

Company: DOVEN LLC

Test of: DV11, DV21, DV31

To: FCC Part 15 Subpart F 15.519 - Hand Held UWB
Devices

Report No.: JANU01-U2C Rev D

TEST REPORT



COMBINED TEST REPORT

FROM



Test of: DOVEN LLC – DV11, DV21, DV31

To: FCC CFR 47 Part 15 Subpart F 15.519 – Hand Held UWB Systems

Test Report Serial No.: JANU01-U2C Rev D

This report supersedes: NONE

Applicant: DOVEN LLC
2408 Timberloch PL Ste A6
The Woodlands TX 77380
USA

Product Function: Distance Measurement

Issue Date: 19th June 2018

This Test Report is Issued Under the Authority of:

MiCOM Labs, Inc.
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MiCOM Labs is an ISO 17025 Accredited Testing Laboratory



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1. ACCREDITATION, LISTINGS & RECOGNITION

1.1. Test Accreditation

MiCOM Labs, Inc. an accredited laboratory complies with the international standard EN ISO/IEC 17025. The company is accredited by the American Association for Laboratory Accreditation (A2LA) www.a2la.org test laboratory number 2381.01. MiCOM Labs test schedule is available at the following URL; <http://www.a2la.org/scopepdf/2381-01.pdf>



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1.2. Recognition

MiCOM Labs, Inc has widely recognized Electrical testing capabilities. Our international recognition includes Conformity Assessment Body designation by APEC MRA** countries. Our test reports are widely accepted for global type approvals.

Country	Recognition Body	Status	Phase	Identification No.
model	Federal Communications Commission (FCC)	TCB	-	US0159 Listing #: 102167
Canada	Industry Canada (IC)	FCB	APEC MRA 2	US0159 Listing #: 4143A-2 4143A-3
Japan	MIC (Ministry of Internal Affairs and Communication)	CAB	APEC MRA 2	RCB 210
	VCCI	--	--	A-0012
Europe	European Commission	NB	EU MRA	NB 2280
Australia	Australian Communications and Media Authority (ACMA)	CAB	APEC MRA 1	US0159
Hong Kong	Office of the Telecommunication Authority (OFTA)	CAB	APEC MRA 1	
Korea	Ministry of Information and Communication Radio Research Laboratory (RRL)	CAB	APEC MRA 1	
Singapore	Infocomm Development Authority (IDA)	CAB	APEC MRA 1	
Taiwan	National Communications Commission (NCC) Bureau of Standards, Metrology and Inspection (BSMI)	CAB	APEC MRA 1	
Vietnam	Ministry of Communication (MIC)	CAB	APEC MRA 1	

**APEC MRA – Asia Pacific Economic Community Mutual Recognition Agreement.

Is a recognition agreement under which test lab is accredited to regulatory standards of the APEC member countries

Phase I - recognition for product testing

Phase II – recognition for both product testing and certification

N/A – Not Applicable

**EU MRA – European Union Mutual Recognition Agreement.

Is a recognition agreement under which test lab is accredited to regulatory standards of the EU member countries

**NB – Notified Body

1.3. Product Certification

MiCOM Labs, Inc. is an accredited Product Certification Body per the international standard ISO/IEC 17065. The company is accredited by the American Association for Laboratory Accreditation (A2LA) www.a2la.org test laboratory number 2381.02. MiCOM Labs test schedule is available at the following URL; <http://www.a2la.org/scopepdf/2381-02.pdf>



United States of America – Telecommunication Certification Body (TCB)

TCB Identifier – US0159

Industry Canada – Certification Body

CAB Identifier – US0159

Europe – Notified Body

Notified Body Identifier - 2280

Japan – Recognized Certification Body (RCB)

RCB Identifier – 210

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2. DOCUMENT HISTORY

Document History		
Revision	Date	Comments
Draft	20 th February 2018	Initial draft for client review
Draft #2	22 nd February 2018	
Rev A	27 th February 2018	Initial Release
Rev B	28 th March 2018	Removed references to 15.511 and 15.517 See reports JANU01-U2A and JANU01-U2C for other rule parts.
Rev C	3 rd May 2018	Updated KDB References
Rev D	19th June 2018	Included additional testing sections 9.3 and 9.5 per FCC request

In the above table the latest report revision will replace all earlier versions.

3. TEST RESULT CERTIFICATE

Manufacturer: DOVEN LLC
2408 Timberloch PL Ste A6
The Woodlands TX 77380
USA

Tested By: MiCOM Labs, Inc.
575 Boulder Court
Pleasanton California 94566
USA

Model(s): DV11AC, DV21AC, DV21DC, DV31DC

Telephone: +1 925 462 0304
Fax: +1 925 462 0306

Equipment Type: Distance Measurement

S/N's: DV11-AC: 1C-11-A4-00-7B-2B-C7-9A
DV21- AC: 1C-11-A5-00-7B-2B-C7-91
DV21-DC: 1C-11-EB-00-7B-2B-C7-94
DV31-DC: 1C-11-A5-00-7B-2B-C7-9B

Test Date(s): 29th – 31st January 2018

Website: www.micomlabs.com

STANDARD(S)

FCC CFR 47 Part 15 Subpart F
15.519

TEST RESULTS

EQUIPMENT COMPLIES

MiCOM Labs, Inc. tested the equipment mentioned in accordance with the requirements set forth in the above standards. Test results indicate that the equipment tested is capable of demonstrating compliance with the requirements as documented within this report.

Notes:

1. This document reports conditions under which testing was conducted and the results of testing performed.
2. Details of test methods used have been recorded and kept on file by the laboratory.
3. Test results apply only to the item(s) tested.

Approved & Released for MiCOM Labs, Inc. by:

Graeme Grieve
Quality Manager MiCOM Labs, Inc.

Gordon Hurst
President & CEO MiCOM Labs, Inc.



TESTING CERT #2381.01

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4. REFERENCES AND MEASUREMENT UNCERTAINTY

4.1. Normative References

REF.	PUBLICATION	YEAR	TITLE
I	FCC 47 CFR Part F	2018	Radio Frequency Devices; Subpart F – Ultra Wide Band Devices
II	A2LA	August 2017	R105 - Requirement's When Making Reference to A2LA Accreditation Status
III	ANSI C63.10	2013	American National Standard for Testing Unlicensed Wireless Devices
IV	ANSI C63.4	2014	American National Standards for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz
V	ETSI TR 100 028	2001-12	Parts 1 and 2 Electromagnetic compatibility and Radio Spectrum Matters (ERM); Uncertainties in the measurement of mobile radio equipment characteristics
VI	M 3003	Edition 3 Nov.2012	Expression of Uncertainty and Confidence in Measurements
VII	FCC 47 CFR Part 2.1033	2016	FCC requirements and rules regarding photographs and test setup diagrams.
VIII	KDB 393764 D01 UWB FAQ v02	January 29, 2018	Ultra-Wideband (UWB) Devices frequently asked questions

4.2. Test and Uncertainty Procedure

Conducted and radiated emission measurements were conducted in accordance with American National Standards Institute ANSI C63.4, listed in the Normative References section of this report.

Measurement uncertainty figures are calculated in accordance with ETSI TR 100 028 Parts 1 and 2.

Measurement uncertainties stated are based on a standard uncertainty multiplied by a coverage factor $k = 2$, providing a level of confidence of approximately 95 % in accordance with UKAS document M 3003 listed in the Normative References section of this report.

5. PRODUCT DETAILS AND TEST CONFIGURATIONS

5.1. Technical Details

Details	Description
Purpose:	Test of the DOVEN DV11, DV21, DV31 to FCC CFR 47 Part 15 Subpart F 15.519
Applicant:	DOVEN LLC 2408 Timberloch PL Ste A6 The Woodlands TX 77380 USA
Manufacturer:	As applicant
Laboratory performing the tests:	MiCOM Labs, Inc. 575 Boulder Court Pleasanton California 94566 USA
Test report reference number:	JANU01-U2
Date EUT received:	29 th January 2018
Standard(s) applied:	FCC CFR 47 Part 15 Subpart F 15.519
Dates of test (from - to):	29 th - 31 st January 2018
No of Units Tested:	4
Product Family Name:	DOVEN
Model(s):	DV11-AC, DV21-AC, DV21-DC, DV31-DC
Location for use:	No fixed location Primarily hand held
Declared Frequency Range(s):	3100-10600 MHz
Type of Modulation:	BPM/BPSK
EUT Modes of Operation:	500 MHz Bandwidth
Declared Nominal Output Power (dBm):	-41 dBm
Transmit/Receive Operation:	Transceiver
Rated Input Voltage and Current:	DV11-AC & DV21-AC: 100 – 240 V _{AC} , 0.018 Amps (Max) DV21-DC & DV31-DC: 24 V _{DC} , 0.085 Amps
Operating Temperature Range:	-20 ~ +70°C
ITU Emission Designator:	500MX0D
Equipment Dimensions:	DV11-AC, DV21-AC, DV21-DC: 369.9x340.1x60.4 mm, DV31-DC: 110.1 x 180.5 x75.2
Weight:	DV11-AC: 2.12 Kg DV21-AC: 2.06 Kg DV21-DC: 1.97 Kg DV31-DC: 0.95 Kg
Hardware Rev:	1.0.0
Software Rev:	1.0.0

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5.2. Scope Of Test Program

The scope of the test program was to test the Janus Automation DOVEN Series configurations in the frequency ranges 3100 - 10600 MHz for compliance against the following specification:

FCC CFR 47 Part 15 Subpart F – 15.519

Compliance Measurement Procedures for Unlicensed National Information Infrastructure devices operating in the 3100 - 10600 MHz bands.

Model Differences

DV11-AC - 120 VAC Unit with integrated directional antenna
DV21-AC - 120 VAC Unit with integrated wide-angle antenna
DV31-DC - 24 VDC Unit with external omnidirectional antenna
DV21-DC - 24 VDC Unit with integrated wide-angle antenna

DV11-AC, DV21-AC, DV21-DC

Front View



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DV11-AC, DV21-AC, DV21-DC

Rear View



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DV31-DC
Front View





5.3. Equipment Model(s) and Serial Number(s)

Type (EUT/Support)	Equipment Description (Including Brand Name)	Mfr.	Model No.	Serial No.
EUT	120 VAC Unit with integrated directional antenna	DOVEN LLC	DV11AC	1C-11-A4-00-7B-2B-C7-9A
EUT	120 VAC Unit with integrated wide-angle antenna	DOVEN LLC	DV21-AC	1C-11-A5-00-7B-2B-C7-91
EUT	24 VDC Unit with integrated wide-angle antenna	DOVEN LLC	DV21-DC	1C-11-A5-00-7B-2B-C7-9B
EUT	24 VDC Unit with external omnidirectional antenna	DOVEN LLC	DV31-DC	1C-11-EB-00-7B-2B-C7-94

5.4. Antenna Details

Type	Manufacturer	Model	Family	Gain (dBi)	BF Gain	Dir BW	X-Pol	Frequency Band (MHz)
Integral	DOVEN LLC	DV11-AC	Directional	13.0	--	--	No	3250 - 4250
Integral	DOVEN LLC	DV21-AC	Wide	9.28	--	--	No	3250 - 4250
Integral	DOVEN LLC	DV21-DC	Wide	9.28	--	--	No	3250 - 4250
External*	DOVEN LLC	DV31-DC	OMNI	6.0	--	--	No	3250 - 4250

BF Gain - Beamforming Gain
Dir BW - Directional BeamWidth
X-Pol - Cross Polarization

*Note: External antenna sold with model DV31-DC is the only antenna permitted to be used with this device. Antenna must also be professionally installed.

5.5. Cabling and I/O Ports

None

5.6. Test Configurations

Results for the following configurations are provided in this report:

Channel Bandwidth(s)	Transmission Rate	Channel Frequency (MHz)		
		Low	Mid	High
500MHz	6.8 Mbit/s	Single Frequency 3492.00		

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5.7. Equipment Modifications

The following modifications were required to bring the equipment into compliance:

1. NONE

5.8. Deviations from the Test Standard

The following deviations from the test standard were required in order to complete the test program:

1. NONE



6. TEST SUMMARY

List of Measurements

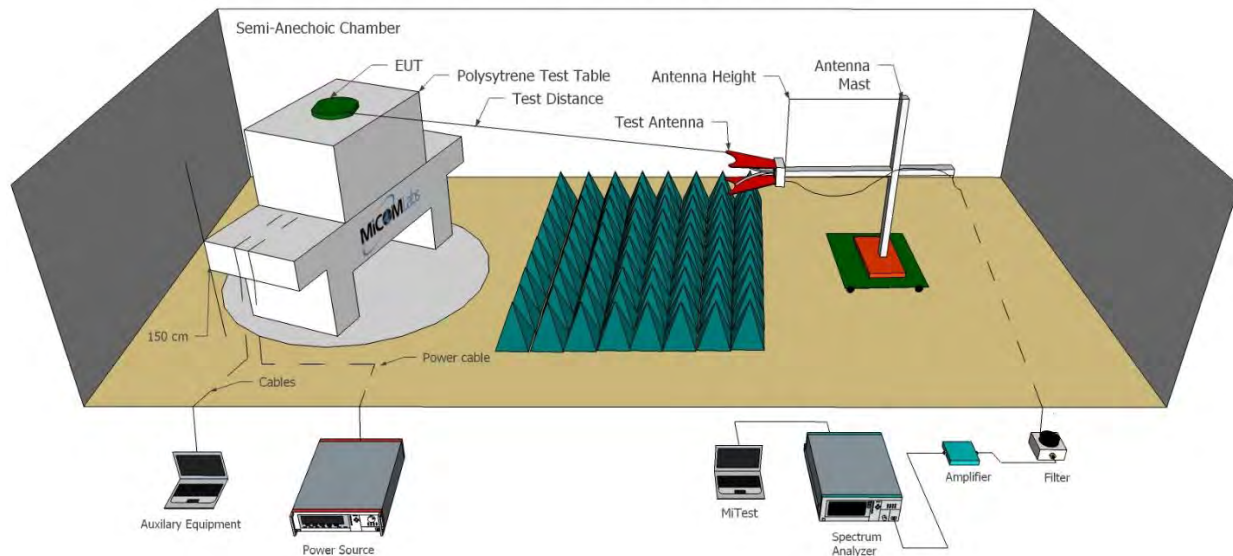
Test Header	Result	Data Link
Radiated Test Methodology	Complies	-
UWB Bandwidth	Complies	View Data
Radiated Power	Complies	View Data
Peak Power Density	Complies	View Data
Spurious Radiated Emissions 30 MHz - 1000 MHz	Complies	View Data
Spurious Radiated Emissions 1000 MHz - 18000 MHz	Complies	View Data
Spurious Radiated Emissions in GPS Bands	Complies	View Data
Shutdown Timing Requirements	Complies	View Data
Comments: None		

7. TEST EQUIPMENT CONFIGURATION(S)

7.1. Radiated Emissions - 3m Chamber

The following tests were performed using the radiated test set-up shown in the diagram below. Radiated emissions above 1GHz.

Radiated Emissions Above 1GHz Test Setup



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A full system calibration was performed on the test station and any resulting system losses (or gains) were taken into account in the production of all final measurement data.

Asset#	Description	Manufacturer	Model#	Serial#	Calibration Due Date
170	Video System Controller for Semi Anechoic Chamber	Panasonic	WV-CU101	04R08507	Not Required
287	Rohde & Schwarz 40 GHz Receiver	Rhode & Schwarz	ESIB40	100201	2 May 2019
298	3M Radiated Emissions Chamber Maintenance Check	MiCOM	3M Chamber	298	27 Jul 2018
338	Sunol 30 to 3000 MHz Antenna	Sunol	JB3	A052907	5 Oct 2018
397	Amp 10 - 2500MHz	MiCOM Labs	Amp 10 - 2500 MHz	NA	12 Oct 2018
399	ETS 1-18 GHz Horn Antenna	ETS	3117	00154575	12 Oct 2018
406	Amplifier for Radiated Emissions	MiCOM Labs	40dB 1 to 18GHz Amp	0406	12 Oct 2018
410	Desktop Computer	Dell	Inspiron 620	WS38	Not Required
411	Mast/Turntable Controller	Sunol Sciences	SC98V	060199-1D	Not Required
412	USB to GPIB Interface	National Instruments	GPIB-USB HS	11B8DC2	Not Required
413	Mast Controller	Sunol Science	TWR95-4	030801-3	Not Required
415	Turntable Controller	Sunol Sciences	Turntable Controller	None	Not Required
416	Gigabit ethernet filter	ETS-Lingren	Gigafoil 260366	None	Not Required
447	MiTest Rad Emissions Test Software	MiCOM	Version 1.0	447	Not Required
462	Schwarzbeck cable from Antenna to Amplifier.	Schwarzbeck	AK 9513	462	4 Oct 2018
463	Schwarzbeck cable from Amplifier to Bulkhead.	Schwarzbeck	AK 9513	463	4 Oct 2018
464	Schwarzbeck cable from Bulkhead to Receiver	Schwarzbeck	AK 9513	464	4 Oct 2018
480	Cable - Bulkhead to Amp	SRC Haverhill	157-3050360	480	6 Oct 2018
481	Cable - Bulkhead to Receiver	SRC Haverhill	151-3050787	481	6 Oct 2018
482	Cable - Amp to Antenna	SRC Haverhill	157-3051574	482	6 Oct 2018
510	Barometer/Thermometer	Control Company	68000-49	170871375	11 Dec 2019

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8. MEASUREMENT AND PRESENTATION OF TEST DATA

The measurement and graphical data presented in this test report was generated automatically using state-of-the-art technology creating an easy to read report structure. Numerical measurement data is separated from supporting graphical data (plots) through hyperlinks. Numerical measurement data can be reviewed without scrolling through numerous graphical pages to arrive at the next data matrix.

Plots have been relegated into the Appendix 'Graphical Data'.

Test and report automation was performed by [MiTest](#). [MiTest](#) is an automated test system developed by MiCOM Labs. [MiTest](#) is the first cloud based modular test system enabling end-to-end automation of regulatory compliance testing for conducted RF testing.



The MiCOM Labs "[MiTest](#)" Automated Test System" (Patent Pending)

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9. TEST RESULTS

9.1. UWB Bandwidth

Conducted Test Conditions for 26 dB and 99% Bandwidth			
Standard:	FCC CFR 47:15.519	Ambient Temp. (°C):	24.0 - 27.5
Test Heading:	UWB Bandwidth	Rel. Humidity (%):	32 - 45
Standard Section(s):	ANSI C63.10 Section 10.1	Pressure (mBars):	999 - 1001
Reference Document(s):	See Normative References		
Test Procedure for UWB Bandwidth Measurement The UWB Bandwidth is measured radiated, at a 3-meter distance, while EUT is operating in transmission mode at the appropriate center frequency. The Resolution Bandwidth was set to 1MHz RBW IAW ANSI C63.10. Testing was performed under ambient conditions at nominal voltage. Test configuration and setup used for the measurement was per the Radiated Test Set-up section specified in this document.			



Equipment Configuration for UWB Bandwidth

Variant:	500 MHz Bandwidth	Duty Cycle (%):	100
Data Rate:	-	Antenna Gain (dBi):	Varies By EUT
Modulation:	BPM/BPSK	Beam Forming Gain (Y)(dB):	Not Applicable
TPC:	Not Applicable	Tested By:	SB
Engineering Test Notes:			

DV11-AC

Test Frequency	Measured 10 dB Bandwidth (MHz)	10 dB Bandwidth (MHz)			
MHz	Port A	Highest	Lowest		
3650.00	430.9	430.9	430.9		

DV21-AC

Test Frequency	Measured 10 dB Bandwidth (MHz)	10 dB Bandwidth (MHz)			
MHz	Port A	Highest	Lowest		
3650.00	543.1	543.1	543.1		

DV21-DC

Test Frequency	Measured 10 dB Bandwidth (MHz)	10 dB Bandwidth (MHz)			
MHz	Port A	Highest	Lowest		
3650.00	501.0	501.0	501.0		

DV31-DC

Test Frequency	Measured 10 dB Bandwidth (MHz)	10 dB Bandwidth (MHz)			
MHz	Port A	Highest	Lowest		
3650.00	545.1	545.1	545.1		

Traceability to Industry Recognized Test Methodologies

Work Instruction:	WI-03 MEASURING RF SPECTRUM MASK
Measurement Uncertainty:	±2.81 dB

Note: click the links in the above matrix to view the graphical image (plot).

The above values are representative of the worst case value between polarities and based on the power measurements.

