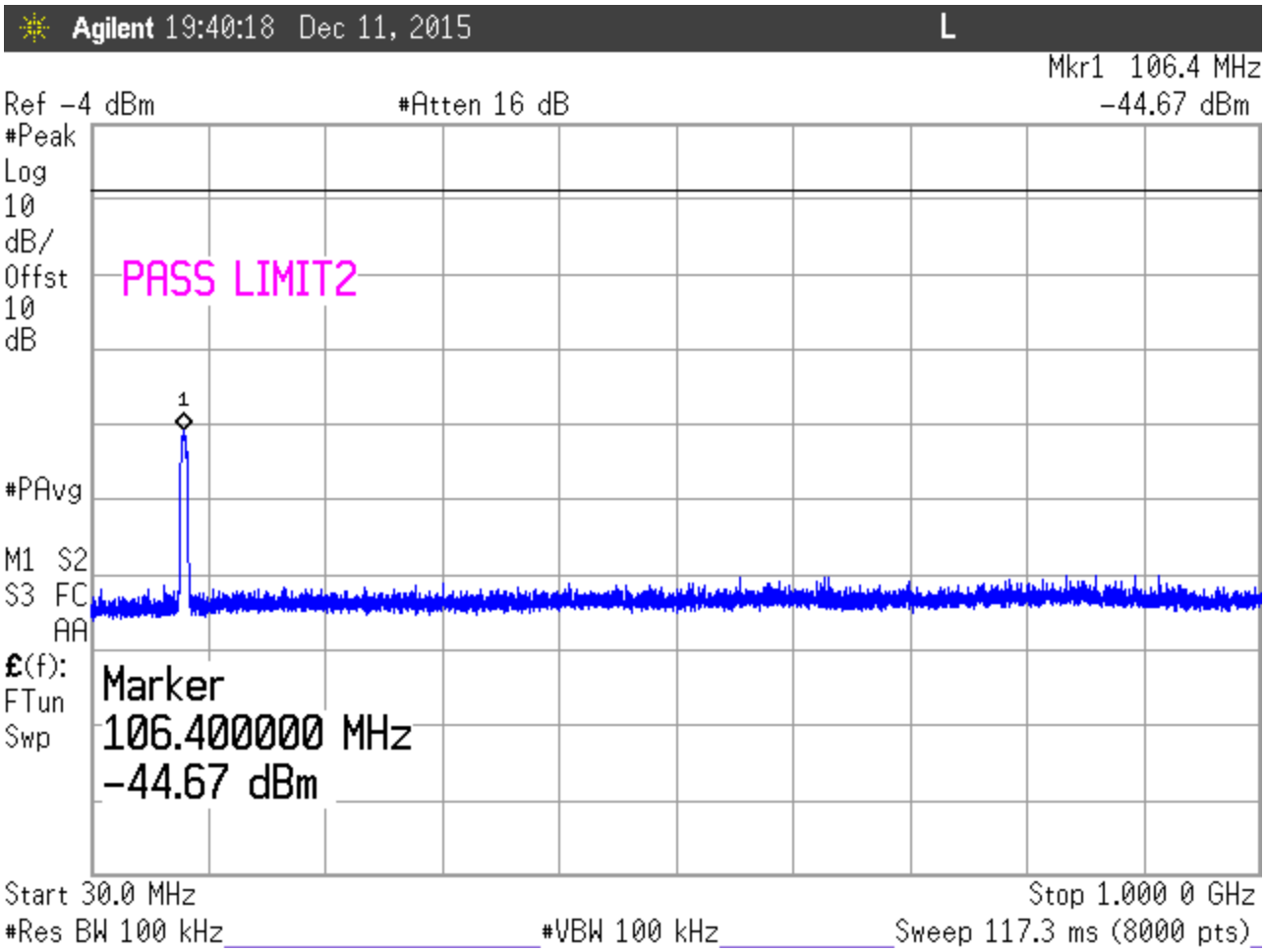

Figure 52: Spurious Emissions, 64QAM Modulation, TX @ 2067.5MHz, 30MHz-1000MHz

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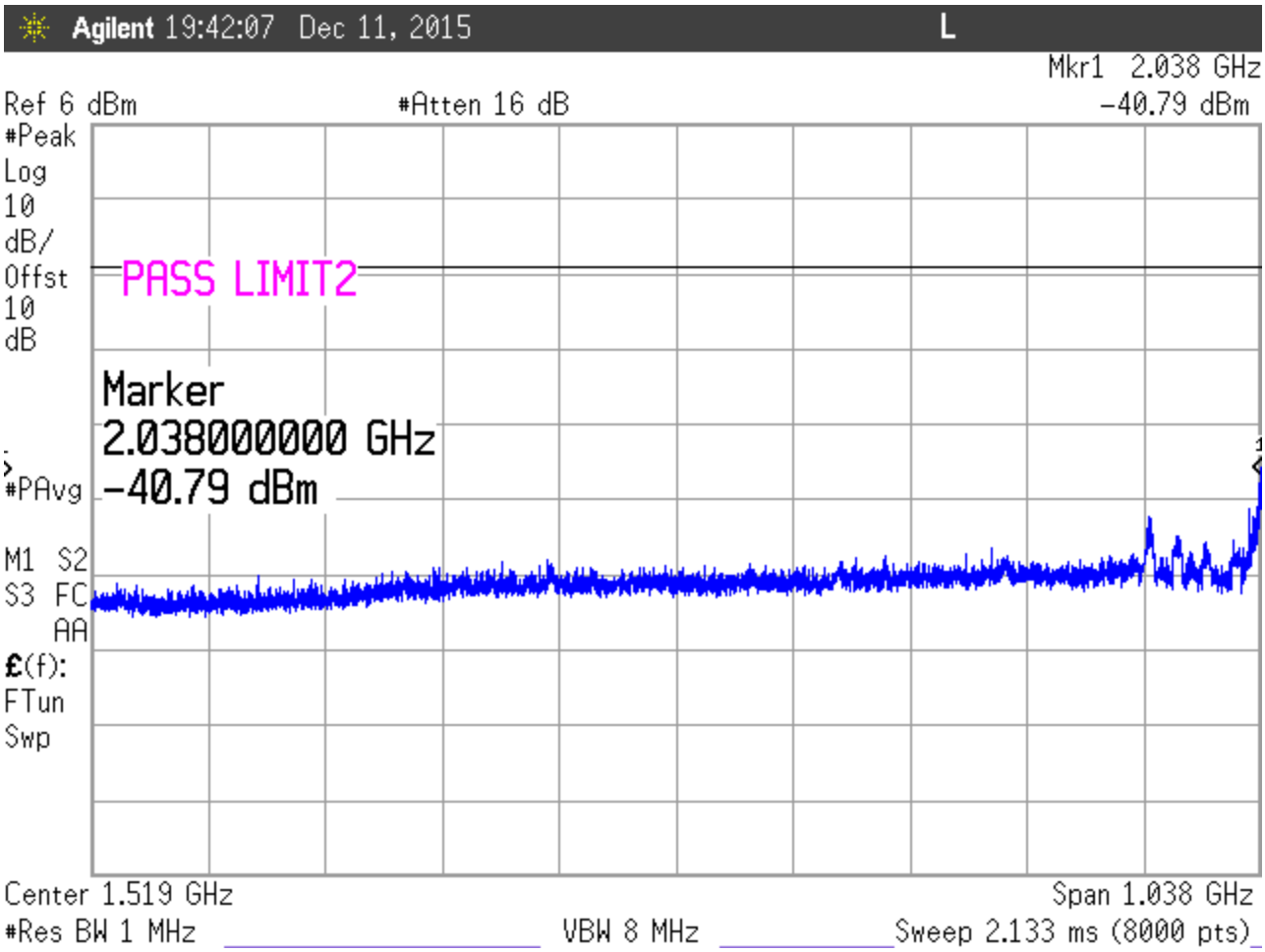

Figure 53: Spurious Emissions, 64QAM Modulation, TX @ 2067.5MHz, 1000MHz-2038MHz

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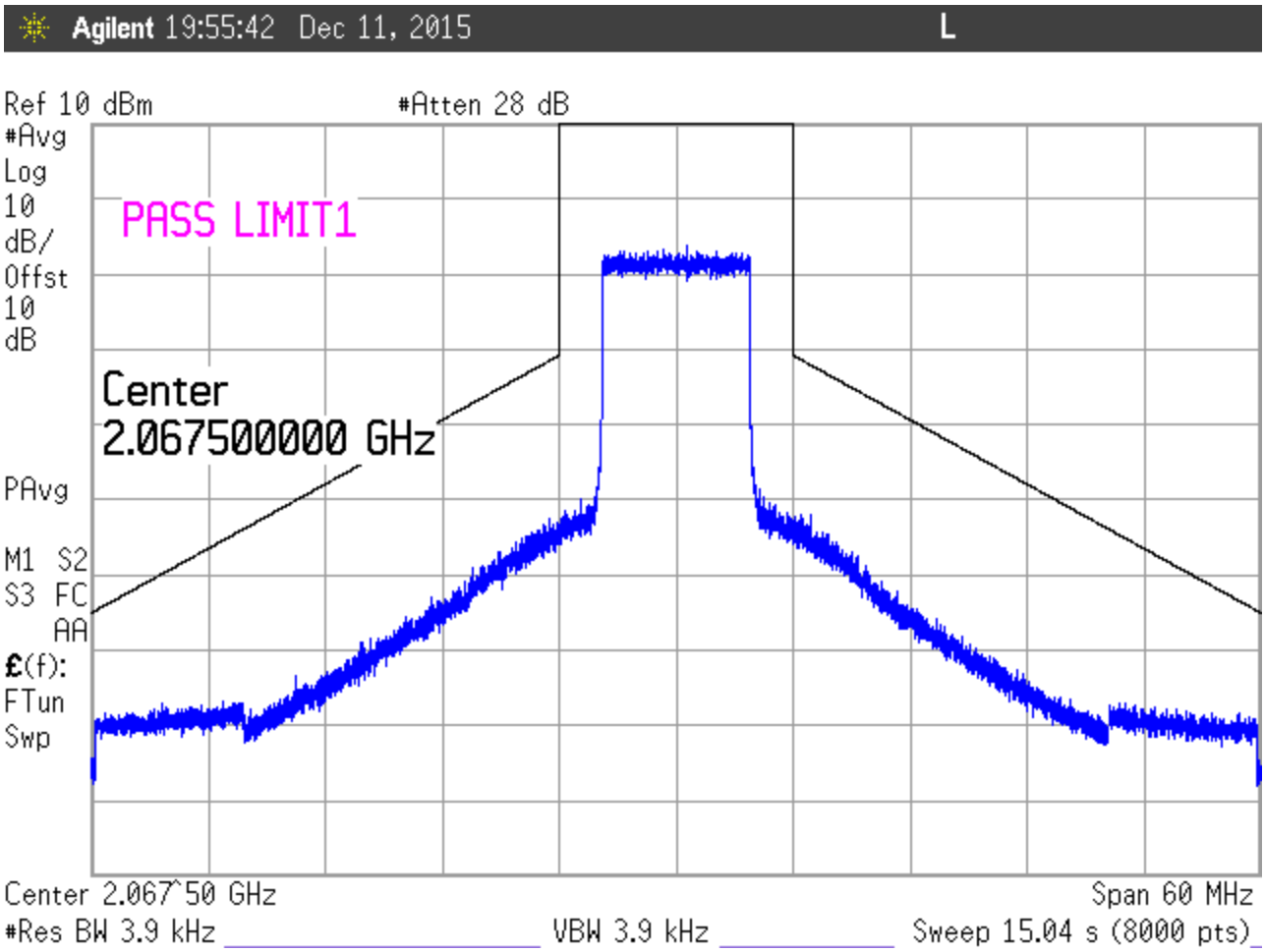

Figure 54: Spurious Emissions, 64QAM Modulation, TX @ 2067.5MHz, Emission Mask

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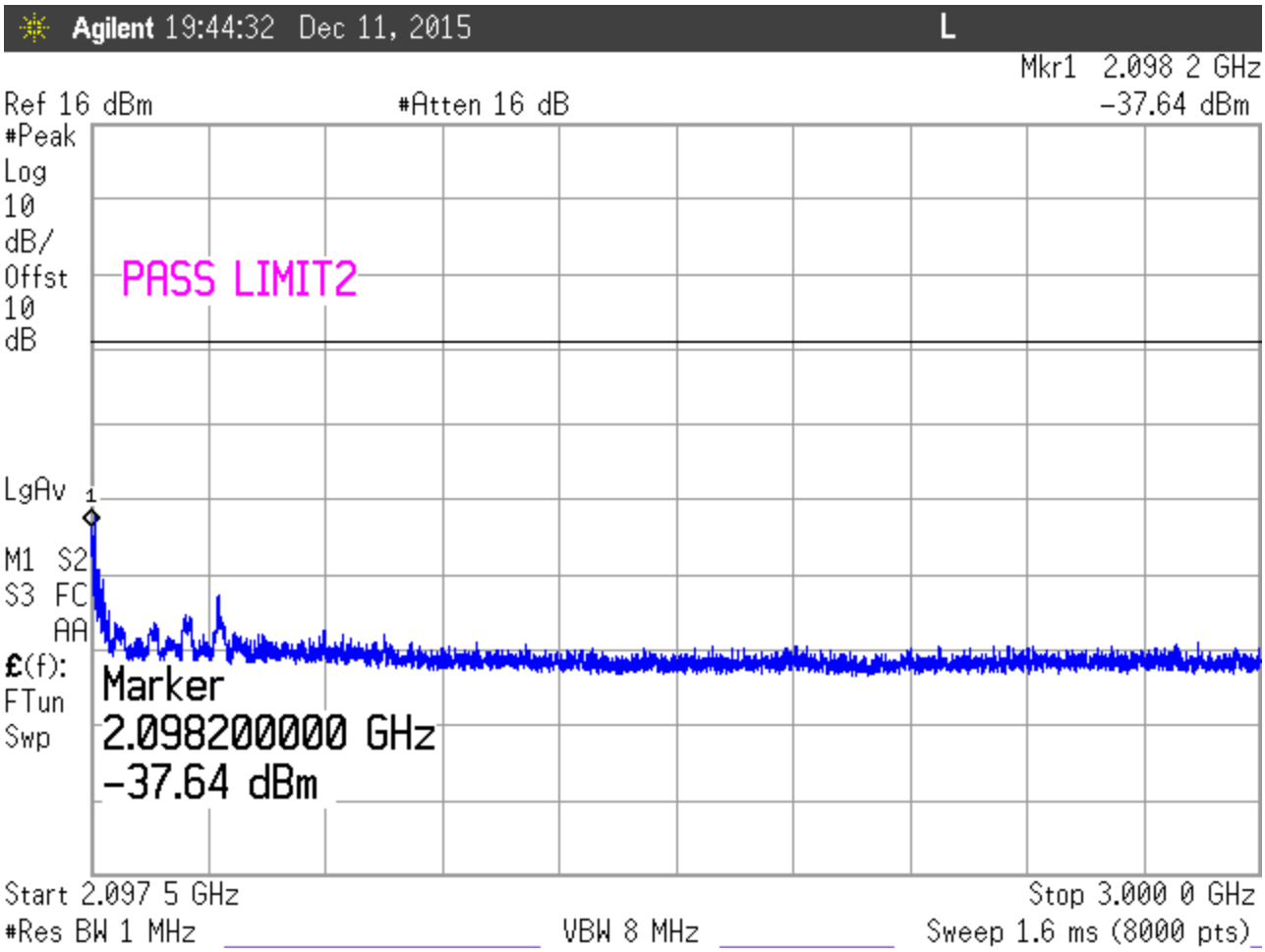

Figure 55: Spurious Emissions, 64QAM Modulation, TX @ 2067.5MHz, 2097.5MHz-3GHz

 © 2016 Washington Laboratories, Ltd.

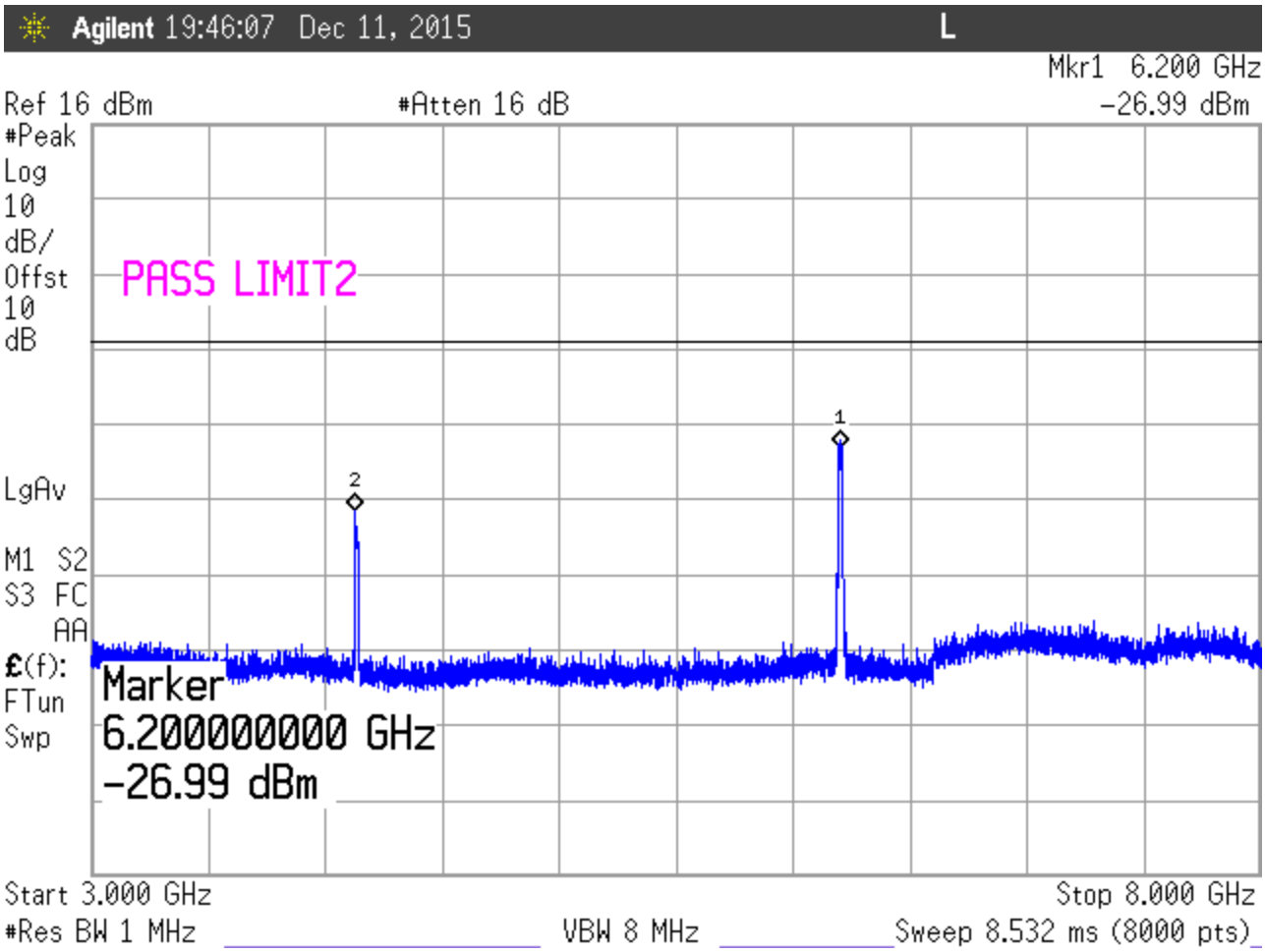

Figure 56: Spurious Emissions, 64QAM Modulation, TX @ 2067.5MHz, 3GHz-8GHz

 © 2016 Washington Laboratories, Ltd.

