



REGULATORY COMPLIANCE TEST REPORT

FCC Part 15 Subpart F 15.519, 15.521 - UWB Device

Report No.: CATA03-U10 Rev A

Company: Catapult Sports Pty Ltd

Model Name: VA7401

REGULATORY COMPLIANCE TEST REPORT

Company: Catapult Sports Pty Ltd

Model Name: VA7401

To: FCC CFR 47 Part 15 Subpart F 15.519, 15.521

Test Report Serial No.: CATA03-U10 Rev A

This report supersedes: NONE

Applicant: Catapult Sports Pty Ltd Company
75-83 High St Prahran
Melbourne, Victoria 3181
Australia

Issue Date: 20th August 2020

This Test Report is Issued Under the Authority of:

MiCOM Labs, Inc.
575 Boulder Court
Pleasanton California 94566
USA
Phone: +1 (925) 462-0304
Fax: +1 (925) 462-0306
www.micomlabs.com



MiCOM Labs is an ISO 17025 Accredited Testing Laboratory

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1. ACCREDITATION, LISTINGS & RECOGNITION

1.1. TESTING ACCREDITATION

MiCOM Labs, Inc. is an accredited Electrical testing laboratory per the international standard ISO/IEC 17025:2017. 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>



Accredited Laboratory

A2LA has accredited

MICOM LABS

Pleasanton, CA

for technical competence in the field of

Electrical Testing

This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2017 General requirements for the competence of testing and calibration laboratories. This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory quality management system (refer to joint ISO-ILAC-IAF Communiqué dated April 2017).



Presented this 24th day of February 2020.



Vice President, Accreditation Services
For the Accreditation Council
Certificate Number 2381.01
Valid to November 30, 2021

For the tests to which this accreditation applies, please refer to the laboratory's Electrical Scope of Accreditation.



1.2. RECOGNITION

MiCOM Labs, Inc has widely recognized wireless testing capabilities. Our international recognition includes Conformity Assessment Body designation by APEC MRA countries. MiCOM Labs test reports are accepted globally.

Country	Recognition Body	Status	Phase	Identification No.
USA	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	Japan MRA 2	RCB 210
	Telecommunications Equipment (JATE)			
	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	

EU MRA – European Union Mutual Recognition Agreement.

NB – Notified Body

APEC MRA – Asia Pacific Economic Community Mutual Recognition Agreement. 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

1.3. PRODUCT CERTIFICATION

MiCOM Labs, Inc. is an accredited Product Certification Body per the international standard ISO/IEC 17065:2012. 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)
Industry Canada – Certification Body, CAB Identifier – US0159
Europe – Notified Body (NB), NB Identifier - 2280
Japan – Recognized Certification Body (RCB), RCB Identifier - 210

2. DOCUMENT HISTORY

Document History		
Revision	Date	Comments
Draft	3 rd June 2020	Draft for comment
Rev A	20th August 2020	Initial Release

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

3. TEST RESULT CERTIFICATE

Manufacturer: Catapult Sports Pty Ltd 75-83 High St Prahran Melbourne, Victoria 3181 Australia	Tested By: MiCOM Labs, Inc. 575 Boulder Court Pleasanton California 94566 USA
Model: VA7401	Telephone: +1 925 462 0304
Equipment Type: Mobile & Portable Client Device	Fax: +1 925 462 0306
S/N's: VEC75ELN;200416	
Test Date(s): 23 rd September - 8 th October 2019	Website: www.micomlabs.com

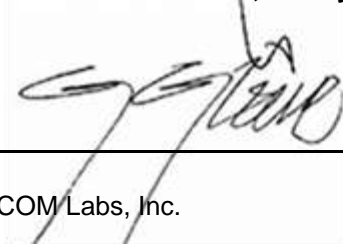
STANDARD(S)	TEST RESULTS
FCC CFR 47 Part 15 Subpart F 15.519, 15.521	EQUIPMENT COMPLIES

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.

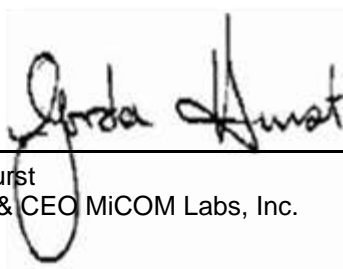
Notes:

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.

4. REFERENCES AND MEASUREMENT UNCERTAINTY

4.1. Normative References

REF.	PUBLICATION	YEAR	TITLE
I	FCC CFR 47 Part 15 F	2018	Radio Frequency Devices; Subpart F –Ultra Wide Band Devices
II	FCC CFR 47 Part 15.519	2002	Technical requirements for hand held UWB systems.
III	FCC 47 CFR Part 15.521	2005	Technical requirements applicable to all UWB devices.
IV	A2LA	October 2019	R105 - Requirement's When Making Reference to A2LA Accreditation Status
V	ANSI C63.10	2013	American National Standard for Testing Unlicensed Wireless Devices
VI	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
VII	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
VIII	M 3003	Edition 3 Nov.2012	Expression of Uncertainty and Confidence in Measurements
IX	FCC 47 CFR Part 2.1033	2016	FCC requirements and rules regarding photographs and test setup diagrams.
X	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 Catapult Sports Pty Ltd VA7401 to FCC CFR 47 Part 15 Subpart F 15.519, 15.521.
Applicant:	Catapult Sports Pty Ltd 75-83 High St Prahran Melbourne, Victoria 3181 Australia
Manufacturer:	As applicant
Laboratory performing the tests:	MiCOM Labs, Inc. 575 Boulder Court Pleasanton California 94566 USA
Test report reference number:	CATA03-U10
Date EUT received:	23 rd September 2019
Standard(s) applied:	FCC Part 15 Subpart F 15.519, 15.521
Dates of test (from - to):	23 rd – 27 th September 2019
No of Units Tested:	1
Product Family Name:	Vector
Model(s):	VA7401
Location for use:	Indoors and Outdoors
Declared Frequency Range(s):	3993.6 GHz;
Type of Modulation:	BPM/BPSK
EUT Modes of Operation:	UWB
Declared Nominal Output Power (dBm):	-8 dBm
Rated Input Voltage and Current:	3.7Vdc (Li-ion Battery)
Operating Temperature Range:	0 to 45°C
Equipment Dimensions:	175 x 130 x 59.5 mm
Weight:	520 g
Hardware Rev:	MP
Software Rev:	7.0.0
Product Application:	Mobile & Portable Client Devices

5.2. Scope Of Test Program

Catapult Sports Pty Ltd Company VA7401

The scope of the test program was to test the Catapult Sports Pty Ltd Company Vector VA7401 configurations in the frequency ranges 3100 - 10600 MHz for compliance against the following specification:

FCC CFR 47 Part 15 Subpart F – Ultra-Wideband Operation; 15.519, 15.521

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

15.519 Technical requirements for hand held UWB systems.

15.521 Technical requirements applicable to all UWB devices.

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

Type (EUT/Support)	Equipment Description	Manufacturer	Model No.	Serial No.
EUT	Mobile & Portable Client Device	Catapult Sports Pty Ltd	VA7401	200416
Support	Charging Cradle	Catapult Sports Pty Ltd	--	--

5.4. Antenna Details

Type	Manufacturer	Model	Family	Gain (dBi)	BF Gain	Dir BW	X-Pol	Frequency Band (MHz)
integral	Catapult Sports Pty Ltd	TaoGlas UWC.21	Bespoke	2.00	--	--	--	3750-4000

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

5.5. Cabling and I/O Ports

Port Type	Max Cable Length	# of Ports	Screened	Connector Type	Data Type	Data Rate(s)
USB	5m	1	Yes	USB	Digital	Unknown

5.6. Test Configurations

Results for the following configurations are provided in this report:

Operational Mode(s)	Data Rate with Highest Power MBit/s	Channel Frequency (MHz)		
		Low	Mid	High
3100-10600 MHz				
UWB	--	--	3993.6	--

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

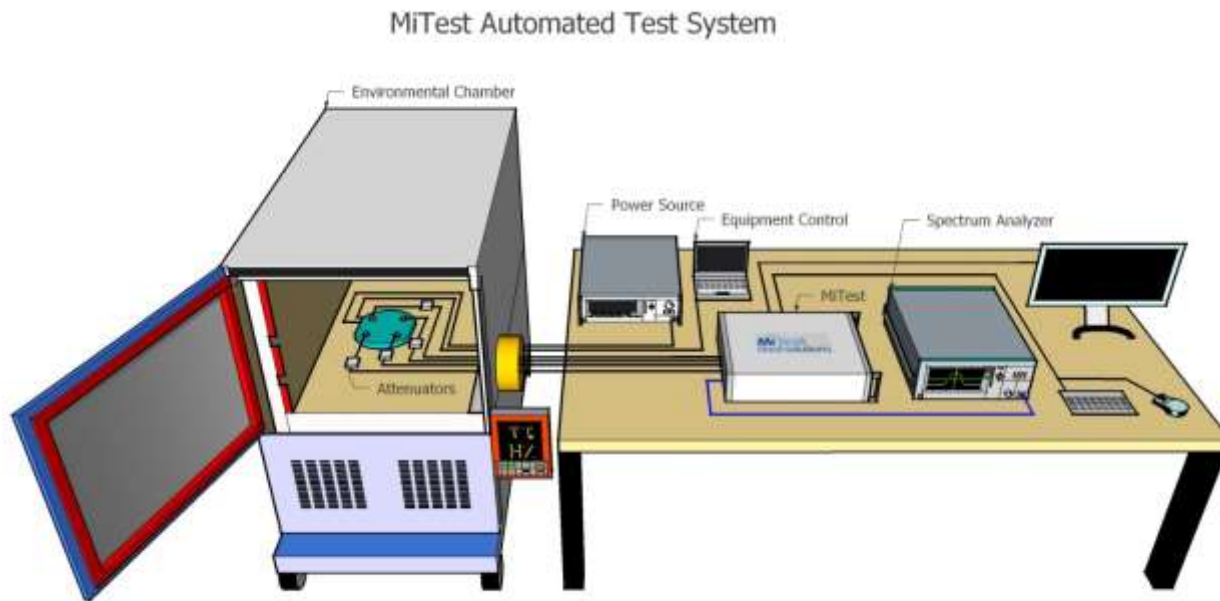
6. TEST SUMMARY

List of Measurements

Test Header	Result	Data Link
UWB Bandwidth	Complies	View Data
Peak Power	Complies	View Data
Peak Power Density	Complies	View Data
Spurious Radiated Emissions	Complies	View Data
Spurious Radiated Emissions in GPS Bands	Complies	View Data
Shutdown Timing Requirements	Complies	View Data
AC Wire Line Emissions	Complies	View Data
Comments: None		

7. TEST EQUIPMENT CONFIGURATION(S)

7.1. Conducted Test Setup



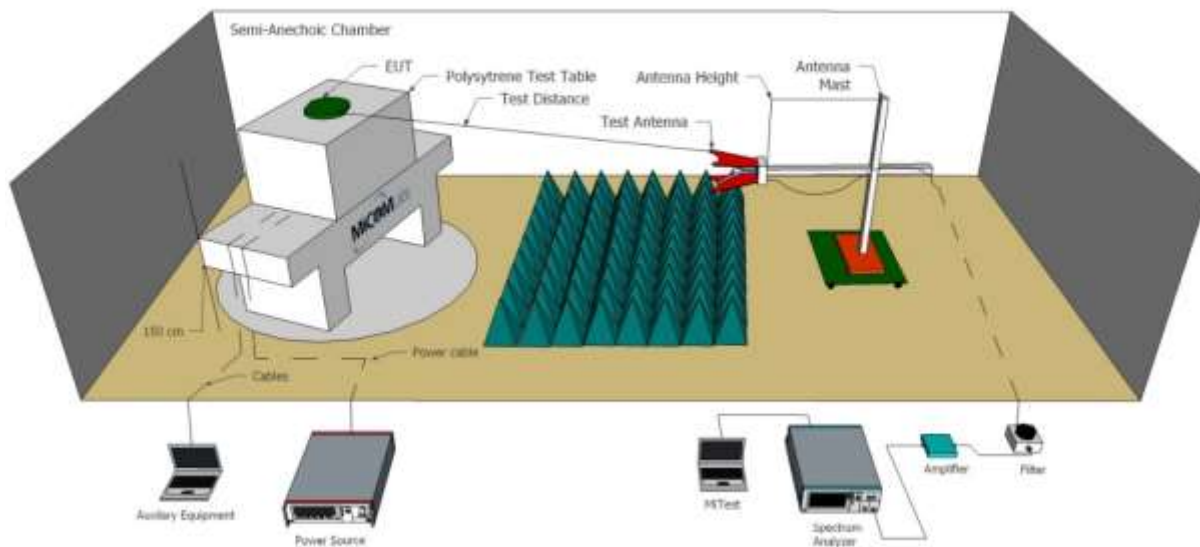
A full system calibration was performed on the test station and any resulting system losses (or gains) were considered in the production of all final measurement data.