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9.2. Peak Transmit Power

Conducted Test Conditions for Maximum Radiated Output Power									
Standard:	FCC CFR 47:15.519 (c)	Ambient Temp. (°C):	24.0 - 27.5						
Test Heading:	Radiated Emissions UWB Transmission	Rel. Humidity (%):	32 - 45						
Standard Section(s):	ANSI C63.10 Section 10.3.5	Pressure (mBars):	999 - 1001						
Reference Document(s):	None								
Test Procedure for UWB Transmission Testing was performed under ambient conditions at nominal voltage. Test configuration and setup used for the measurement was per the Radiated Test Set-up section specified in this document. Supporting KDB's referenced below. Operating Frequency Band: 3100-10600 MHz Limits Maximum EIRP (dBm) <table><tr><th>Frequency (MHz)</th><th>EIRP Limit (dBm)</th><th>EIRP at 3 Meters (dBuv/m)</th></tr><tr><td>3100 - 10600</td><td>-41.3</td><td>53.9</td></tr></table>				Frequency (MHz)	EIRP Limit (dBm)	EIRP at 3 Meters (dBuv/m)	3100 - 10600	-41.3	53.9
Frequency (MHz)	EIRP Limit (dBm)	EIRP at 3 Meters (dBuv/m)							
3100 - 10600	-41.3	53.9							



Equipment Configuration for RF Output Power

Variant:	500 MHz Bandwidth	Duty Cycle (%):	99
Data Rate:	-	Antenna Gain (dBi):	Varies by EUT
Modulation:	BPM/BPSK	Beam Forming Gain (Y)(dB):	Not Applicable
TPC:	Not Applicable	Tested By:	SB
Engineering Test Notes:			

Test Measurement Results

Test Frequency MHz	Measured Output Power (dBuv/m)	Calculated Total Power	Limit	Margin	EUT Power Setting
	Port A	dBuv/m	dBuv/m	Numeric	Numeric
DV11-AC	52.9	52.9	53.9	-1.0	Max
DV21-AC	49.8	49.8	53.9	-4.1	Max
DV21-DC	49.1	49.1	53.9	-4.8	Max
DV31-DC	51.7	51.7	53.9	-2.2	Max

Traceability to Industry Recognized Test Methodologies

Work Instruction:	WI-01 MEASURING RF OUTPUT POWER
Uncertainty:	±1.33 dB

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9.3. Peak Power Density

Radiated Test Conditions for Maximum Peak Power Density			
Standard:	FCC CFR 47:15.519 (e)	Ambient Temp. (°C):	24.0 - 27.5
Test Heading:	Radiated Emissions UWB Transmission	Rel. Humidity (%):	32 - 45
Standard Section(s):	ANSI C63.10 Section 10.3.6	Pressure (mBars):	999 - 1001
Reference Document(s):	None		
Test Procedure for UWB Transmission			
Testing was performed under ambient conditions at nominal voltage.			
Test configuration and setup used for the measurement was per the Radiated Test Set-up section specified in this document. Supporting KDB's referenced below.			
Measurements were gathered with a RBW of 1MHz and converted to 50MHz using the following formula:			
$\text{EIRP}_{1\text{ MHz}} = \text{EIRP}_{50\text{ MHz}} + 20\log(1\text{MHz}/50\text{MHz}) = 0\text{dBm} + (-34\text{dBm}) = -34\text{dBm}$			
Operating Frequency Band: 3100-10600 MHz			
Limits Maximum EIRP (dBm)			
Frequency (MHz)	EIRP Limit (dBm/50MHz)	EIRP Limit (dBm/1MHz)	EIRP at 3 Meters (dBuv/m)
3100 - 10600	0	-34	61.23



Equipment Configuration for Peak Power Density

Variant:	500 MHz Bandwidth	Duty Cycle (%):	99
Data Rate:	-	Antenna Gain (dBi):	Varies by EUT
Modulation:	BPM/BPSK	Beam Forming Gain (Y)(dB):	Not Applicable
TPC:	Not Applicable	Tested By:	JH
Engineering Test Notes:			

Test Measurement Results

Device	Measured Output Power	Limit	Margin	EUT Power Setting
	dBuv/m	dBuv/m	Numeric	Numeric
DV11-AC	55.06	61.23	-6.17	Max
DV21-AC	47.86	61.23	-13.37	Max
DV21-DC	46.32	61.23	-14.91	Max
DV31-DC	42.75	61.23	-18.48	Max

Traceability to Industry Recognized Test Methodologies

Work Instruction:	WI-01 MEASURING RF OUTPUT POWER
Uncertainty:	±1.33 dB

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9.4. Radiated Spurious Emissions

Radiated Test Conditions for Radiated Spurious and Band-Edge Emissions			
Standard:	FCC CFR 47 15.519	Ambient Temp. (°C):	20.0 - 24.5
Test Heading:	Radiated Spurious and Band-Edge Emissions	Rel. Humidity (%):	32 - 45
Standard Section(s):	ANSI C63.10 Section 10.2 + 10.3	Pressure (mBars):	999 - 1001
Reference Document(s):	See Normative References		
Test Procedure for Radiated Spurious and Band-Edge Emissions Radiated emissions for restricted bands above 1 GHz are measured in the anechoic chamber at a 3-meter distance on every azimuth in both horizontal and vertical polarities. The emissions are recorded and maximized as a function of azimuth by rotation through 360° with a spectrum analyzer in peak hold mode. Depending on the frequency band spanned a notch filter was used to remove the fundamental frequency. The highest emissions relative to the limit are listed for each frequency spanned. Measurements on any restricted band frequency or frequencies above 1 GHz are based on the use of measurement instrumentation employing peak and average detectors. All measurements were performed using a resolution bandwidth of 1 MHz.			
Limits for Restricted Bands (15.205, 15.209) Peak emission: 68.23 dBuV/m Average emission: 54 dBuV/m			
Field Strength Calculation The field strength is calculated by adding the Antenna Factor and Cable Loss, and subtracting Amplifier Gain from the measured reading. All factors are included in the reported data. FS = R + AF + CORR - FO where: FS = Field Strength R = Measured Spectrum analyzer Input Amplitude AF = Antenna Factor CORR = Correction Factor = CL – AG + NFL CL = Cable Loss AG = Amplifier Gain FO = Distance Falloff Factor NFL = Notch Filter Loss			
Frequency Range		Limit	
MHz	MHz	EIRP (dBm)	EIRP at 3 Meters (dBuV/m)
960	1610	-75.3	19.9
1610	1990	-63.3	31.9
1990	3100	-61.3	33.9
3100	10600	-41.3	53.9
10600	18000	-61.3	33.9

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Radiated Spurious Emissions in the GPS Bands 15.519 (d)

Frequency Range		Limit	
MHz	MHz	EIRP (dBm)	EIRP at 3 Meters (dBuV/m)
1164	1240	-85.3	9.9
1559	1610	-85.3	9.9

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9.4.1. TX Spurious Band Emissions

9.4.1.1. DV21-AC

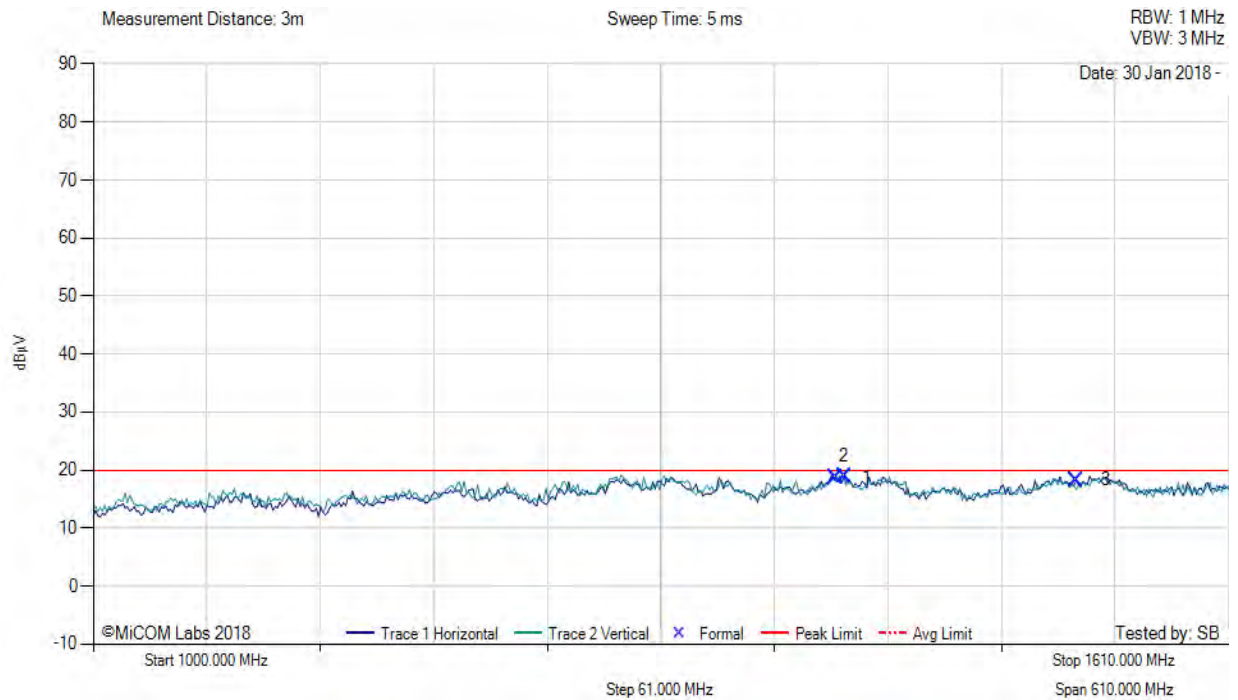
Equipment Configuration for Spurious Emissions

Antenna:	DV21-AC	Variant:	500 MHz Bandwidth
Antenna Gain (dBi):	9.28	Modulation:	BPM/BPSK
Beam Forming Gain (Y):	Not Applicable	Duty Cycle (%):	99%
Channel Frequency (MHz):	3492.00	Data Rate:	
Power Setting:	Max	Tested By:	SB

Test Measurement Results



Variant: , Test Freq: 3492.00 MHz, Power Setting: Max



1000.00 - 1610.00 MHz

Num	Frequency MHz	Raw dBμV	Cable Loss dB	AF dB	Level dBμV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBμV/m	Margin dB	Pass /Fail
1	1399.22	33.07	1.83	-16.28	18.62	Peak (Scan)	Vertical	100	0	19.9	-1.3	Pass
2	1403.63	33.39	1.83	-16.28	18.94	Peak (Scan)	Horizontal	100	0	19.9	-1.0	Pass
3	1528.16	33.04	1.88	-16.62	18.30	Peak (Scan)	Vertical	100	0	19.9	-1.6	Pass

Test Notes:

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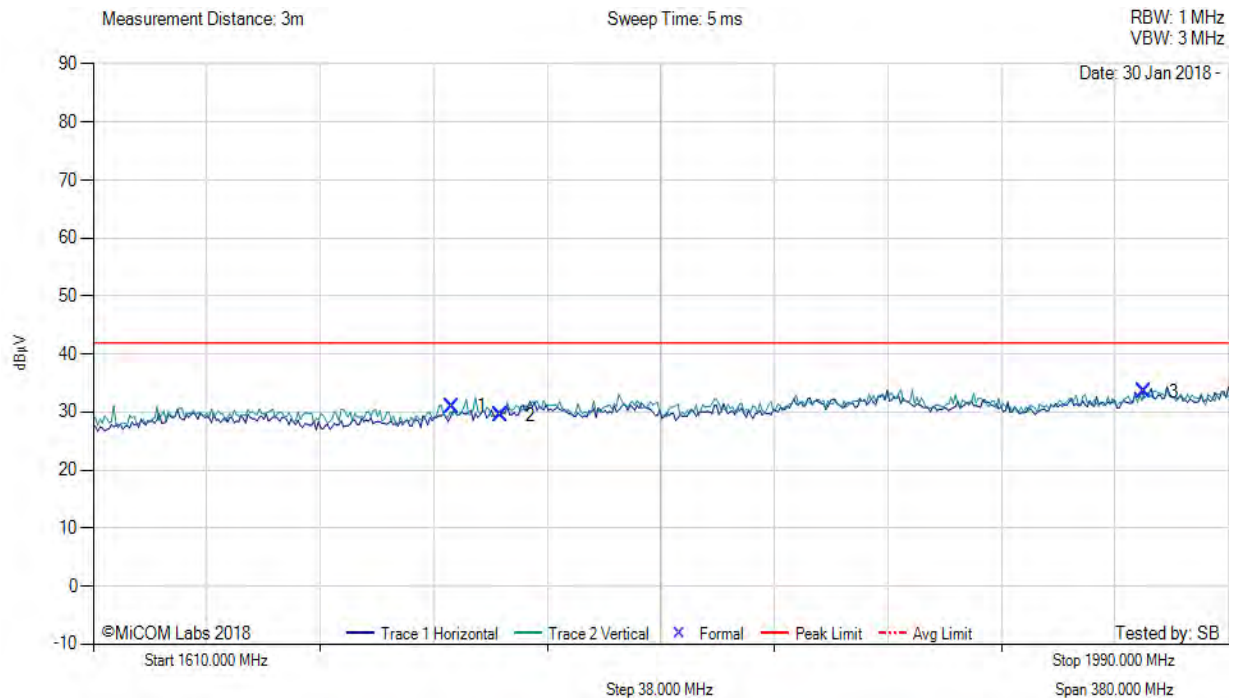
Equipment Configuration for Spurious Emissions

Antenna:	DV21-AC	Variant:	500 MHz Bandwidth
Antenna Gain (dBi):	9.28	Modulation:	BPM/BPSK
Beam Forming Gain (Y):	Not Applicable	Duty Cycle (%):	99%
Channel Frequency (MHz):	3492.00	Data Rate:	
Power Setting:	Max	Tested By:	SB

Test Measurement Results



Variant: , Test Freq: 3492.00 MHz, Power Setting: Max



1610.00 - 1990.00 MHz

Num	Frequency MHz	Raw dBμV	Cable Loss dB	AF dB	Level dBμV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBμV/m	Margin dB	Pass /Fail
1	1730.00	44.38	1.96	-15.35	30.99	Peak (NRB)	Horizontal	100	0	--	--	Pass
2	1746.42	42.67	1.99	-15.16	29.50	Peak (NRB)	Horizontal	100	0	--	--	Pass
3	1961.67	44.54	2.09	-13.12	33.51	Peak (NRB)	Horizontal	100	0	--	--	Pass

Test Notes:

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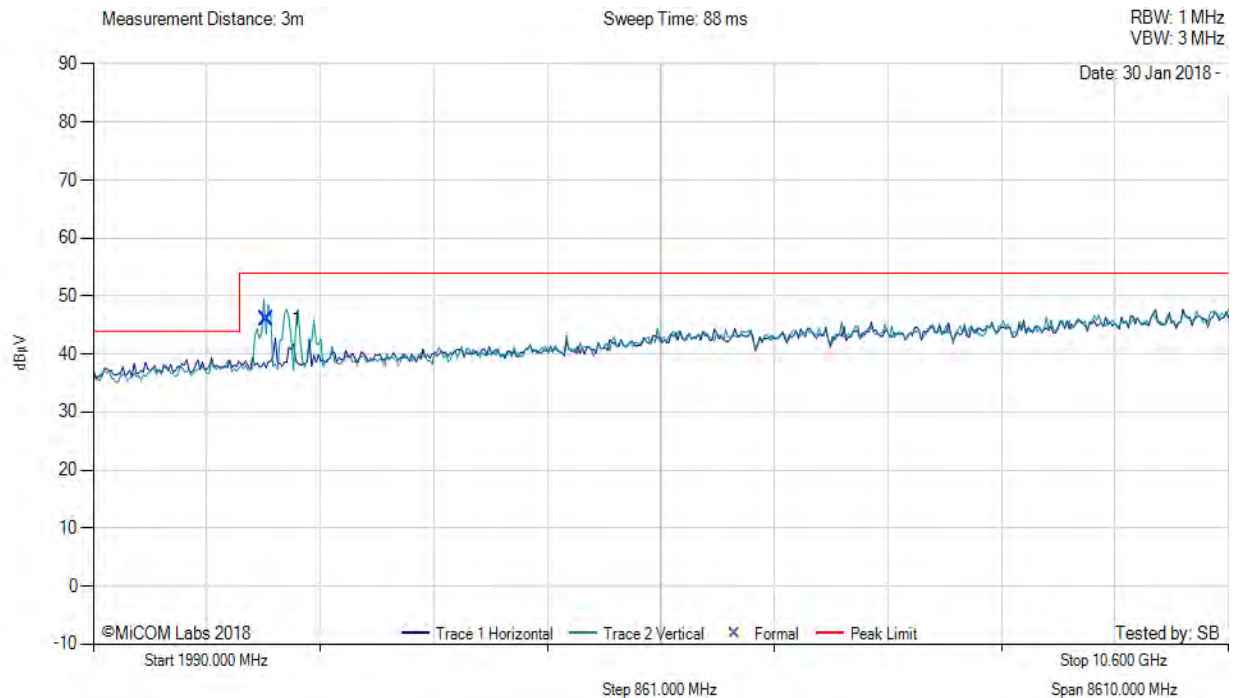
Equipment Configuration for Restricted Band Spurious Emissions

Antenna:	DV21-AC	Variant:	500 MHz Bandwidth
Antenna Gain (dBi):	9.28	Modulation:	BPM/BPSK
Beam Forming Gain (Y):	Not Applicable	Duty Cycle (%):	99%
Channel Frequency (MHz):	3492.00	Data Rate:	
Power Setting:	Max	Tested By:	SB

Test Measurement Results



Variant: , Test Freq: 3492.00 MHz, Power Setting: Max



1990.00 - 10600.00 MHz

Num	Frequency MHz	Raw dBμV	Cable Loss dB	AF dB	Level dBμV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBμV/m	Margin dB	Pass /Fail
1	3301.01	55.15	2.58	-11.77	45.96	Fundamental	Vertical	100	0	--	--	

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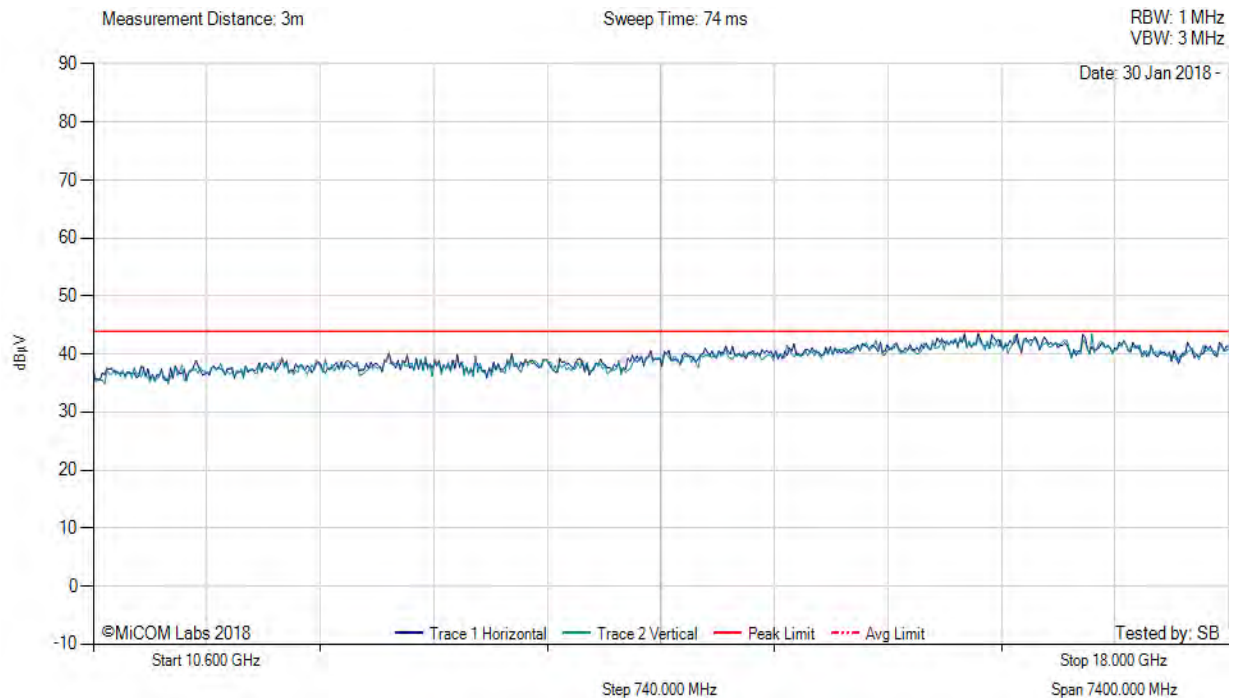
Equipment Configuration for Restricted Band Spurious Emissions

Antenna:	DV21-AC	Variant:	500 MHz Bandwidth
Antenna Gain (dBi):	9.28	Modulation:	BPM/BPSK
Beam Forming Gain (Y):	Not Applicable	Duty Cycle (%):	99%
Channel Frequency (MHz):	3492.00	Data Rate:	
Power Setting:	Max	Tested By:	SB

Test Measurement Results



Variant: , Test Freq: 3492.00 MHz, Power Setting: Max



There are no emissions found within 6dB of the limit line.