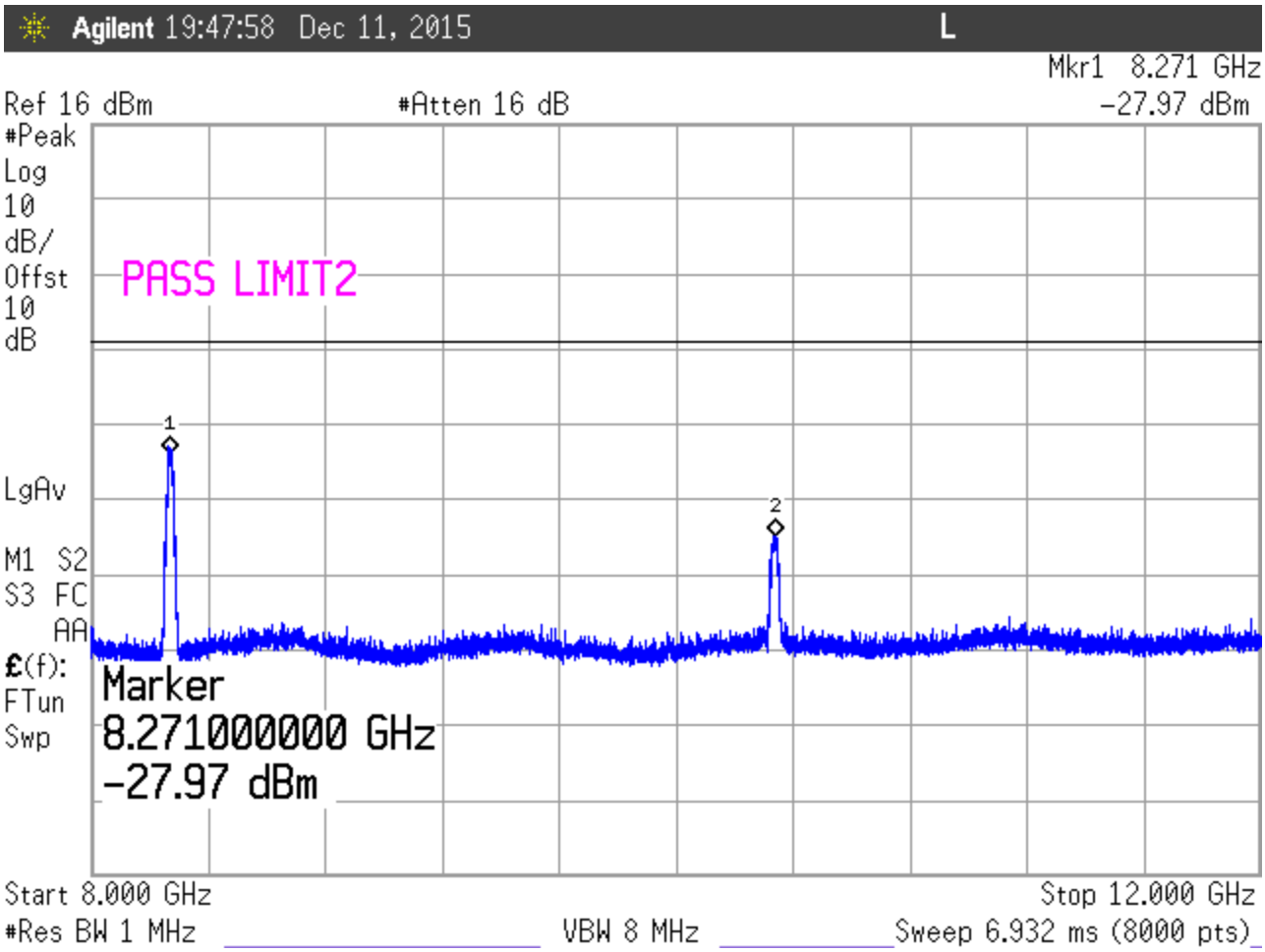

Figure 57: Spurious Emissions, 64QAM Modulation, TX @ 2067.5MHz, 8GHz-12GHz

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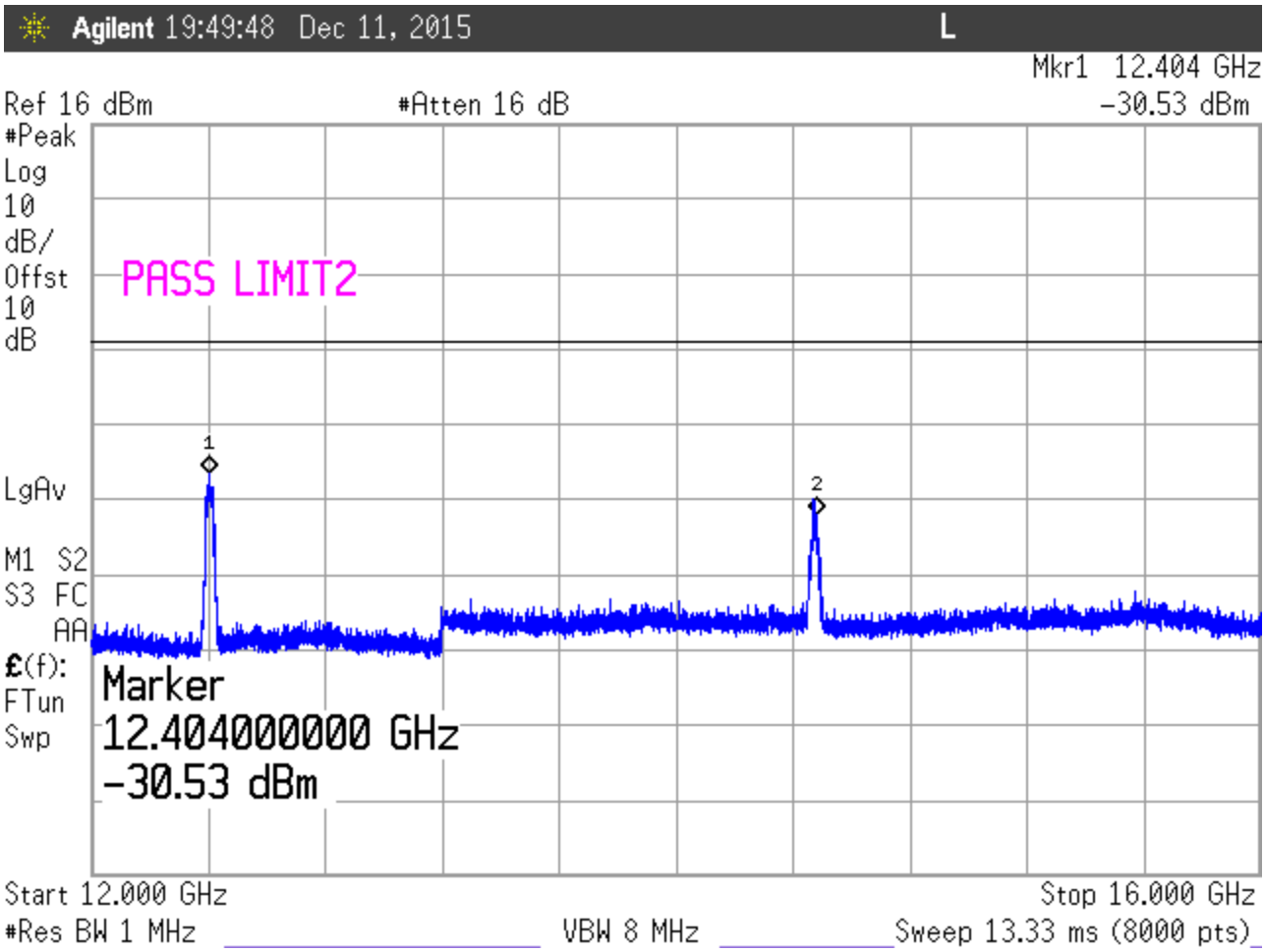

Figure 58: Spurious Emissions, 64QAM Modulation, TX @ 2067.5MHz, 12GHz-16GHz

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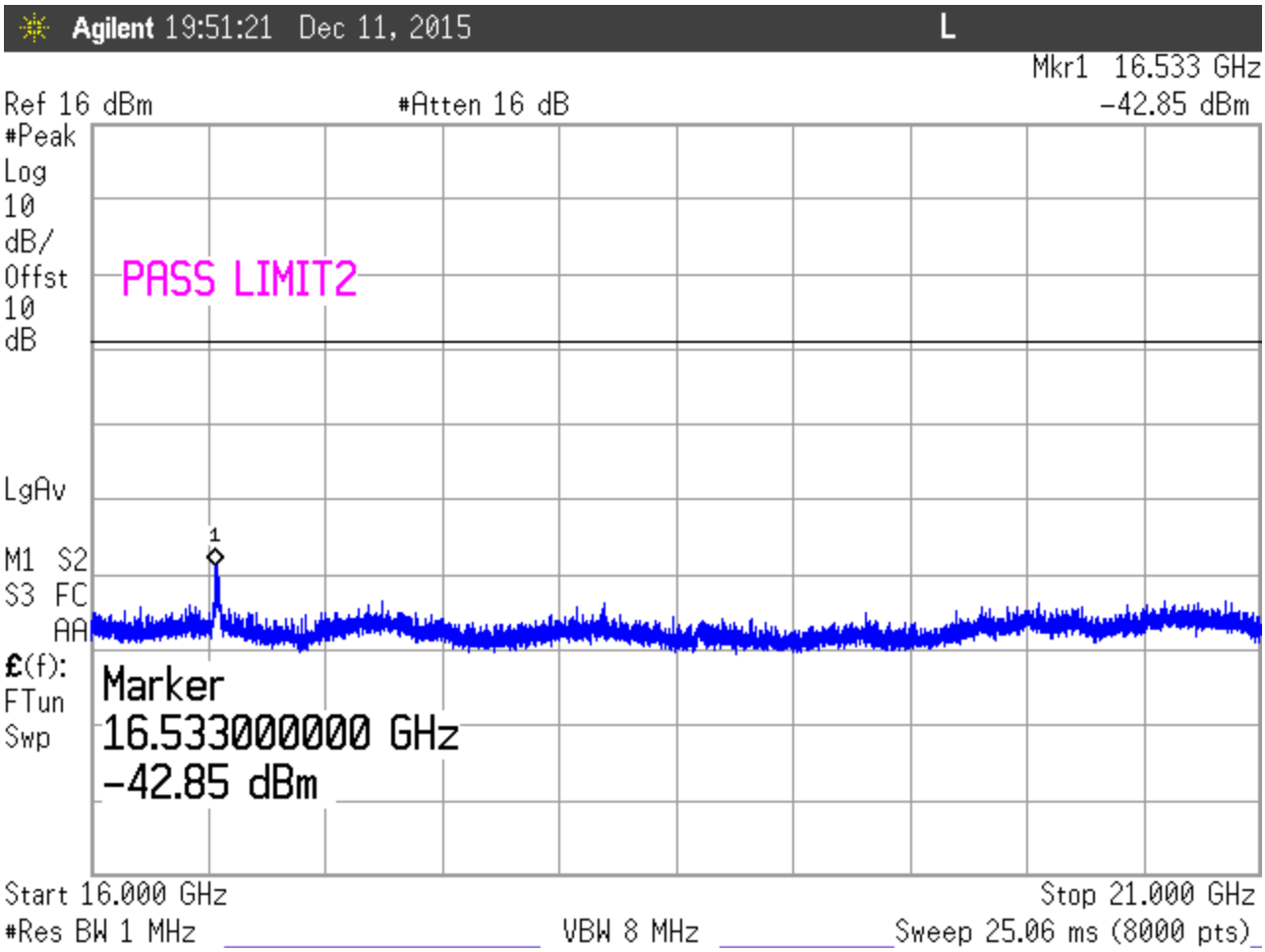

Figure 59: Spurious Emissions, 64QAM Modulation, TX @ 2067.5MHz, 16GHz-21GHz

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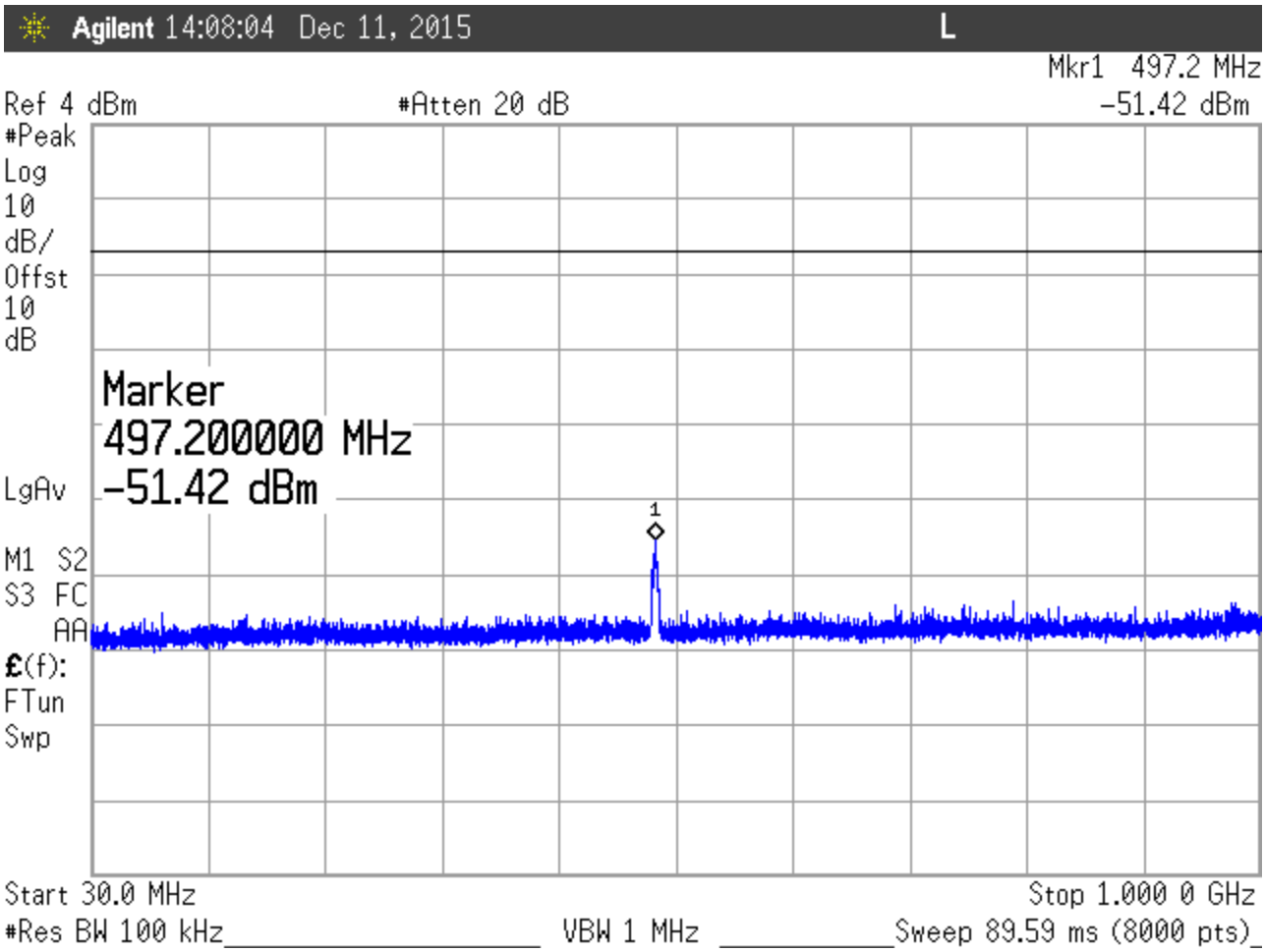

Figure 60: Spurious Emissions, QPSK Modulation, TX @ 2458.5MHz, 30MHz-1000MHz

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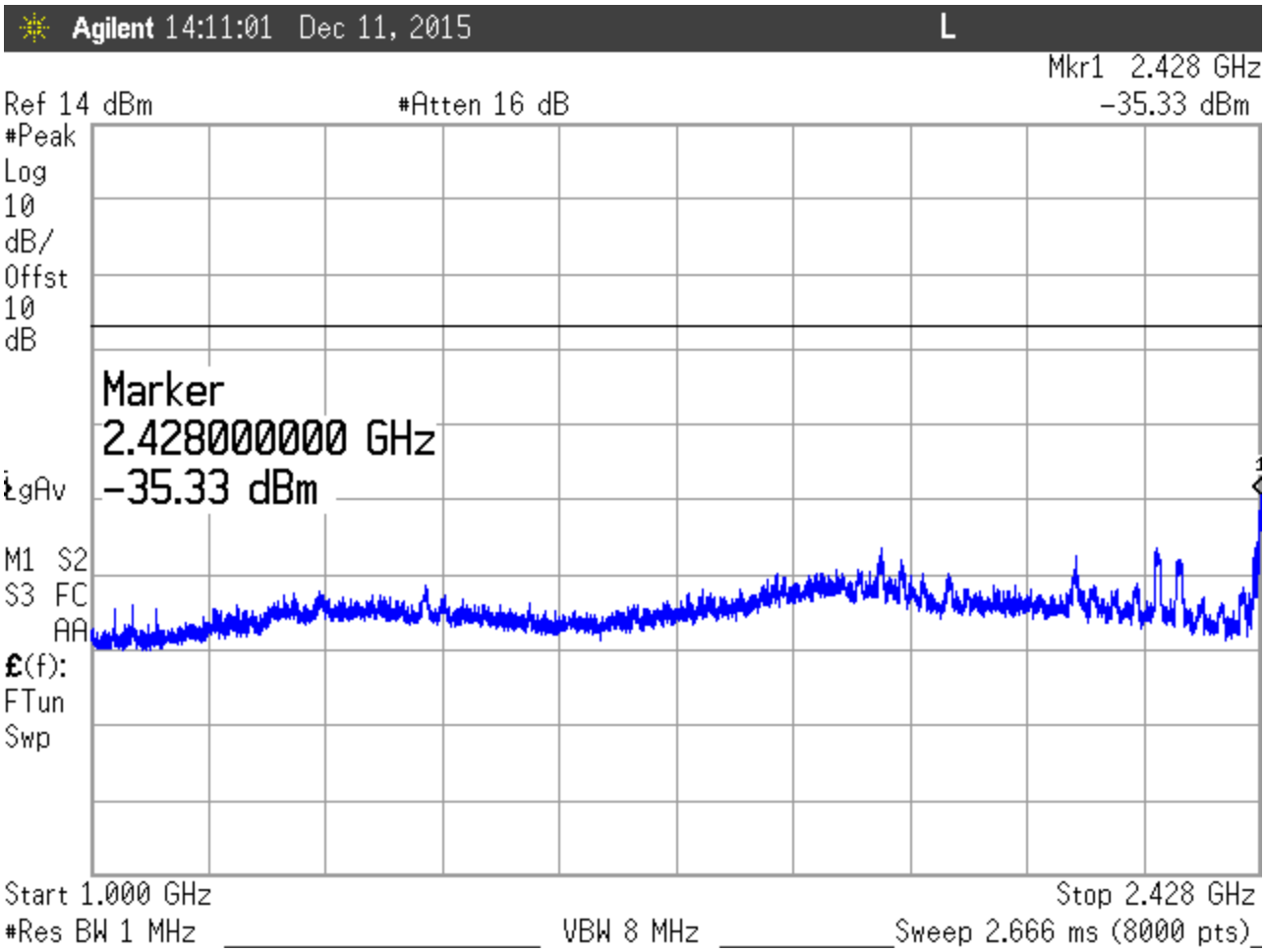