Asset#	Description	Manufacturer	Model#	Serial#	Calibration Due Date
249	Resistance Thermometer	Thermotronics	GR2105-02	9340 #2	30 Oct 2019
361	Desktop for RF#1, Labview Software installed	Dell	Vostro 220	WS RF#1	Not Required
378	Rohde & Schwarz 40 GHz Receiver with Generator	Rhode & Schwarz	ESIB40	100107/040	12 Oct 2019
405	DC Power Supply 0-60V	Agilent	6654A	MY4001826	Cal when used
408	USB to GPIB interface	National Instruments	GPIB-USB HS	14C0DE9	Not Required
445	PoE Injector	D-Link	DPE-101GL	QTAH1E2000625	Not Required
510	Barometer/Thermometer	Control Company	68000-49	170871375	11 Dec 2019
75	Environmental Chamber	Thermatron	SE-300-2-2	27946	24 Feb 2020

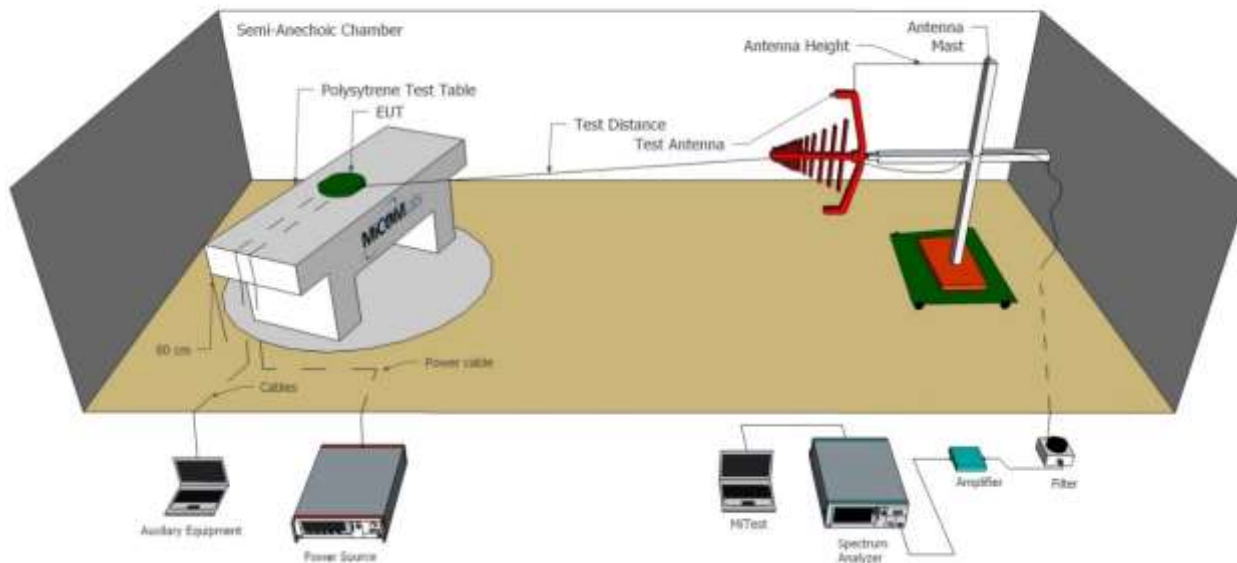
7.2. Radiated Emissions - 3m Chamber

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

Radiated Emissions Above 1GHz Test Setup



Radiated Emissions Below 1GHz Test Setup



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

Asset#	Description	Manufacturer	Model#	Serial#	Calibration Due Date
107	26–40 GHz Horn Antenna	Millimeter Products	261A	None	15 Jan 2020
145	18–26 GHz Horn Antenna	Millimeter Products	261K	None	15 Jan 2020
170	Video System Controller for Semi Anechoic Chamber	Panasonic	WV-CU101	04R08507	Not Required
298	3M Radiated Emissions Chamber Maintenance Check	MiCOM	3M Chamber	298	21 Apr 2020
336	Active Loop Antenna	Emco	6502	00060498	29 Nov 2019
338	Sunol 30 to 3000 MHz Antenna	Sunol	JB3	A052907	4 Apr 2020
378	Rohde & Schwarz 40 GHz Receiver	Rhode & Schwarz	ESIB40	100107/040	12 Oct 2019
397	Amp 10 - 2500MHz	MiCOM Labs	Amp 10 - 2500 MHz	NA	12 Apr 2020
399	ETS 1-18 GHz Horn Antenna	ETS	3117	00154575	12 Oct 2019
406	Amplifier for Radiated Emissions	MiCOM Labs	40dB 1 to 18GHz Amp	0406	12 Apr 2020
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
447	MiTest Rad Emissions Test Software	MiCOM	Test Software Version 1.0	447	Not Required
462	Schwarzbeck cable from Antenna to Amplifier.	Schwarzbeck	AK 9513	462	9 Oct 2019
463	Schwarzbeck cable from Amplifier to Bulkhead.	Schwarzbeck	AK 9513	463	9 Oct 2019
464	Schwarzbeck cable from Bulkhead to Receiver	Schwarzbeck	AK 9513	464	9 Oct 2019
465	Low Pass Filter DC-1000 MHz	Mini-Circuits	NLP-1200+	VUU01901402	9 Oct 2019
480	Cable - Bulkhead to Amp	SRC Haverhill	157-3050360	480	24 Sep 2019
481	Cable - Bulkhead to Receiver	SRC Haverhill	151-3050787	481	24 Sep 2019
510	Barometer/Thermometer	Control Company	68000-49	170871375	11 Dec 2019
518	Cable - Amp to Antenna	SRC Haverhill	157-3051574	518	24 Sep 2019

Rented Equipment

ISO17025 Accredited Calibration Certificate Number: 5000-309101859(A2LA)

Calibrated By: Rohde & Schwarz

Description	Manufacturer	Model#	Serial#	Calibration Date
Signal Analyzer	Rohde & Schwarz	FSW26	101532	12 Sep 2019

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)

9. TEST RESULTS

9.1. USB Bandwidth

Conducted Test Conditions for UWB Bandwidth			
Standard:	FCC CFR 47:15.519(b)	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

15.519 (b) The UWB bandwidth of a device operating under the provisions of this section must be contained between 3100 MHz and 10,600 MHz.

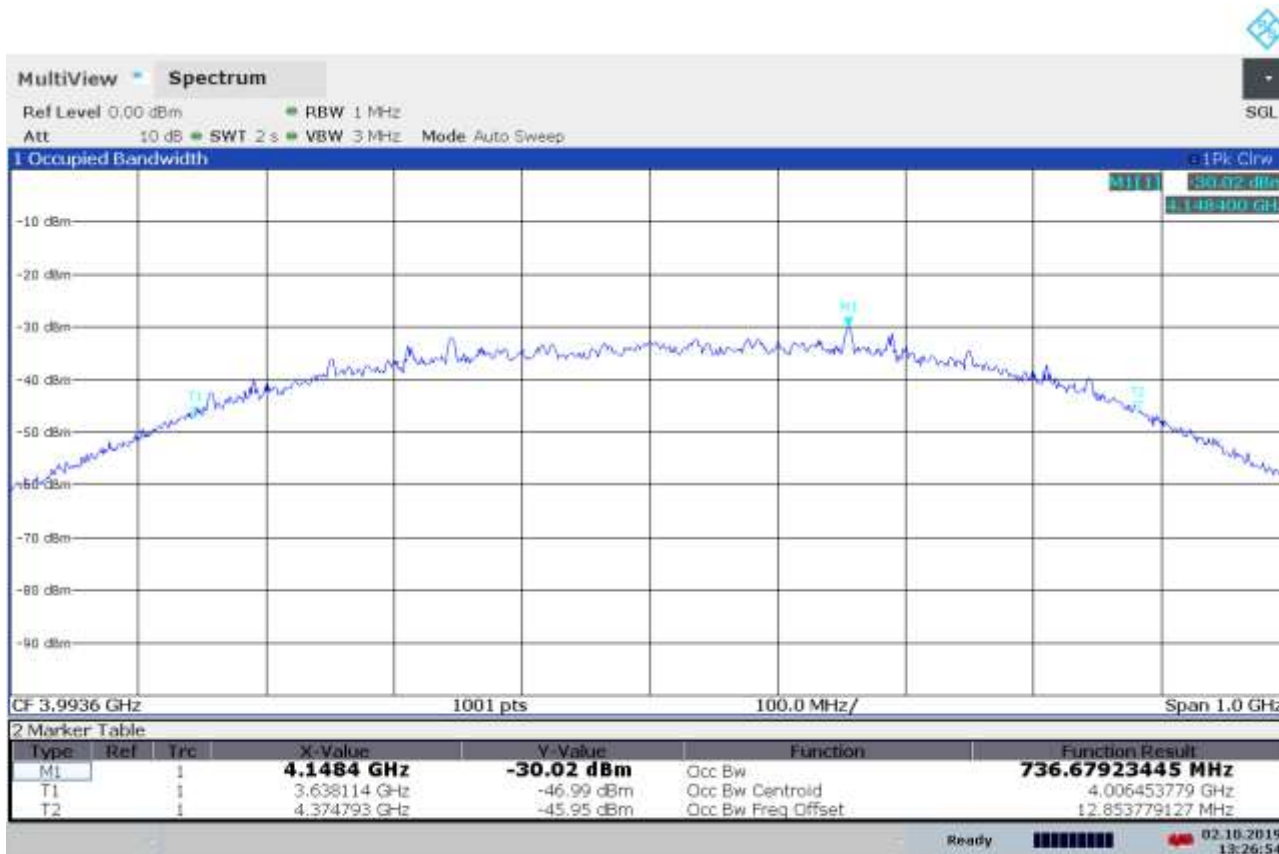
The UWB Bandwidth is measured radiated, at a 3-meter distance, while EUT is operating in transmission mode at the appropriate center frequency. The Resolution Bandwidth was set to 1MHz RBW IAW ANSI C63.10. Testing was performed under ambient conditions at nominal voltage.

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:	UWB	Duty Cycle (%):	100
Data Rate:	-	Antenna Gain (dBi):	2.0
Modulation:	--	Beam Forming Gain (Y)(dB):	Not Applicable
TPC:	Not Applicable	Tested By:	SB
Engineering Test Notes:			

Test Frequency	Measured 10 dB Bandwidth (MHz)	10 dB Bandwidth (MHz)	
		Highest	Lowest
3993.6	736.679	736.679	736.679



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Traceability to Industry Recognized Test Methodologies

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

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

9.2. 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								
<p>Test Procedure for UWB Transmission</p> <p>Testing was performed under ambient conditions at nominal voltage.</p> <p>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.</p> <p>15.519 (c) The radiated emissions at or below 960 MHz from a device operating under the provisions of this section shall not exceed the emission levels in §15.209. The radiated emissions above 960 MHz from a device operating under the provisions of this section shall not exceed the following average limits when measured using a resolution bandwidth of 1 MHz:</p> <p>Operating Frequency Band: 3100-10600 MHz</p> <p>Limits Maximum EIRP (dBm)</p> <table border="1"> <thead> <tr> <th>Frequency (MHz)</th> <th>EIRP Limit (dBm)</th> <th>EIRP at 3 Meters (dBuv/m)</th> </tr> </thead> <tbody> <tr> <td>3100 - 10600</td> <td>-41.3</td> <td>53.9</td> </tr> </tbody> </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