Test Notes:

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9.4.1.2. DV21-DC

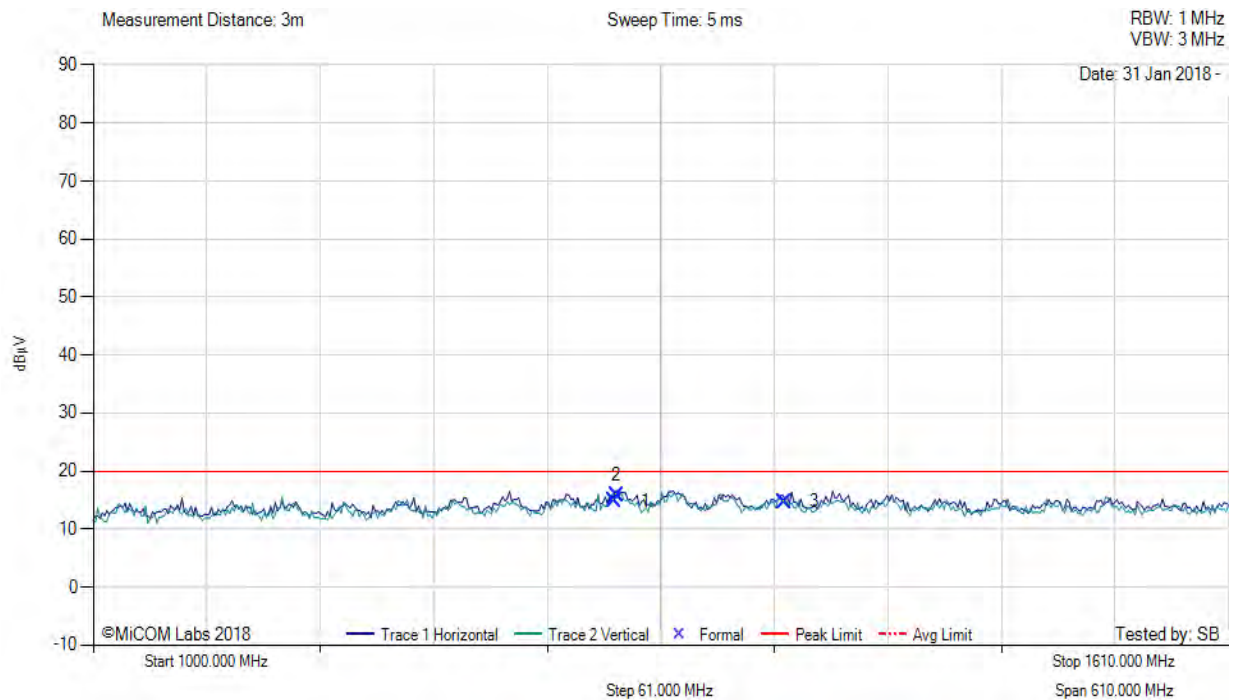
Equipment Configuration for Restricted Band Spurious Emissions

Antenna:	DV21-DC	Variant:	500 MHz Bandwidth
Antenna Gain (dBi):	9.28	Modulation:	BPM/BPSK
Beam Forming Gain (Y):	Not Applicable	Duty Cycle (%):	99%
Channel Frequency (MHz):	3492.00	Data Rate:	
Power Setting:	Max	Tested By:	SB

Test Measurement Results



Variant: , Test Freq: 3492.00 MHz, Power Setting: Max



1000.00 - 1610.00 MHz

Num	Frequency MHz	Raw dBμV	Cable Loss dB	AF dB	Level dBμV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBμV/m	Margin dB	Pass /Fail
1	1280.33	29.05	1.78	-16.01	14.82	Peak (NRB)	Vertical	100	0	--	--	Pass
2	1281.16	30.00	1.78	-16.01	15.77	Peak (NRB)	Horizontal	100	0	--	--	Pass
3	1371.16	28.94	1.82	-16.02	14.74	Peak (Scan)	Horizontal	100	0	19.9	-5.2	Pass

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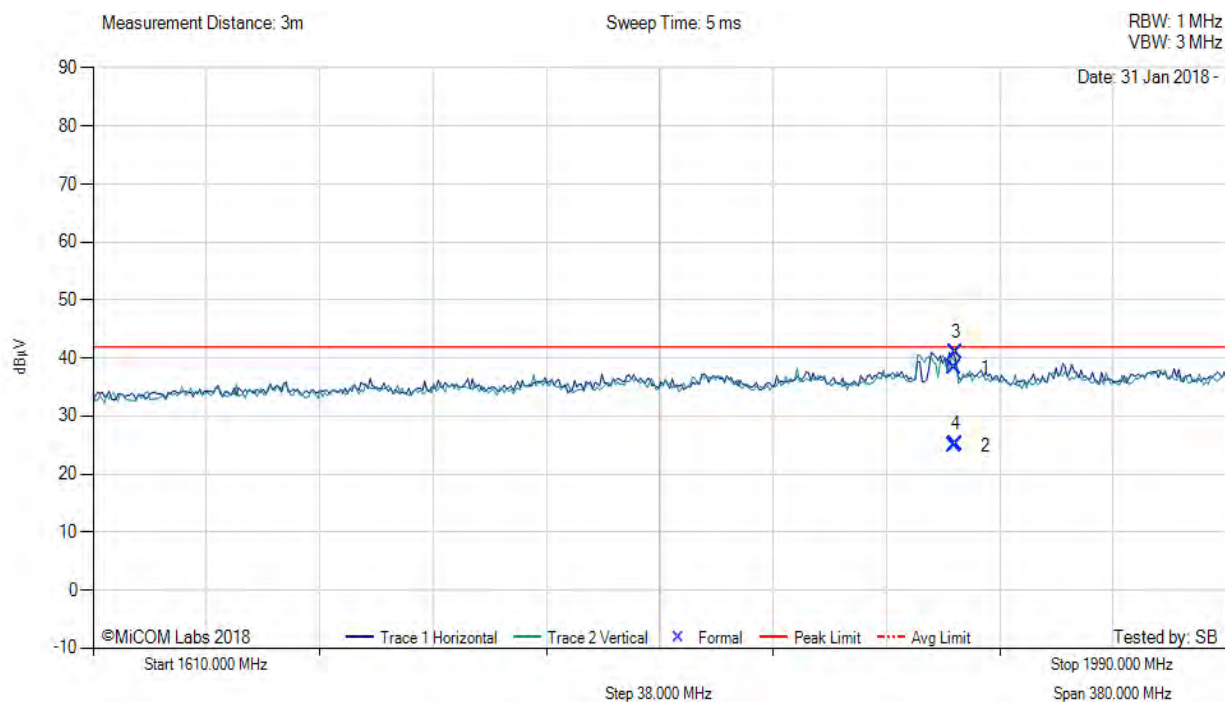
Equipment Configuration for Restricted Band Spurious Emissions

Antenna:	DV21-DC	Variant:	500 MHz Bandwidth
Antenna Gain (dBi):	9.28	Modulation:	BPM/BPSK
Beam Forming Gain (Y):	Not Applicable	Duty Cycle (%):	99%
Channel Frequency (MHz):	3492.00	Data Rate:	
Power Setting:	Max	Tested By:	SB

Test Measurement Results



Variant: , Test Freq: 3492.00 MHz, Power Setting: Max



1610.00 - 1990.00 MHz

Num	Frequency MHz	Raw dBμV	Cable Loss dB	AF dB	Level dBμV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBμV/m	Margin dB	Pass /Fail
1	1898.99	49.87	2.05	-13.67	38.25	Max Peak	Horizontal	172	66	41.9	-3.7	Pass
2	1898.99	36.58	2.05	-13.67	24.96	Max Avg	Horizontal	172	66	41.9	-17.0	Pass
3	1899.21	52.49	2.05	-13.67	40.87	Max Peak	Vertical	99	135	41.9	-1.1	Pass
4	1899.21	36.68	2.05	-13.67	25.06	Max Avg	Vertical	99	135	41.9	-16.9	Pass

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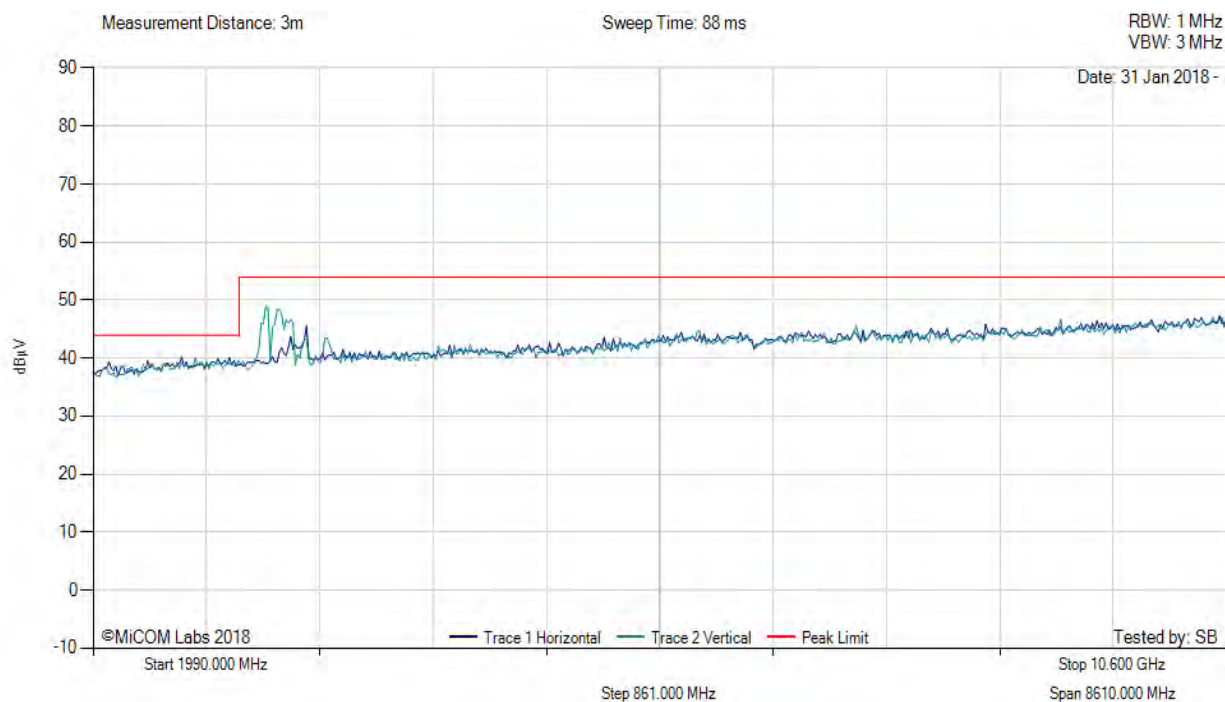
Equipment Configuration for Restricted Band Spurious Emissions

Antenna:	DV21-DC	Variant:	500 MHz Bandwidth
Antenna Gain (dBi):	9.28	Modulation:	BPM/BPSK
Beam Forming Gain (Y):	Not Applicable	Duty Cycle (%):	99%
Channel Frequency (MHz):	3492.00	Data Rate:	
Power Setting:	Max	Tested By:	SB

Test Measurement Results



Variant: , Test Freq: 3492.00 MHz, Power Setting: Max



There are no emissions found within 6dB of the limit line.

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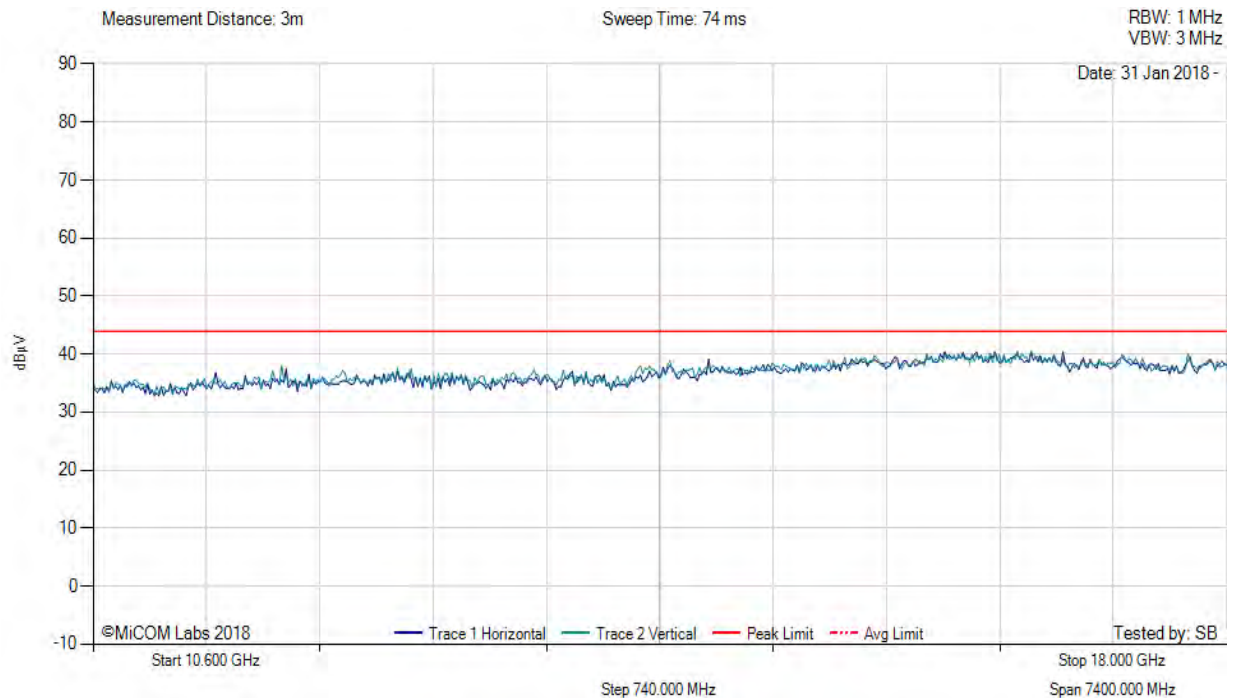
Equipment Configuration for Restricted Band Spurious Emissions

Antenna:	DV21-DC	Variant:	500 MHz Bandwidth
Antenna Gain (dBi):	9.28	Modulation:	BPM/BPSK
Beam Forming Gain (Y):	Not Applicable	Duty Cycle (%):	99%
Channel Frequency (MHz):	3492.00	Data Rate:	
Power Setting:	Max	Tested By:	SB

Test Measurement Results



Variant: , Test Freq: 3492.00 MHz, Power Setting: Max



There are no emissions found within 6dB of the limit line.

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9.4.1.3. DV11-AC

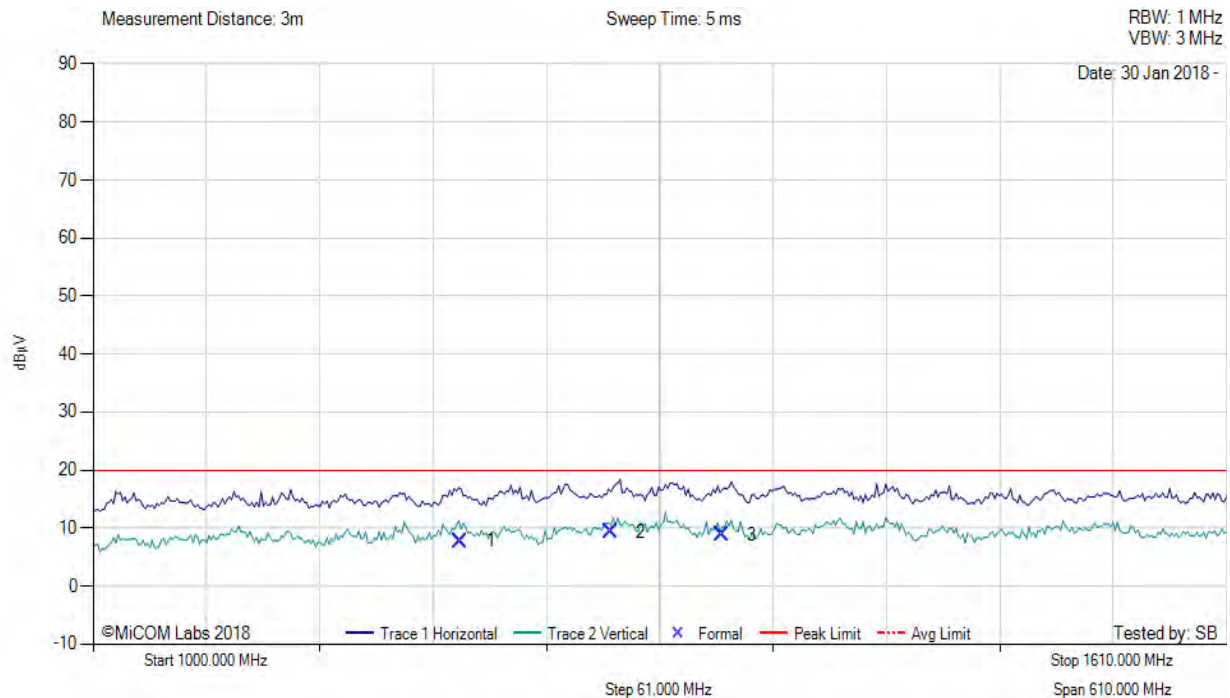
Equipment Configuration for Restricted Band Spurious Emissions

Antenna:	DV11-AC	Variant:	500 MHz Bandwidth
Antenna Gain (dBi):	13.0	Modulation:	BPM/BPSK
Beam Forming Gain (Y):	Not Applicable	Duty Cycle (%):	99%
Channel Frequency (MHz):	3492.00	Data Rate:	
Power Setting:	Max	Tested By:	SB

Test Measurement Results



Variant: , Test Freq: 3492.00 MHz, Power Setting: Max



1000.00 - 1610.00 MHz

Num	Frequency MHz	Raw dBμV	Cable Loss dB	AF dB	Level dBμV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBμV/m	Margin dB	Pass /Fail
1	1197.87	22.77	1.73	-16.77	7.73	Peak (Scan)	Horizontal	100	0	19.9	-12.2	Pass
2	1278.59	23.66	1.77	-16.05	9.38	Peak (NRB)	Horizontal	100	0	--	--	Pass
3	1338.49	22.74	1.80	-15.74	8.80	Peak (Scan)	Horizontal	100	0	19.9	-11.1	Pass

Test Notes:

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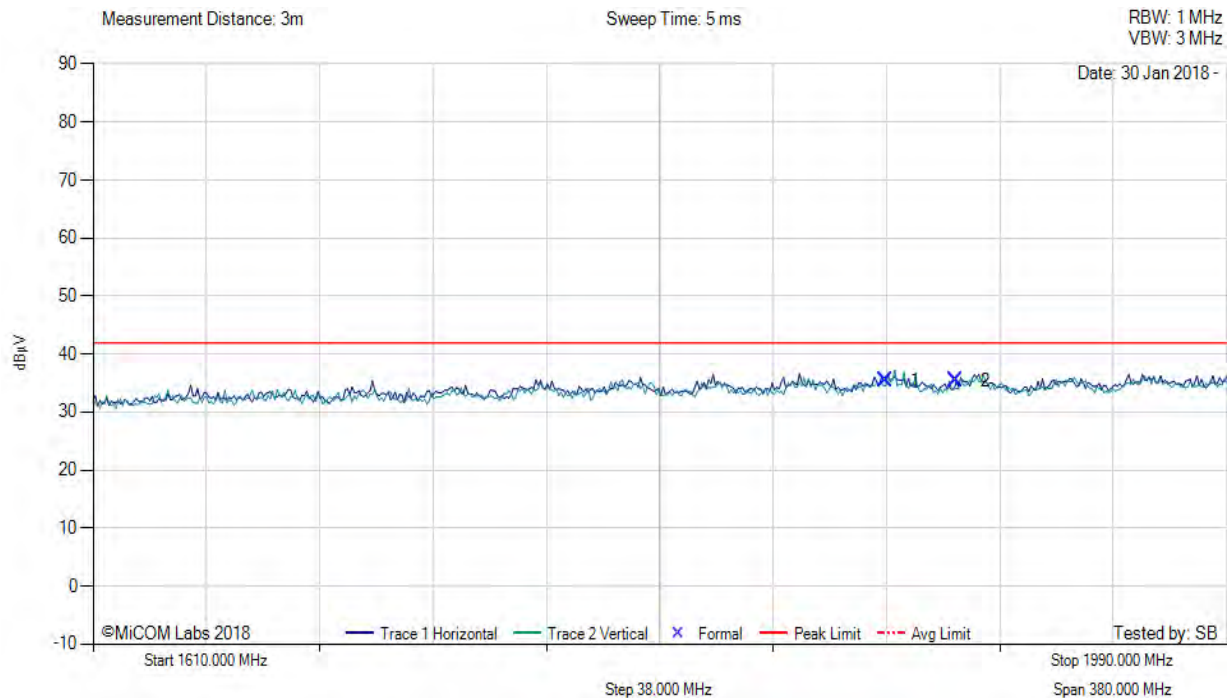
Equipment Configuration for Restricted Band Spurious Emissions

Antenna:	DV11-AC	Variant:	500 MHz Bandwidth
Antenna Gain (dBi):	13.0	Modulation:	BPM/BPSK
Beam Forming Gain (Y):	Not Applicable	Duty Cycle (%):	99%
Channel Frequency (MHz):	3492.00	Data Rate:	
Power Setting:	Max	Tested By:	SB

Test Measurement Results



Variant: , Test Freq: 3492.00 MHz, Power Setting: Max



1610.00 - 1990.00 MHz

Num	Frequency MHz	Raw dBμV	Cable Loss dB	AF dB	Level dBμV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBμV/m	Margin dB	Pass /Fail
1	1875.68	47.10	2.04	-13.70	35.44	Peak (NRB)	Vertical	100	0	--	--	Pass
2	1899.33	47.06	2.05	-13.67	35.44	Peak (NRB)	Horizontal	100	0	--	--	Pass