Figure 61: Spurious Emissions, QPSK Modulation, TX @ 2458.5MHz, 1000MHz-2428MHz

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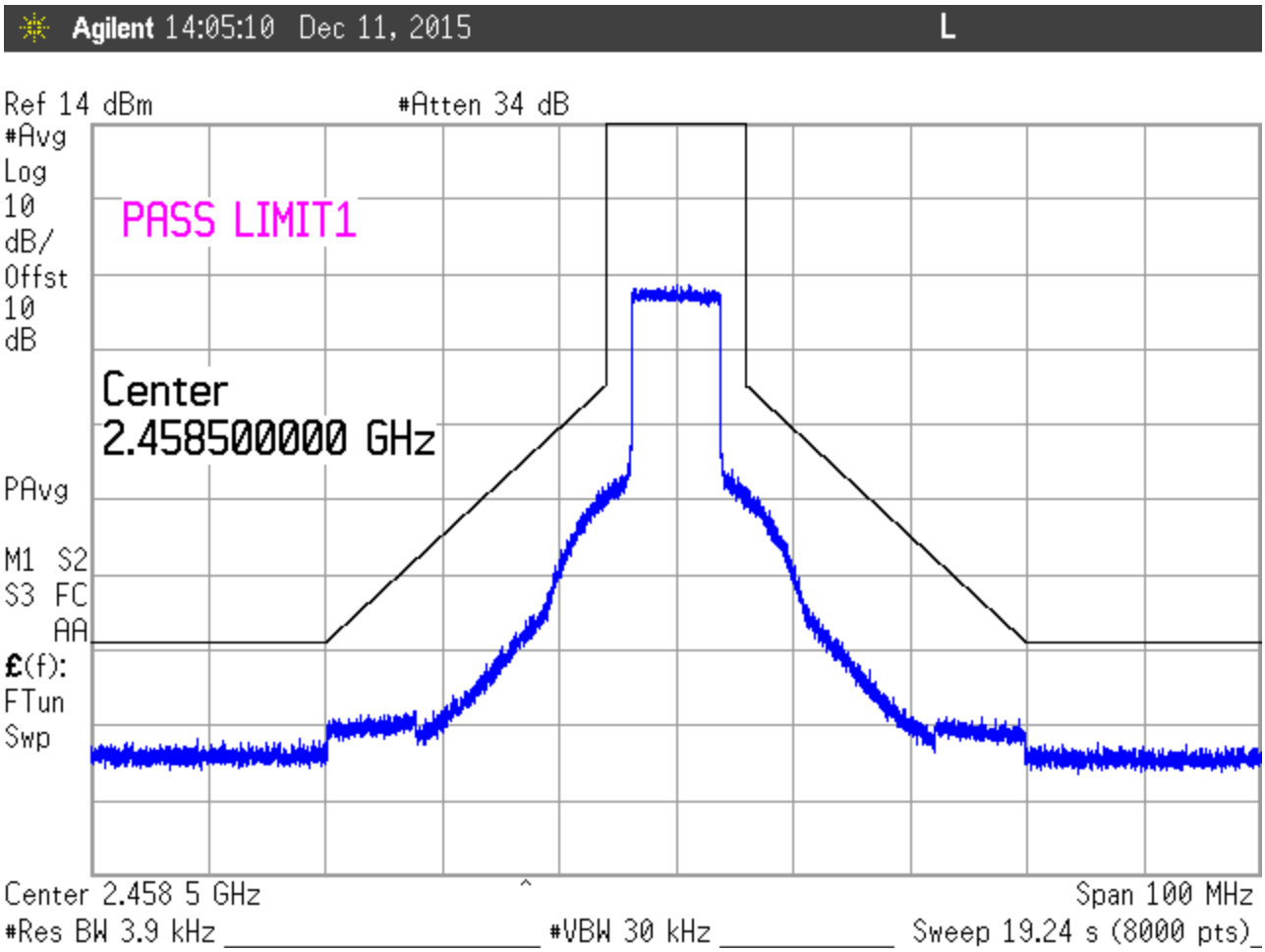

Figure 62: Spurious Emissions, QPSK Modulation, TX @ 2458.5MHz, Emission Mask

 © 2016 Washington Laboratories, Ltd.

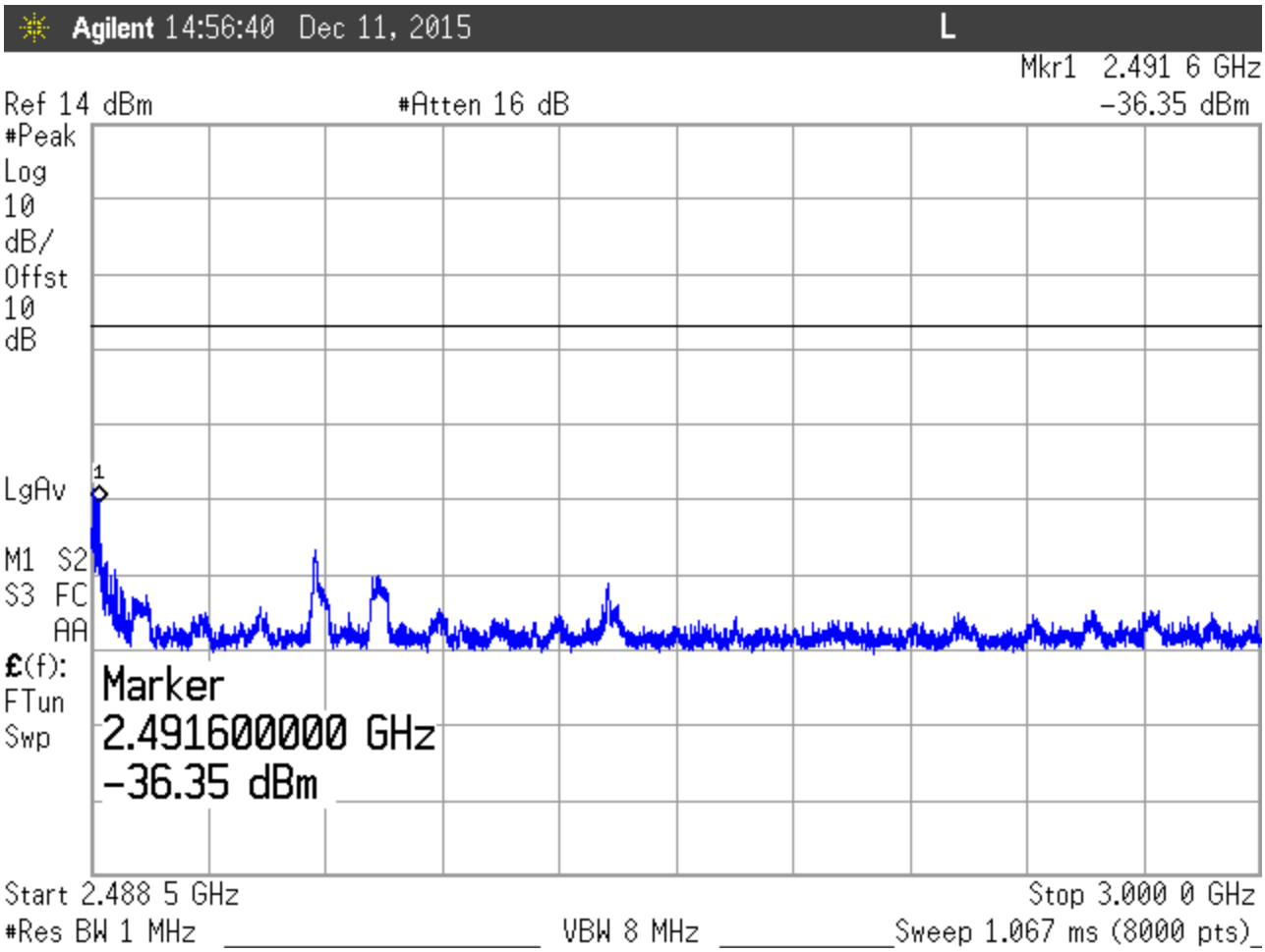

Figure 63: Spurious Emissions, QPSK Modulation, TX @ 2458.5MHz, 2488.5MHz-3GHz

 © 2016 Washington Laboratories, Ltd.

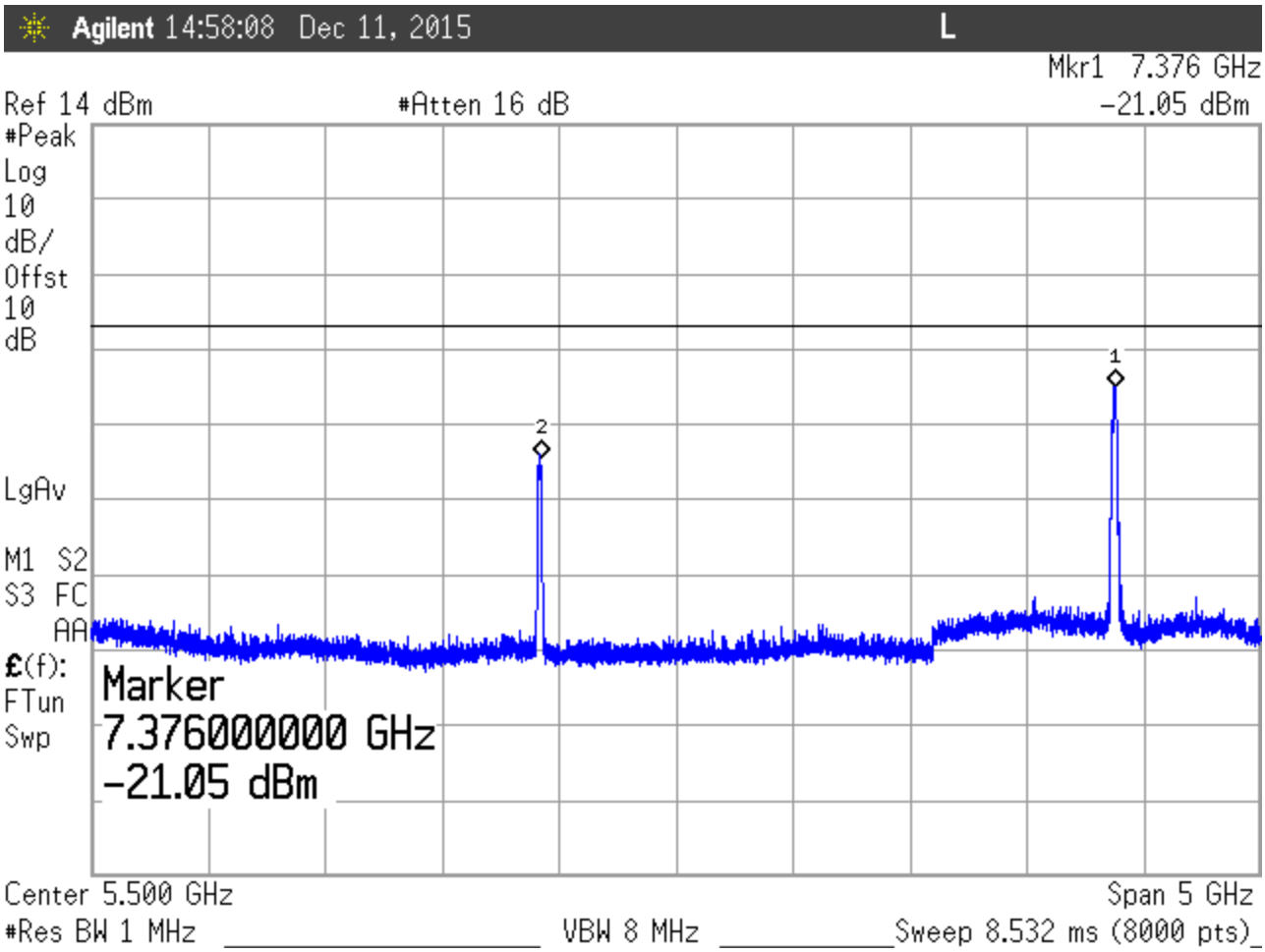

Figure 64: Spurious Emissions, QPSK Modulation, TX @ 2458.5MHz, 3GHz-8GHz

 © 2016 Washington Laboratories, Ltd.

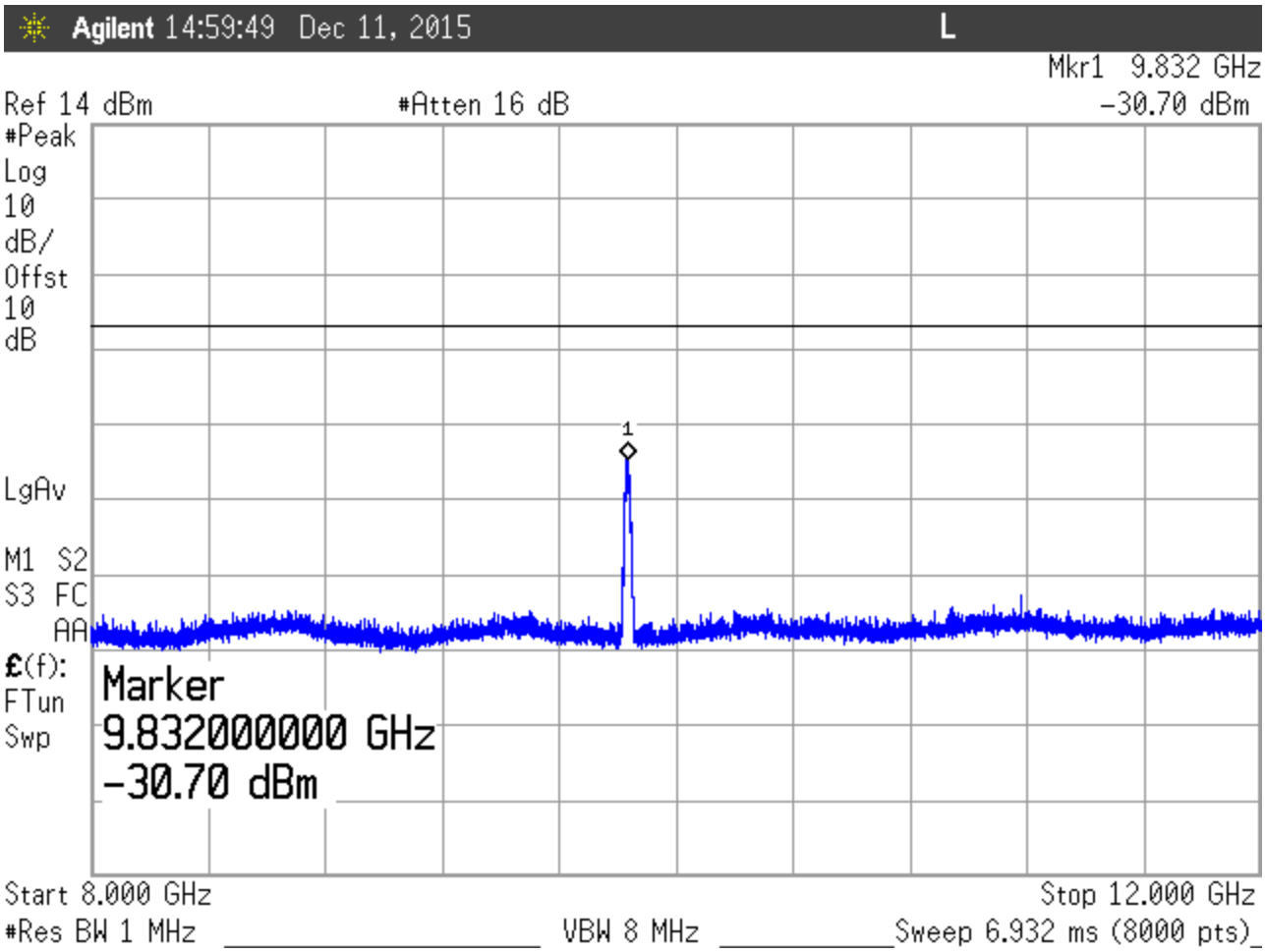

Figure 65: Spurious Emissions, QPSK Modulation, TX @ 2458.5MHz, 8GHz-12GHz

 © 2016 Washington Laboratories, Ltd.