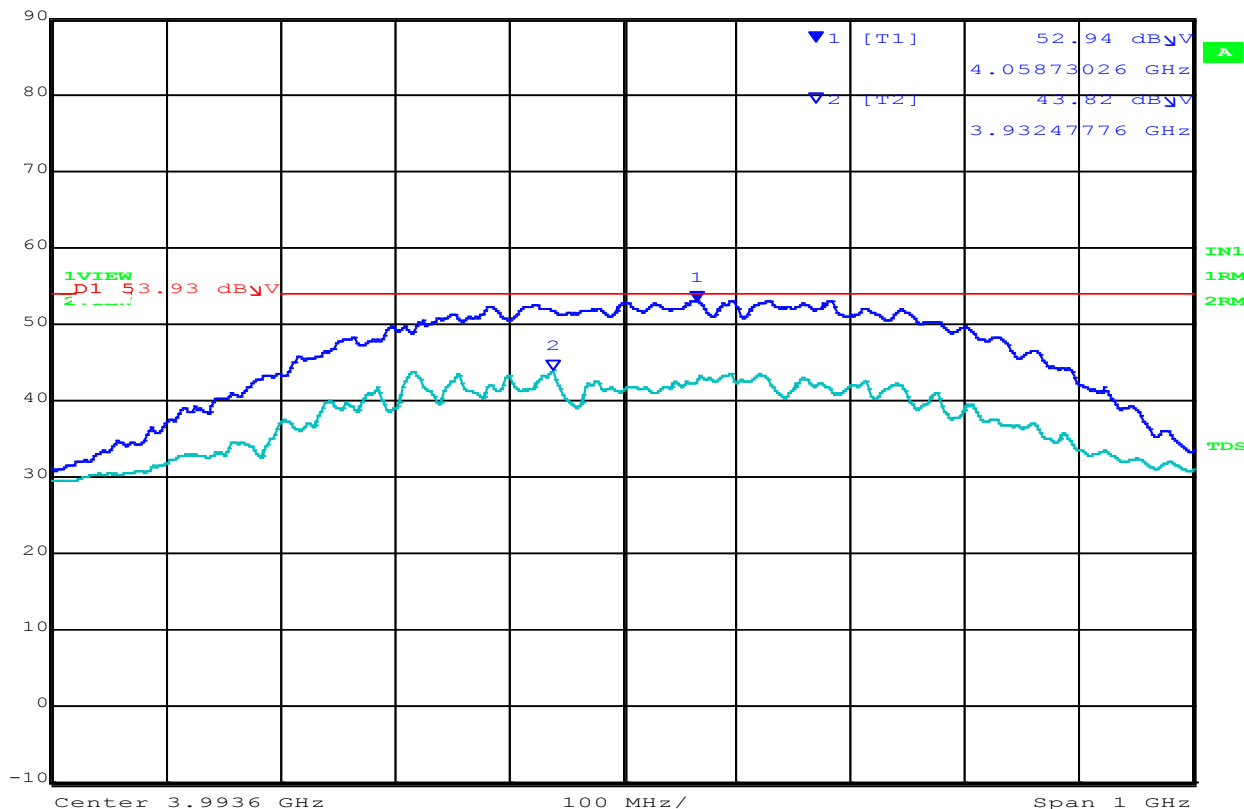
Variant:	UWB	Duty Cycle (%):	99
Data Rate:	-	Antenna Gain (dBi):	2.0
Modulation:	-	Beam Forming Gain (Y)(dB):	Not Applicable
TPC:	Not Applicable	Tested By:	SB
Engineering Test Notes:			

Test Measurement Results

Test Frequency MHz	Measured Radiated Output Power (dBm)	EIRP + Duty Cycle Correction Factor (99%)	Limit (dBm)	Margin (dB)	EUT Power Setting
3993.6	-42.29	-42.29	-41.3	-0.99	14.0

Traceability to Industry Recognized Test Methodologies

Max (Ref. Lvl)	Marker 1 [T1]	RBW	1 MHz	RF Att	10 dB
90 dB μ V	52.94 dB μ V	VBW	3 MHz		
87 dB μ V	4.05873026 GHz	SWT	1 s	Unit	dB μ V



Date: 8.OCT.2019 15:43:38

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

9.3. Peak Power Density

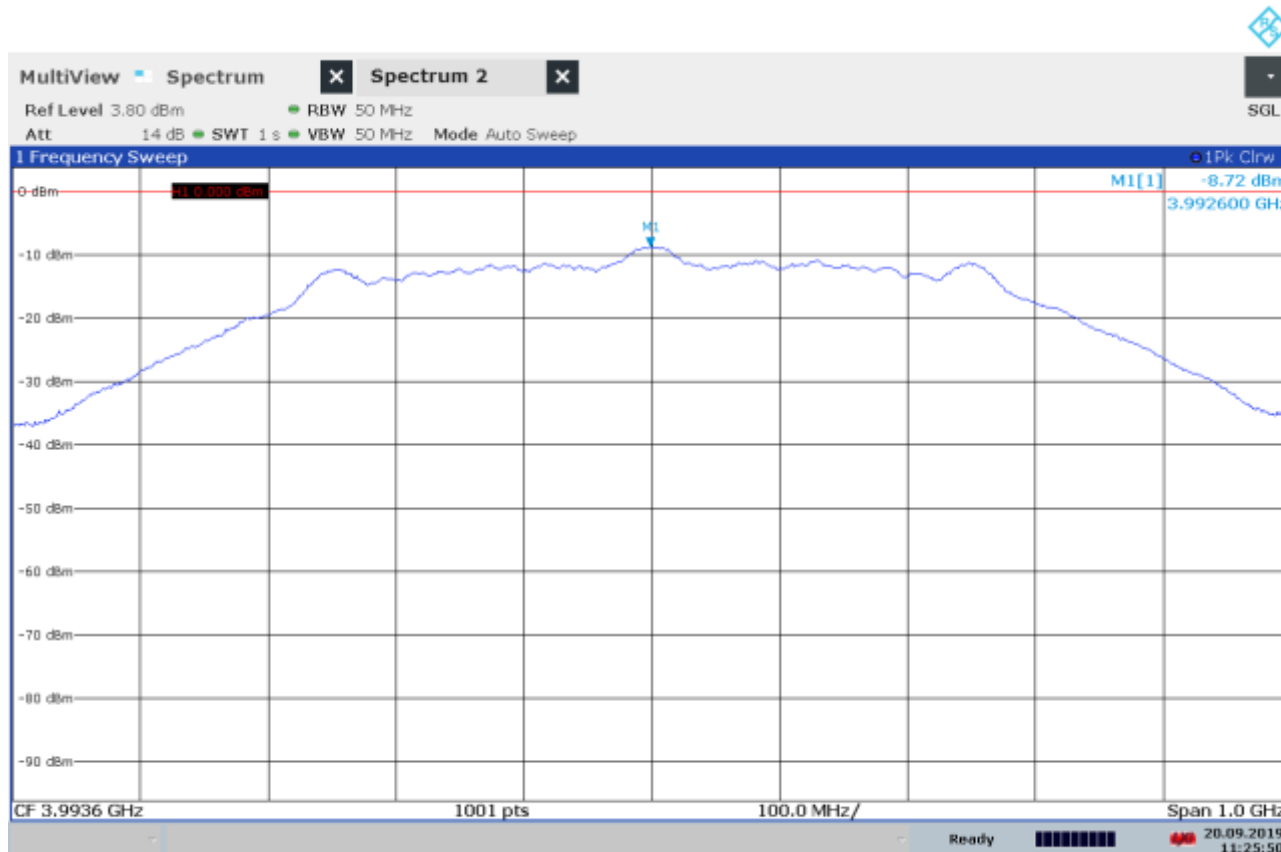
Test Conditions for Maximum Peak Power Density									
Standard:	FCC CFR 47:15.519(e), 15.521	Ambient Temp. (°C):	24.0 - 27.5						
Test Heading:	Radiated Emissions UWB Transmission	Rel. Humidity (%):	32 - 45						
Standard Section(s):	ANSI C63.10 Section 10.3.6	Pressure (mBars):	999 - 1001						
Reference Document(s):	None								
<p>Test Procedure for UWB Transmission</p> <p>15.519 (e) There is a limit on the peak level of the emissions contained within a 50 MHz bandwidth centered on the frequency at which the highest radiated emission occurs, fM. That limit is 0 dBm EIRP. It is acceptable to employ a different resolution bandwidth, and a correspondingly different peak emission limit, following the procedures described in §15.521.</p> <p>Testing was performed under ambient conditions at nominal voltage.</p> <p>Test configuration and setup used for the measurement was per the Radiated Test Set-up section specified in this document.</p> <p>Operating Frequency Band: 3100-10600 MHz</p> <p>Limits Maximum EIRP (dBm)</p> <table border="1"> <thead> <tr> <th>Frequency (MHz)</th> <th>EIRP Limit (dBm/50MHz)</th> <th>EIRP Limit (dBm/1MHz)</th> </tr> </thead> <tbody> <tr> <td>3100 - 10600</td> <td>0</td> <td>-34</td> </tr> </tbody> </table>				Frequency (MHz)	EIRP Limit (dBm/50MHz)	EIRP Limit (dBm/1MHz)	3100 - 10600	0	-34
Frequency (MHz)	EIRP Limit (dBm/50MHz)	EIRP Limit (dBm/1MHz)							
3100 - 10600	0	-34							

Equipment Configuration for Peak Power Density

Variant:	UWB	Duty Cycle (%):	99
Data Rate:	-	Antenna Gain (dBi):	2.0
Modulation:	--	Beam Forming Gain (Y)(dB):	Not Applicable
TPC:	Not Applicable	Tested By:	SB
Engineering Test Notes:			

Test Measurement Results

Test Frequency MHz	Measured Peak Power Density (dBm)	EIRP + Duty Cycle Correction Factor (99%)	Limit (dBm)	Margin (dB)	EUT Power Setting
3993.6	-8.72	-9.58	0.0	-9.58	16.0



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Traceability to Industry Recognized Test Methodologies

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

9.4. Transmitter Spurious Band Emissions

Radiated Test Conditions for Radiated Spurious and Band-Edge Emissions			
Standard:	FCC CFR 47 15.519(c) (d) (e) , 15.521(d)	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 max 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

Measurements made at 1 meter to meet noise floor to limit requirements

Radiated Spurious Emissions in the GPS Bands 15.519 (c), 15.521 (d)

15.519 (c) The radiated emissions at or below 960 MHz from a device operating under the provisions of this section shall not exceed the emission levels in §15.209. The radiated emissions above 960 MHz from a device operating under the provisions of this section shall not exceed the following average limits when measured using a resolution bandwidth of 1 MHz:

Frequency Range		Average Limit	
MHz	MHz	EIRP (dBm)	EIRP at 1 Meters (dBuV/m)
960	1610	-75.3	29.4
1610	1990	-63.3	41.4
1990	3100	-61.3	43.4
3100	10600	-41.3	63.4
10600	18000	-61.3	43.4

Radiated Spurious Emissions in the GPS Bands 15.519(d), 15.521 (d)

15.519 (d) In addition to the radiated emission limits specified in the table in paragraph (c) of this section, UWB transmitters operating under the provisions of this section shall not exceed the following average limits when measured using a resolution bandwidth of no less than 1 kHz:

Frequency Range		Average Limit	
MHz	MHz	EIRP (dBm)	EIRP at 1 Meters (dBuV/m)
1164	1240	-85.3	19.47
1559	1610	-85.3	19.47

50 MHz Peak Emissions 15.519, 15.521

15.519 (e) There is a limit on the peak level of the emissions contained within a 50 MHz bandwidth centered on the frequency at which the highest radiated emission occurs, f_M . That limit is 0 dBm EIRP. It is acceptable to employ a different resolution bandwidth, and a correspondingly different peak emission limit, following the procedures described in §15.521

Within 50 MHz bandwidth centered on highest radiated emissions f_M , Limit is 0.0 dBm EIRP. At 1-meter distance the equivalent level is 104.77 dBuV/m

9.4.1. Transmitter Spurious Emissions

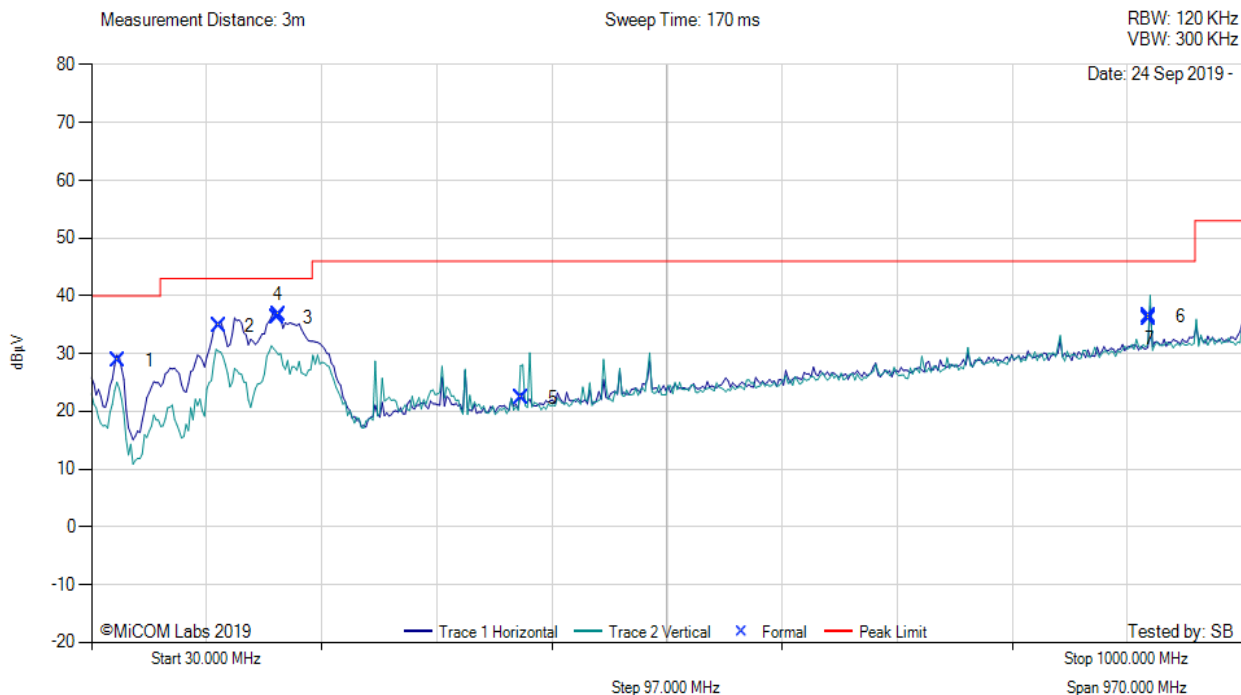
Equipment Configuration for Radiated Digital Emissions