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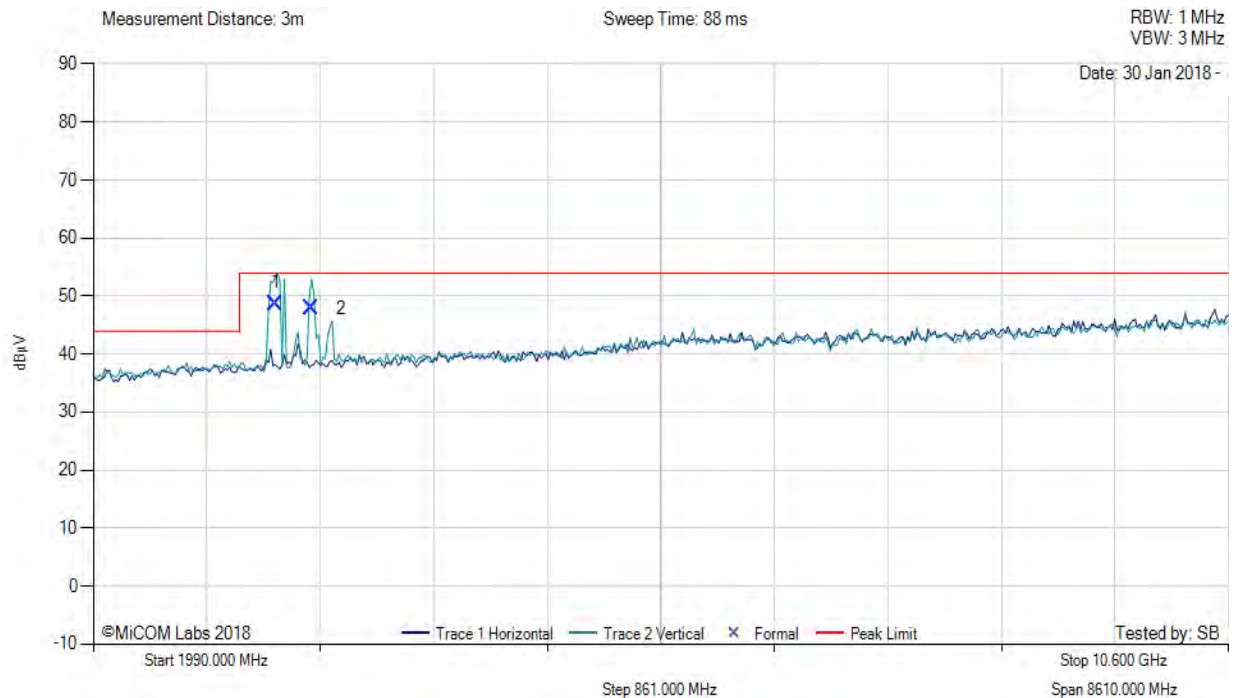
Equipment Configuration for Restricted Band Spurious Emissions

Antenna:	DV11-AC	Variant:	500 MHz Bandwidth
Antenna Gain (dBi):	13.0	Modulation:	BPM/BPSK
Beam Forming Gain (Y):	Not Applicable	Duty Cycle (%):	99%
Channel Frequency (MHz):	3492.00	Data Rate:	
Power Setting:	Max	Tested By:	SB

Test Measurement Results



Variant: , Test Freq: 3492.00 MHz, Power Setting: Max



1990.00 - 10600.00 MHz

Num	Frequency MHz	Raw dBμV	Cable Loss dB	AF dB	Level dBμV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBμV/m	Margin dB	Pass /Fail
1	3370.36	57.97	2.62	-11.84	48.75	Fundamental	Vertical	100	0	--	--	
2	3646.43	56.85	2.73	-11.74	47.84	Fundamental	Vertical	100	0	--	--	

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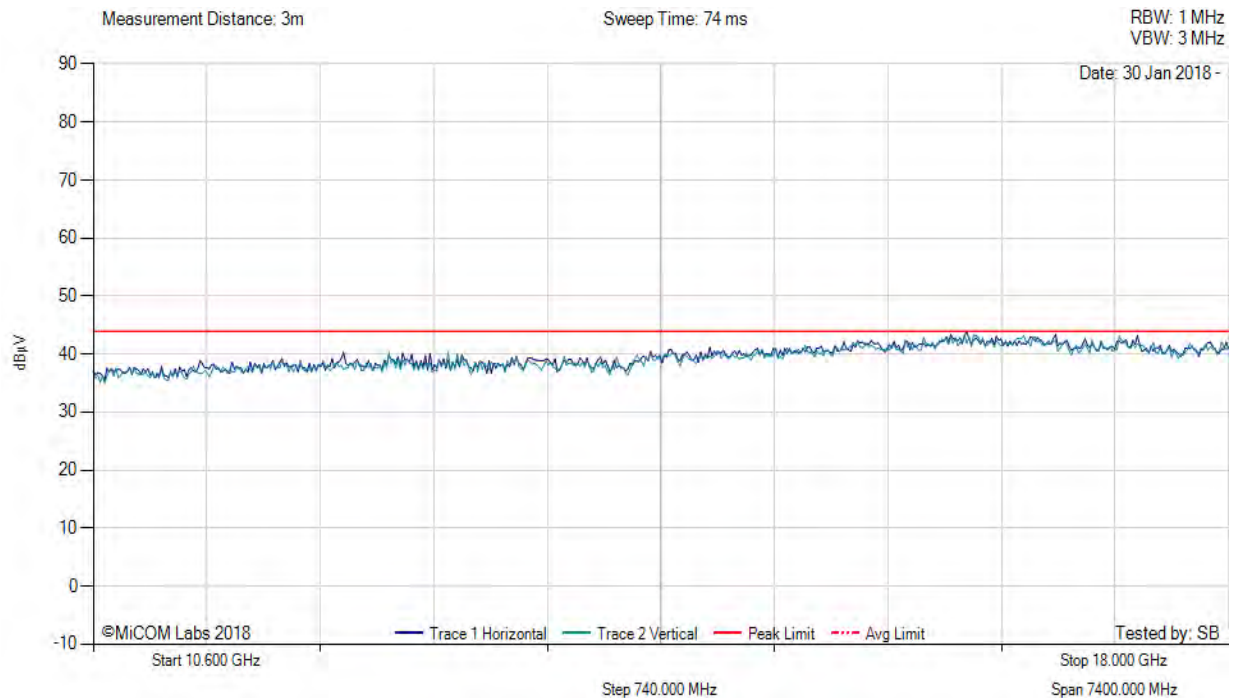
Equipment Configuration for Restricted Band Spurious Emissions

Antenna:	DV11-AC	Variant:	500 MHz Bandwidth
Antenna Gain (dBi):	13.0	Modulation:	BPM/BPSK
Beam Forming Gain (Y):	Not Applicable	Duty Cycle (%):	99%
Channel Frequency (MHz):	3492.00	Data Rate:	
Power Setting:	Max	Tested By:	SB

Test Measurement Results



Variant: , Test Freq: 3492.00 MHz, Power Setting: Max



There are no emissions found within 6dB of the limit line.

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9.4.1.4. DV31-DC

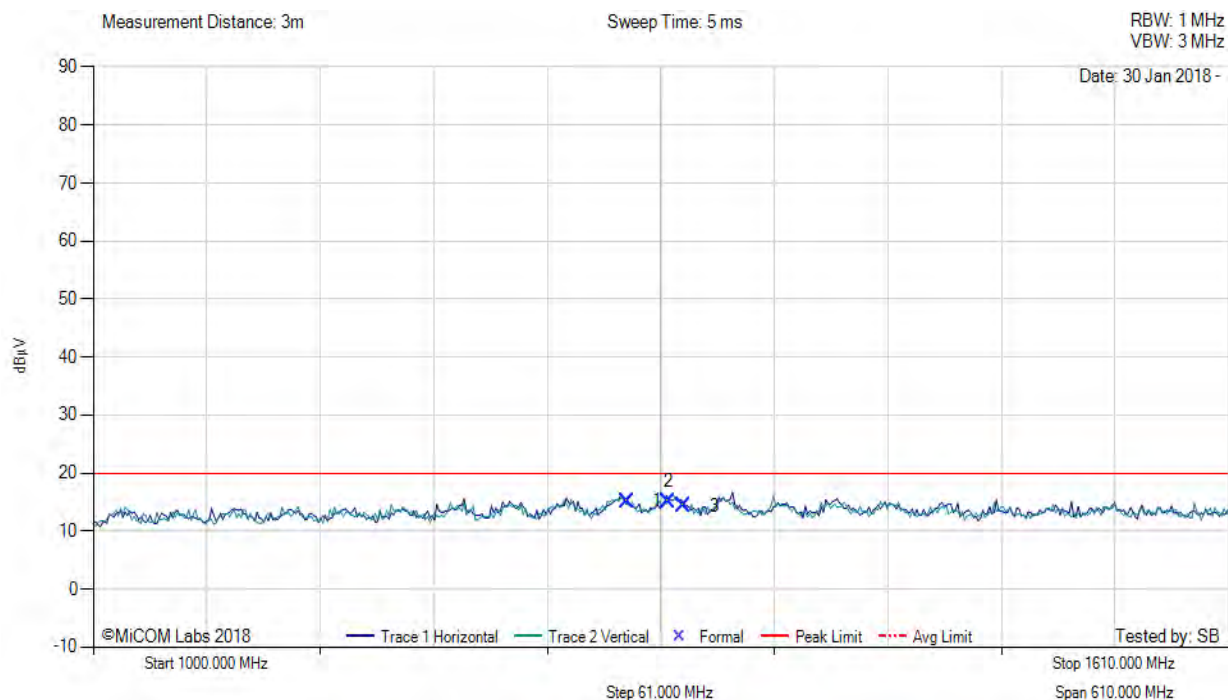
Equipment Configuration for Restricted Band Spurious Emissions

Antenna:	DV31-DC	Variant:	500 MHz Bandwidth
Antenna Gain (dBi):	13.0	Modulation:	BPM/BPSK
Beam Forming Gain (Y):	Not Applicable	Duty Cycle (%):	99%
Channel Frequency (MHz):	3492.00	Data Rate:	
Power Setting:	Max	Tested By:	SB

Test Measurement Results



Variant: , Test Freq: 3492.00 MHz, Power Setting: Max



1000.00 - 1610.00 MHz												
Num	Frequency MHz	Raw dBμV	Cable Loss dB	AF dB	Level dBμV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBμV/m	Margin dB	Pass /Fail
1	1286.86	29.35	1.79	-15.92	15.22	Peak (NRB)	Horizontal	100	0	--	--	Pass
2	1309.22	29.09	1.80	-15.79	15.10	Peak (Scan)	Horizontal	100	0	19.9	-4.8	Pass
3	1317.44	28.20	1.80	-15.68	14.32	Peak (Scan)	Horizontal	100	0	19.9	-5.6	Pass

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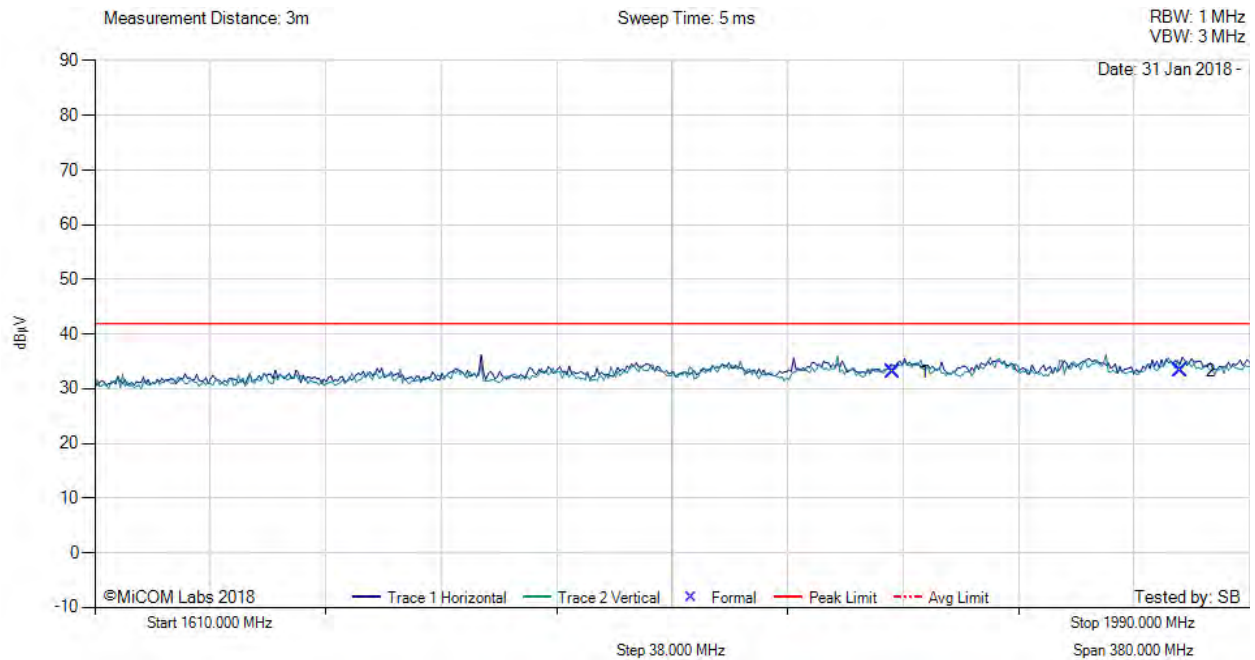
Equipment Configuration for Restricted Band Spurious Emissions

Antenna:	DV31-DC	Variant:	500 MHz Bandwidth
Antenna Gain (dBi):	13.0	Modulation:	BPM/BPSK
Beam Forming Gain (Y):	Not Applicable	Duty Cycle (%):	99%
Channel Frequency (MHz):	3492.00	Data Rate:	
Power Setting:	Max	Tested By:	SB

Test Measurement Results



Variant: , Test Freq: 3492.00 MHz, Power Setting: Max



1610.00 - 1990.00 MHz												
Num	Frequency MHz	Raw dBμV	Cable Loss dB	AF dB	Level dBμV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBμV/m	Margin dB	Pass /Fail
1	1872.80	44.72	2.04	-13.74	33.02	Peak (NRB)	Vertical	100	0	--	--	Pass
2	1967.31	44.27	2.09	-13.12	33.24	Peak (NRB)	Vertical	100	0	--	--	Pass
3	1990.19	45.27	2.09	-12.90	34.46	Peak (NRB)	Vertical	100	0	--	--	Pass

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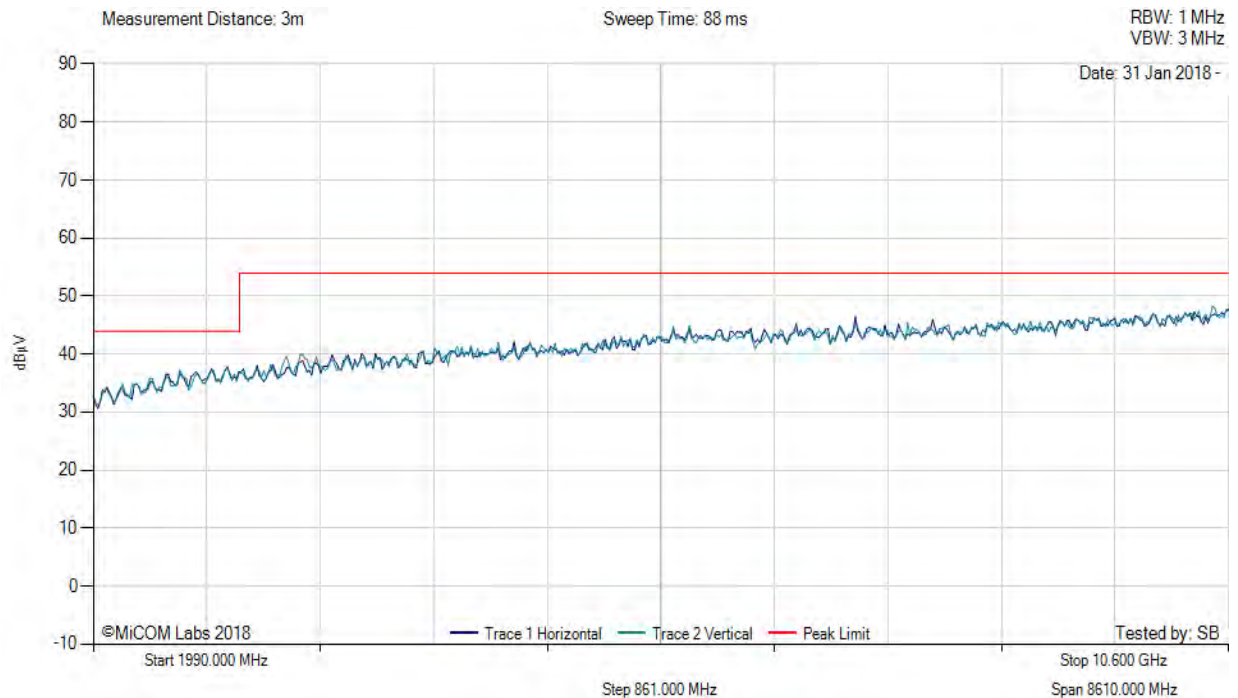
Equipment Configuration for Restricted Band Spurious Emissions

Antenna:	DV31-DC	Variant:	500 MHz Bandwidth
Antenna Gain (dBi):	13.0	Modulation:	BPM/BPSK
Beam Forming Gain (Y):	Not Applicable	Duty Cycle (%):	99%
Channel Frequency (MHz):	3492.00	Data Rate:	
Power Setting:	Max	Tested By:	SB

Test Measurement Results



Variant: , Test Freq: 3492.00 MHz, Power Setting: Max



There are no emissions found within 6dB of the limit line.

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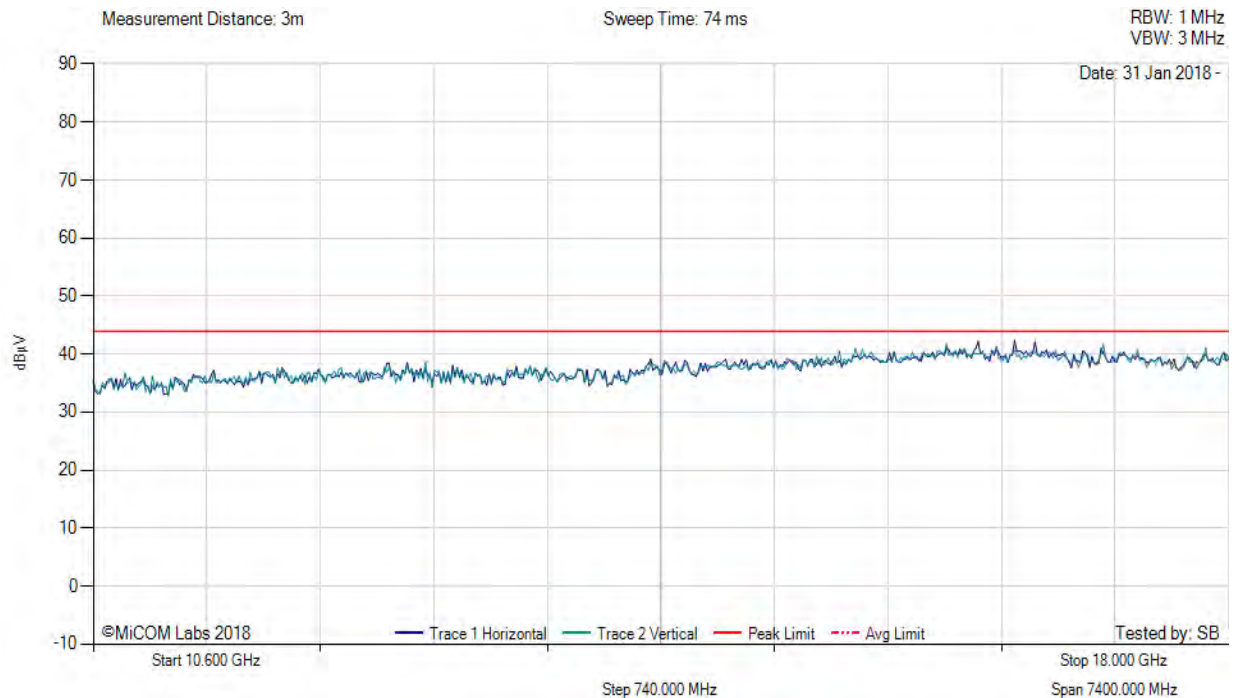
Equipment Configuration for Restricted Band Spurious Emissions

Antenna:	DV31-DC	Variant:	500 MHz Bandwidth
Antenna Gain (dBi):	13.0	Modulation:	BPM/BPSK
Beam Forming Gain (Y):	Not Applicable	Duty Cycle (%):	99%
Channel Frequency (MHz):	3492.00	Data Rate:	
Power Setting:	Max	Tested By:	SB

Test Measurement Results



Variant: , Test Freq: 3492.00 MHz, Power Setting: Max

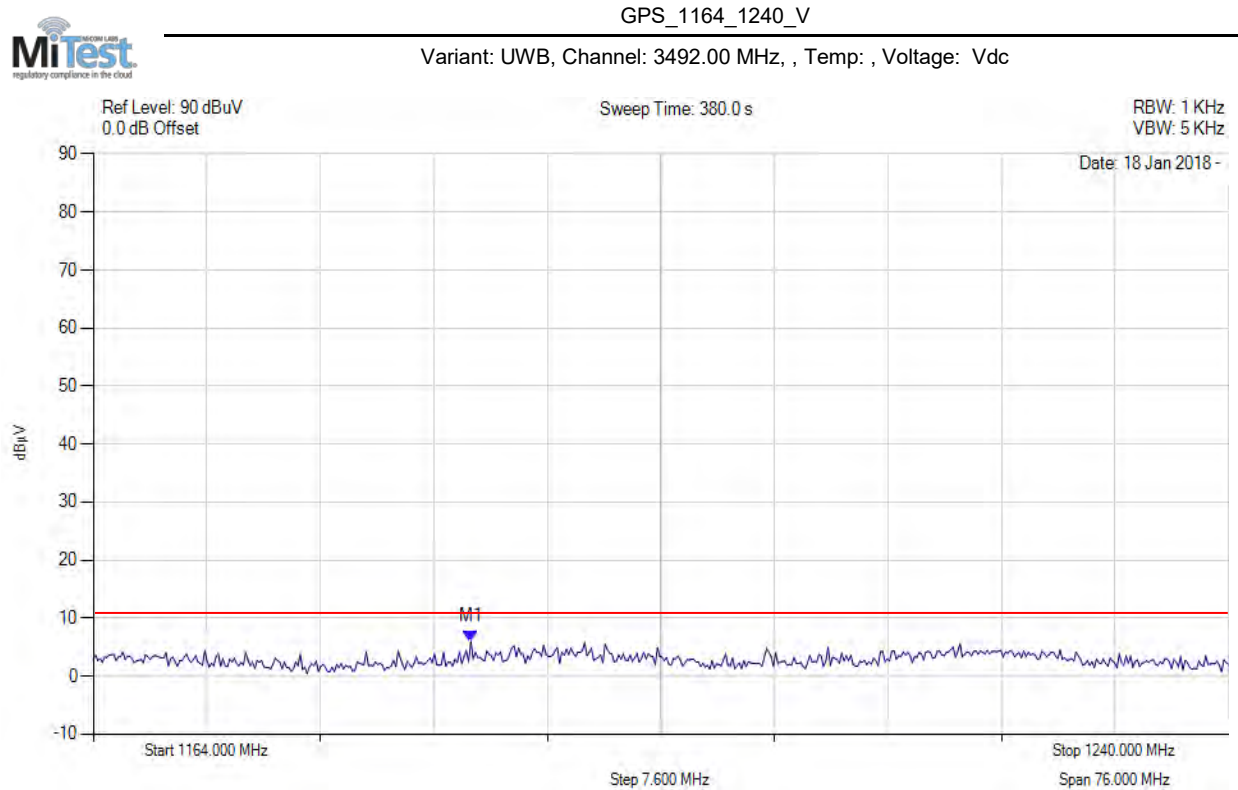


There are no emissions found within 6dB of the limit line.