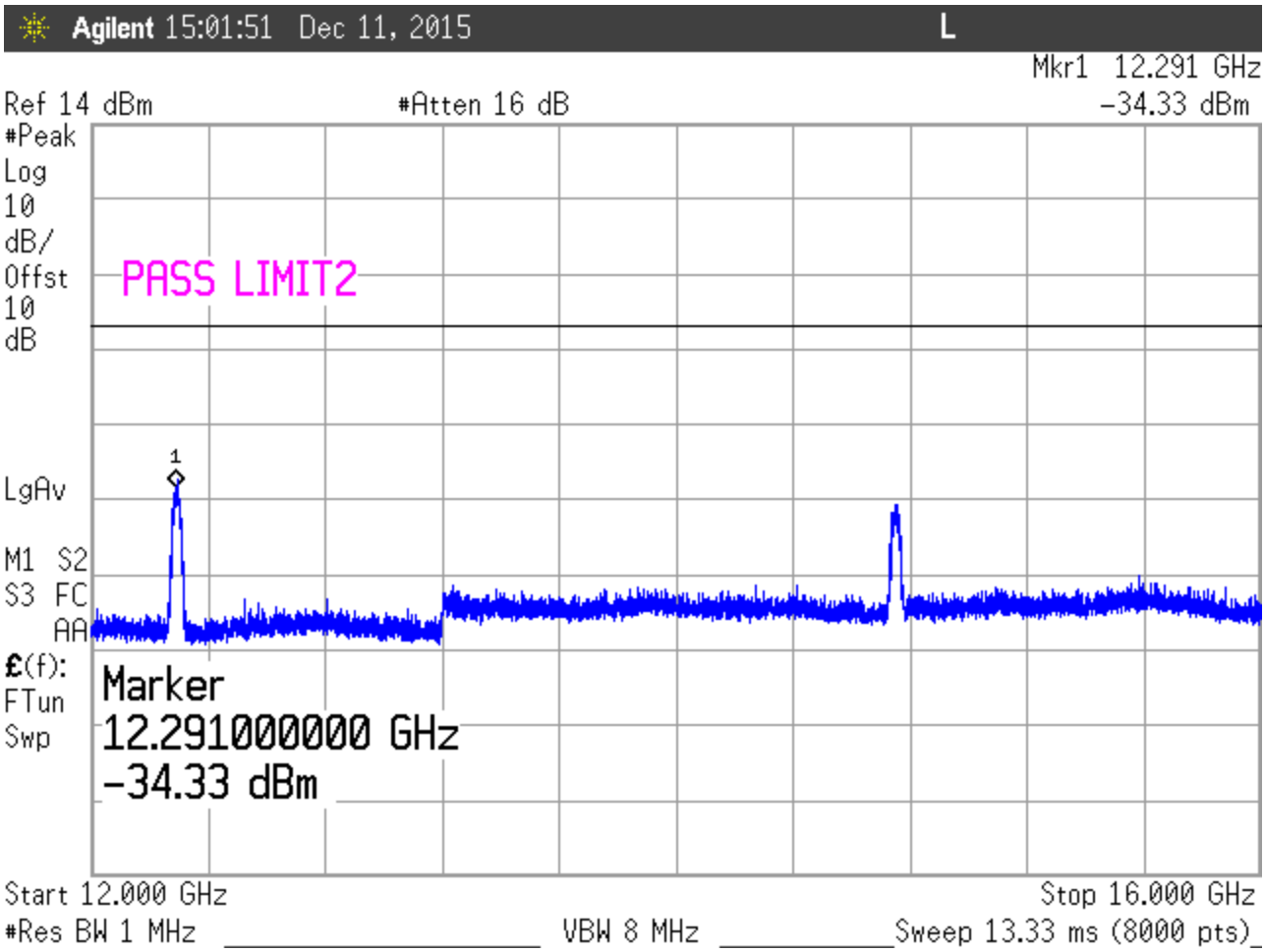

Figure 66: Spurious Emissions, QPSK Modulation, TX @ 2458.5MHz, 12GHz-16GHz

 © 2016 Washington Laboratories, Ltd.

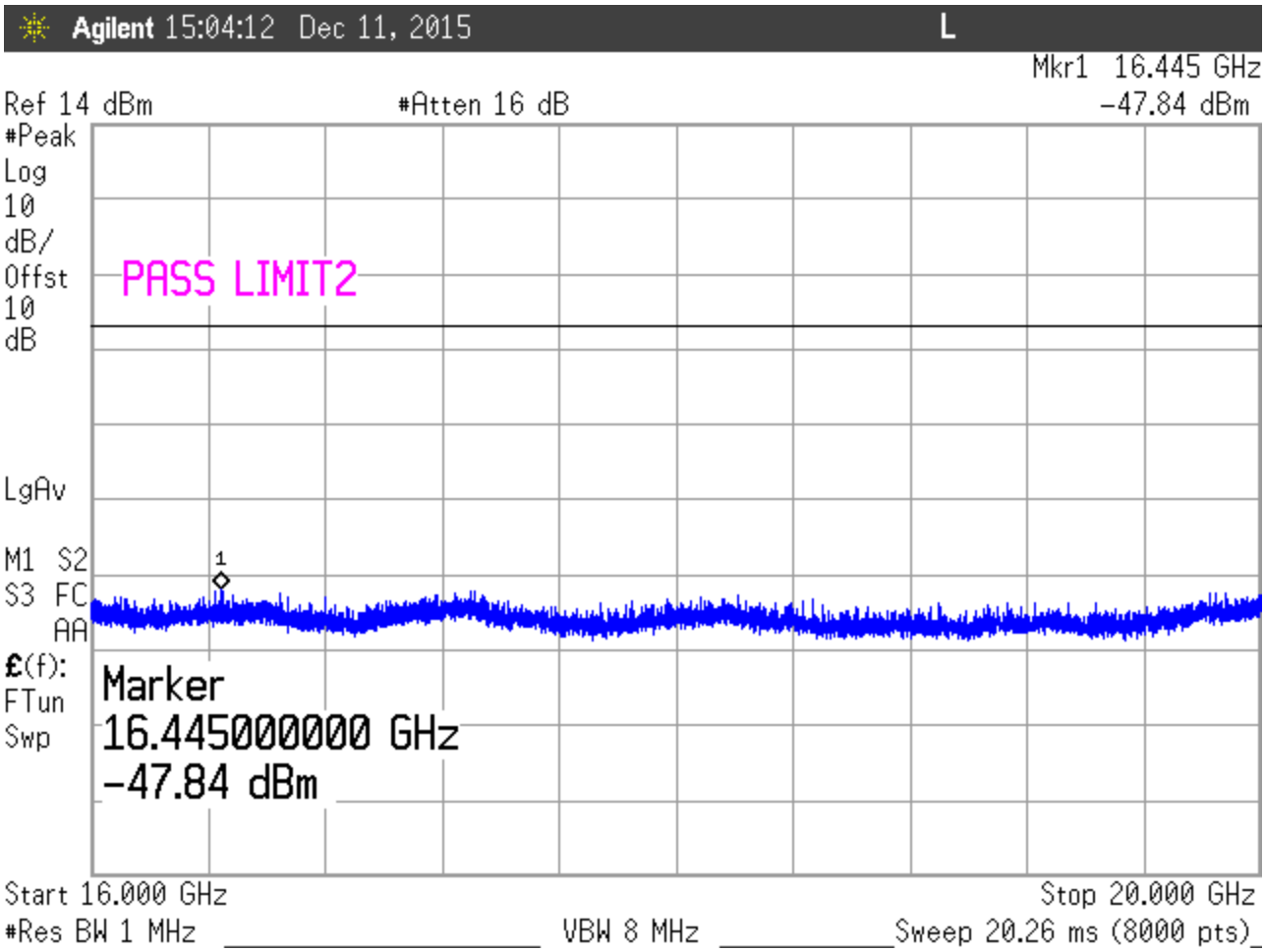

Figure 67: Spurious Emissions, QPSK Modulation, TX @ 2458.5MHz, 16GHz-20GHz

 © 2016 Washington Laboratories, Ltd.

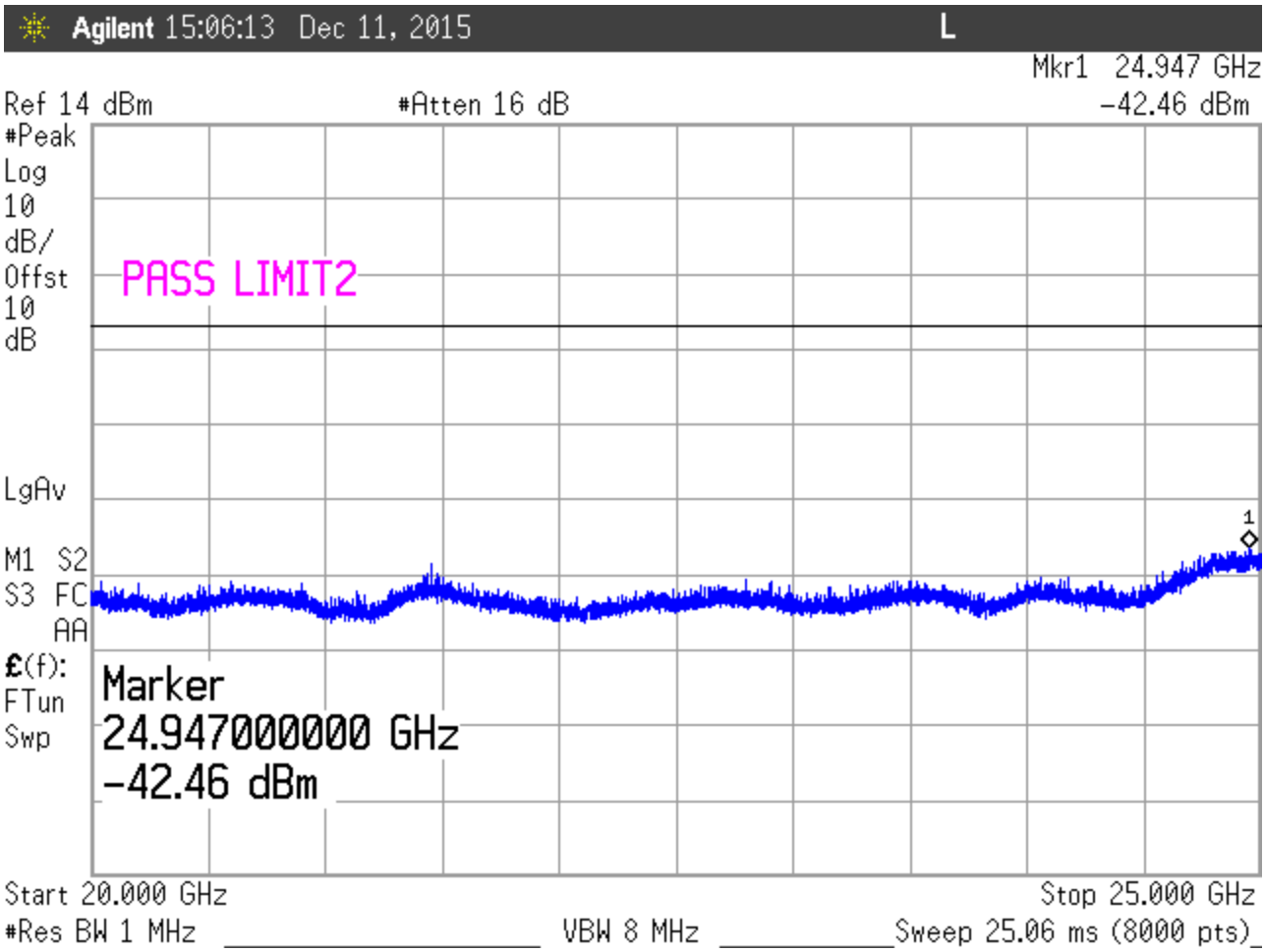

Figure 68: Spurious Emissions, QPSK Modulation, TX @ 2458.5MHz, 20GHz-25GHz

 © 2016 Washington Laboratories, Ltd.

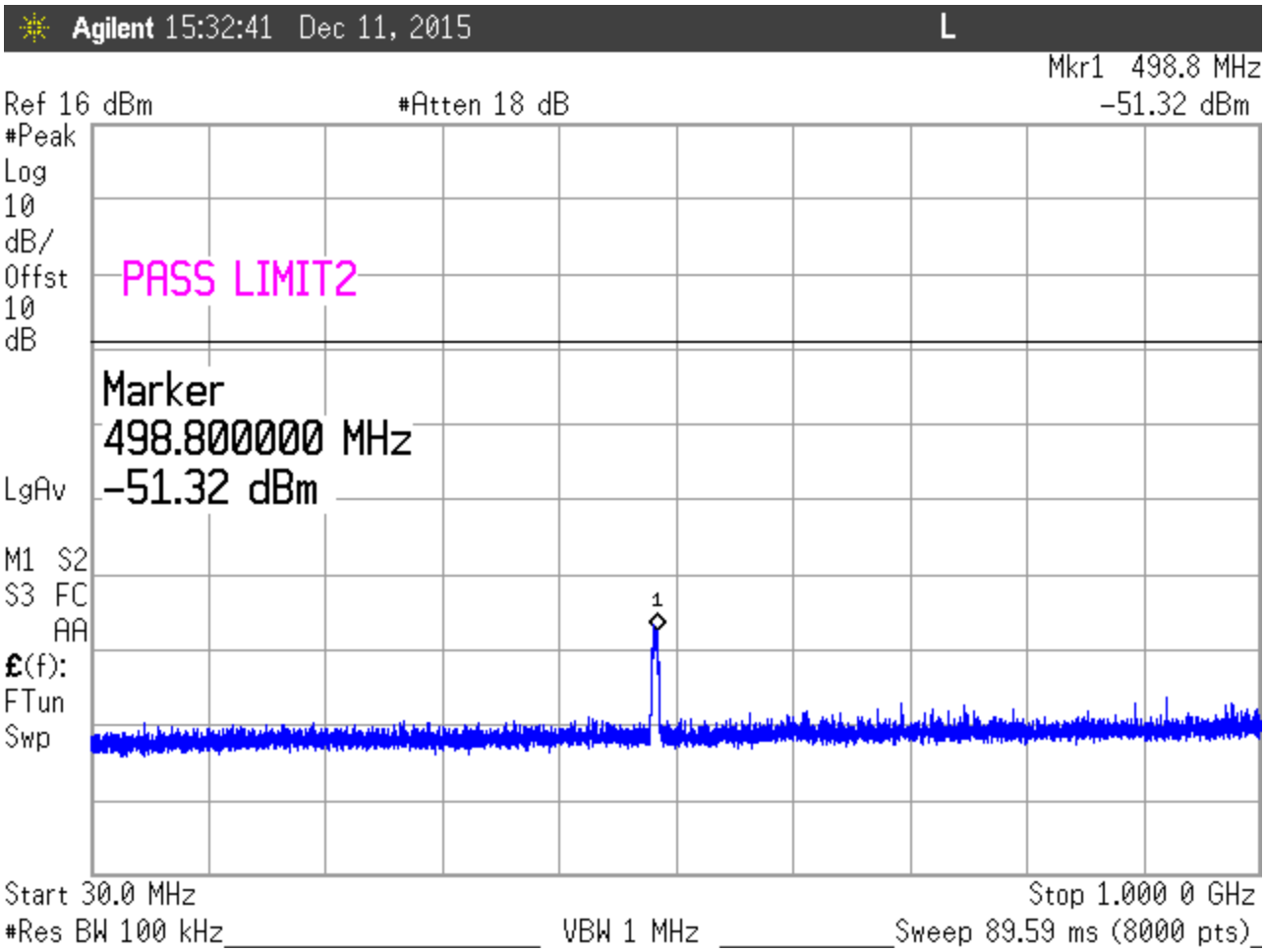

Figure 69: Spurious Emissions, 16QAM Modulation, TX @ 2458.5MHz, 30MHz-1000MHz

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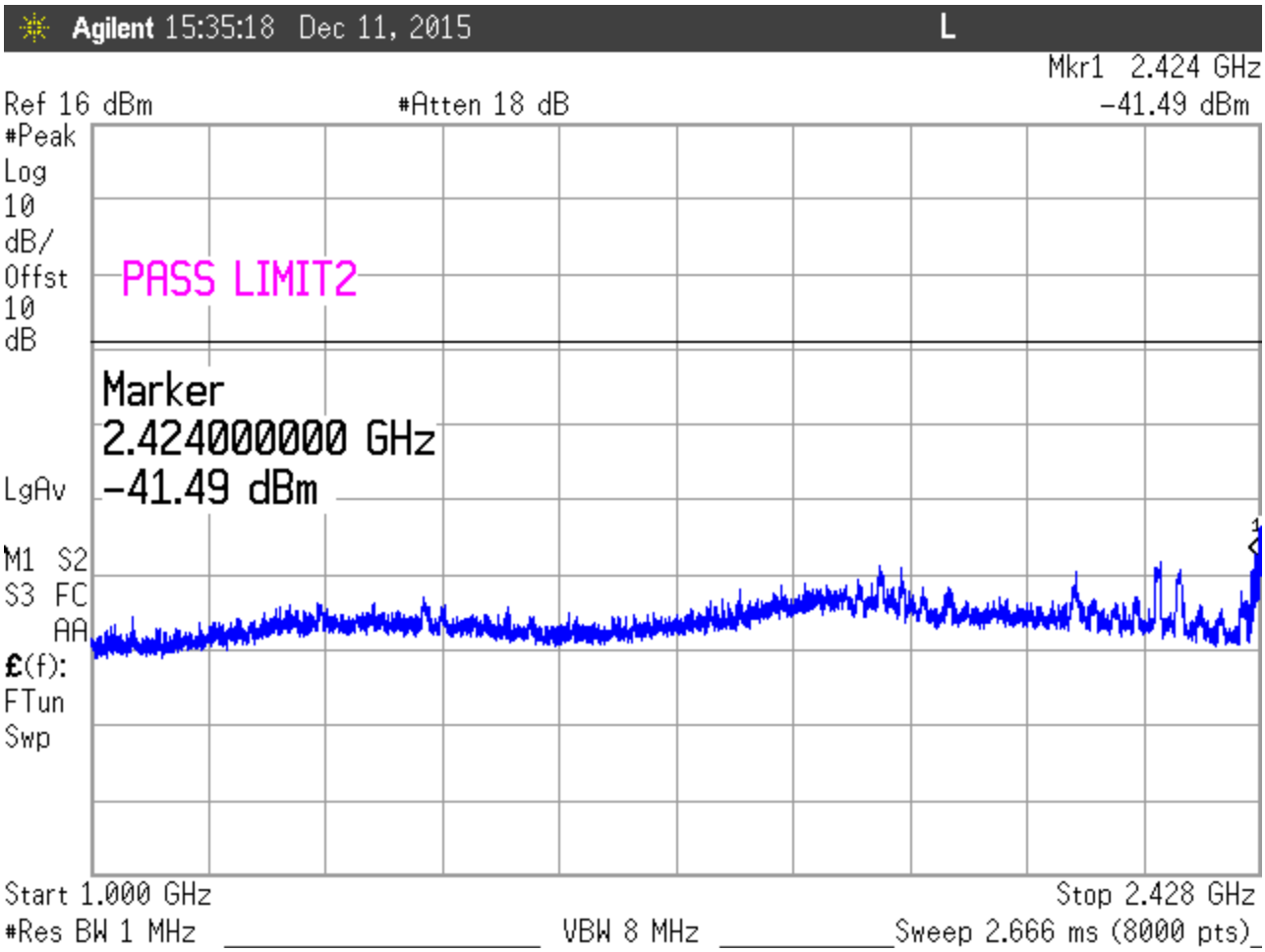