Antenna:	Taoglas UWC.21	Variant:	UWB
Antenna Gain (dBi):	2.0	Modulation:	--
Beam Forming Gain (Y):	Not Applicable	Duty Cycle (%):	99%
Channel Frequency (MHz):	3993.6	Data Rate:	
Power Setting:	Max	Tested By:	SB

Test Measurement Results



Variant: UWB, Test Freq: 3993.60 MHz, Power Setting: 14



30.00 - 1000.00 MHz

Num	Frequency MHz	Raw dBµV	Cable Loss dB	AF dB/m	Level dBµV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBµV/m	Margin dB	Pass /Fail
1	52.88	46.15	3.71	-21.00	28.86	Peak (NRB)	Horizontal	100	0	--	--	Pass
2	137.59	45.72	4.18	-15.20	34.70	Peak (Scan)	Horizontal	100	0	43.0	-8.3	Pass
3	186.27	48.92	4.40	-17.10	36.22	Peak (NRB)	Horizontal	100	0	--	--	Pass
4	187.66	49.32	4.41	-17.10	36.63	Peak (NRB)	Horizontal	100	0	--	--	Pass
5	392.77	29.70	5.15	-12.50	22.35	Peak (NRB)	Vertical	100	0	--	--	Pass
6	921.64	34.71	6.70	-5.00	36.41	Peak (NRB)	Vertical	100	0	--	--	Pass
7	921.64	34.39	6.70	-5.00	36.09	Peak (NRB)	Horizontal	100	0	--	--	Pass

Test Notes: ACDC 110V-Receiver Unit

Equipment Configuration for Spurious Emissions

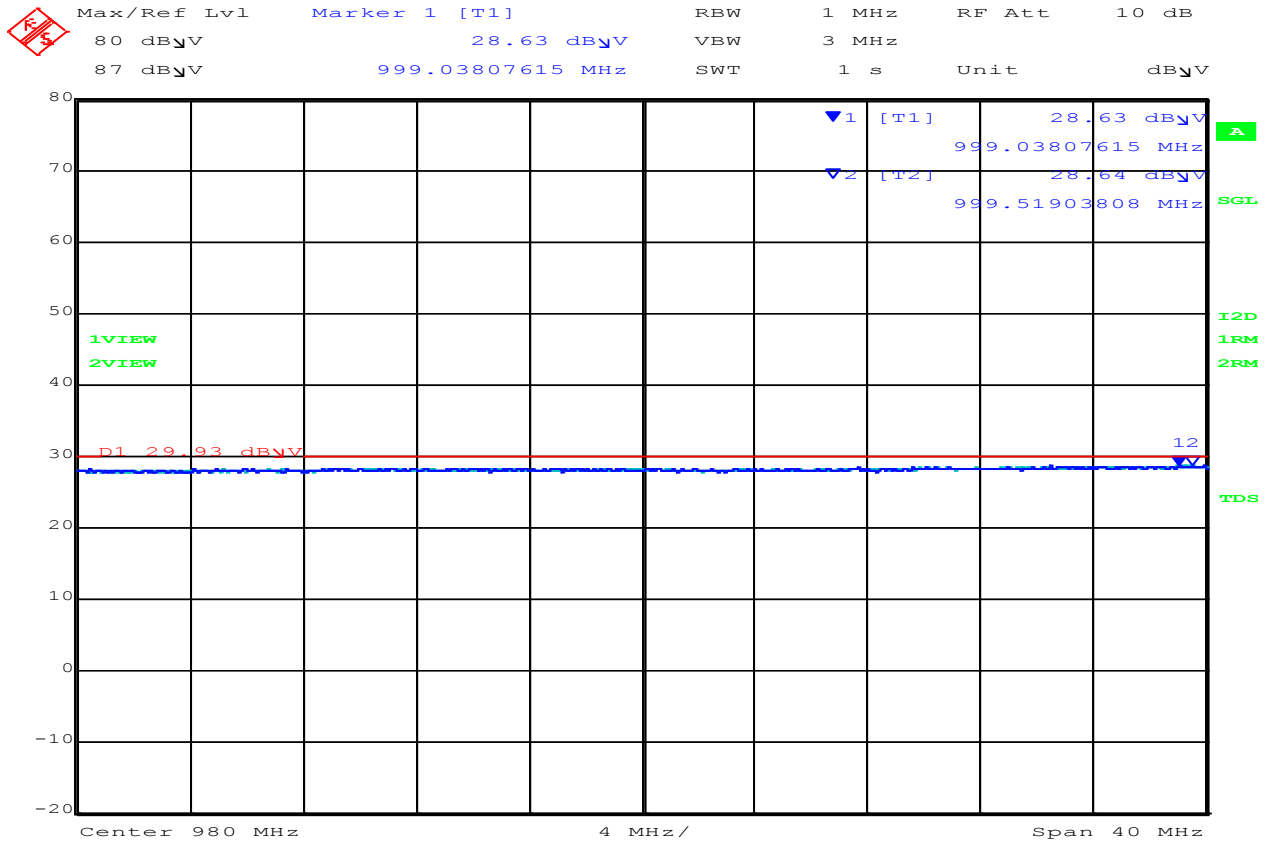
Antenna:	Taoglas UWC.21	Variant:	UWB
Antenna Gain (dBi):	2.0	Modulation:	--
Beam Forming Gain (Y):	Not Applicable	Duty Cycle (%):	99%
Channel Frequency (MHz):	3993.6	Data Rate:	
Power Setting:	Max	Tested By:	SB

Test Measurement Results



RADIATED SPURIOUS EMISSIONS 960MHz-1.00GHz

Test Freq: 3993.6 MHz, Antenna: integral, Power Setting: 14, Duty Cycle (%): 99



Date: 20.SEP.2019 11:41:51

960.00- 1000.00 MHz									
Num	Frequency MHz	Level dBμV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBμV/m	Margin dB	Pass /Fail
1	999.03*	28.63	Average	Vertical	150	0	29.4	-0.77	Pass
2	999.51*	28.64	Average	Horizontal	150	0	29.4	-0.76	Pass

Test Notes: None

Equipment Configuration for Spurious Emissions

Antenna:	Taoglas UWC.21	Variant:	UWB
Antenna Gain (dBi):	2.0	Modulation:	--
Beam Forming Gain (Y):	Not Applicable	Duty Cycle (%):	99%
Channel Frequency (MHz):	3993.6	Data Rate:	
Power Setting:	Max	Tested By:	SB

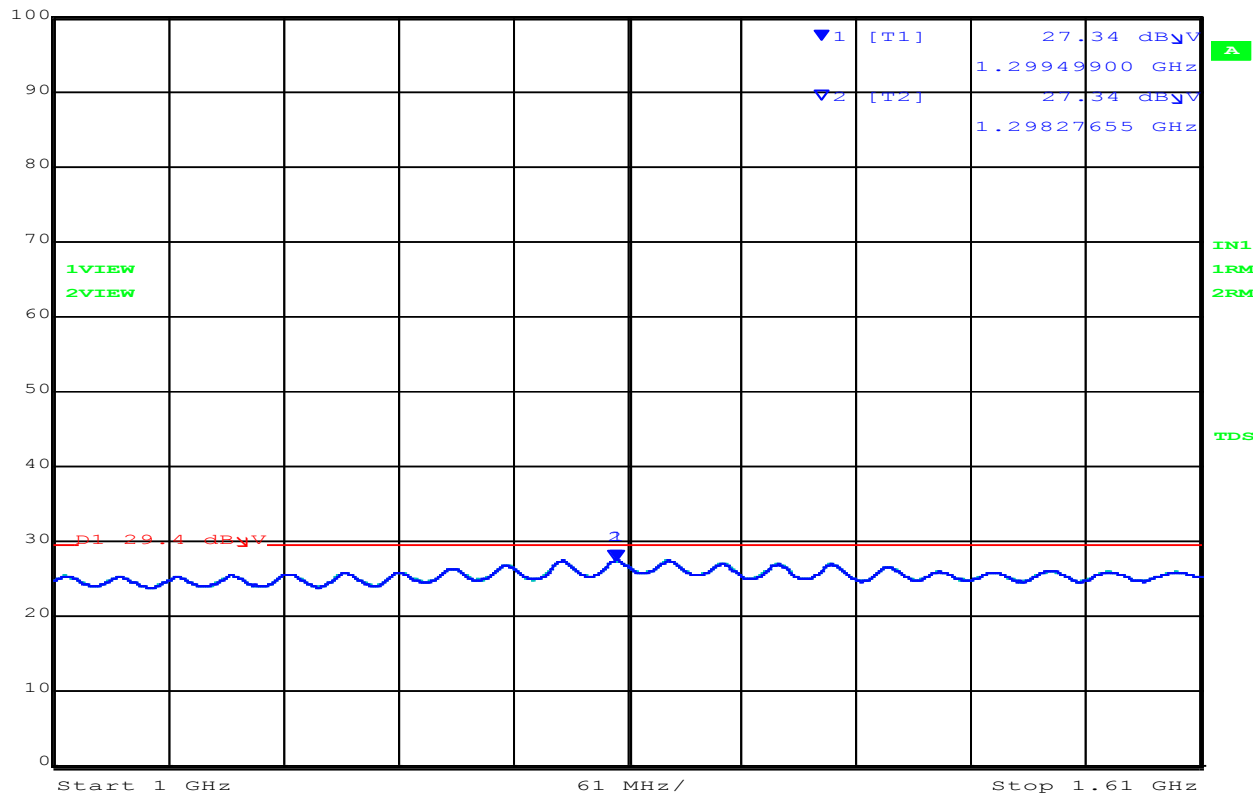
Test Measurement Results



RADIATED SPURIOUS EMISSIONS 1.0-1.61GHz

Test Freq: 3993.6 MHz, Antenna: integral, Power Setting: 14, Duty Cycle (%): 99

	Max/Ref Lvl	Marker 1 [T1]	RBW	1 MHz	RF Att	0 dB
	100 dB μ V	27.34 dB μ V	VBW	3 MHz		
	97 dB μ V	1.29949900 GHz	SWT	2 s	Unit	dB μ V



Date: 19.SEP.2019 11:35:35

1000.00– 1610.00 MHz									
Num	Frequency MHz	Level dB μ V/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dB μ V/m	Margin dB	Pass /Fail
1	1299.4	27.34	Average	Vertical	150	0	29.4	-2.06	Pass
2	1298.2	27.34	Average	Horizontal	150	0	29.4	-2.06	Pass

Test Notes: None

Equipment Configuration for Spurious Emissions

Antenna:	Taoglas UWC.21	Variant:	UWB
Antenna Gain (dBi):	2.0	Modulation:	--
Beam Forming Gain (Y):	Not Applicable	Duty Cycle (%):	99%
Channel Frequency (MHz):	3993.6	Data Rate:	
Power Setting:	Max	Tested By:	SB