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9.4.2. GPS Band Emissions

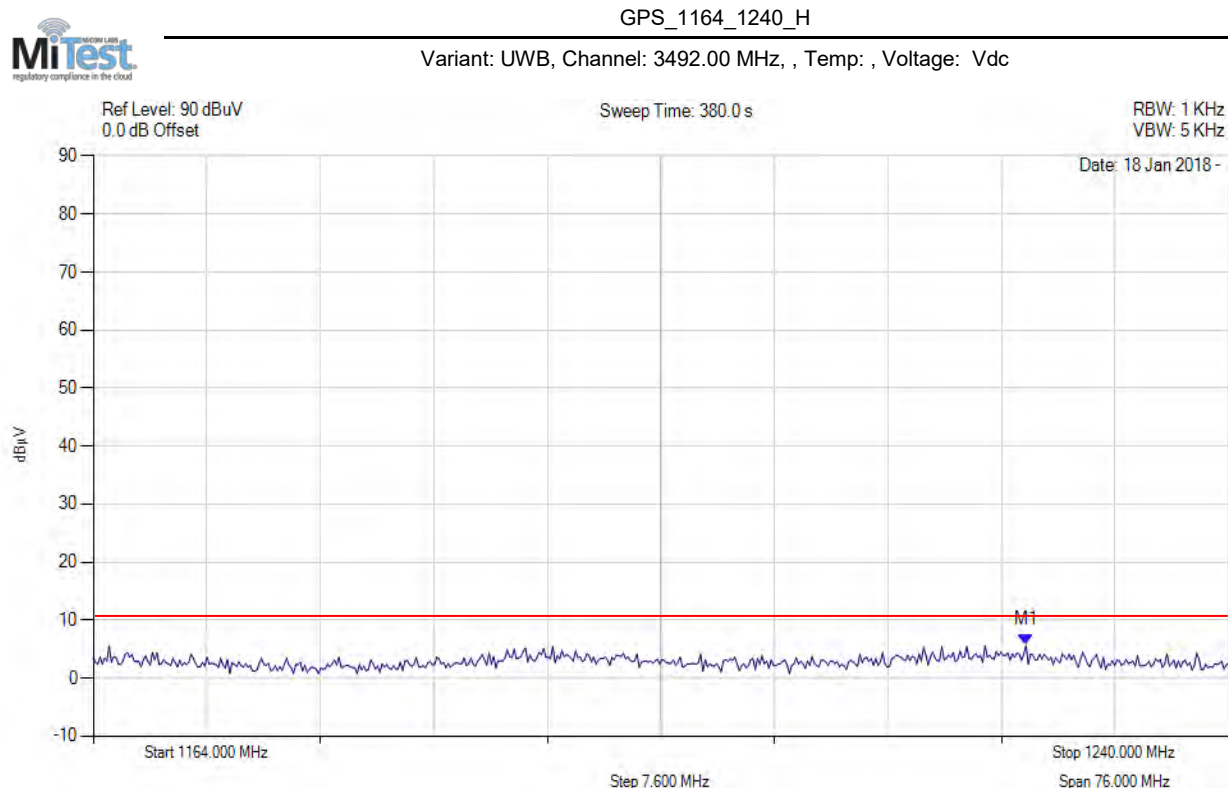
9.4.2.5. DV21-AC V 1164-1240



Analyzer Setup	Marker:Frequency:Amplitude	Test Results
Detector = MAX PEAK Sweep Count = 0 RF Atten (dB) = 10 Trace Mode = CLR/WRITE	M1 : 1189.283 MHz : 5.982 dBμV	Channel Frequency: 3492.00 MHz

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DV21-AC H 1164-1240



Analyzer Setup	Marker:Frequency:Amplitude	Test Results
Detector = MAX PEAK Sweep Count = 0 RF Atten (dB) = 10 Trace Mode = CLR/WRITE	M1 : 1226.445 MHz : 5.694 dBuV	Channel Frequency: 3492.00 MHz

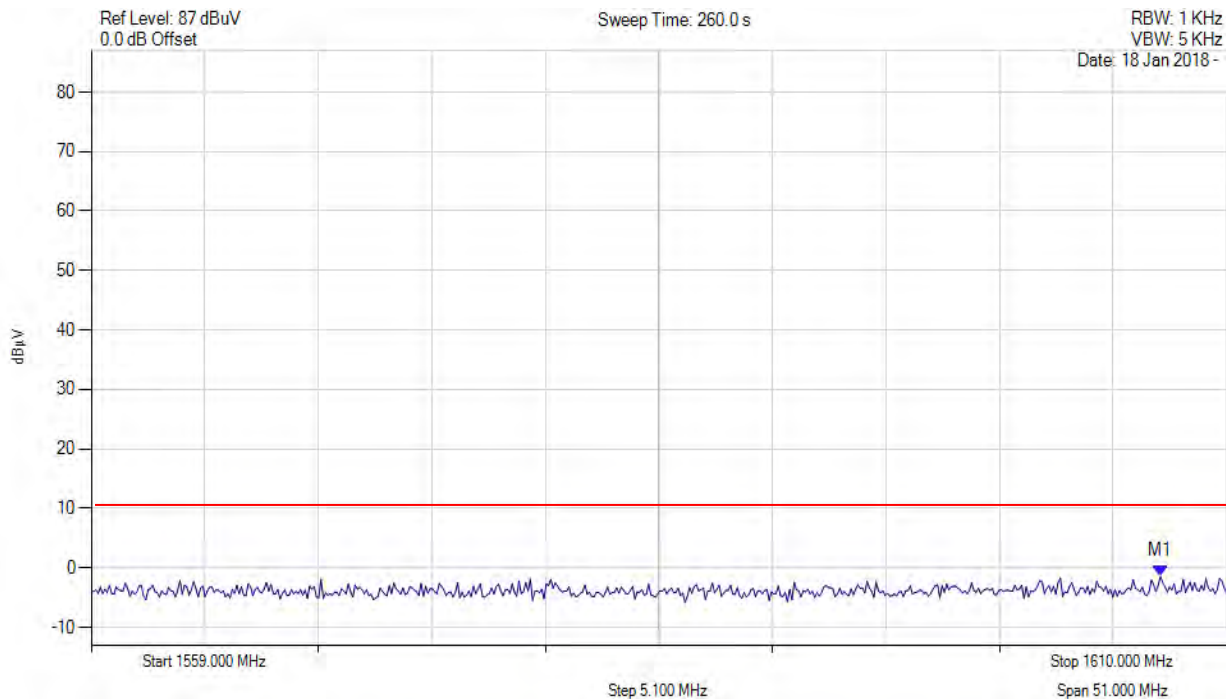
This test report may be reproduced in full only. The document may only be updated by MiCOM Labs personnel. All changes will be noted in the Document History section of the report.

V 1559-1610



GPS_1559_1610_V

Variant: UWB, Channel: 3492.00 MHz, , Temp: , Voltage: Vdc



Analyzer Setup	Marker:Frequency:Amplitude	Test Results
Detector = MAX PEAK Sweep Count = 0 RF Atten (dB) = 10 Trace Mode = CLR/WRITE	M1 : 1607.036 MHz : -1.419 dBuV	Channel Frequency: 3492.00 MHz

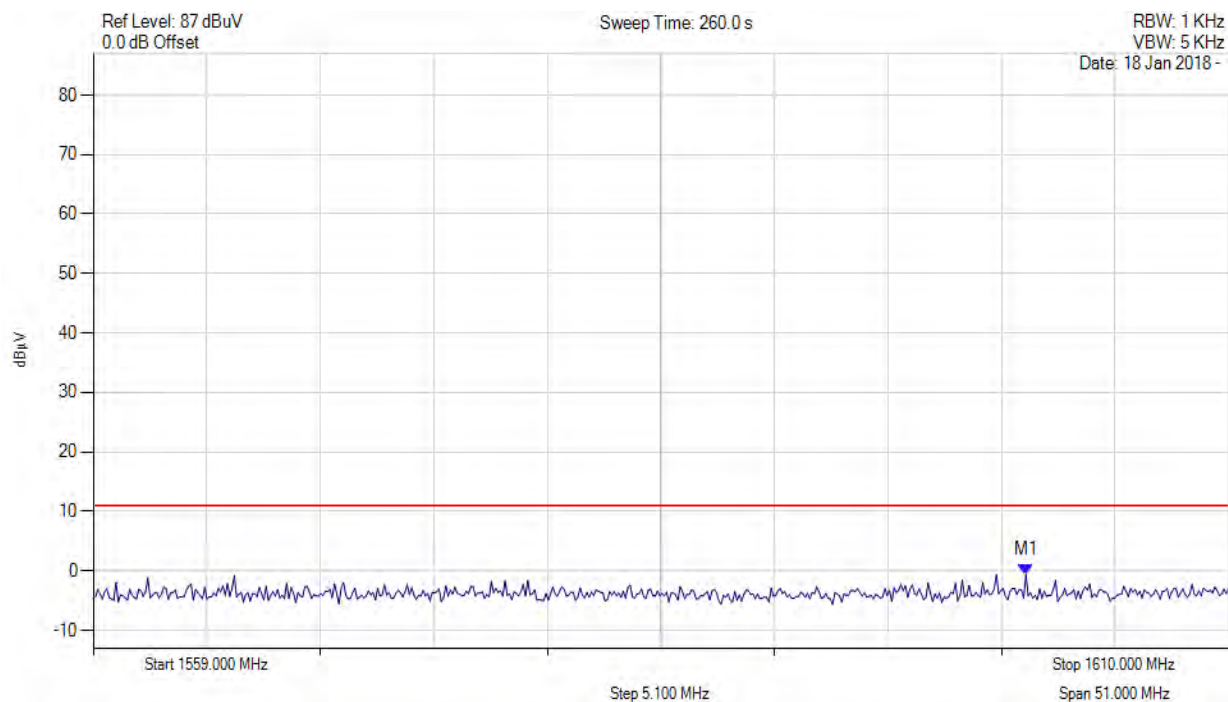
This test report may be reproduced in full only. The document may only be updated by MiCOM Labs personnel. All changes will be noted in the Document History section of the report.

H 1559-1610



GPS_1559_1610_H

Variant: UWB, Channel: 3492.00 MHz, , Temp: , Voltage: Vdc



Analyzer Setup	Marker:Frequency:Amplitude	Test Results
Detector = MAX PEAK Sweep Count = 0 RF Atten (dB) = 10 Trace Mode = CLR/WRITE	M1 : 1600.904 MHz : -0.638 dBuV	Channel Frequency: 3492.00 MHz

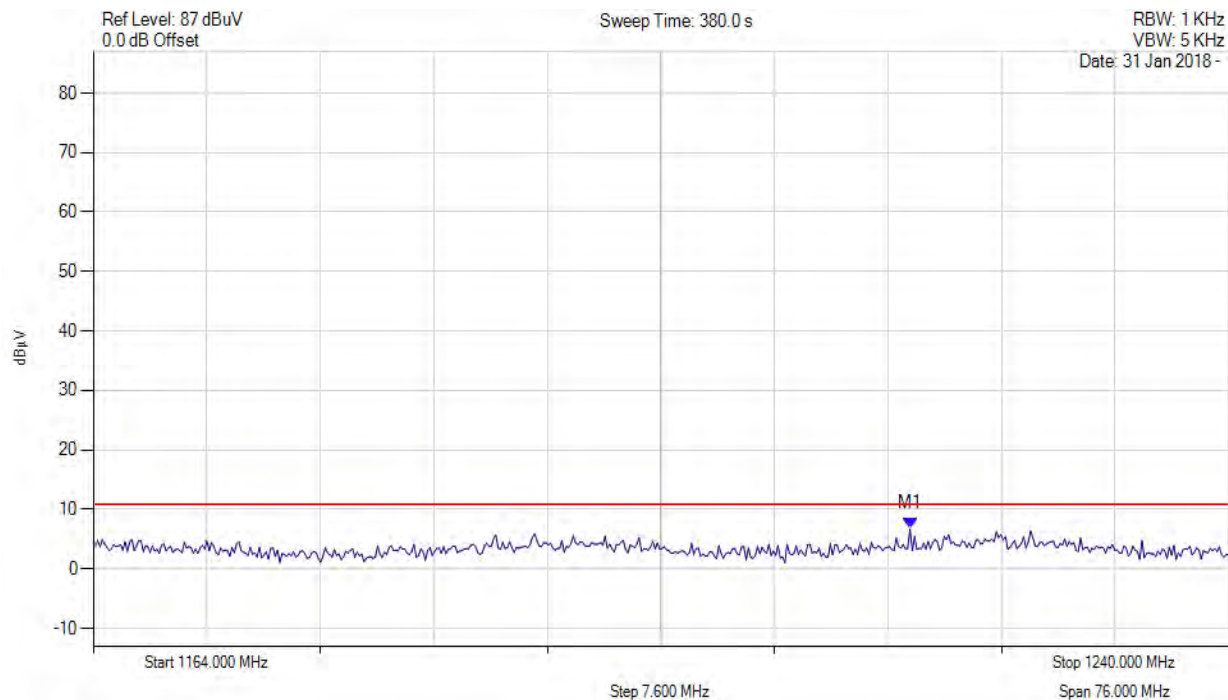
This test report may be reproduced in full only. The document may only be updated by MiCOM Labs personnel. All changes will be noted in the Document History section of the report.

9.4.2.6. DV21-DC V 1164-1240



GPS 1164_1240MHz V

Variant: UWB, Channel: 3492.00 MHz, , Temp: , Voltage: Vdc



Analyzer Setup	Marker:Frequency:Amplitude	Test Results
Detector = MAX PEAK Sweep Count = 0 RF Atten (dB) = 10 Trace Mode = CLR/WRITE	M1 : 1218.677 MHz : 6.735 dBuV	Channel Frequency: 3492.00 MHz

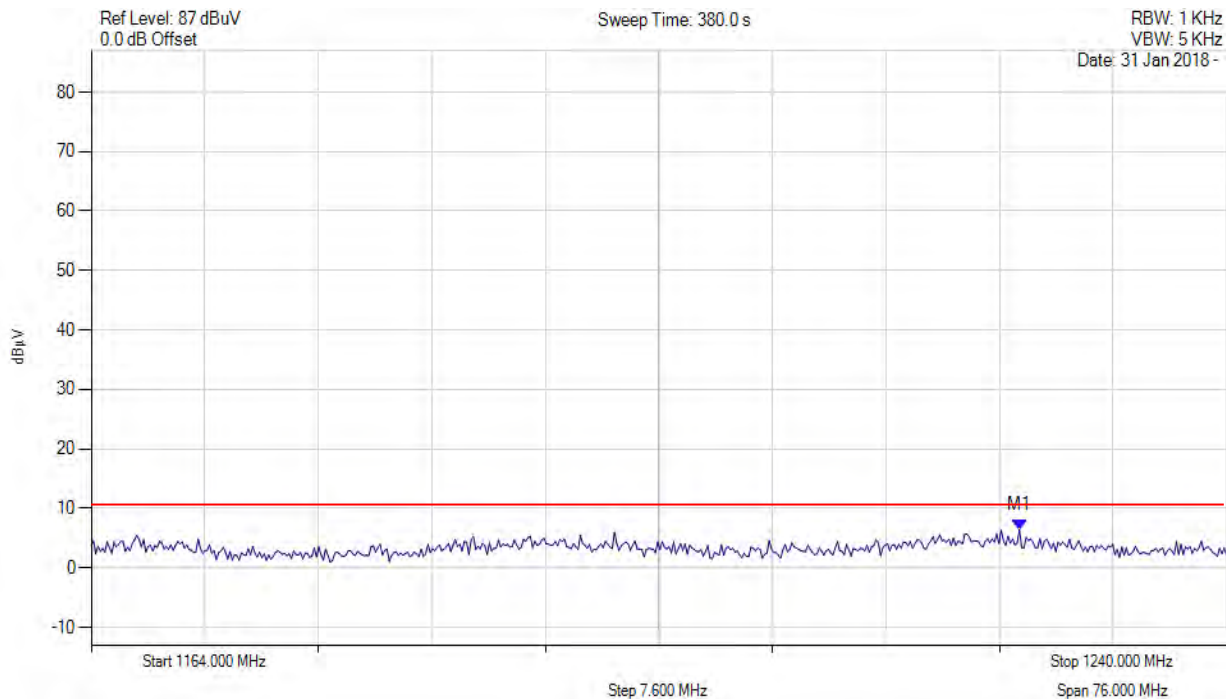
This test report may be reproduced in full only. The document may only be updated by MiCOM Labs personnel. All changes will be noted in the Document History section of the report.

H 1164-1240



GPS 1164_1240MHz H

Variant: UWB, Channel: 3492.00 MHz, , Temp: , Voltage: Vdc



Analyzer Setup	Marker:Frequency:Amplitude	Test Results
Detector = MAX PEAK Sweep Count = 0 RF Atten (dB) = 10 Trace Mode = CLR/WRITE	M1 : 1226.140 MHz : 6.424 dBuV	Channel Frequency: 3492.00 MHz

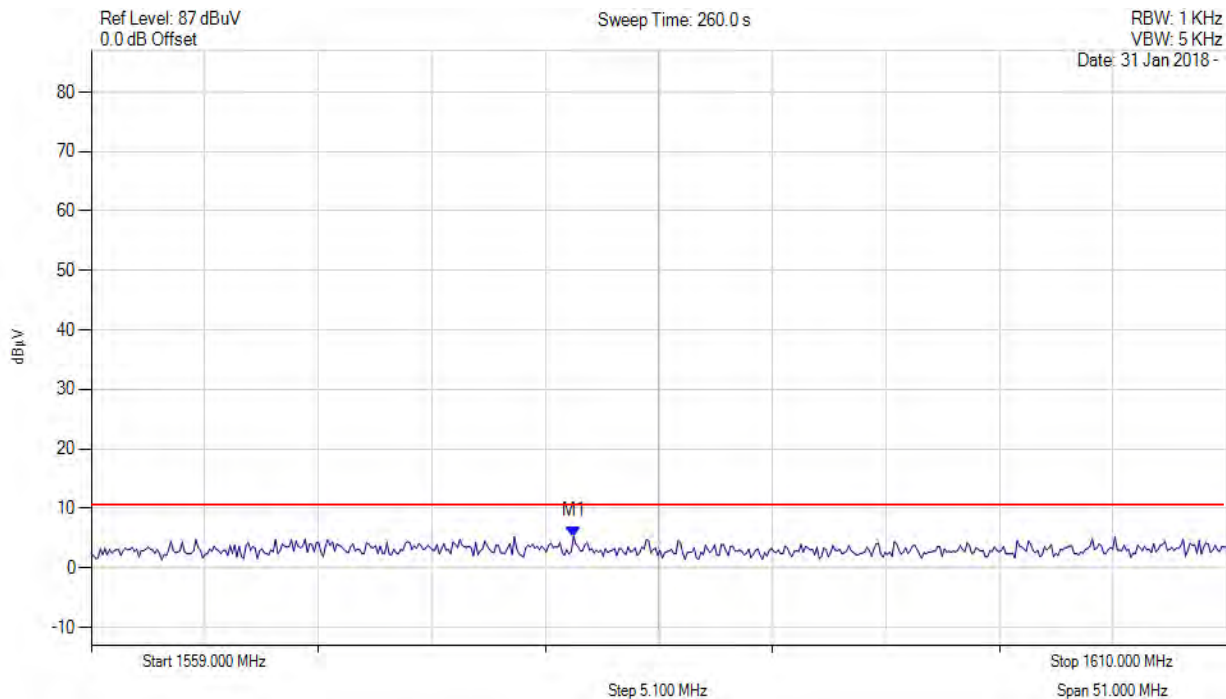
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V 1559-1610



GPS 1559_1610MHz V

Variant: UWB, Channel: 3492.00 MHz, , Temp: , Voltage: Vdc



Analyzer Setup	Marker:Frequency:Amplitude	Test Results
Detector = MAX PEAK Sweep Count = 0 RF Atten (dB) = 10 Trace Mode = CLR/WRITE	M1 : 1580.667 MHz : 5.294 dBμV	Channel Frequency: 3492.00 MHz