Figure 70: Spurious Emissions, 16QAM Modulation, TX @ 2458.5MHz, 1000MHz-2428MHz

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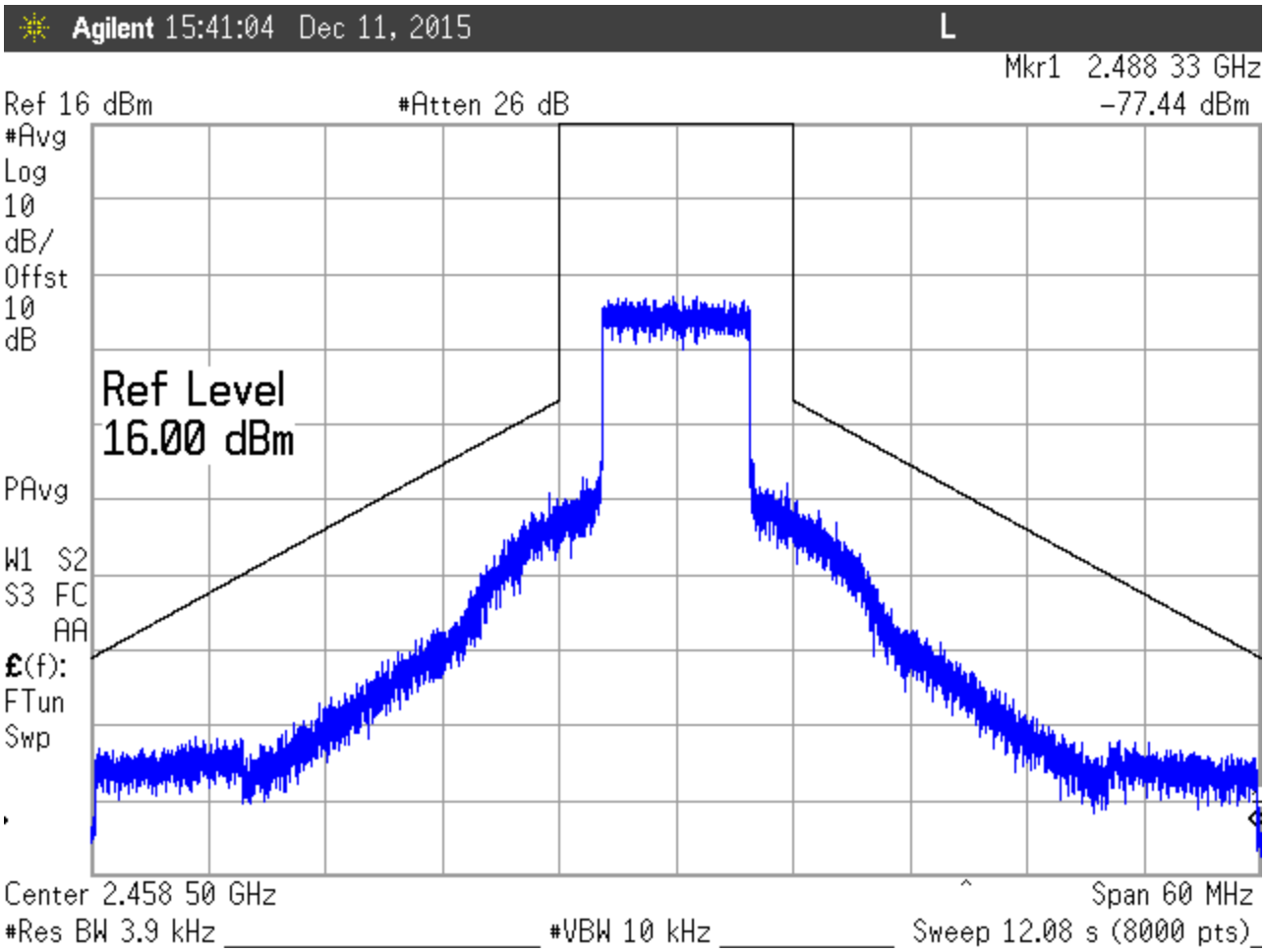

Figure 71: Spurious Emissions, 16QAM Modulation, TX @ 2458.5MHz, Emission Mask

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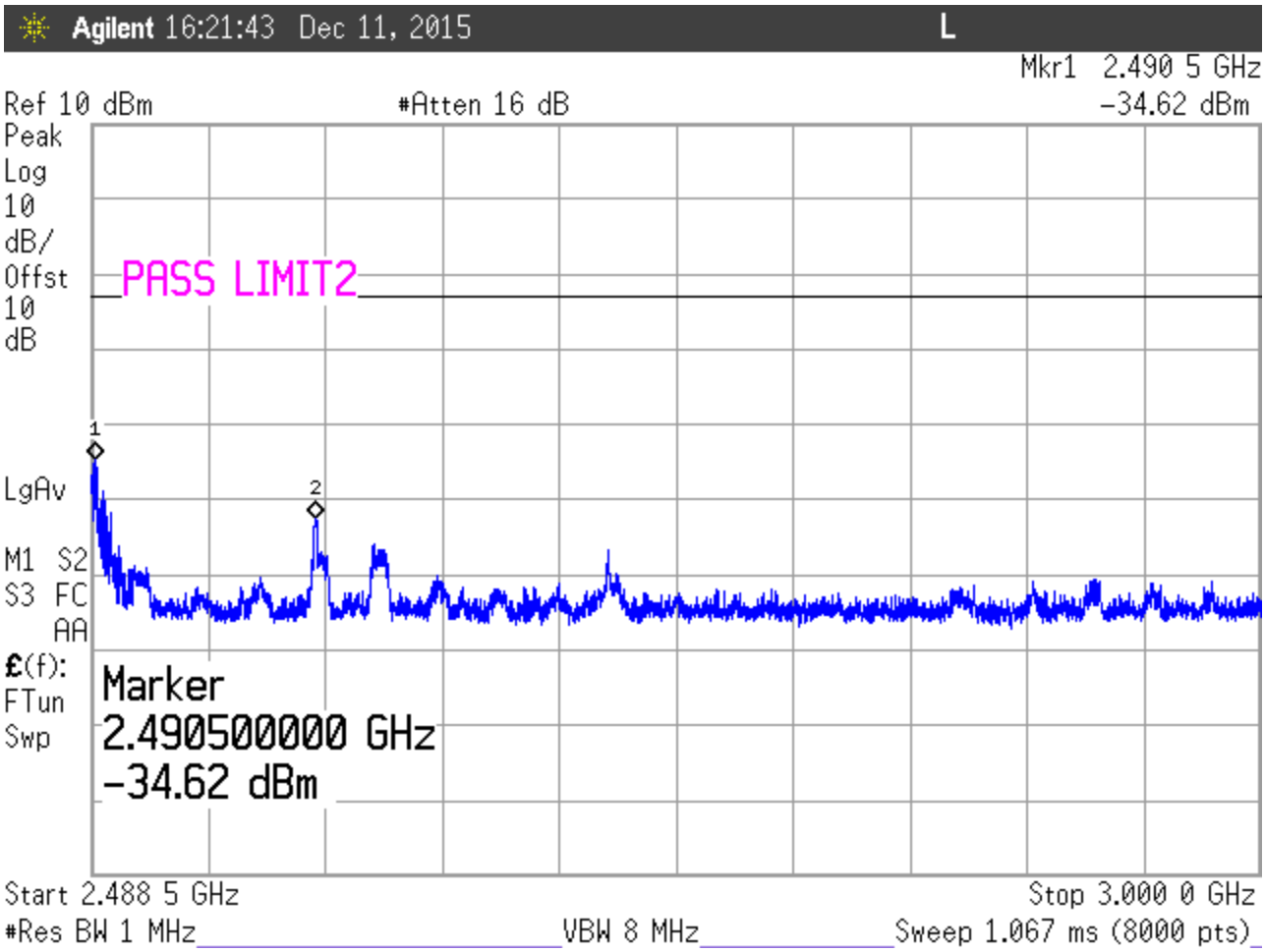

Figure 72: Spurious Emissions, 16QAM Modulation, TX @ 2458.5MHz, 2438MHz-3GHz

 © 2016 Washington Laboratories, Ltd.

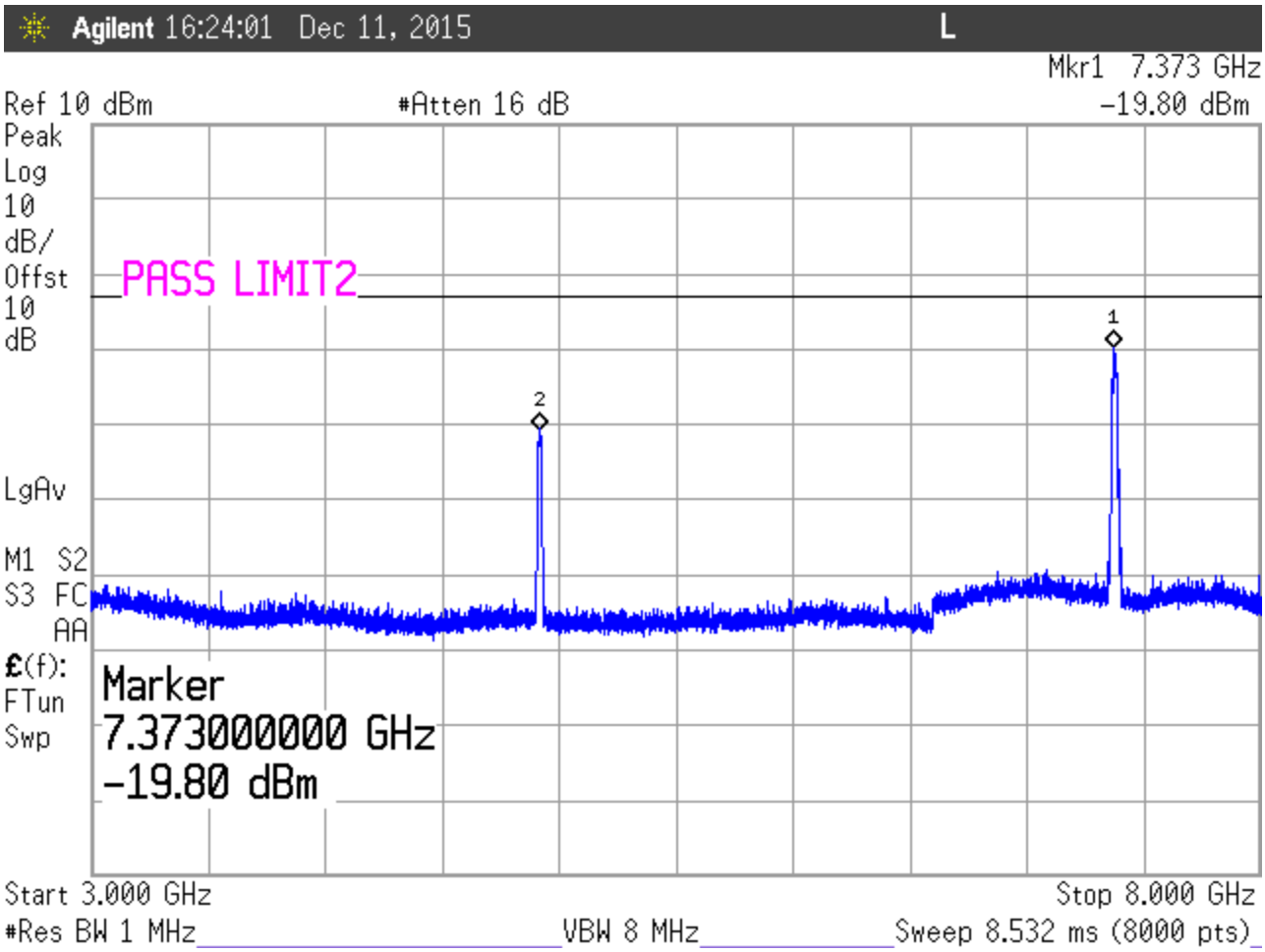

Figure 73: Spurious Emissions, 16QAM Modulation, TX @ 2458.5MHz, 3GHz-8GHz

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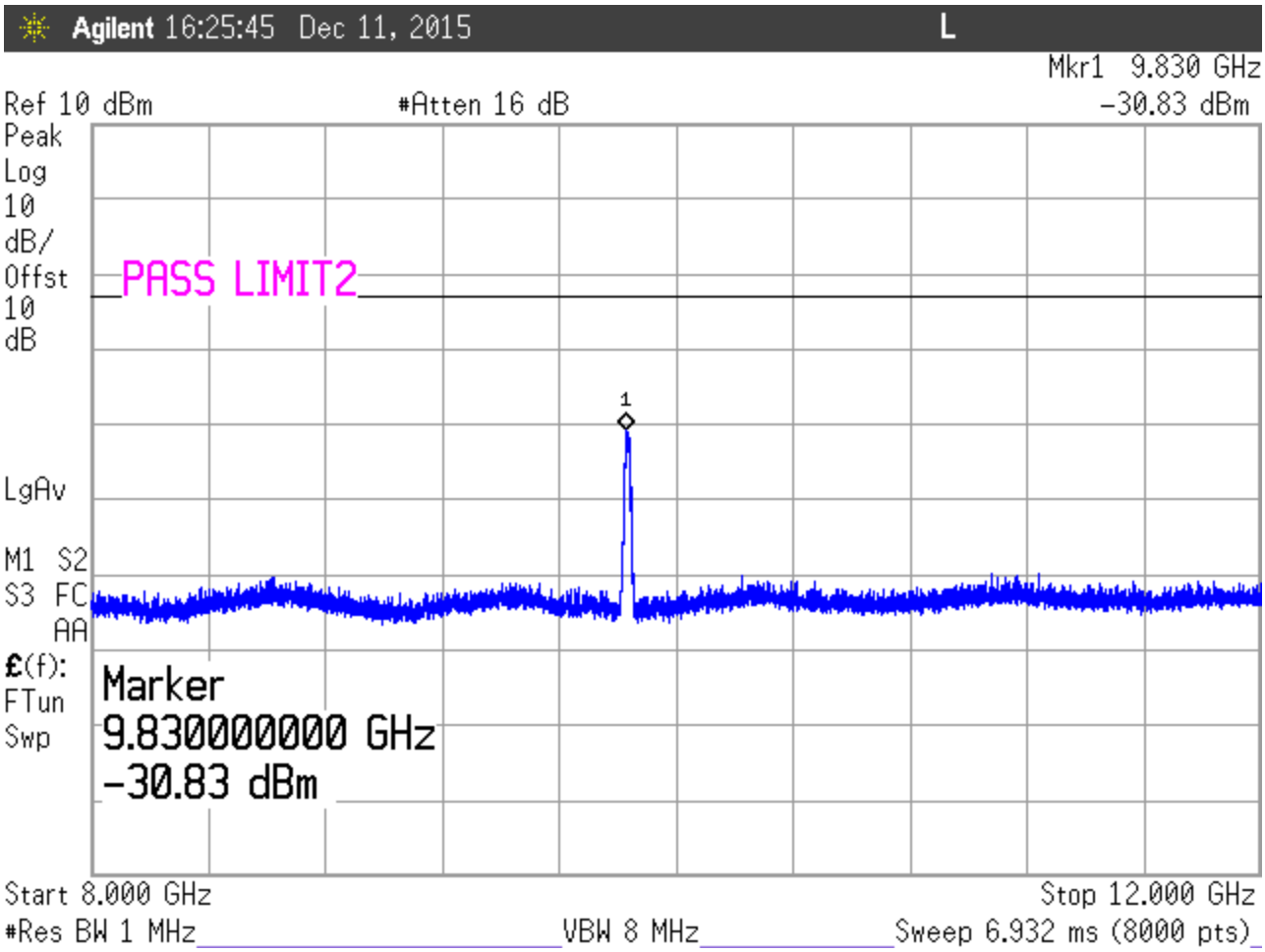

Figure 74: Spurious Emissions, 16QAM Modulation, TX @ 2458.5MHz, 8GHz-12GHz

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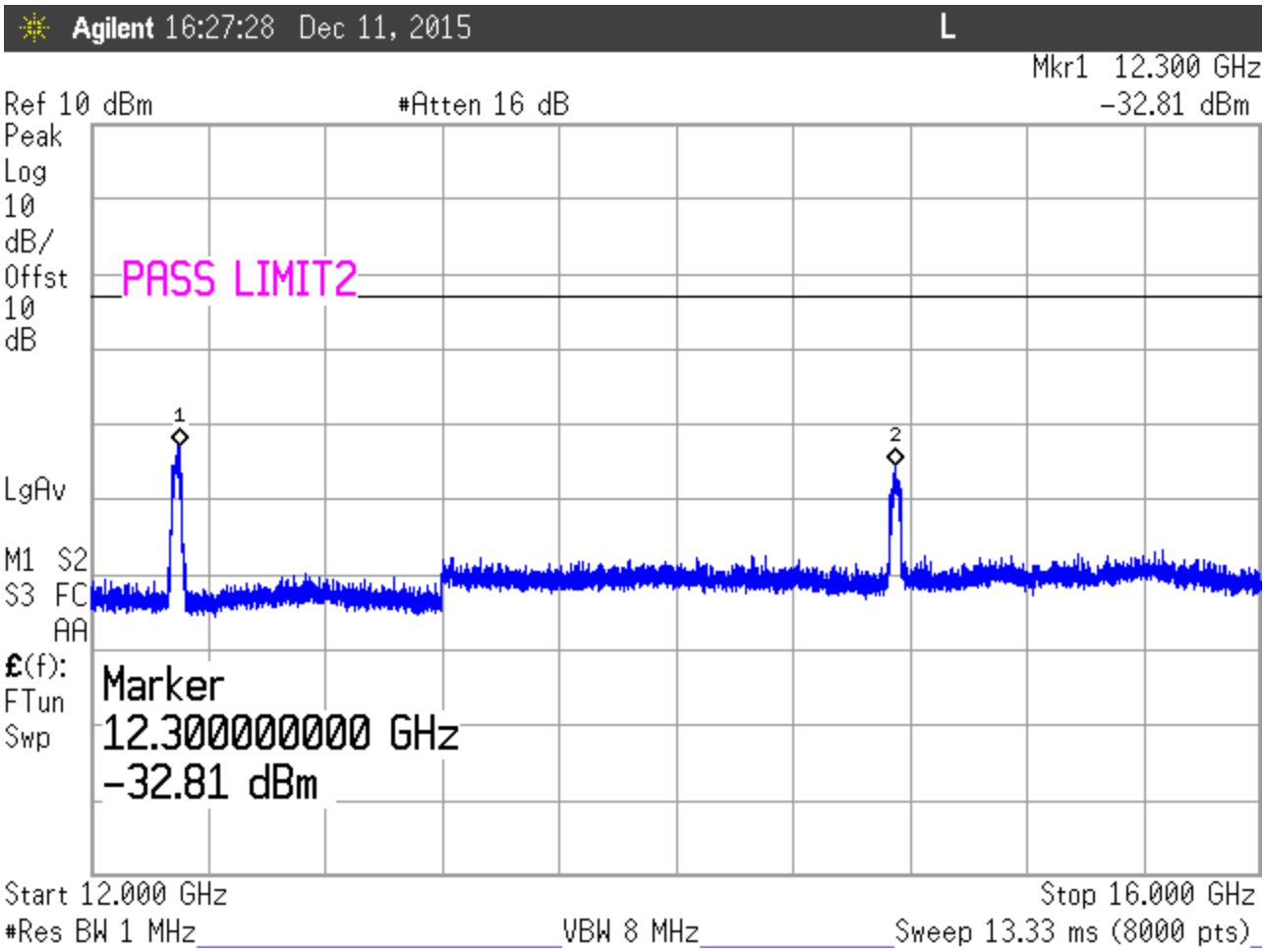