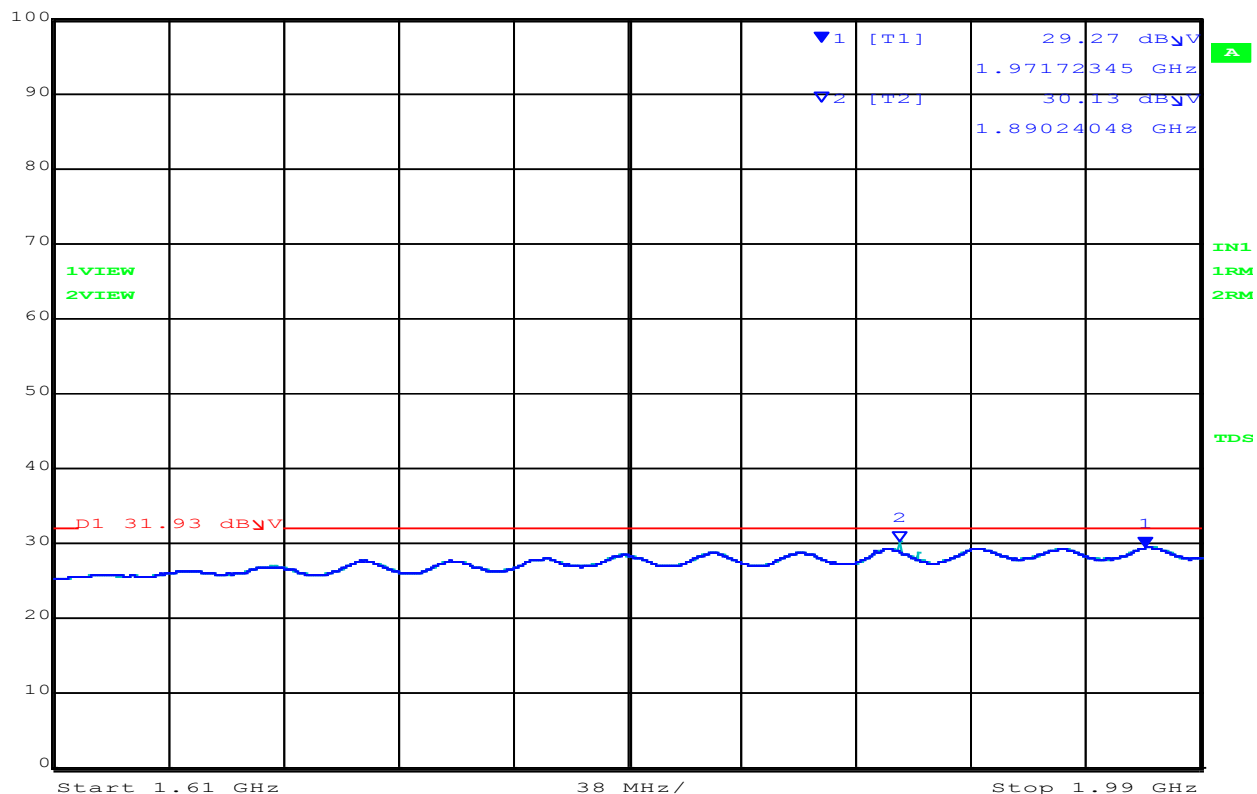
Test Measurement Results



RADIATED SPURIOUS EMISSIONS 1.61-1.99GHz

Test Freq: 3993.6 MHz, Antenna: integral, Power Setting: 14, Duty Cycle (%): 99

	Max/Ref Lvl	Marker 1 [T1]	RBW	1 MHz	RF Att	0 dB
	100 dBµV	29.27 dBµV	VBW	3 MHz		
	97 dBµV	1.97172345 GHz	SWT	2 s	Unit	dBµV



Date: 19.SEP.2019 11:46:19

1610.00 – 1990.00 MHz									
Num	Frequency MHz	Level dBµV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBµV/m	Margin dB	Pass /Fail
1	1971.72	29.27	Average	Vertical	150	0	31.93	-2.66	Pass
2	1890.24	30.13	Average	Horizontal	150	0	31.93	-1.8	Pass

Test Notes: None

Equipment Configuration for Spurious Emissions

Antenna:	Taoglas UWC.21	Variant:	UWB
Antenna Gain (dBi):	2.0	Modulation:	--
Beam Forming Gain (Y):	Not Applicable	Duty Cycle (%):	99%
Channel Frequency (MHz):	3993.6	Data Rate:	
Power Setting:	Max	Tested By:	SB

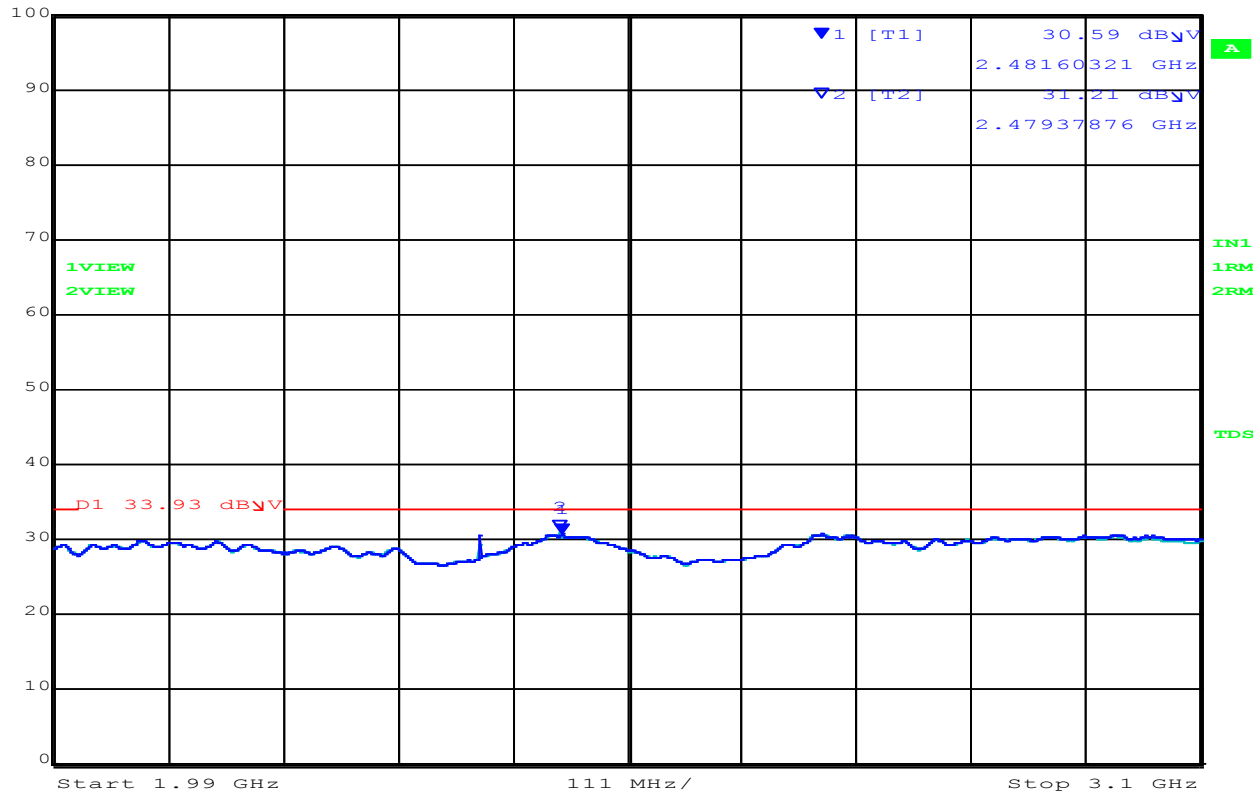
Test Measurement Results



RADIATED SPURIOUS EMISSIONS 1.99-3.1GHz

Test Freq: 3993.6 MHz, Antenna: integral, Power Setting: 14, Duty Cycle (%): 99

	Max/Ref Lvl	Marker 1 [T1]	RBW	1 MHz	RF Att	0 dB
	100 dBµV	30.59 dBµV	VBW	3 MHz		
	97 dBµV	2.48160321 GHz	SWT	2 s	Unit	dBµV



Date: 19.SEP.2019 11:54:38

1990.00 – 3100.00 MHz									
Num	Frequency MHz	Level dBµV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBµV/m	Margin dB	Pass /Fail
1	2481.60	30.59	Average	Vertical	150	0	33.93	-3.34	Pass
2	2479.37	31.21	Average	Horizontal	150	0	33.93	-2.72	Pass

Test Notes: None

Equipment Configuration for Spurious Emissions

Antenna:	Taoglas UWC.21	Variant:	UWB
Antenna Gain (dBi):	2.0	Modulation:	--
Beam Forming Gain (Y):	Not Applicable	Duty Cycle (%):	99%
Channel Frequency (MHz):	3993.6	Data Rate:	
Power Setting:	Max	Tested By:	SB

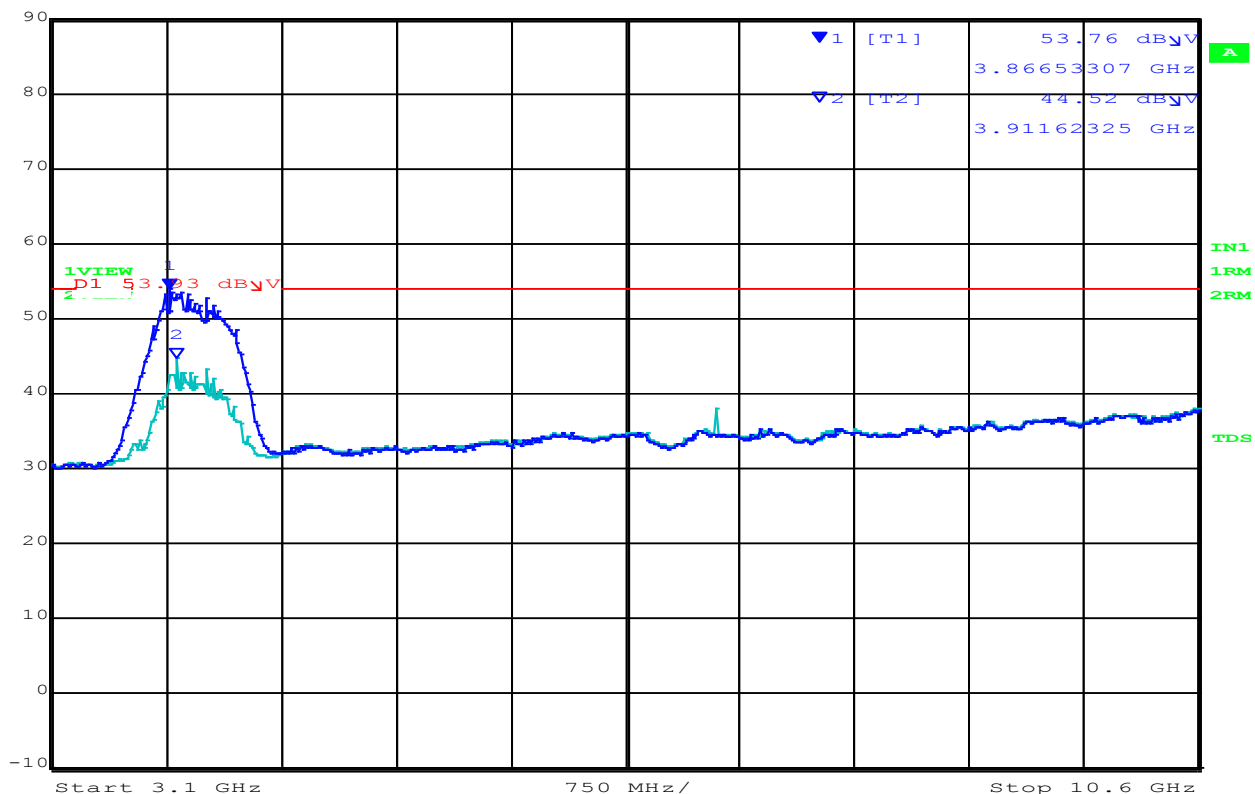
Test Measurement Results



RADIATED SPURIOUS EMISSIONS 3.1-10.6GHz

Test Freq: 3993.6 MHz, Antenna: integral, Power Setting: 14, Duty Cycle (%): 99

	Max/Ref Lvl	Marker 1 [T1]	RBW	1 MHz	RF Att	10 dB
	90 dBµV	53.76 dBµV	VBW	3 MHz		
	87 dBµV	3.86653307 GHz	SWT	1 s	Unit	dBµV



Date: 20.SEP.2019 09:10:35

3100.00 – 10600.00 MHz									
Num	Frequency MHz	Level dBµV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBµV/m	Margin dB	Pass /Fail
1	3866.53	53.76	Average	Vertical	150	0	53.93	-0.17	Pass
2	3911.62	44.52	Average	Horizontal	150	0	53.93	-9.41	Pass

Test Notes: None

Equipment Configuration for Spurious Emissions

Antenna:	Taoglas UWC.21	Variant:	UWB
Antenna Gain (dBi):	2.0	Modulation:	--
Beam Forming Gain (Y):	Not Applicable	Duty Cycle (%):	99%
Channel Frequency (MHz):	3993.6	Data Rate:	
Power Setting:	Max	Tested By:	SB