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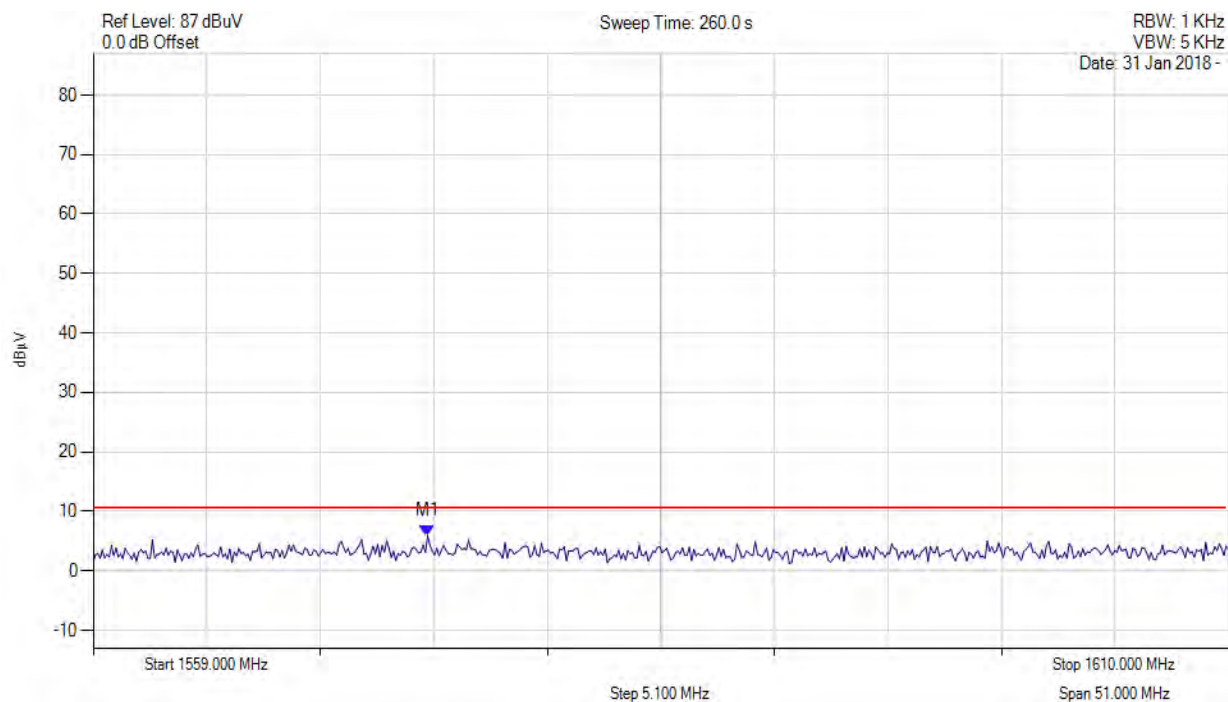


H 1559-1610



GPS 1559_1610MHz H

Variant: UWB, Channel: 3492.00 MHz, , Temp: , Voltage: Vdc



Analyzer Setup	Marker:Frequency:Amplitude	Test Results
Detector = MAX PEAK Sweep Count = 0 RF Atten (dB) = 10 Trace Mode = CLR/WRITE	M1 : 1574.024 MHz : 5.934 dBuV	Channel Frequency: 3492.00 MHz

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9.5. Shutoff Timing Requirements

Radiated Test Conditions for Shutoff Timing Requirements			
Standard:	FCC CFR 47:15.519 (a)(1)	Ambient Temp. (°C):	24.0 - 27.5
Test Heading:	Shutoff Timing Requirements	Rel. Humidity (%):	32 - 45
Standard Section(s):	ANSI C63.10 Section 10.3.6	Pressure (mBars):	999 - 1001
Reference Document(s):	None		
Test Procedure for UWB Transmission Testing was performed under ambient conditions at nominal voltage. Test configuration and setup used for the measurement was per the Radiated Test Set-up section specified in this document. Operating Frequency Band: 3100-10600 MHz Limits The UWB intentional radiator shall cease transmission within 10 seconds unless it receives an acknowledgement from the associated receiver that its transmission is being received.			



Equipment Configuration for Shutdown Timing Requirements

Variant:	500 MHz Bandwidth	Duty Cycle (%):	99
Data Rate:	-	Antenna Gain (dBi):	Varies by EUT
Modulation:	BPM/BPSK	Beam Forming Gain (Y)(dB):	Not Applicable
TPC:	Not Applicable	Tested By:	EM
Engineering Test Notes:	1. Timing behavior is identical in all 4 models. Testing performed on the DV31-DC is representative of all 4 models. 2. Additional Timing plots are shown in Annex A for informative purposes only.		

Test Measurement Results

Frequency (MHz)	Shutdown Time	Limit	Margin	EUT Power Setting
	(s)	(s)	Numeric	Numeric
3492	9.833	10	0.167	Max

Traceability to Industry Recognized Test Methodologies

Work Instruction:	WI-01 MEASURING RF OUTPUT POWER
Uncertainty:	±1.33 dB

A. APPENDIX - GRAPHICAL IMAGES

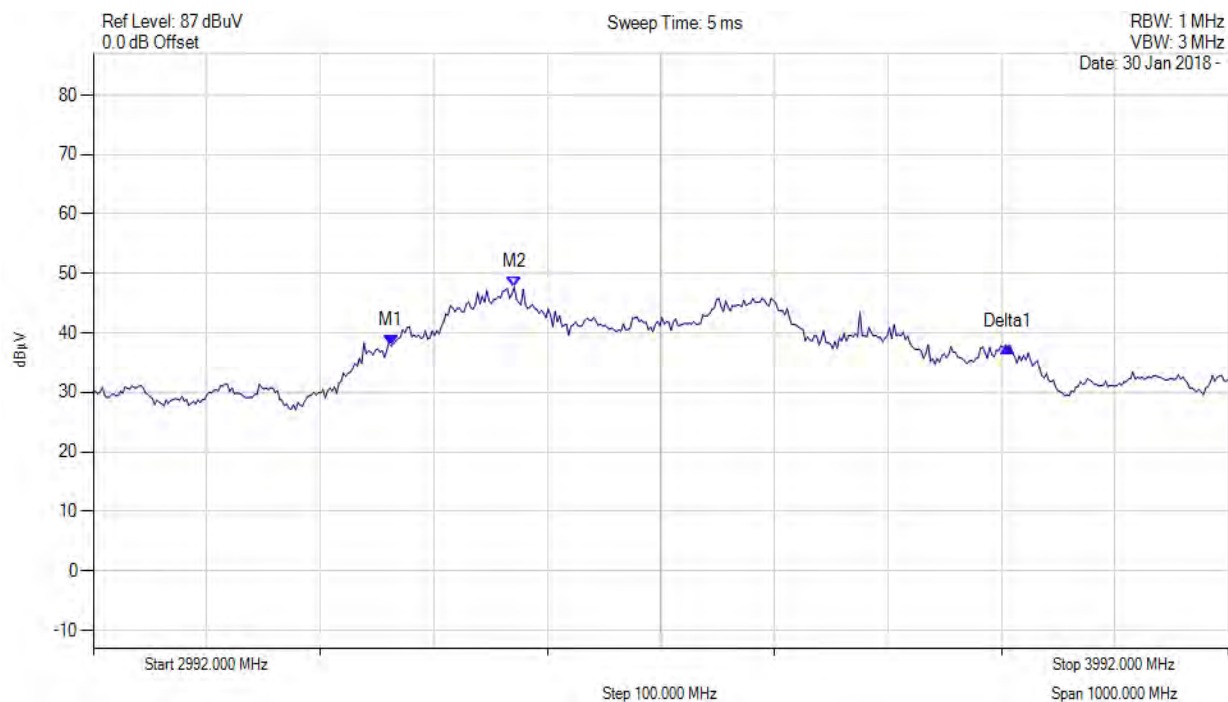
A.1. UWB Bandwidth

DV21-AC

OBW_10dB



Variant: UWB, Channel: 3492.00 MHz, , Temp: , Voltage: 24 Vdc



Analyzer Setup	Marker:Frequency:Amplitude	Test Results
Detector = RMS Sweep Count = 0 RF Atten (dB) = 0 Trace Mode = VIEW	M1 : 3254.525 MHz : 37.797 dBuV M2 : 3362.741 MHz : 47.699 dBuV Delta1 : 543.086 MHz : -0.176 dB	Channel Frequency: 3492.00 MHz

[back to matrix](#)

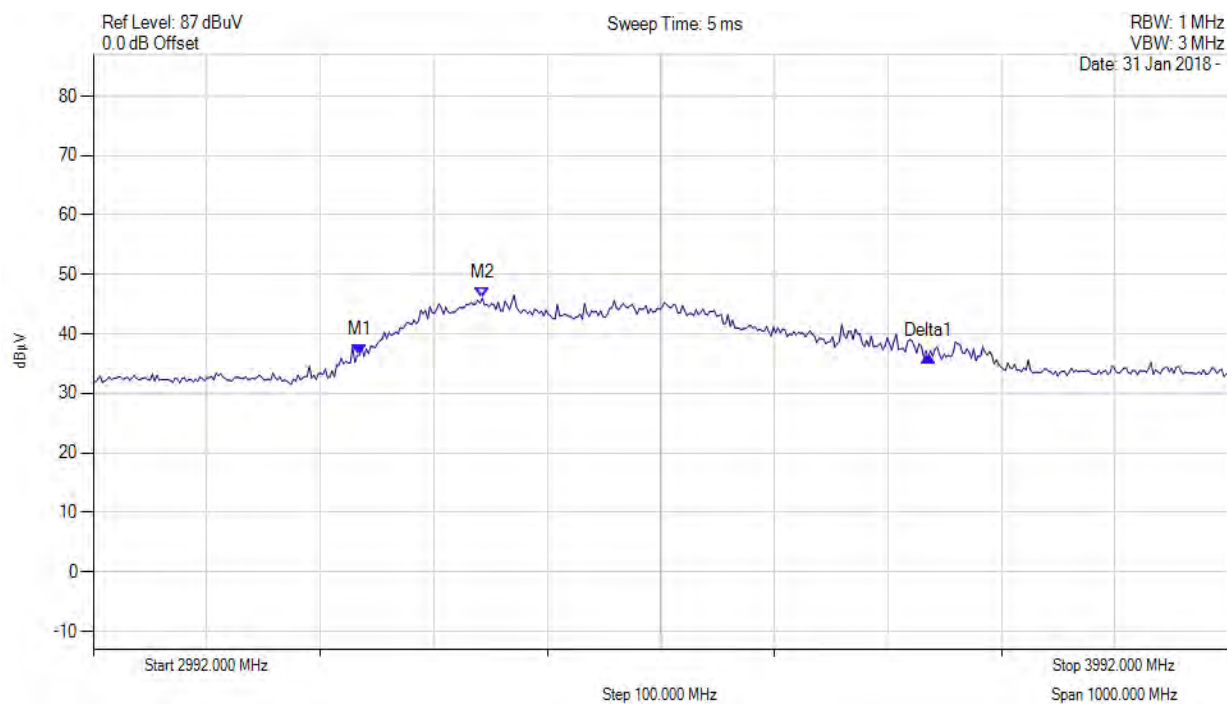
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DV21-DC



OBW_10dB

Variant: UWB, Channel: 3492.00 MHz, , Temp: , Voltage: Vdc

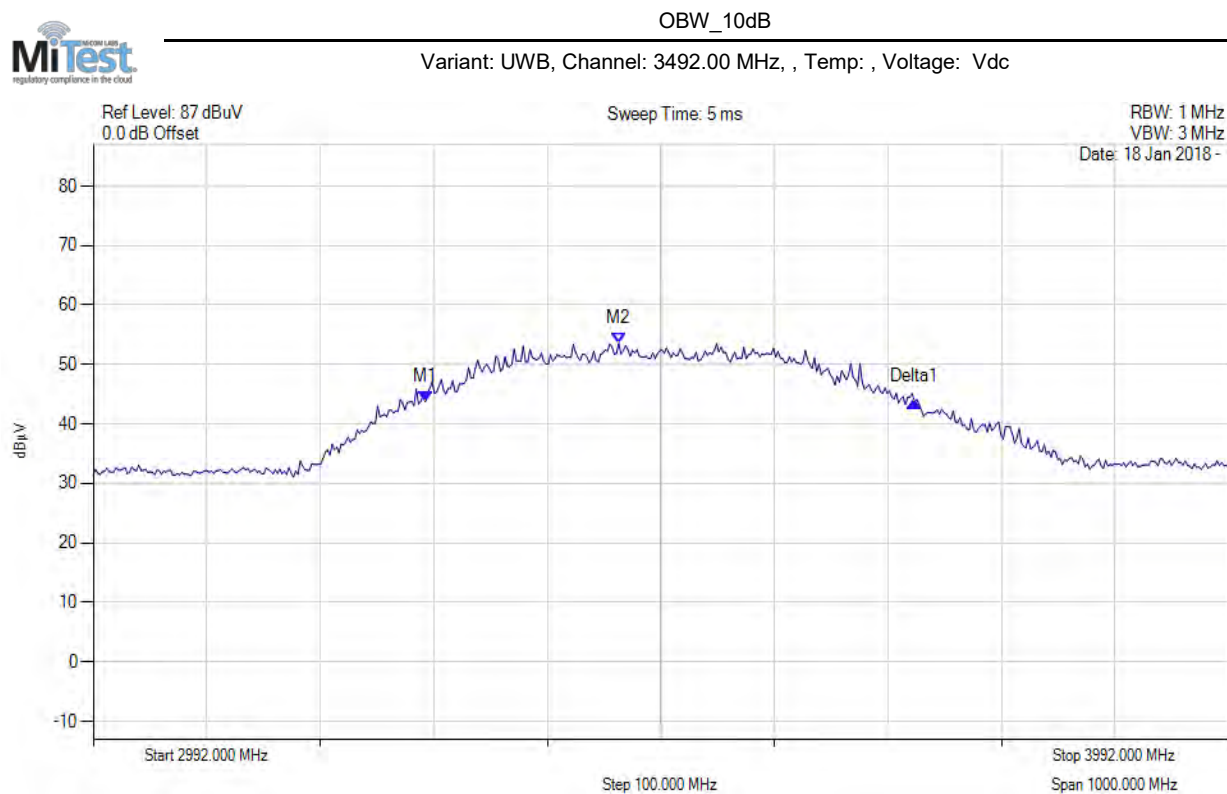


Analyzer Setup	Marker:Frequency:Amplitude	Test Results
Detector = RMS Sweep Count = 0 RF Atten (dB) = 10 Trace Mode = MAX HOLD	M1 : 3226.469 MHz : 36.409 dBuV M2 : 3334.685 MHz : 46.012 dBuV Delta1 : 501.002 MHz : -0.172 dB	Channel Frequency: 3492.00 MHz

[back to matrix](#)

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DV11-AC

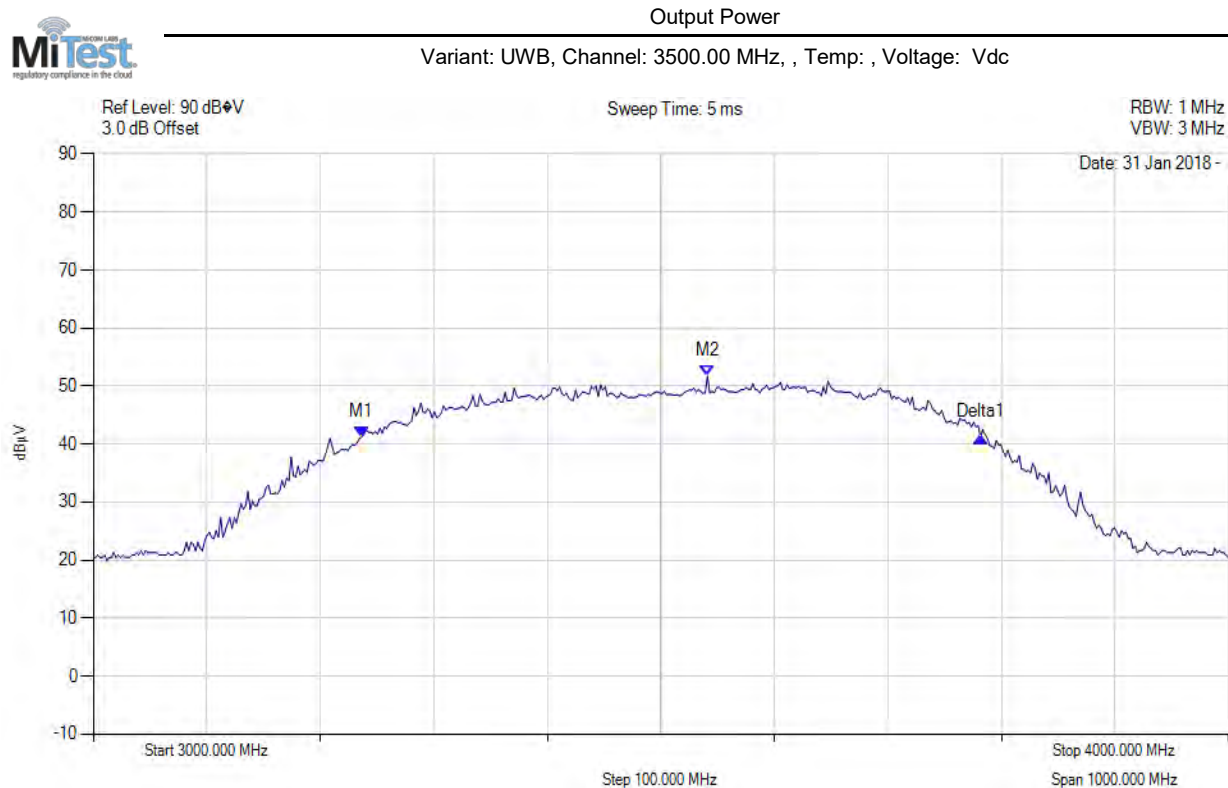


Analyzer Setup	Marker:Frequency:Amplitude	Test Results
Detector = RMS Sweep Count = 0 RF Atten (dB) = 10 Trace Mode = VIEW	M1 : 3284.585 MHz : 43.803 dBμV M2 : 3454.926 MHz : 53.514 dBμV Delta1 : 430.862 MHz : -0.140 dB	Channel Frequency: 3492.00 MHz

[back to matrix](#)

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DV31-DC



Analyzer Setup	Marker:Frequency:Amplitude	Test Results
Detector = RMS Sweep Count = 0 RF Atten (dB) = 0 Trace Mode = VIEW	M1 : 3236.473 MHz : 41.244 dBμV M2 : 3541.082 MHz : 51.689 dBμV Delta1 : 545.090 MHz : -0.042 dB	Channel Frequency: 3500.00 MHz

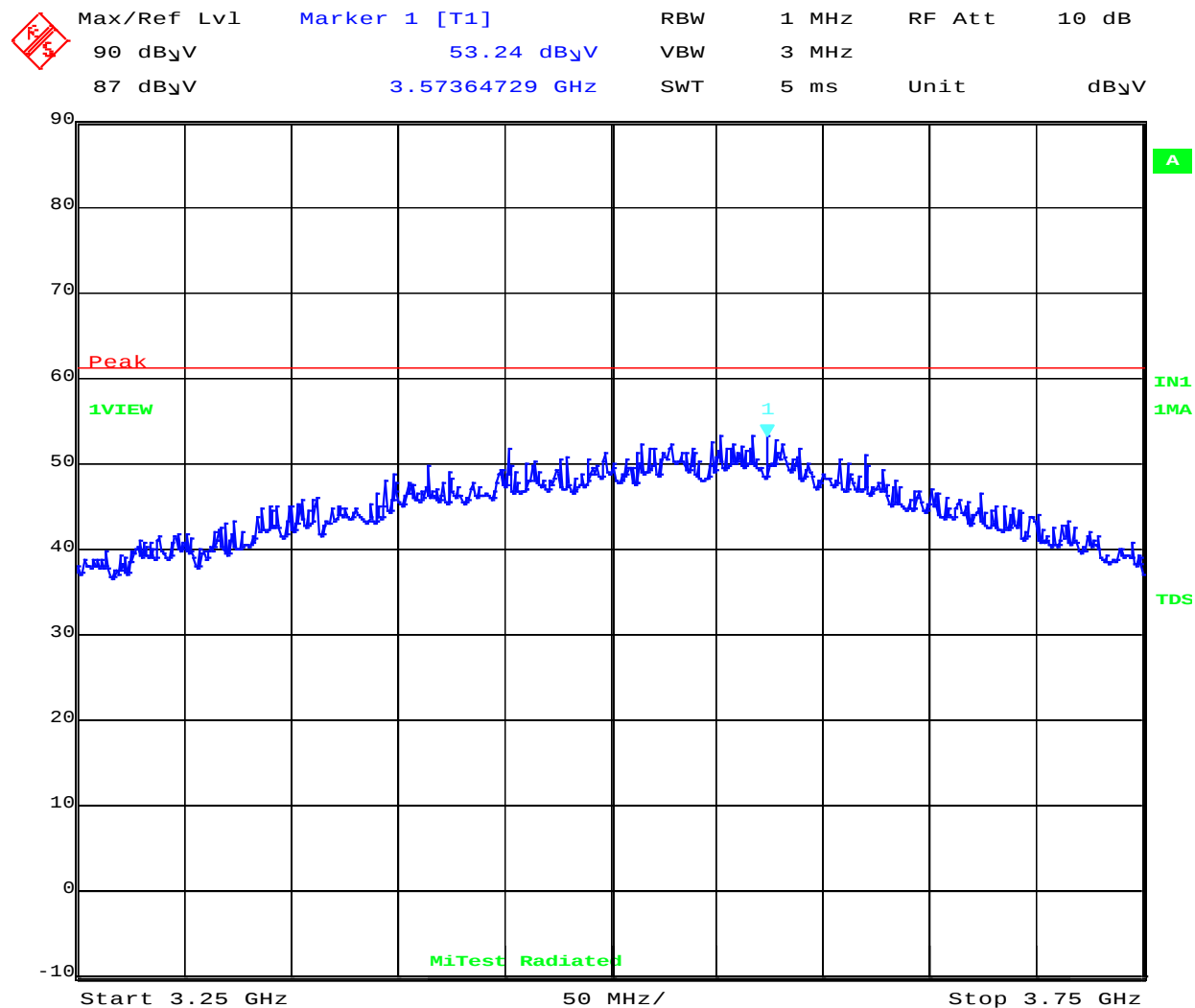
[back to matrix](#)