Figure 75: Spurious Emissions, 16QAM Modulation, TX @ 2458.5MHz, 12GHz-16GHz

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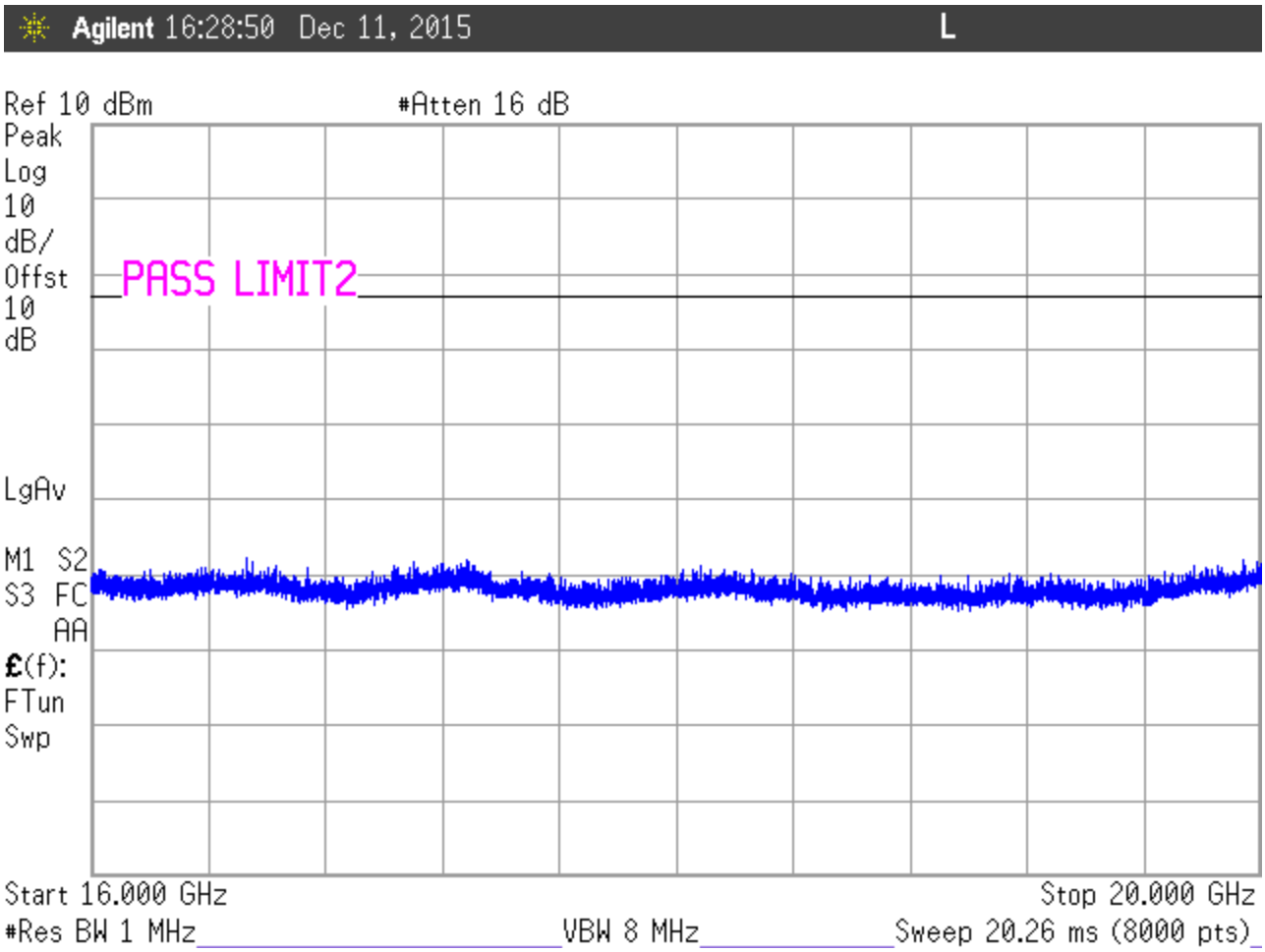

Figure 76: Spurious Emissions, 16QAM Modulation, TX @ 2458.5MHz, 16GHz-20GHz

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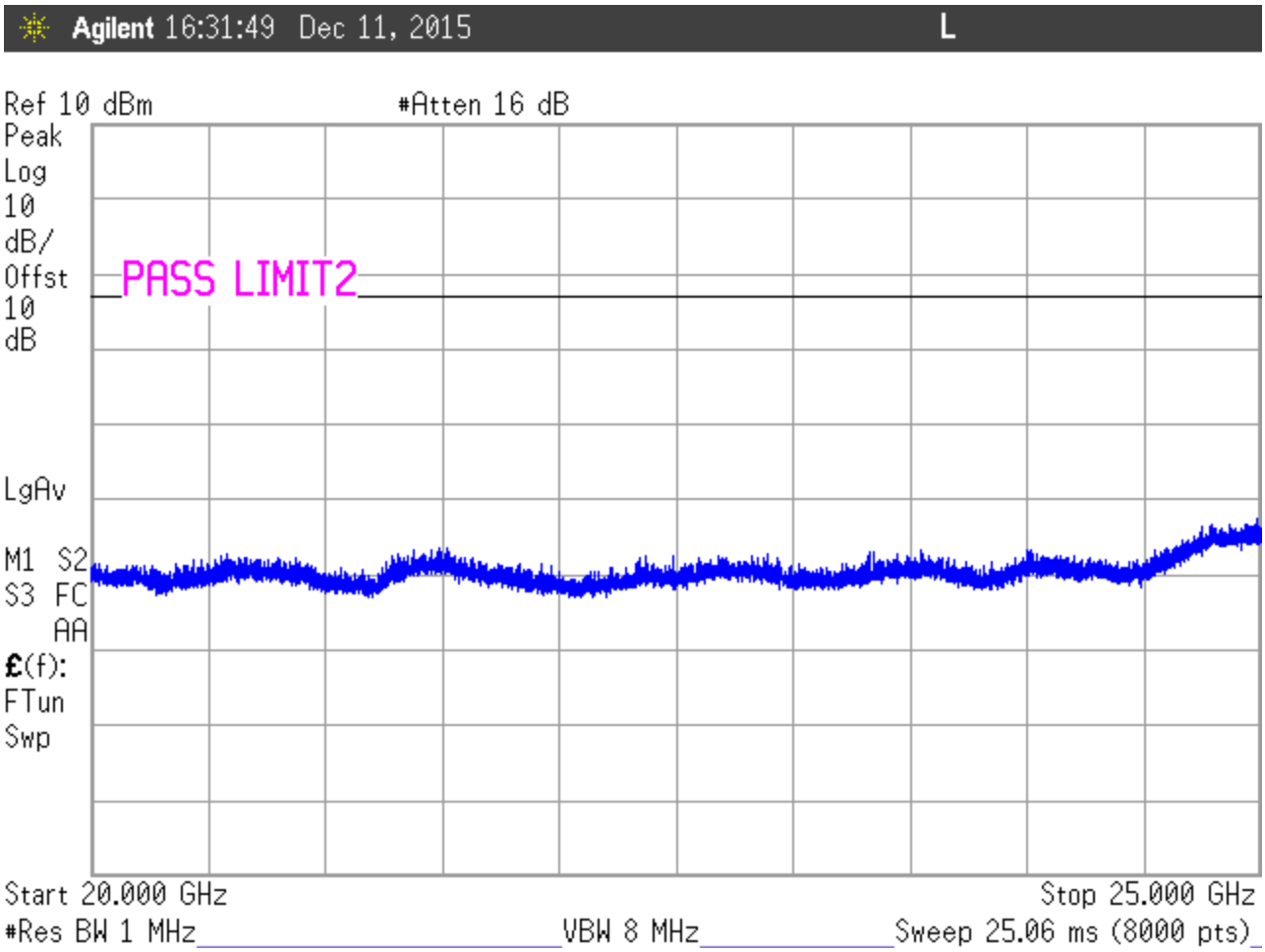

Figure 77: Spurious Emissions, 16QAM Modulation, TX @ 2458.5MHz, 20GHz-25GHz

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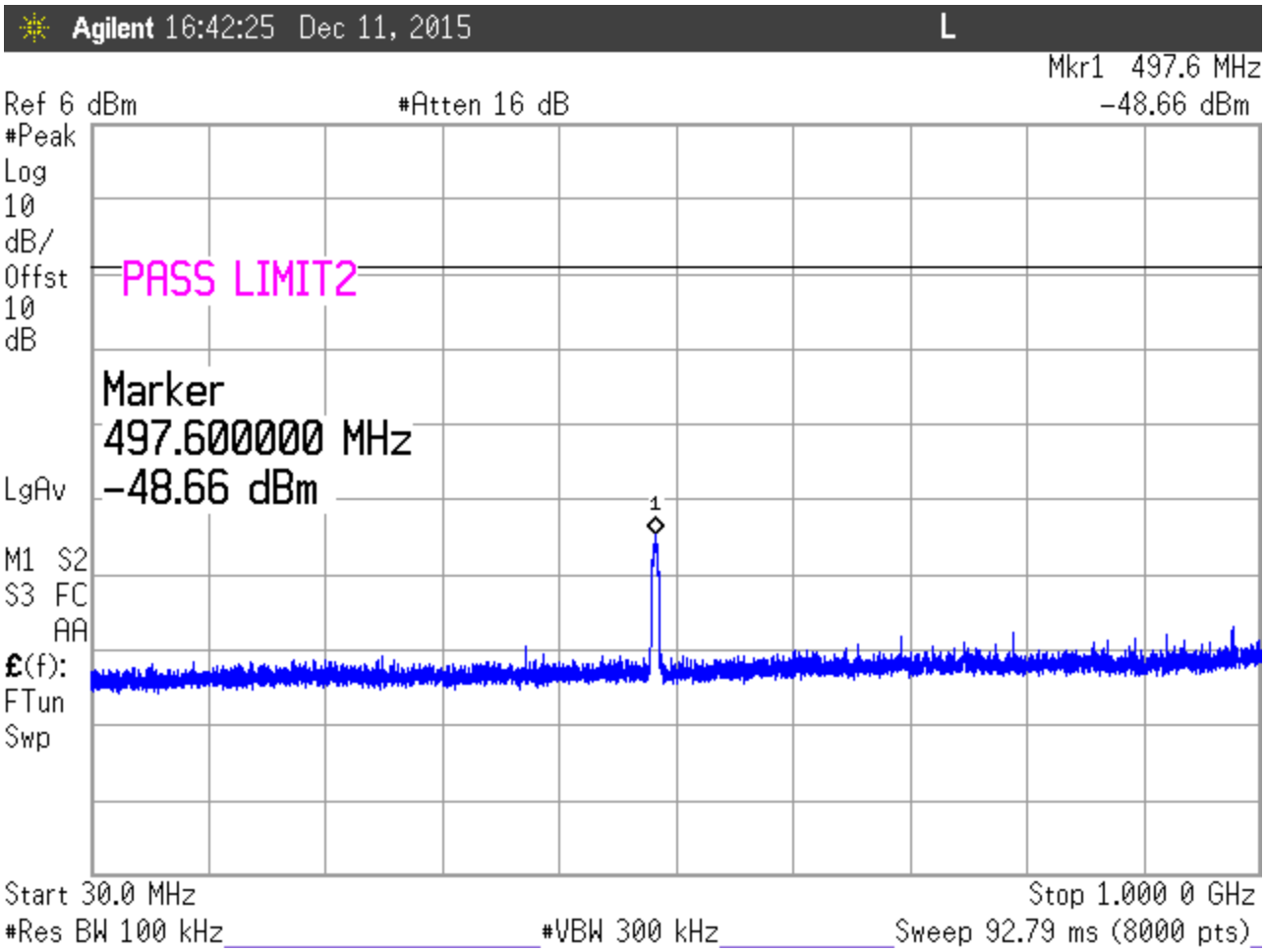

Figure 78: Spurious Emissions, 64QAM Modulation, TX @ 2458.5MHz, 30MHz-1000MHz

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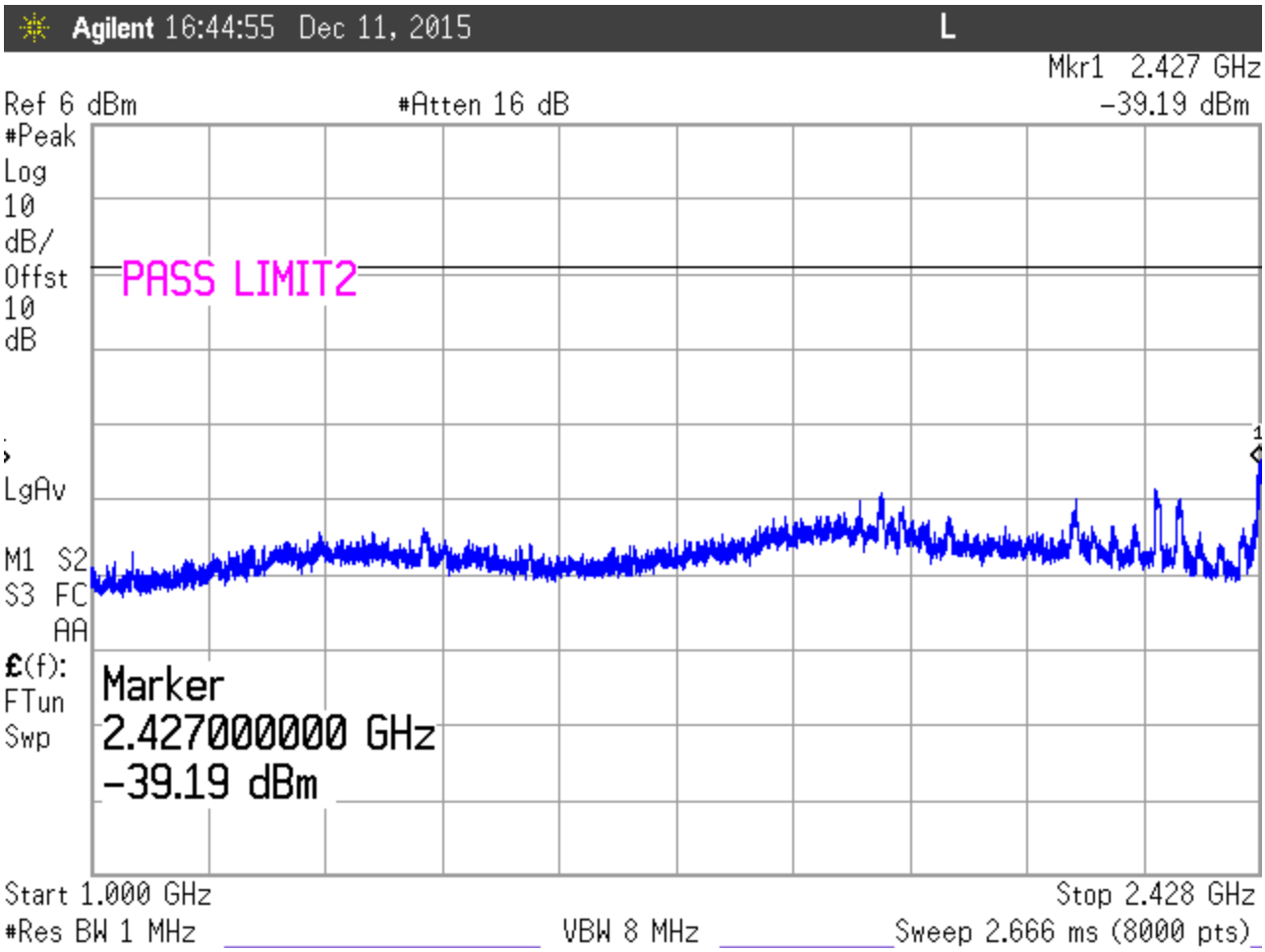

Figure 79: Spurious Emissions, 64QAM Modulation, TX @ 2458.5MHz, 1000MHz-2428MHz

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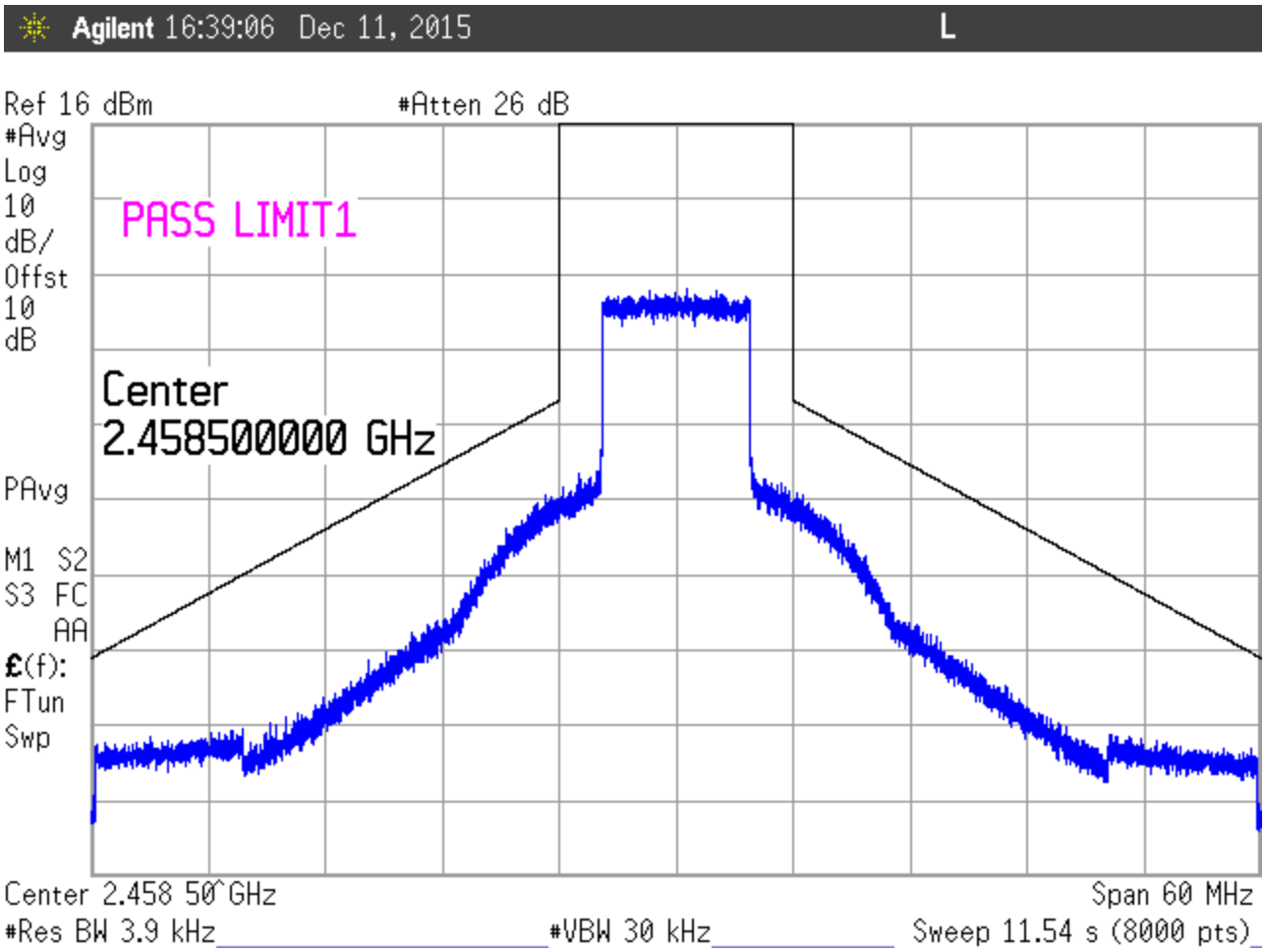