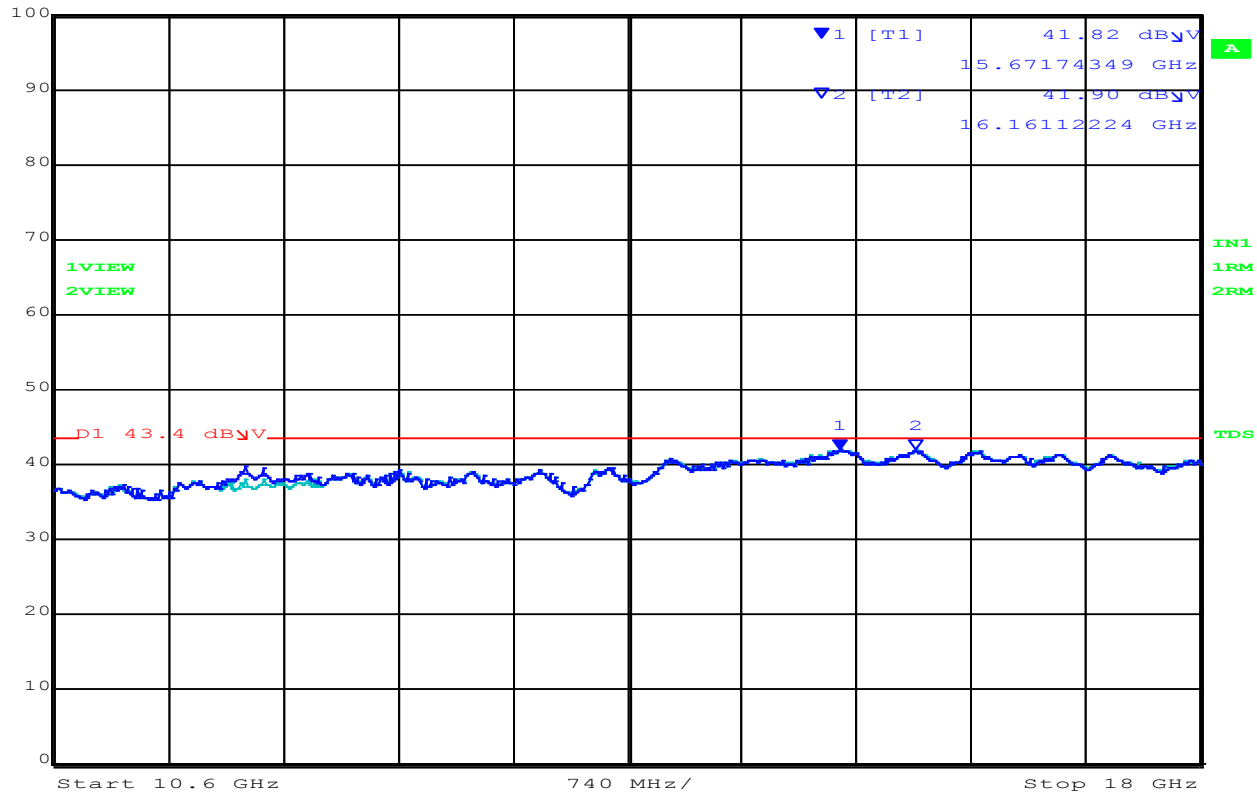
Test Measurement Results



RADIATED SPURIOUS EMISSIONS 10.6-18GHz

Test Freq: 3993.6 MHz, Antenna: integral, Power Setting: 14, Duty Cycle (%): 99

	Max/Ref Lvl	Marker 1 [T1]	RBW	1 MHz	RF Att	0 dB
	100 dBµV	41.82 dBµV	VBW	3 MHz		
	97 dBµV	15.67174349 GHz	SWT	2 s	Unit	dBµV



Date: 19.SEP.2019 14:31:36

10600.00 – 18000.00 MHz									
Num	Frequency MHz	Level dBµV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBµV/m	Margin dB	Pass /Fail
1	15671.17	41.82	Average	Vertical	150	0	43.4	-1.58	Pass
2	1616.11*	41.90	Average	Horizontal	150	0	43.4	-1.5	Pass

Test Notes: None

Equipment Configuration for Spurious Emissions Vertical

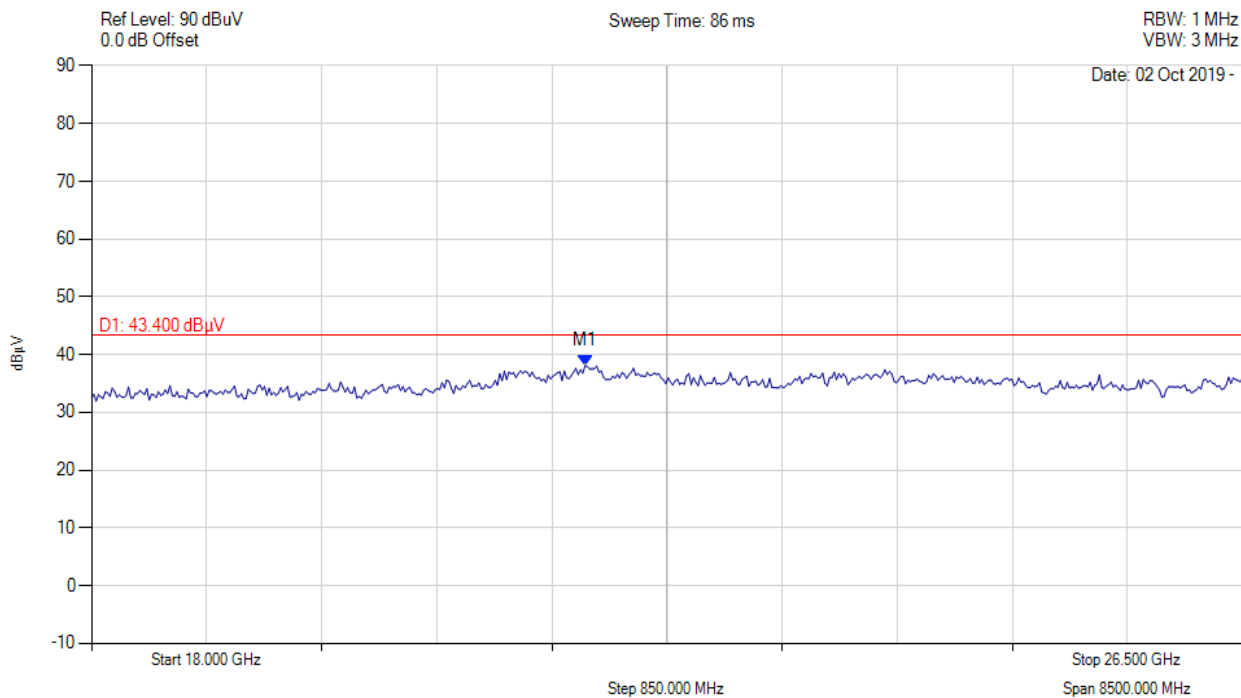
Antenna:	Taoglas UWC.21	Variant:	UWB
Antenna Gain (dBi):	2.0	Modulation:	--
Beam Forming Gain (Y):	Not Applicable	Duty Cycle (%):	99%
Channel Frequency (MHz):	3993.6	Data Rate:	
Power Setting:	Max	Tested By:	SB

Test Measurement Results



RADIATED SPURIOUS EMISSIONS 18-26GHz

Test Freq: 3993.6 MHz, Antenna: integral, Power Setting: 14, Duty Cycle (%): 99



Analyzer Setup	Marker:Frequency:Amplitude	Test Results
Detector = MAX PEAK Sweep Count = 0 RF Atten (dB) = 10 Trace Mode = VIEW	M1 : 21.645 GHz : 38.096 dBµV	Channel Frequency: 3993.60 MHz

Equipment Configuration for Spurious Emissions Vertical

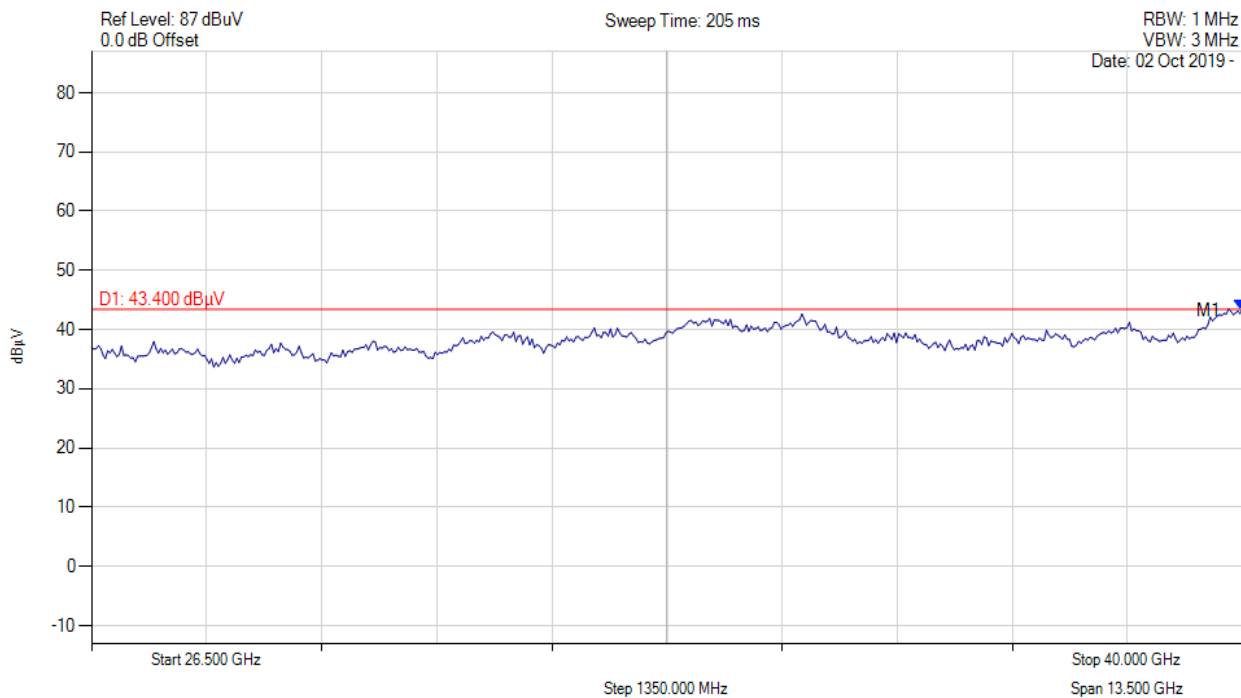
Antenna:	Taoglas UWC.21	Variant:	UWB
Antenna Gain (dBi):	2.0	Modulation:	--
Beam Forming Gain (Y):	Not Applicable	Duty Cycle (%):	99%
Channel Frequency (MHz):	3993.6	Data Rate:	
Power Setting:	Max	Tested By:	SB

Test Measurement Results



RADIATED SPURIOUS EMISSIONS 26 – 40 GHz

Test Freq: 3993.6 MHz, Antenna: integral, Power Setting: 14, Duty Cycle (%): 99



Analyzer Setup	Marker:Frequency:Amplitude	Test Results
Detector = MAX PEAK Sweep Count = 0 RF Atten (dB) = 10 Trace Mode = VIEW	M1 : 40.000 GHz : 43.234 dBµV	Channel Frequency: 3993.60 MHz

Equipment Configuration for Spurious Emissions Horizontal

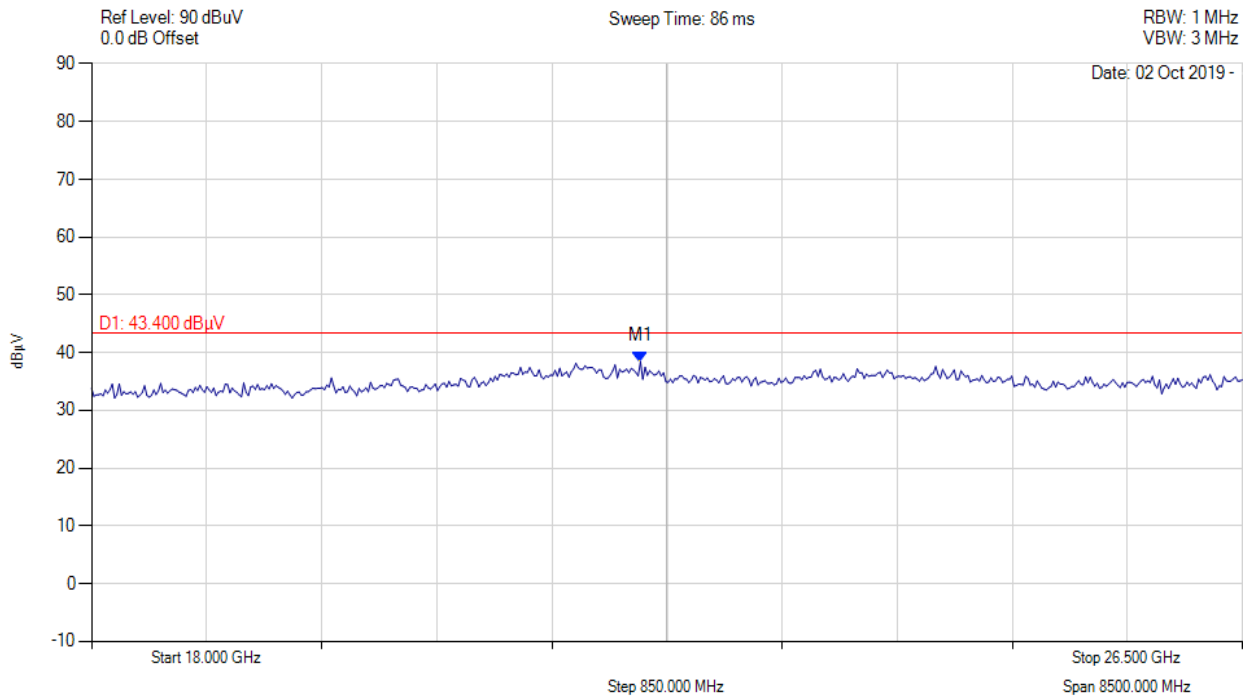
Antenna:	Taoglas UWC.21	Variant:	UWB
Antenna Gain (dBi):	2.0	Modulation:	--
Beam Forming Gain (Y):	Not Applicable	Duty Cycle (%):	99%
Channel Frequency (MHz):	3993.6	Data Rate:	
Power Setting:	Max	Tested By:	SB