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A.2. Peak Power Density

DV11-AC – 500MHz Span



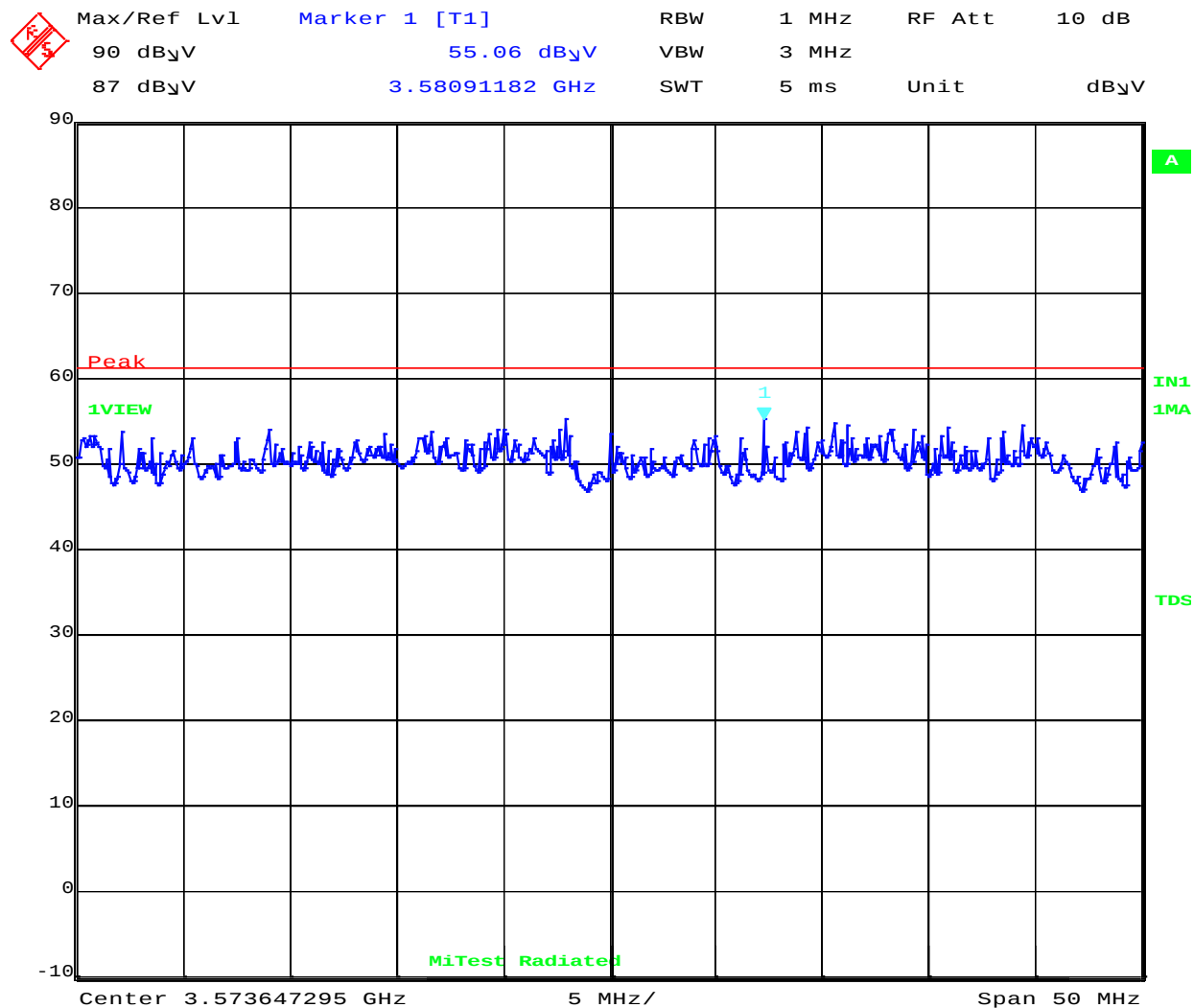
Date: 18.JUN.2018 12:37:10

[back to matrix](#)

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DV11-AC – 50MHz Span

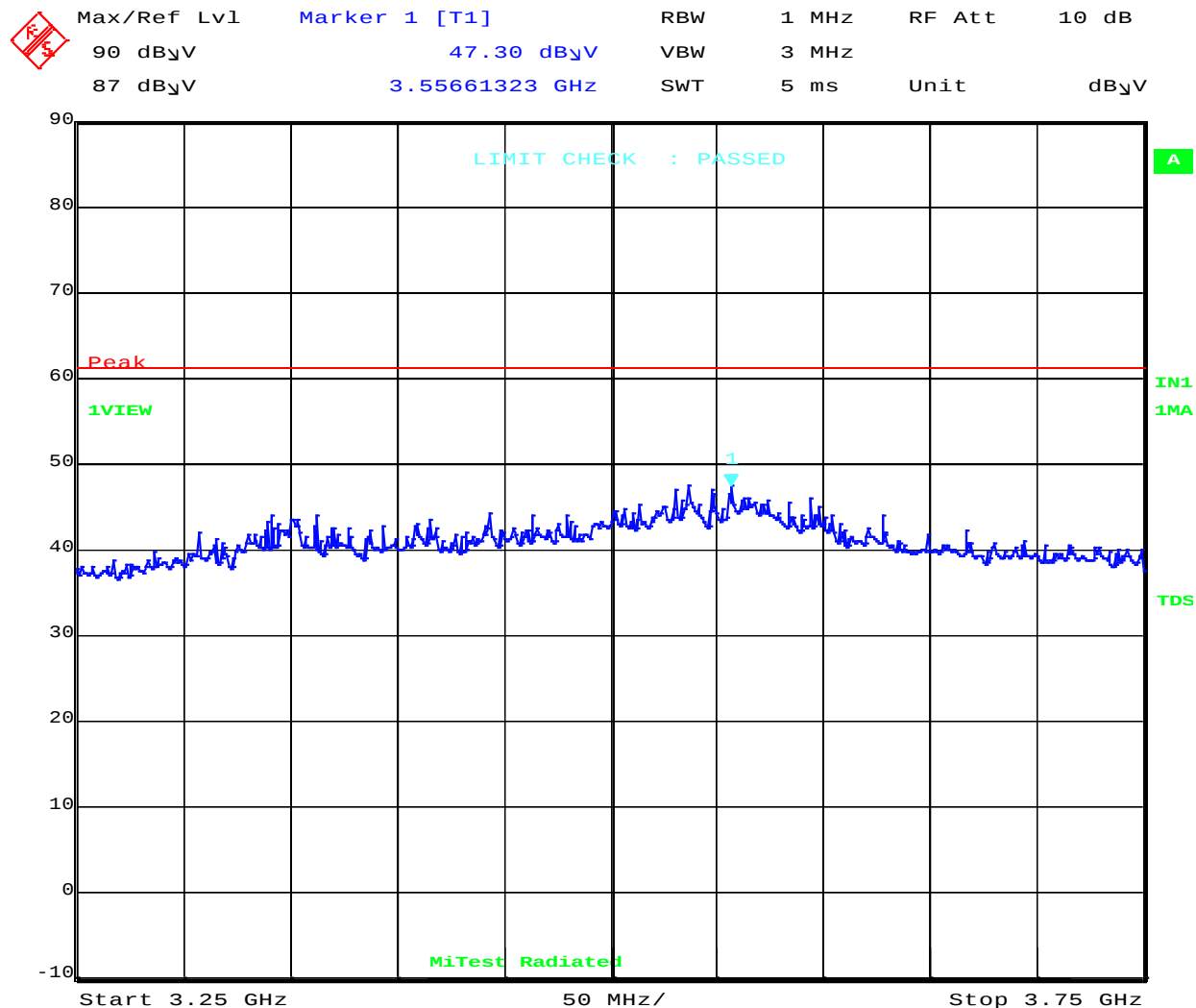


Date: 18.JUN.2018 12:39:07

[back to matrix](#)

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DV21-AC – 500MHz Span

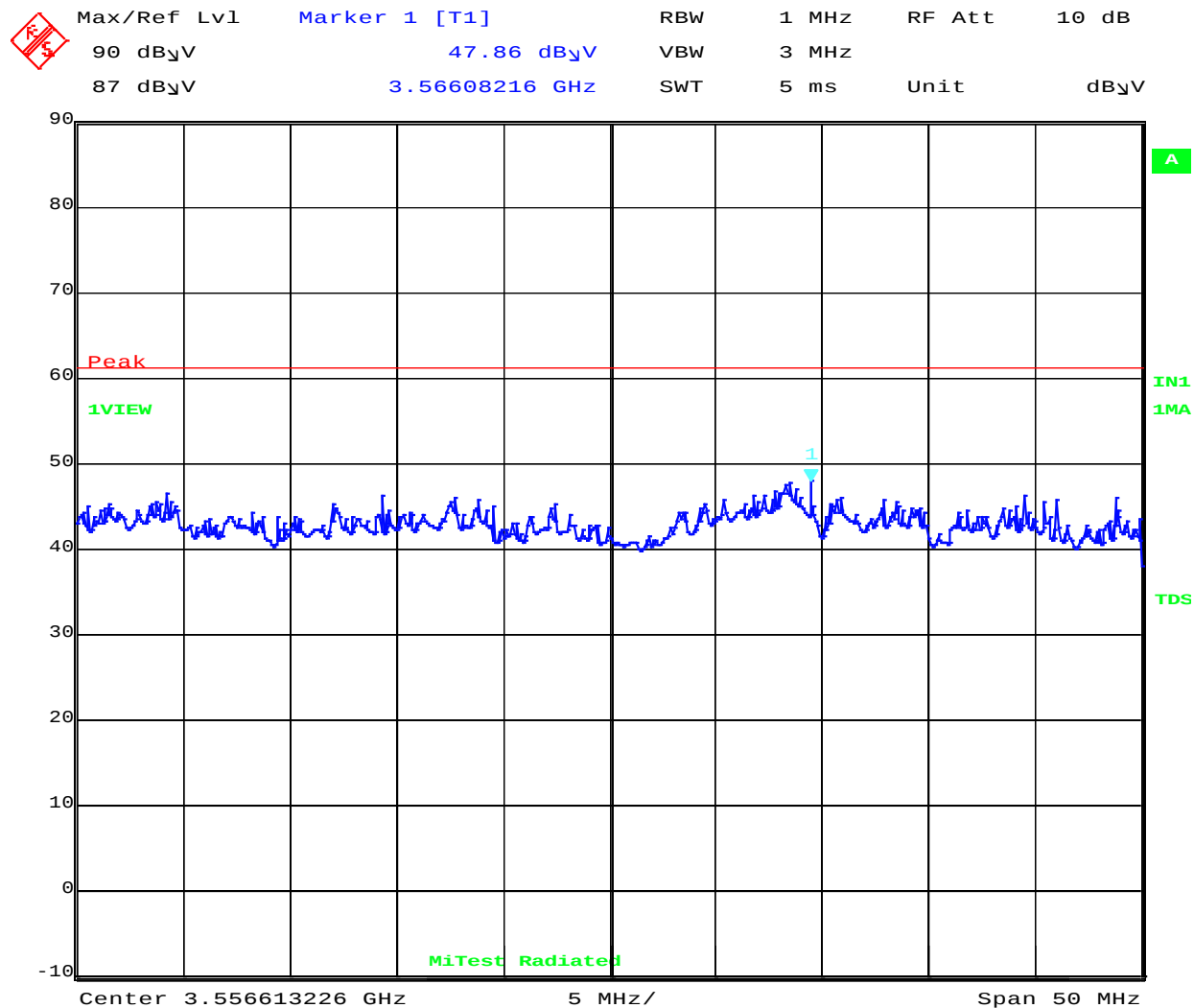


Date: 18.JUN.2018 12:44:14

[back to matrix](#)



DV21-AC – 50MHz Span

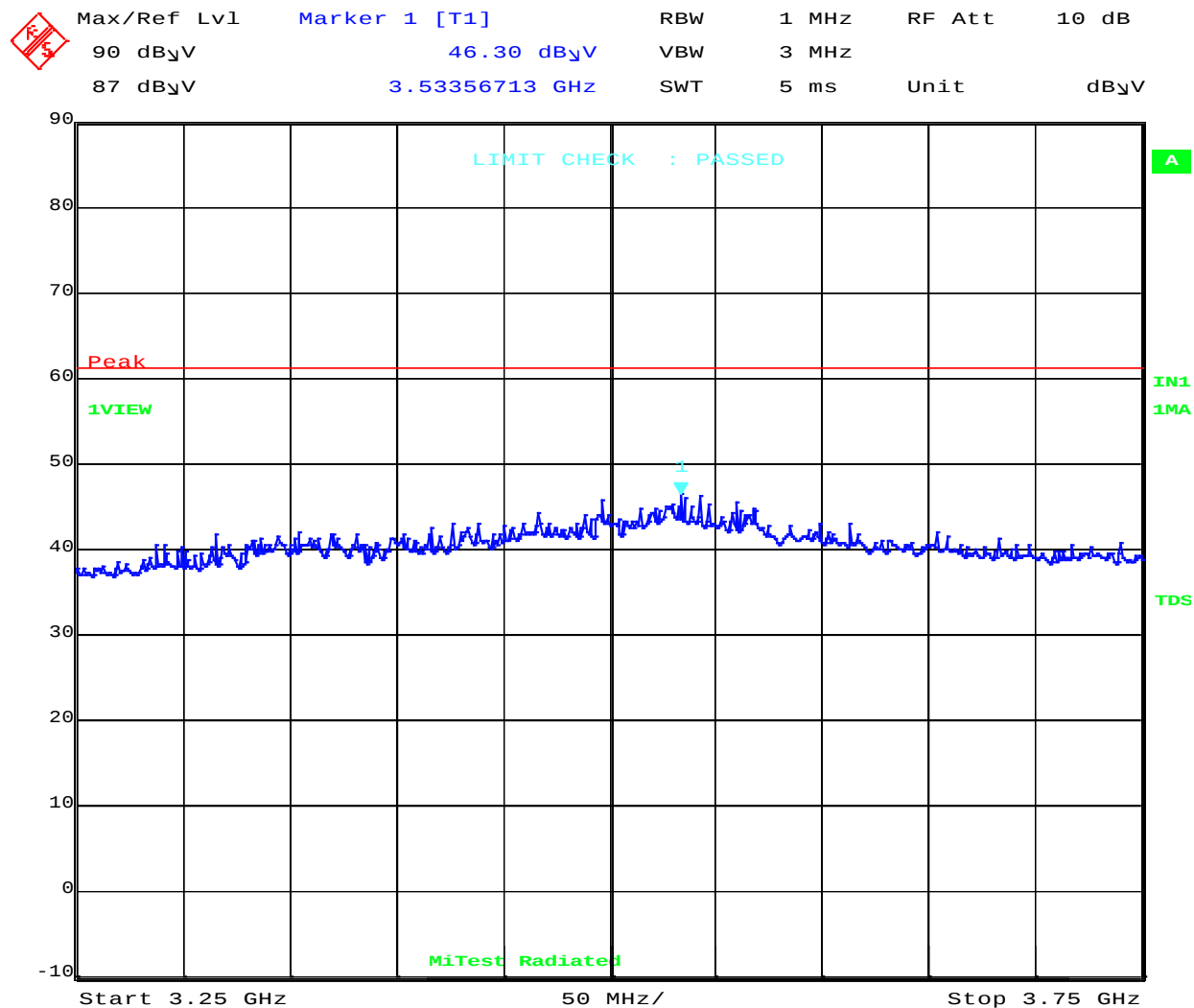


Date: 18.JUN.2018 12:46:40

[back to matrix](#)

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DV21-DC – 500MHz Span

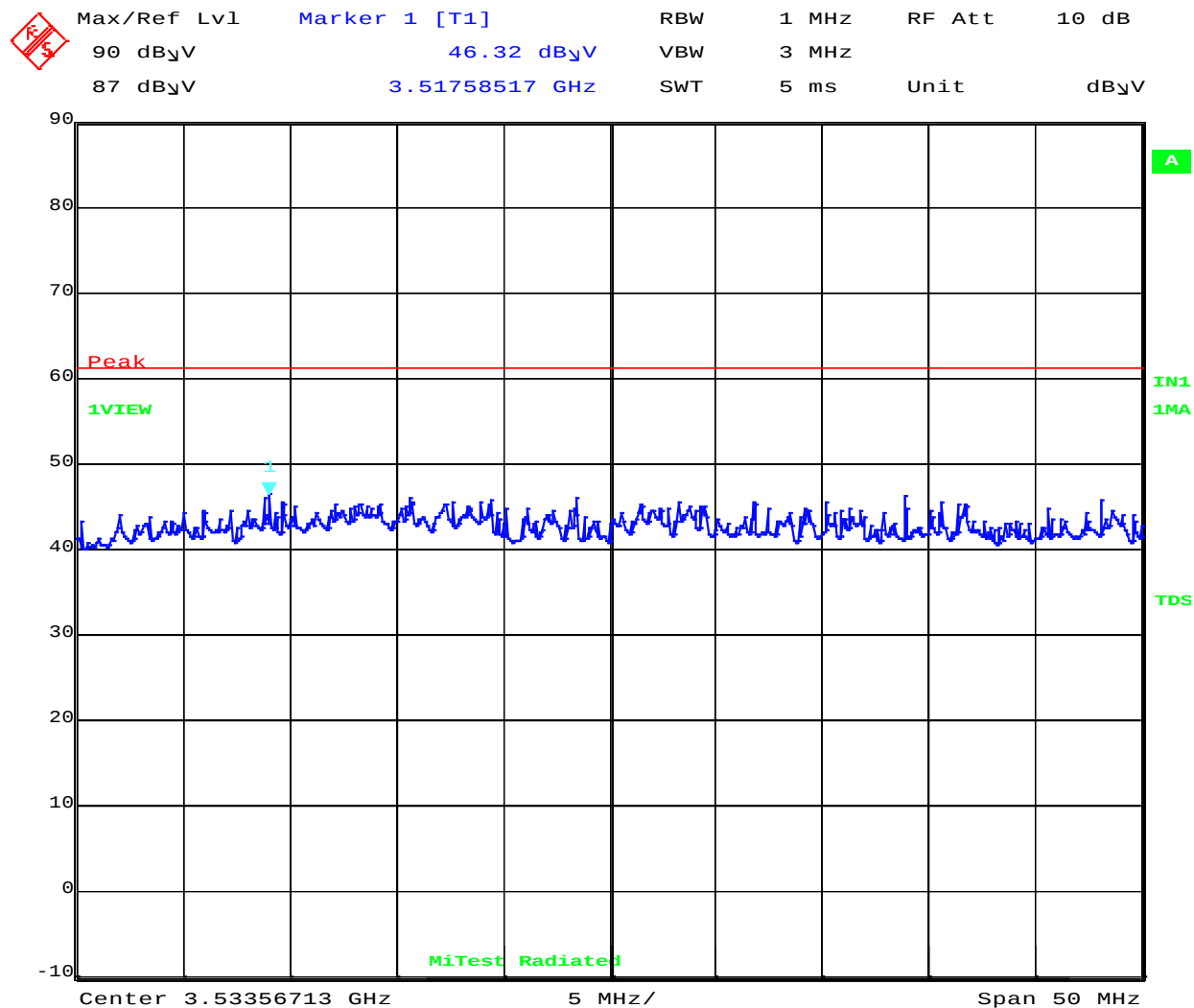


Date: 18. JUN. 2018 13:04:36

[back to matrix](#)