Figure 80: Spurious Emissions, 64QAM Modulation, TX @ 2458.5MHz, Emission Mask

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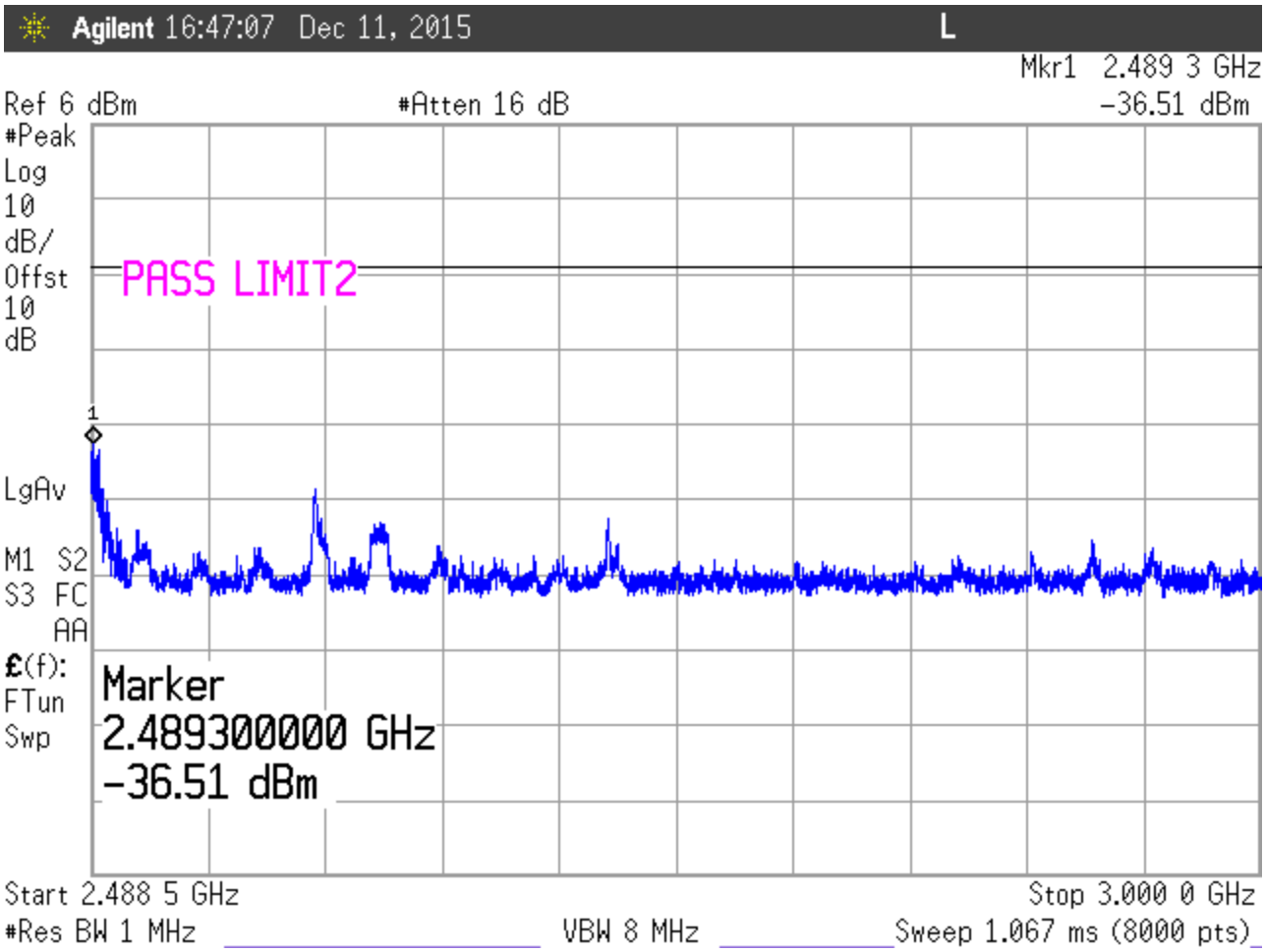

Figure 81: Spurious Emissions, 64QAM Modulation, TX @ 2458.5MHz, 2488MHz-3GHz

 © 2016 Washington Laboratories, Ltd.

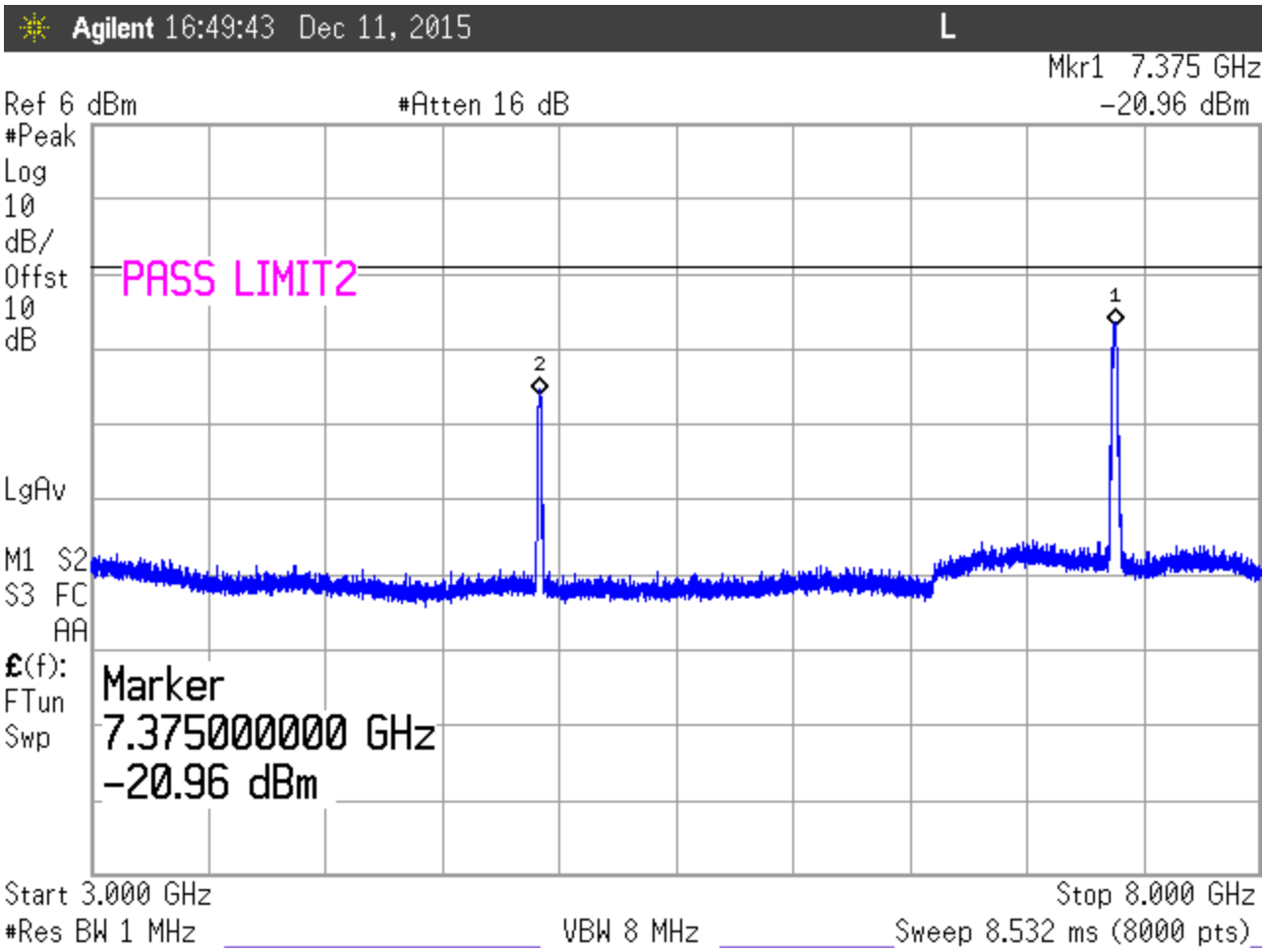

Figure 82: Spurious Emissions, 64QAM Modulation, TX @ 2458.5MHz, 3GHz-8GHz

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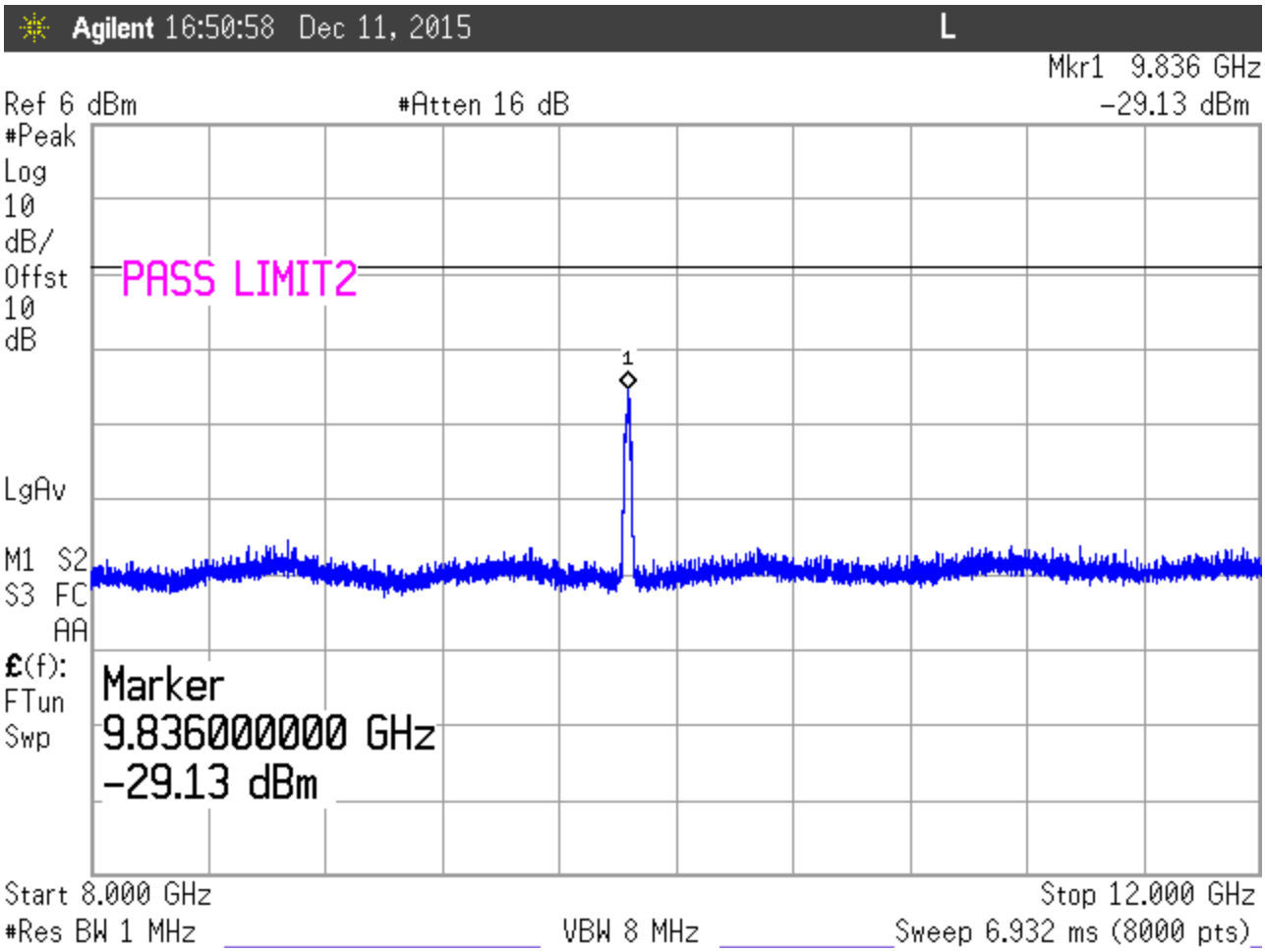

Figure 83: Spurious Emissions, 64QAM Modulation, TX @ 2458.5MHz, 8GHz-12GHz

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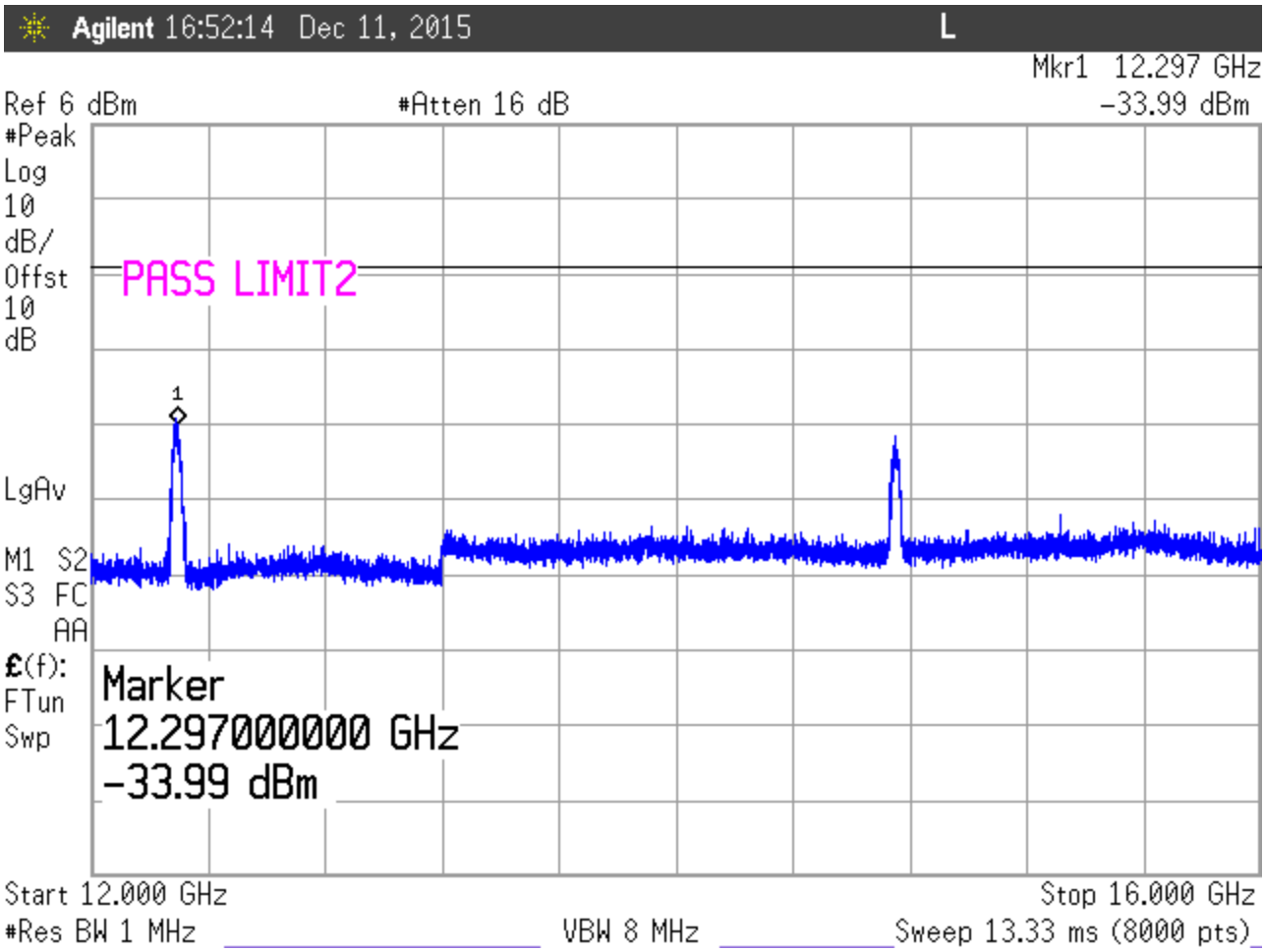

Figure 84: Spurious Emissions, 64QAM Modulation, TX @ 2458.5MHz, 12GHz-16GHz

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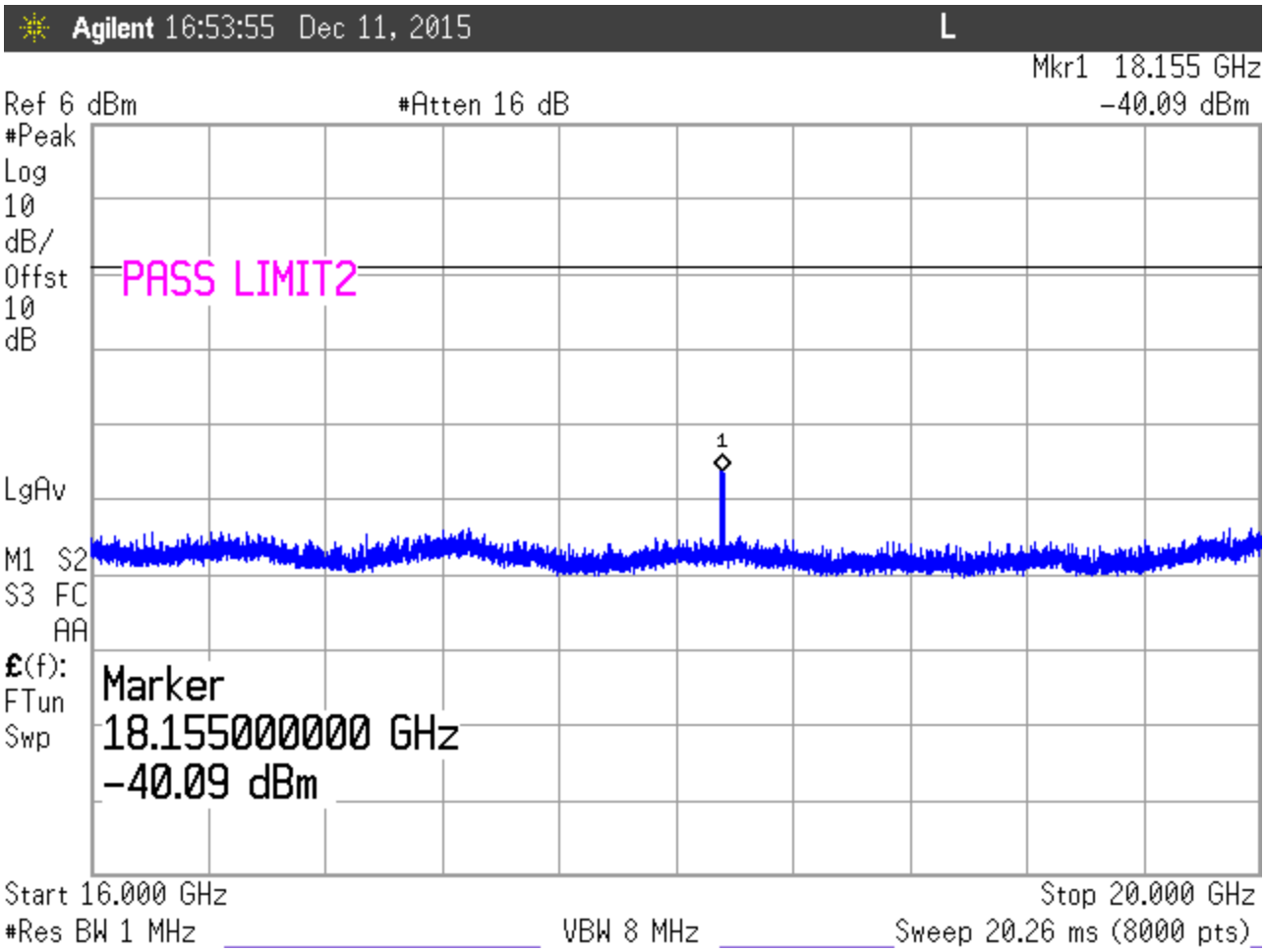