Test Measurement Results



RADIATED SPURIOUS EMISSIONS 18-26GHz

Test Freq: 3993.6 MHz, Antenna: integral, Power Setting: 14, Duty Cycle (%): 99



Analyzer Setup	Marker:Frequency:Amplitude	Test Results
Detector = MAX PEAK Sweep Count = 0 RF Atten (dB) = 10 Trace Mode = VIEW	M1 : 22.054 GHz : 38.456 dBµV	Channel Frequency: 3993.60 MHz

Equipment Configuration for Spurious Emissions Horizontal

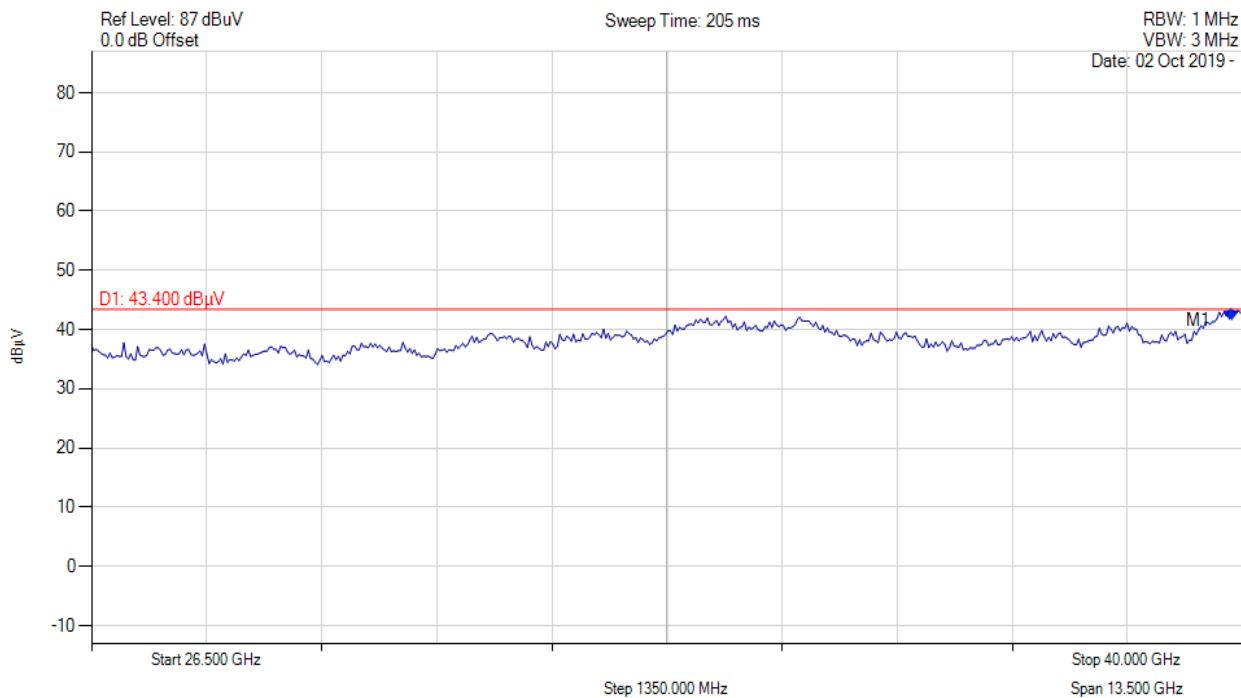
Antenna:	Taoglas UWC.21	Variant:	UWB
Antenna Gain (dBi):	2.0	Modulation:	--
Beam Forming Gain (Y):	Not Applicable	Duty Cycle (%):	99%
Channel Frequency (MHz):	3993.6	Data Rate:	
Power Setting:	Max	Tested By:	SB

Test Measurement Results



RADIATED SPURIOUS EMISSIONS 26 – 40 GHz

Test Freq: 3993.6 MHz, Antenna: integral, Power Setting: 14, Duty Cycle (%): 99



Analyzer Setup	Marker:Frequency:Amplitude	Test Results
Detector = MAX PEAK Sweep Count = 0 RF Atten (dB) = 10 Trace Mode = VIEW	M1 : 39.865 GHz : 41.481 dBµV	Channel Frequency: 3993.60 MHz

9.4.2. GPS Band Emissions

Equipment Configuration for Spurious Emissions

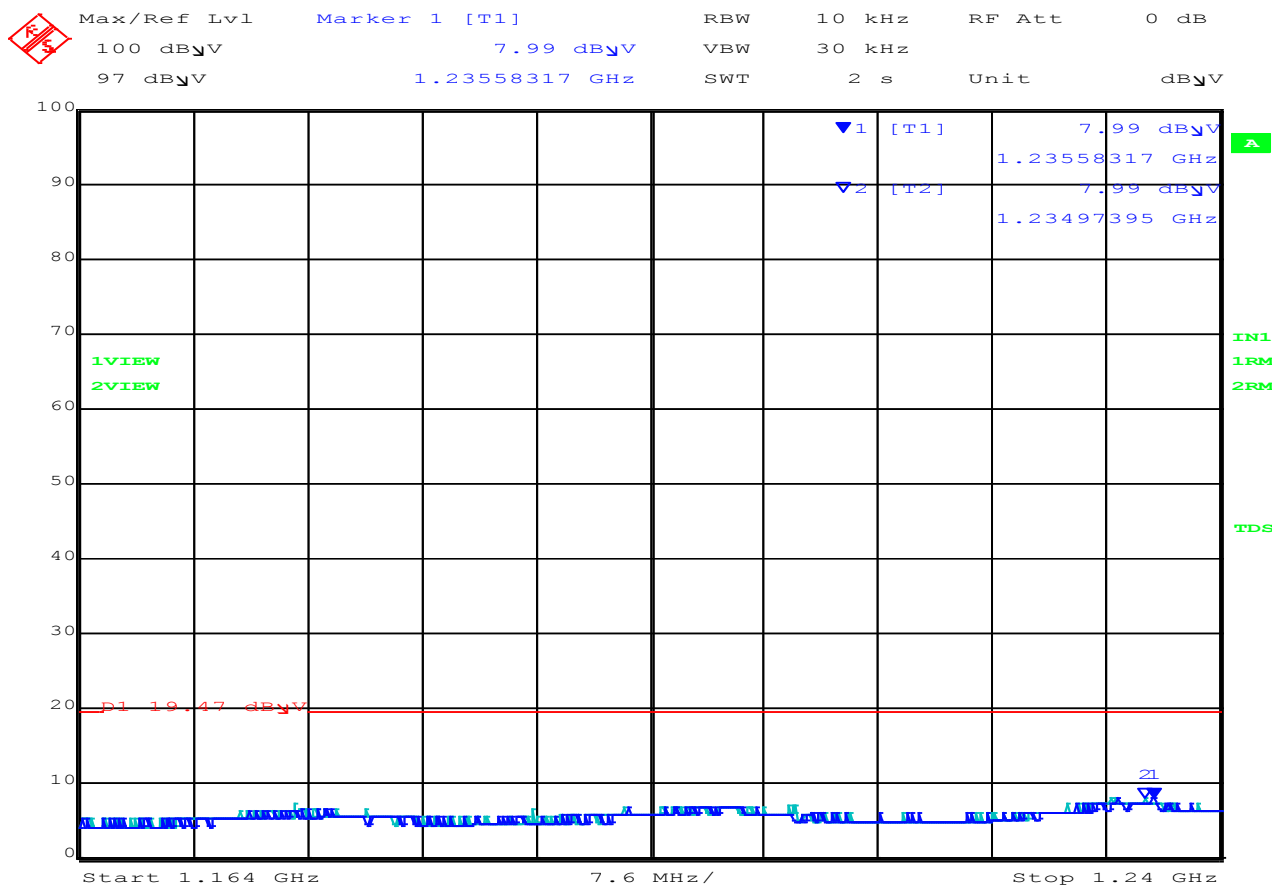
Antenna:	Taoglas UWC.21	Variant:	UWB
Antenna Gain (dBi):	2.0	Modulation:	--
Beam Forming Gain (Y):	Not Applicable	Duty Cycle (%):	99%
Channel Frequency (MHz):	3993.6	Data Rate:	
Power Setting:	Max	Tested By:	SB

Test Measurement Results



RADIATED SPURIOUS EMISSIONS GPS 1.164-1.240GHz

Test Freq: 3993.6 MHz, Antenna: integral, Power Setting: 14, Duty Cycle (%): 99



Date: 19.SEP.2019 14:38:00

1164.00-1240.00 MHz									
Num	Frequency MHz	Level dBµV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBµV/m	Margin dB	Pass /Fail
No Signals Found within 6 dB of Limit									
Test Notes: None									

Equipment Configuration for Spurious Emissions

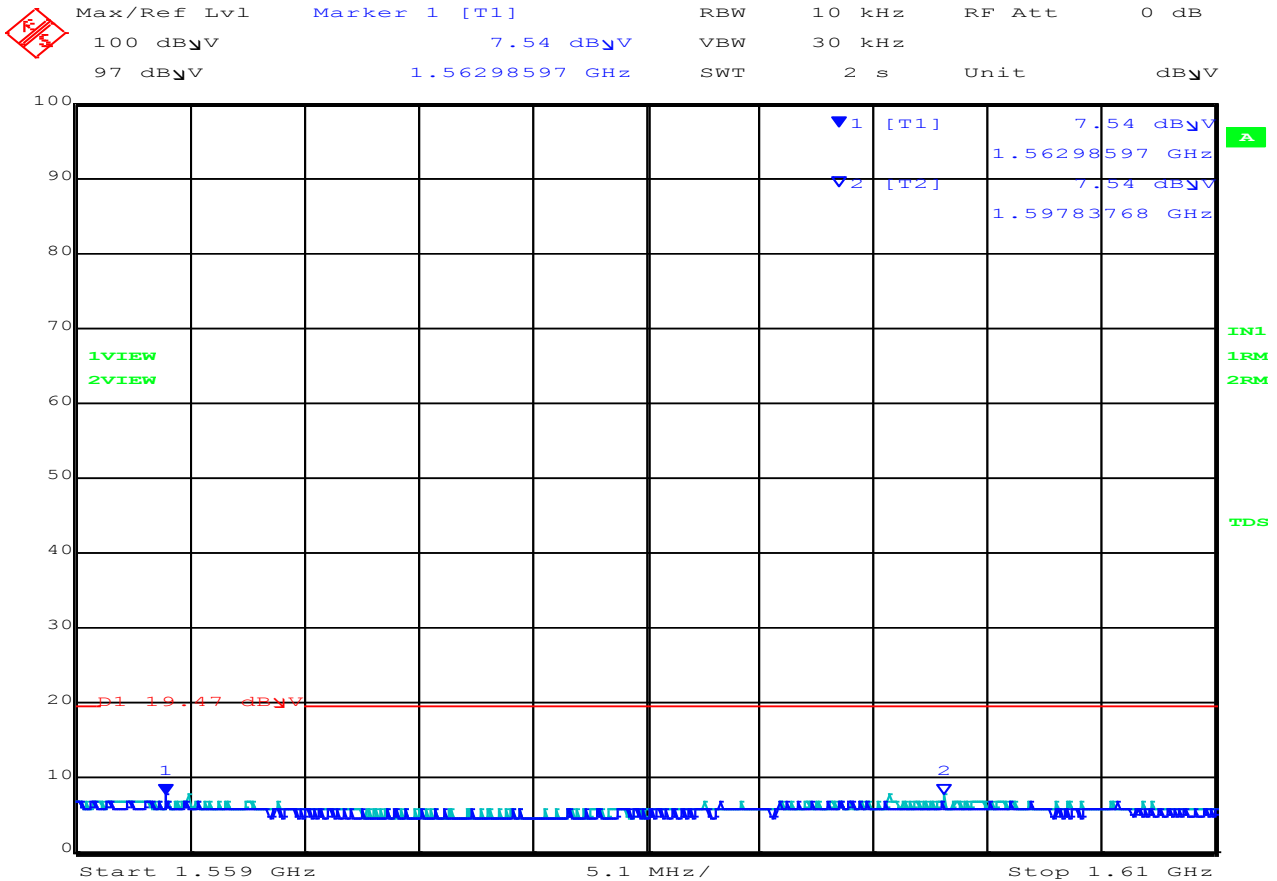
Antenna:	Taoglas UWC.21	Variant:	UWB
Antenna Gain (dBi):	2.0	Modulation:	--
Beam Forming Gain (Y):	Not Applicable	Duty Cycle (%):	99%
Channel Frequency (MHz):	3993.6	Data Rate:	
Power Setting:	Max	Tested By:	SB