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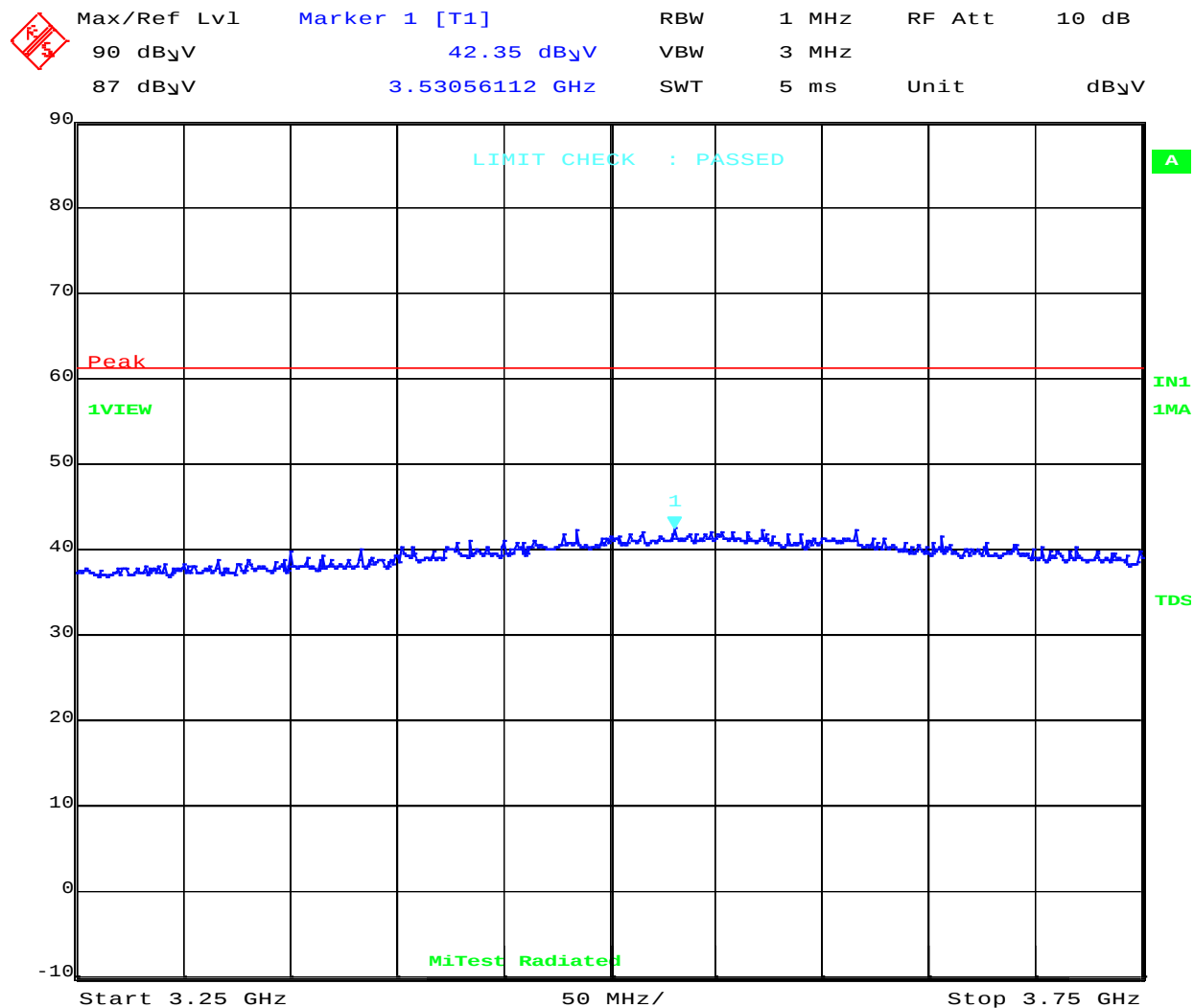
DV21-DC – 50MHz Span



Date: 18.JUN.2018 13:09:14

[back to matrix](#)

DV31-DC – 500MHz Span

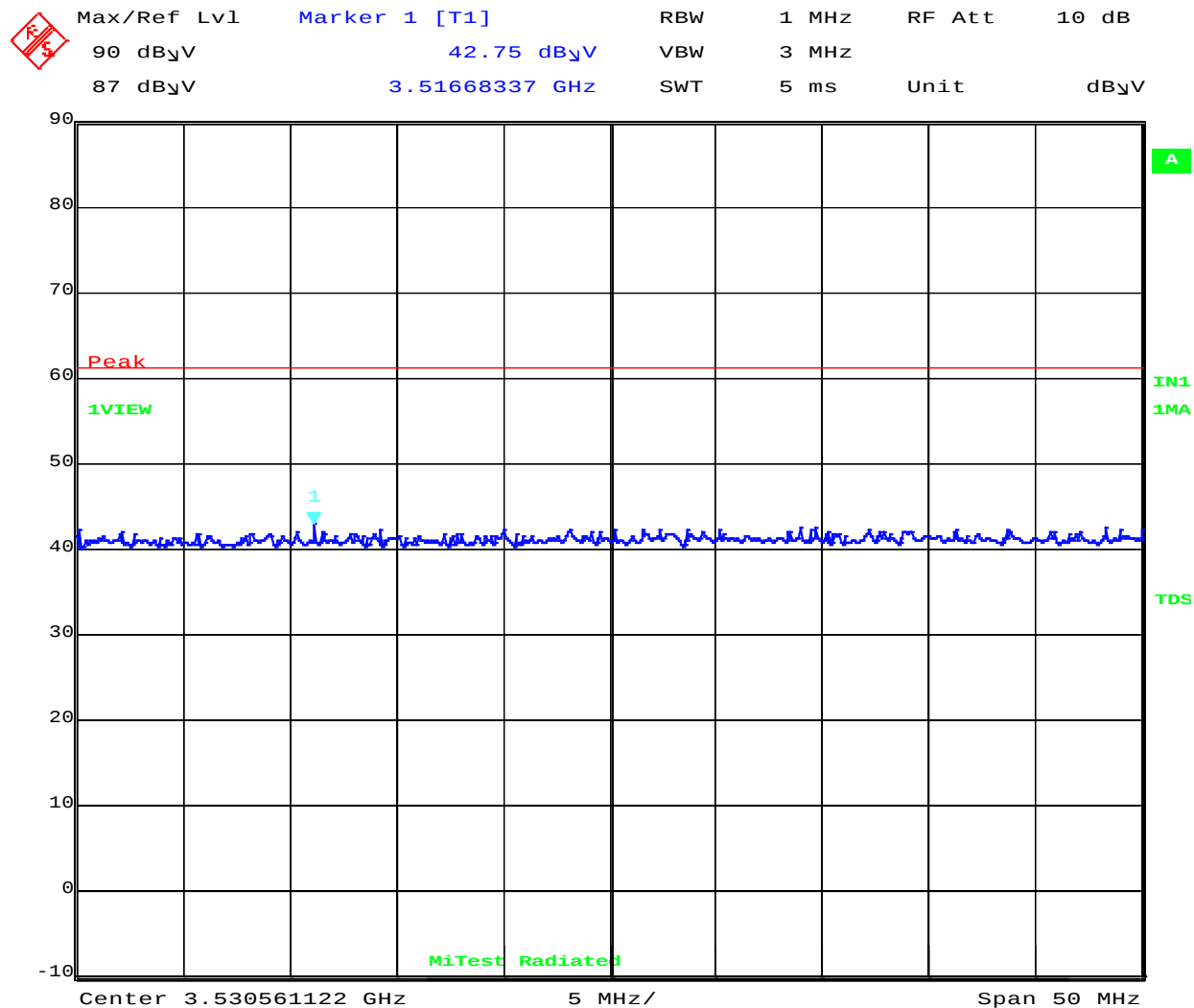


Date: 18.JUN.2018 12:54:51

[back to matrix](#)



DV31-DC – 50MHz Span



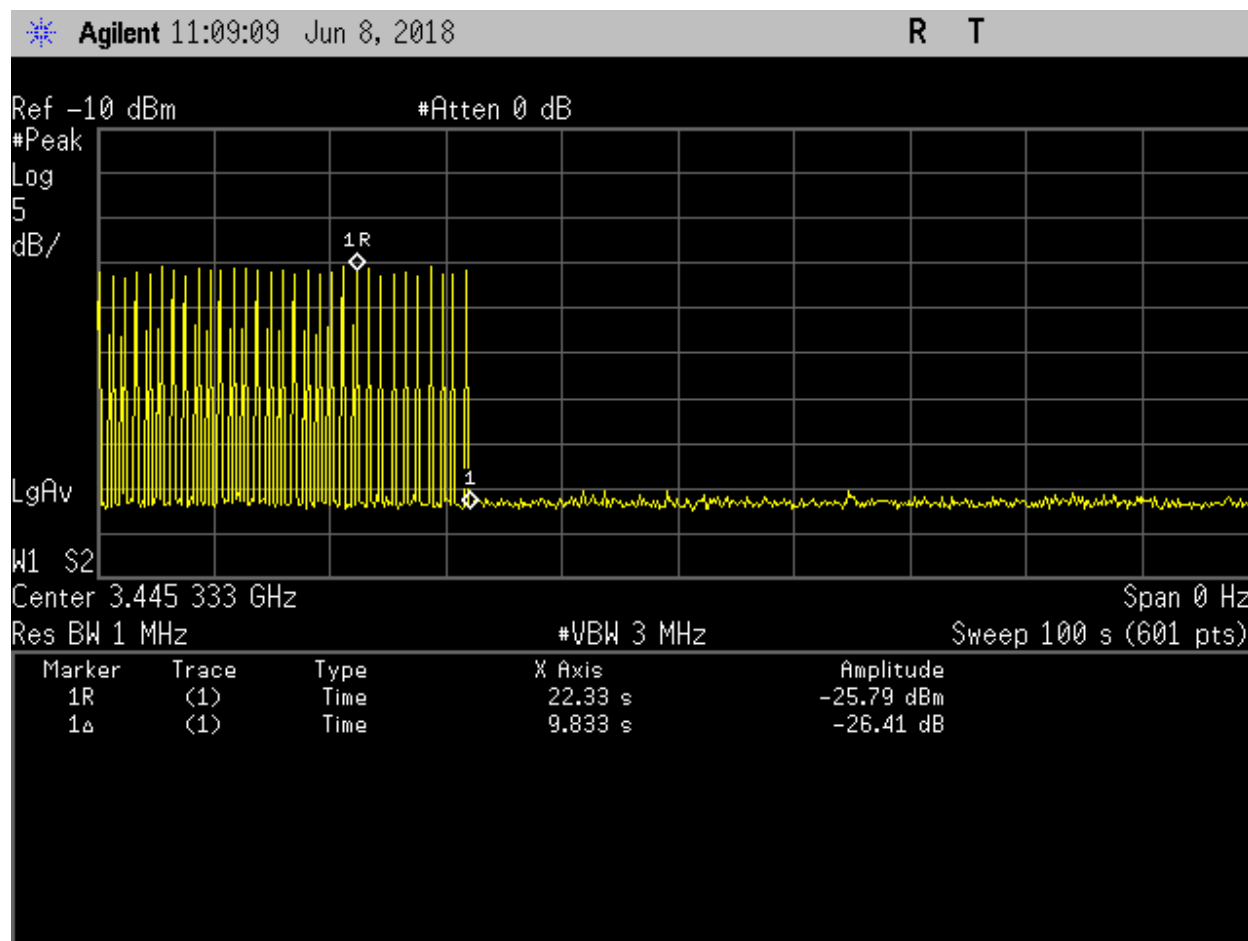
Date: 18. JUN. 2018 12:57:41

[back to matrix](#)

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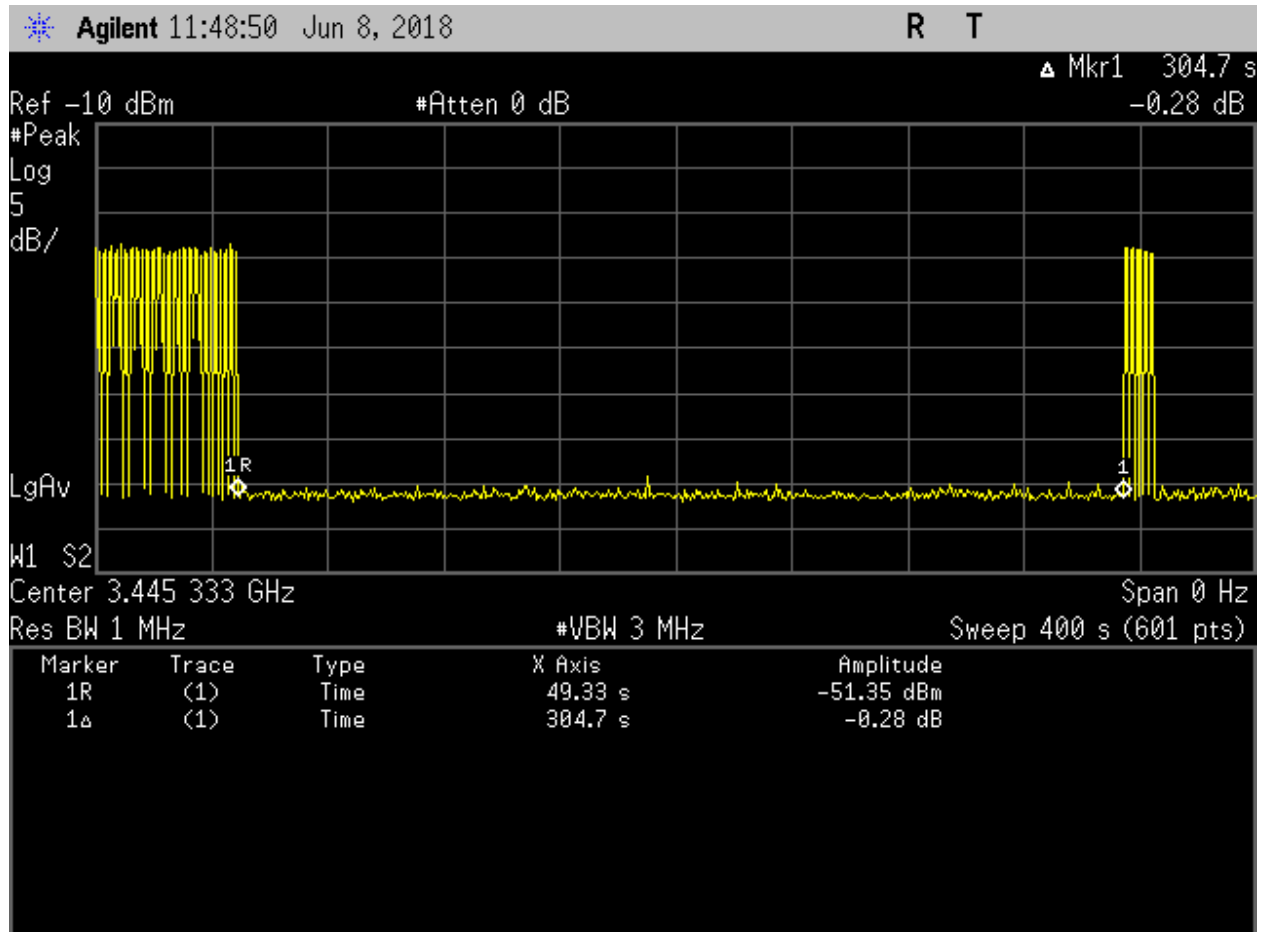
A.3. Shutoff Timing Requirements

10s Shutdown Time



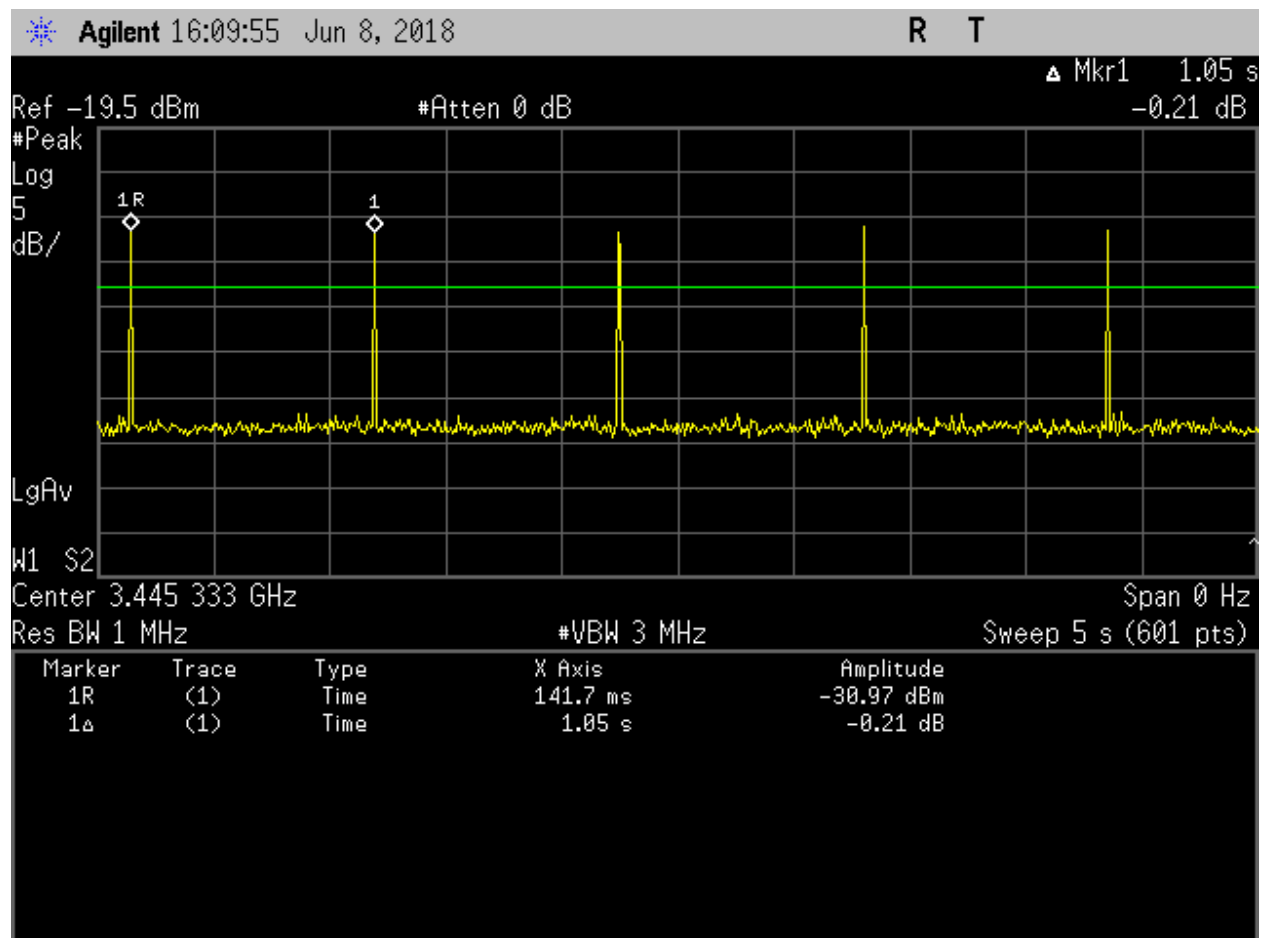
[back to matrix](#)

5min Shutdown Time



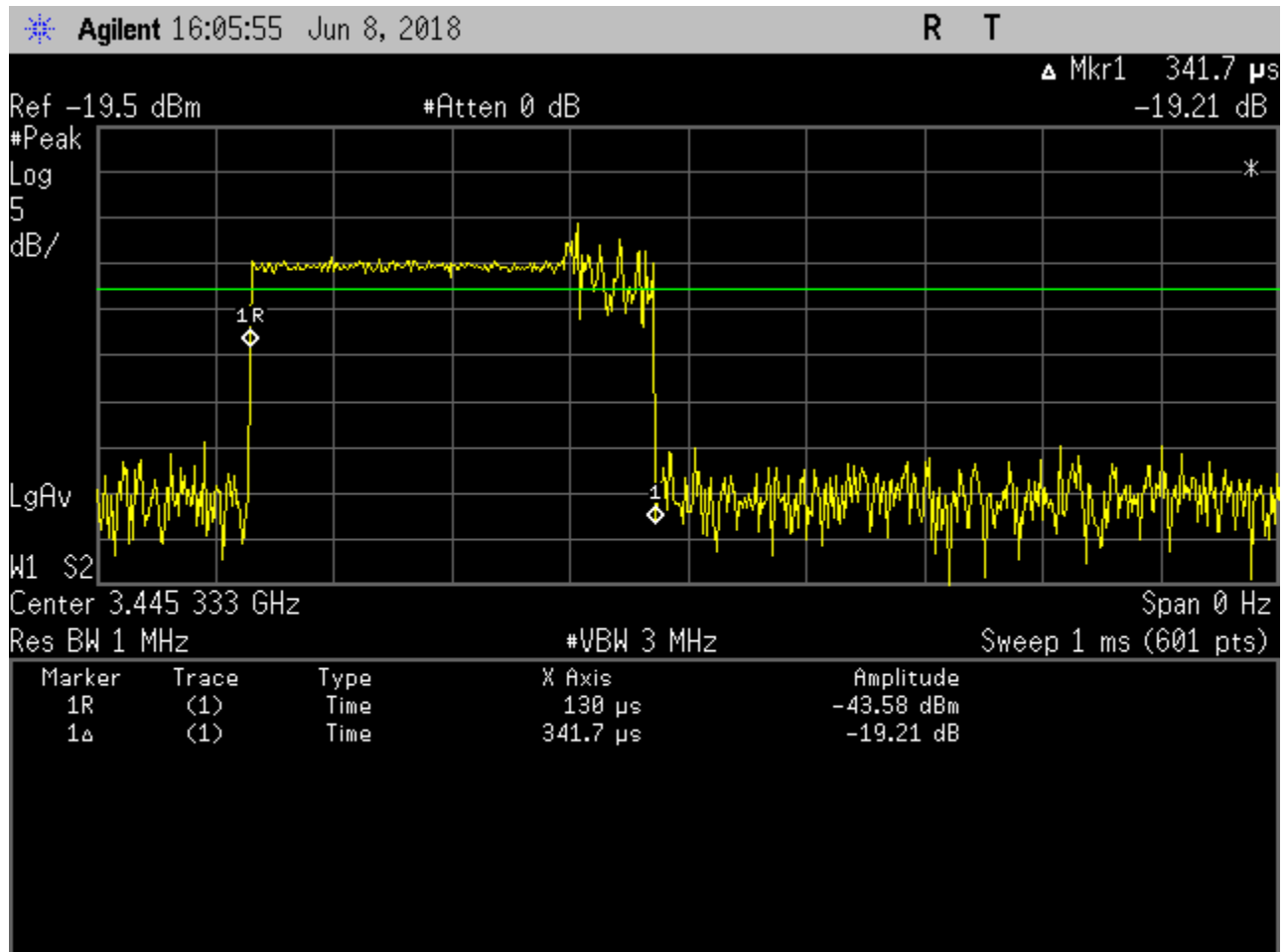
[back to matrix](#)

On Time – 5s sweep



[back to matrix](#)

On Time – Single Pulse



[back to matrix](#)



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