Figure 85: Spurious Emissions, 64QAM Modulation, TX @ 2458.5MHz, 16GHz-20GHz

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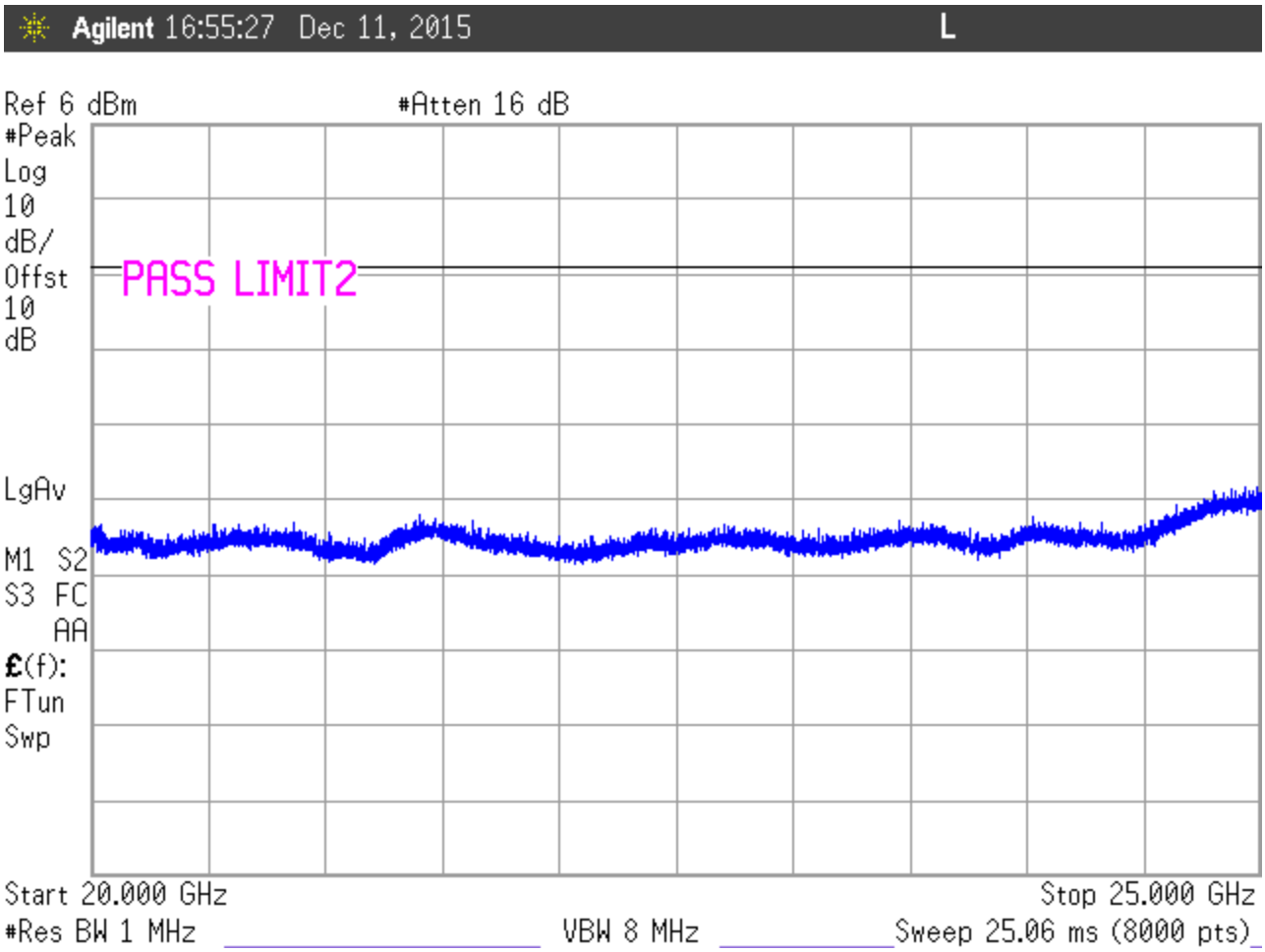

Figure 86: Spurious Emissions, 64QAM Modulation, TX @ 2458.5MHz, 20GHz-25GHz

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4.4 Radiated Spurious Emissions (EIRP): (FCC Part §2.1053)

The EUT was placed on motorized turntable for radiated testing on a 3-meter open field test site. The emissions from the EUT were measured continuously at every azimuth by rotating the turntable. Receiving antennas were mounted on an antenna mast to determine the height of maximum emissions. The height of the antenna was varied between 1 and 4 meters. The peripherals were placed on the table in accordance with ANSI C63.4-2014. Cables were varied in position to produce maximum emissions. Both the horizontal and vertical field components were measured.

The Effective Isotropic Radiated Power (EIRP) levels were measured and were compared with the limit of –13dBm per FCC Part 74. The limit of -13dB is derived from the formula of 43+10 log (P) dB per §74.637(a)(3).

Emissions were measured for a Low Channel 2033MHz, a middle channel 2067.5MHz and a high channel 2458.5MHz representing channels across the operating band and falling within the specific frequency range of Part 74F. Emissions were scanned up to the 10th harmonic of the fundamental. Worst case measurements are reported. The signal substitution method was used to obtain EIRP levels.

4.4.1 Test Procedure

The EUT was placed on motorized turntable for radiated testing on a 3-meter open field test site. The emissions from the EUT were measured continuously at every azimuth by rotating the turntable. Receiving antennas were mounted on an antenna mast to determine the height of maximum emissions. The height of the antenna was varied between 1 and 4 meters. The peripherals were placed on the table in accordance with ANSI C63.4-2014. Cables were varied in position to produce maximum emissions. Both the horizontal and vertical field components were measured.

Where emissions were detected, the EIRP levels were determined using the method of signal substitution. The measurement bandwidth used was set to 4 kHz. The actual EIRP level was calculated as follows.

EIRP (dBm) = Signal generator substitution level (dBm) + Antenna Gain (dBi)

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4.4.2 Test Results

Table 13: Radiated Emission Test Data

Frequency (MHz)	Polarity (H/V)	Azimuth (Degree)	Ant. Height (m)	SA Level (dBuV)	Corr Factors (dB)	Corr. Level (dBuV/m)	EIRP Calc (dBm)	Limit (dBm)	Margin (dB)	Peak or Average	Comments
38.18	V	90.00	1.00	32.91	-8.7	24.2	-71.0	-13.0	-58.0	Peak	
43.08	V	0.0	1.00	33.5	-12.3	21.2	-74.1	-13.0	-61.1	Peak	
47.66	V	180.0	1.10	34.2	-15.1	19.2	-76.1	-13.0	-63.1	Peak	
73.25	V	0.00	1.20	31.20	-15.5	15.7	-79.5	-13.0	-66.5	Peak	
112.95	V	165.00	1.20	27.77	-9.9	17.9	-77.4	-13.0	-64.4	Peak	
133.50	V	10.00	1.20	32.17	-9.4	22.8	-72.5	-13.0	-59.5	Peak	
255.56	V	270.00	2.73	37.91	-11.4	26.5	-68.7	-13.0	-55.7	Peak	
38.18	H	90.0	3.9	29.1	-8.7	20.4	-74.8	-13.0	-61.8	Peak	
47.66	H	270.0	3.9	34.0	-15.1	19.0	-76.3	-13.0	-63.3	Peak	
48.48	H	90.0	3.9	33.6	-15.4	18.2	-77.1	-13.0	-64.1	Peak	
73.25	H	0.0	3.8	33.7	-15.5	18.3	-77.0	-13.0	-64.0	Peak	
112.95	H	10.0	3.8	32.3	-9.9	22.4	-72.9	-13.0	-59.9	Peak	
133.50	H	190.0	3.5	30.1	-9.4	20.7	-74.6	-13.0	-61.6	Peak	
255.56	H	170.0	2.3	30.3	-11.4	18.9	-76.3	-13.0	-63.3	Peak	

Table 14: Radiated Emission Test Data, TX @ 2.033GHz

Frequency (MHz)	Polarity	Azimuth	Ant. Height (m)	Spurious Level (dBuV)	Sub. Sig. Gen. Level (dBm)	Sub. Power Level (dBm)	Sub. Ant. Factor (dB)	Sub. Ant. Gain (dB)	EIRP Level (dBm)	Limit (dBm)	Margin (dB)
2033.50											
4067.00	V	45.0	2.2	63.50	-39.2	-41.8	36.8	5.5	-36.2	-13	-23.2
6100.50	V	45.0	2.2	59.67	-43.2	-46.7	39.1	6.8	-39.9	-13	-26.9
8134.00	V	45.0	2.2	52.00	-48.8	-54.0	42.5	5.8	-48.1	-13	-35.1
10167.50	V	45.0	2.2	47.50	-44.5	-51.0	45.8	4.6	-46.4	-13	-33.4
2033.50											
4067.00	H	0.0	2.6	62	-41.3	-43.9	36.8	5.5	-38.3	-13	-25.3
6100.50	H	0.0	2.6	58.2	-43.5	-47.0	39.1	6.8	-40.2	-13	-27.2
8134.00	H	0.0	2.6	50.5	-46.3	-51.5	42.5	5.8	-45.6	-13	-32.6
10167.50	H	0.0	2.6	44.7	-47.8	-54.3	45.8	4.6	-49.7	-13	-36.7

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Table 15: Radiated Emission Test Data, TX @ 2.0675GHz

Frequency (MHz)	Polarity	Azimuth	Ant. Height (m)	Spurious Level (dBuV)	Sub. Sig. Gen. Level (dBm)	Sub. Power Level (dBm)	Sub. Ant. Factor (dB)	Sub. Ant. Gain (dB)	EIRP Level (dBm)	Limit (dBm)	Margin (dB)
4135.00	V	45.0	2.2	64.88	-38.2	-40.8	36.6	5.7	-35.1	-13	-22.1
6202.50	V	45.0	2.2	59.91	-43.2	-46.6	39.5	6.3	-40.3	-13	-27.3
8270.00	V	45.0	2.2	51.81	-49.5	-54.6	42.4	5.8	-48.7	-13	-35.7
10337.50	V	45.0	2.2	47.50	-44.5	-50.9	44.5	5.7	-45.2	-13	-32.2
2067.50											
4135.00	H	0.0	2.6	60.3	-42.1	-44.7	36.6	5.7	-39.0	-13	-26.0
6202.50	H	0.0	2.6	55.2	-45.4	-48.8	39.5	6.3	-42.5	-13	-29.5
8270.00	H	0.0	2.6	45.6	-51.2	-56.3	42.4	5.8	-50.4	-13	-37.4
10337.50	H	0.0	2.6	44.7	-47.8	-54.2	44.5	5.7	-48.5	-13	-35.5

Table 16: Radiated Emission Test Data, TX @ 2.1015GHz

Frequency (MHz)	Polarity	Azimuth	Ant. Height (m)	Spurious Level (dBuV)	Sub. Sig. Gen. Level (dBm)	Sub. Power Level (dBm)	Sub. Ant. Factor (dB)	Sub. Ant. Gain (dB)	EIRP Level (dBm)	Limit (dBm)	Margin (dB)
2101.50											
4203.00	V	45.0	2.1	47.3	-48.5	-51.1	36.5	6.3	-44.8	-13	-31.8
6304.50	V	45.0	2.1	49.8	-44.6	-48.3	39.3	7.0	-41.3	-13	-28.3
8406.00	V	45.0	2.1	53.2	-36.4	-41.8	43.6	5.1	-36.7	-13	-23.7
10507.50	V	45.0	2.1	48.4	-38.2	-44.9	45.3	5.4	-39.5	-13	-26.5
2101.50											
4203.00	H	0.0	2.6	45.3	-49.5	-52.1	36.5	6.3	-45.8	-13	-32.8
6304.50	H	0.0	2.6	47.2	-41.3	-45.0	39.3	7.0	-38.0	-13	-25.0
8406.00	H	0.0	2.6	50.8	-31.6	-37.0	43.7	5.1	-31.9	-13	-18.9
10507.50	H	0.0	2.6	44.2	-41.4	-48.1	45.3	5.4	-42.7	-13	-29.7

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Table 17: Radiated Emission Test Data, TX @ 2.4585GHz

Frequency (MHz)	Polarity	Azimuth	Ant. Height (m)	Spurious Level (dBuV)	Sub. Sig. Gen. Level (dBm)	Sub. Power Level (dBm)	Sub. Ant. Factor (dB)	Sub. Ant. Gain (dB)	EIRP Level (dBm)	Limit (dBm)	Margin (dB)
2458.50											
4917.00	V	45.0	2.2	62.83	-35	-37.8	37.2	6.9	-30.9	-13	-17.9
7375.50	V	45.0	2.2	56.7	-35.4	-40.1	41.0	6.6	-33.5	-13	-20.5
9834.00	V	45.0	2.2	54.67	-38.15	-44.5	45.0	5.1	-39.4	-13	-26.4
12292.50	V	45.0	2.2	61.83	-27.15	-34.8	47.5	4.6	-30.2	-13	-17.2
2458.50											
4917.00	H	0.0	2.6	60.33	-36.5	-39.3	37.2	6.9	-32.4	-13	-19.4
7375.50	H	0.0	2.6	51.8	-42.5	-47.2	41.0	6.6	-40.6	-13	-27.6
9834.00	H	0.0	2.6	50.67	-42.5	-48.9	45.0	5.1	-43.7	-13	-30.7
12292.50	H	0.0	2.6	56.33	-28.4	-36.1	47.5	4.6	-31.5	-13	-18.5

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4.5 Frequency Stability: (FCC Part §2.1055 & FCC Part §74.661)

Frequency as a function of temperature and voltage variation shall be maintained within the FCC-prescribed tolerances.

The temperature stability was measured with the unit in an environmental chamber used to vary the temperature of the sample. The sample was held at each temperature step to allow the temperature of the sample to stabilize.

The EUT is powered by DC voltage supplied externally. The manufacturer's power requirements for the EUT include the following:

Low DC Voltage of 10 VDC (manufacturer's specification)

High DC Voltage of 13.8VDC (manufacturer's specifications)

The frequency stability of the transmitter was examined at the voltage extremes and for the temperature range of -30°C to +50°C. The carrier frequency was measured while the EUT was in the temperature chamber. The reference frequency of the EUT was measured at the ambient room temperature with the frequency counter.

Two limits were evaluated which are dependent on the frequency band of operation. In the frequency range 2.025-2.11GHz a frequency tolerance of 0.005% must be maintained. In the frequency range 2.45-2.4835GHz a frequency tolerance of 0.001% must be maintained.

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4.5.1 Test Procedure

The temperature stability was measured with the unit in an environmental chamber used to vary the temperature of the sample. The sample was held at each temperature step to allow the temperature of the sample to stabilize.

The frequency stability of the transmitter was examined at the voltage extremes and for the temperature range of -30°C to +50°C. The carrier frequency was measured while the EUT was in the temperature chamber. The reference frequency of the EUT was measured at the ambient room temperature with the frequency counter.

4.5.2 Test Results

The EUT complies with the temperature stability requirements of FCC Part §2.1055 & Part §74.661. Test results are given in Tables 12-15.

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Table 18: Frequency Stability Test Data TX @ 2101.5MHz

Temperature (Centigrade)	Frequency (MHz)	Difference (Hz)	Deviation (%)
Ambient	2101.499791	0.0	0
-30	2101.500711	920.0	0.000044
-20	2101.500660	869.0	0.000041
-10	2101.500555	764.0	0.000036
0	2101.499917	126.0	0.000006
10	2101.499916	125.0	0.000006
20	2101.499851	60.0	0.000003
30	2101.499624	-167.0	0.000008
40	2101.499441	-350.0	0.000017
50	2101.499840	49.0	0.000002

Table 19: Frequency Stability Test Data TX @ 2458.5MHz

Temperature (Centigrade)	Frequency (MHz)	Difference (Hz)	Deviation (%)
Ambient	2458.499435	0.0	0
-30	2458.500665	1230.0	0.000050
-20	2458.500695	1260.0	0.000051
-10	2458.500554	1119.0	0.000046
0	2458.499857	422.0	0.000017
10	2458.499777	342.0	0.000014
20	2458.499672	237.0	0.000010
30	2458.499364	-71.0	0.000003
40	2458.499242	-193.0	0.000008
50	2458.499844	409.0	0.000017

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Table 20: Frequency Stability Test Data (Voltage Variation) TX @2101.5MHz

Voltage (Volts)	Frequency (MHz)	Difference (Hz)	Deviation (%)	Voltage (Volts)
At rated	2101.499791	0	0.0	12VDC
At 85%	2101.499651	140	0.000007	10.9VDC
At 115%	2101.500562	-771	0.000037	13.8VDC

Table 21: Frequency Stability Test Data (Voltage Variation) TX @2458.5MHz

Voltage (Volts)	Frequency (MHz)	Difference (Hz)	Deviation (%)	Voltage (Volts)
At rated	2458.499435	0	0.0	12VDC
At 85%	2458.499132	303	0.000012	10.9VDC
At 115%	2458.500265	-830	0.000034	13.8VDC

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