Test Measurement Results



RADIATED SPURIOUS EMISSIONS GPS 1.164-1.240GHz

Test Freq: 3993.6 MHz, Antenna: integral, Power Setting: 14, Duty Cycle (%): 99



Date: 19.SEP.2019 14:45:58

1164.00-1240.00 MHz									
Num	Frequency MHz	Level dBuV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBuV/m	Margin dB	Pass /Fail
No Signals Found within 6 dB of Limit									
Test Notes: None									

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	Pressure (mBars):	999 - 1001
Reference Document(s):	None		
<p>Test Procedure for UWB Transmission</p> <p>15.519 (a) (1) A UWB device operating under the provisions of this section shall transmit only when it is sending information to an associated receiver. 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. An acknowledgment of reception must continue to be received by the UWB intentional radiator at least every 10 seconds or the UWB device must cease transmitting</p> <p>Testing was performed under ambient conditions at nominal voltage.</p> <p>Test configuration and setup used for the measurement was per the Radiated Test Set-up section specified in this document.</p> <p>Operating Frequency Band: 3100-10600 MHz</p> <p>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.</p>			

Equipment Configuration for Shutdown Timing Requirements

Variant:	Taoglas UWC.21	Variant:	UWB
Antenna Gain (dBi):	2.0	Modulation:	--
Modulation:	Not Applicable	Duty Cycle (%):	99%
TPC:	3993.6	Data Rate:	
Engineering Test Notes:			

Test Measurement Results

Frequency (MHz)	Shutdown Time	Limit	Margin	EUT Power Setting
	(s)	(s)	(s)	Numeric
3993.60	1.694	10	-8.306	16



17:07:38 01.10.2019

Traceability to Industry Recognized Test Methodologies

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

9.6. AC Mains Power Input / Output Ports

Scope

This test assesses the ability of the EUT to limit its internal noise from being present on the AC mains power input/output ports.

Test Procedure

The EUT is configured in accordance with ANSI C63.4. The conducted emissions are measured in a shielded room with a spectrum analyzer in peak hold in the first instance. Emissions closest to the limit are measured in the quasi-peak mode (QP) with the tuned receiver using a bandwidth of 9 kHz. The emissions are maximized further by cable manipulation. The highest emissions relative to the limit are listed.

Limits

The equipment shall meet the class B limits given in FCC 15.207 & ICES-003. Alternatively, for equipment intended to be used in telecommunication centres only, the class A limits given in FCC 15B, ICES-003 may be used.

Limits for conducted disturbance at the mains ports of class B ITE

Frequency of emission (MHz)	Quasi-peak dBuV	Average dBuV
0.15–0.5	66 to 56*	56 to 46*
0.5–5	56	46
5–30	60	50
Note 1	* Decreases with the logarithm of the frequency	
Note 2	* The lower limit applies at the boundary between frequency ranges	

Limits for conducted disturbance at the mains ports of class A ITE

Frequency of emission (MHz)	Quasi-peak dBuV	Average dBuV
0.15–0.5	79	66
0.5–30	73	60
Note 1	* The lower limit shall apply at the transition frequency.	

Traceability

All conducted emission measurements are traceable to national standards. The uncertainty of measurement at a confidence level of not less than 95 %, with a coverage factor of k=2, in the range 9 kHz – 30 MHz (Average & Quasi-peak) is ± 2.64 dB.

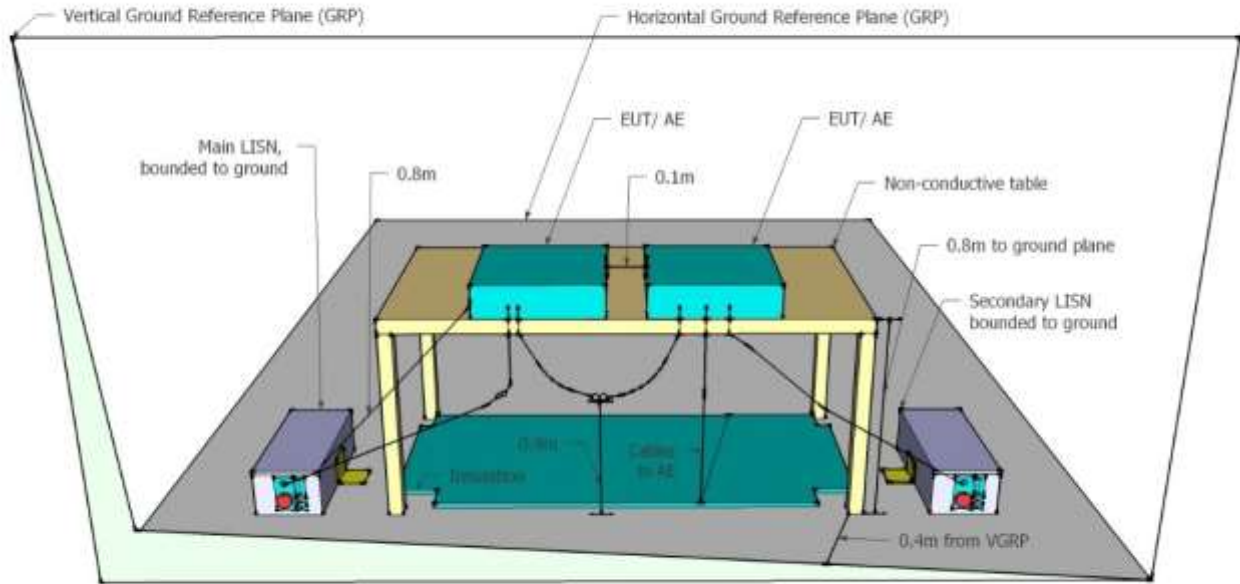
Laboratory Measurement Uncertainty	
Measurement uncertainty	± 2.64 dB

Method
Measurements were made per work instruction WI-EMC-01 'Measurement of Conducted Emissions'

Test Equipment Utilized

Asset#	Description	Manufacturer	Model#	Serial#	Calibration Due Date
184	Pulse Limiter	Rhode & Schwarz	ESH3Z2	357.8810.52	6 Oct 2019
190	LISN (two-line V-network)	Rhode & Schwarz	ESH3Z5	836679/006	18 Oct 2019
193	Receiver 20 Hz to 7 GHz	Rhode & Schwarz	ESI 7	838496/007	10 Oct 2019
295	Conducted Emissions Chamber Maintenance Check	MiCOM	Conducted Emissions Chamber	295	18 Sep 2019
307	BNC-CABLE	Megaphase	1689 1GVT4	15F50B002	11 Sep 2019
316	Dell desktop computer workstation	Dell	Desktop	WS04	Not Required
372	AC Variable PS	California Instruments	1251P	L06951	Cal when used
378	Rohde & Schwarz 40 GHz Receiver with Generator	Rhode & Schwarz	ESIB40	100107/040	12 Oct 2019
388	LISN (3 Phase) 9kHz - 30MHz	Rohde & Schwarz	ESH2-Z5	892107/022	20 Oct 2019
496	MiTest Conducted Emissions test software.	MiCOM	Conducted Emissions Test Software Version 1.0	496	Not Required
510	Barometer/Thermometer	Control Company	68000-49	170871375	11 Dec 2019
CCEMC01	Confidence Check.	MiCOM	CCEMC01	None	11 Sep 2019

Test Setup – Power Input / Output Port



Model:	Vector Tag Receiver VR7401	Configuration tested:	AC/DC PS
Input power:	120V _{AC} /60 _{Hz}	Standard:	FCC 15B

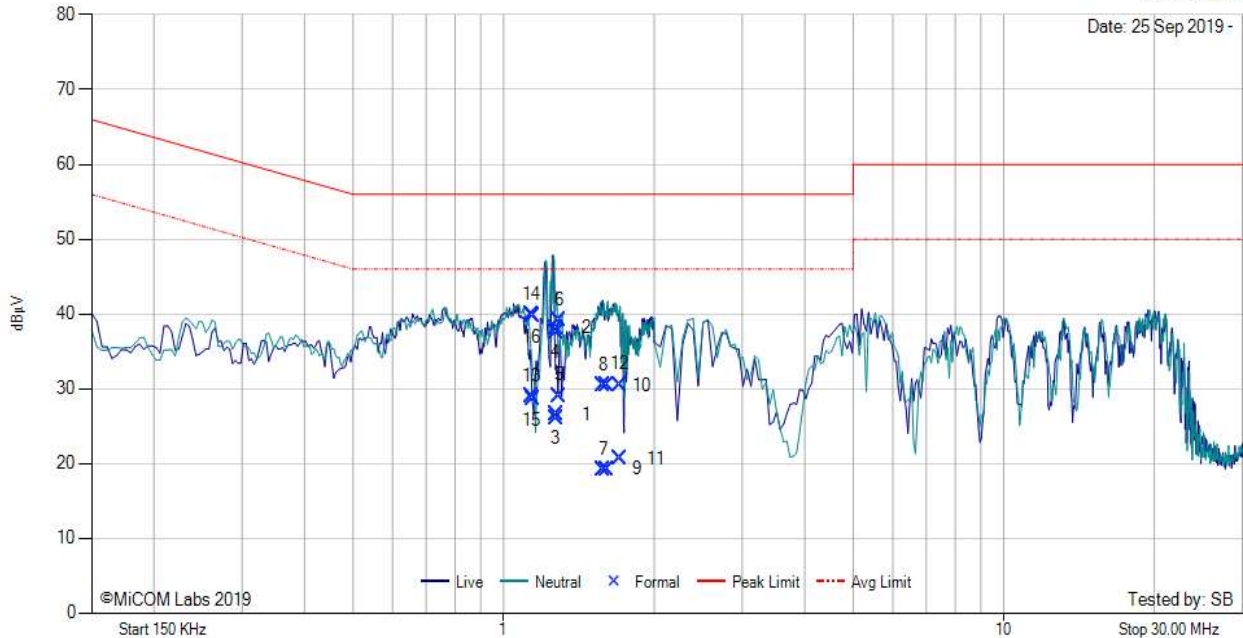


Test Freq: 3993.6 MHz

Measurement Distance: N/A

Sweep Time: 940 ms

RBW: 9 KHz
VBW: 10 KHz



Num	Frequency MHz	Raw dBµV	Cable Loss dB	Factor dB	Total Correction dBµV	Corrected Value dBµV	Measurement Type	Line	Limit dBµV/m	Margin dB	Pass /Fail
1	1.274	16.49	0.10	9.95	10.05	26.54	Max Avg	Live	46.0	-19.5	Pass
2	1.274	28.10	0.10	9.95	10.05	38.15	Max Qp	Live	56.0	-17.9	Pass
3	1.273	16.02	0.10	9.95	10.05	26.07	Max Avg	Neutral	46.0	-19.9	Pass
4	1.273	27.52	0.10	9.95	10.05	37.57	Max Qp	Neutral	56.0	-18.4	Pass
5	1.293	18.99	0.10	9.95	10.05	29.04	Max Avg	Neutral	46.0	-17.0	Pass
6	1.293	29.13	0.10	9.95	10.05	39.18	Max Qp	Neutral	56.0	-16.8	Pass
7	1.579	9.04	0.14	9.96	10.10	19.14	Max Avg	Live	46.0	-26.9	Pass
8	1.579	20.41	0.14	9.96	10.10	30.51	Max Qp	Live	56.0	-25.5	Pass
9	1.608	9.16	0.14	9.97	10.11	19.27	Max Avg	Neutral	46.0	-26.7	Pass
10	1.608	20.37	0.14	9.97	10.11	30.48	Max Qp	Neutral	56.0	-25.5	Pass
11	1.712	10.48	0.16	9.96	10.12	20.60	Max Avg	Neutral	46.0	-25.4	Pass
12	1.712	20.41	0.16	9.96	10.12	30.53	Max Qp	Neutral	56.0	-25.5	Pass
13	1.138	18.89	0.09	9.94	10.03	28.92	Max Avg	Live	46.0	-17.1	Pass
14	1.138	29.87	0.09	9.94	10.03	39.90	Max Qp	Live	56.0	-16.1	Pass
15	1.142	18.61	0.09	9.94	10.03	28.64	Max Avg	Neutral	46.0	-17.4	Pass
16	1.142	29.69	0.09	9.94	10.03	39.72	Max Qp	Neutral	56.0	-16.3	Pass

Test Notes: EUT powered by Catapult Charging Cradle AC 110V



575 Boulder Court
Pleasanton, California 94566, USA
Tel: +1 (925) 462 0304
Fax: +1 (925) 462 0306
www.micomlabs.com