



427 West 12800 South
Draper, UT 84020

Test Report Certification

FCC ID	SWX-WAVEPRO
IC ID	6545A-WAVEPRO
Equipment Under Test	WAVE-PRO
Test Report Serial Number	TR7894_01
Date of Test(s)	August 12, through September 22, 2022, and November 16 through November 18, 2022
Report Issue Date	February 9, 2023

Test Specification	Applicant
47 CFR FCC Part 15, Subpart C RSS-GEN Issue 5	Ubiquiti Inc. 685 Third Avenue, 27 th Floor New York, NY 10019 U.S.A.



NVLAP LAB CODE 600241-0

Certification of Engineering Report

This report has been prepared by Unified Compliance Laboratory (UCL) to document compliance of the device described below with the requirement of Federal Communication Commissions (FCC) Part 15, Subpart C. This report may be reproduced in full. Partial reproduction of this report may only be made with the written consent of the laboratory. The results in this report apply only to the sample tested.

Applicant	Ubiquiti Inc.
Manufacturer	Ubiquiti Inc.
Brand Name	Wave
Model Number	WAVE-PRO
FCC ID	SWX-WAVEPRO
IC ID	6545A-WAVEPRO

On this 9th day of February 2023, I individually and for Unified Compliance Laboratory certify that the statements made in this engineering report are true, complete, and correct to the best of my knowledge and are made in good faith.

Although NVLAP has accredited the Unified Compliance Laboratory testing facilities, this report must not be used to claim product certification, approval, or endorsement by NVLAP, NIST or any agency of the U.S. federal government.

Unified Compliance Laboratory



Written By: Clay Allred



Reviewed By: Richard L. Winter

Revision History		
Revision	Description	Date
01	Original Report Release	February 9, 2023

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1 Client Information

1.1 Applicant

Company	Ubiquiti Inc. 685 Third Avenue, 27 th Floor New York, NY 10017 U.S.A.
Contact Name	Alex Macon
Title	Compliance

1.2 Manufacturer

Company	Ubiquiti Inc. 685 Third Avenue, 27 th Floor New York, NY 10017 U.S.A.
Contact Name	Alex Macon
Title	Compliance

2 Equipment Under Test (EUT)

2.1 Identification of EUT

Brand Name	Wave
Model Number	Wave-Pro
Serial Number	A26196
Dimensions (cm)	42.4 x 42.4 x 16.6

2.2 Description of EUT

The Wave-Pro is a client 60 GHz point-to-point customer premise equipment that features wave technology with a 2.5 Gbps throughput rate. The Wave-Pro is also equipped with a 5 GHz WiFi 6 backup radio to sustain connectivity during a 60 GHz link disruption caused by inclement weather conditions. A Bluetooth LE transceiver is included for device management. The Wave-Pro is an outdoor device and has an Ethernet port which is used for data transfer and to provide power using an Ubiquiti U-POE-at 48-volt PoE power adapter.

This report covers the circuitry of the device subject to FCC Part 15, Subpart C. The circuitry of the device subject to FCC Part 15 Subpart B was found to be compliant and is covered under a separate Unified Compliance Laboratory test report.

2.3 EUT and Support Equipment

The EUT and support equipment used during the test are listed below.

Brand Name Model Number Serial Number	Description	Name of Interface Ports / Interface Cables
BN: airFiber MN: Wave-Pro (Note 1) SN: A26196	Wireless Access Point	See Section 2.4
BN: Ubiquiti MN: U-POE-at SN: N/A	PoE Power Adapter	Shielded or Un-shielded cat 5e cable
BN: Dell MN: XPS 13 SN: N/A	Laptop Computer	Shielded or Un-shielded cat 5e cable

Notes: (1) EUT

(2) Interface port connected to EUT (See Section 2.4)

The support equipment listed above was not modified in order to achieve compliance with this standard.

2.4 Interface Ports on EUT

Name of Ports	No. of Ports Fitted to EUT	Cable Description/Length
AC (PoE Injector)	1	3 conductor power cord/80cm
LAN (PoE Injector)	1	Shielded or Un-shielded cat 5e cable/1 meter
Data	1	Shielded or Un-shielded cat 5e cable/1 meter

2.5 Operating Environment

Power Supply	120 Volts AC to 48 Volts PoE
AC Mains Frequency	60 Hz
Temperature	22.1-22.8 °C
Humidity	19.3-23.9 %
Barometric Pressure	1009 mBar

2.6 Operating Modes

The Wave-Pro was tested using test software in order to enable a constant transmission. The measurements within this report are corrected to reference a 100% duty cycle. All emission modes of 802.11 ax were investigated.

2.7 EUT Exercise Software

EUT firmware version 1.0 was used to operate the transmitter using a constant transmit mode.

2.8 Block Diagram of Test Configuration

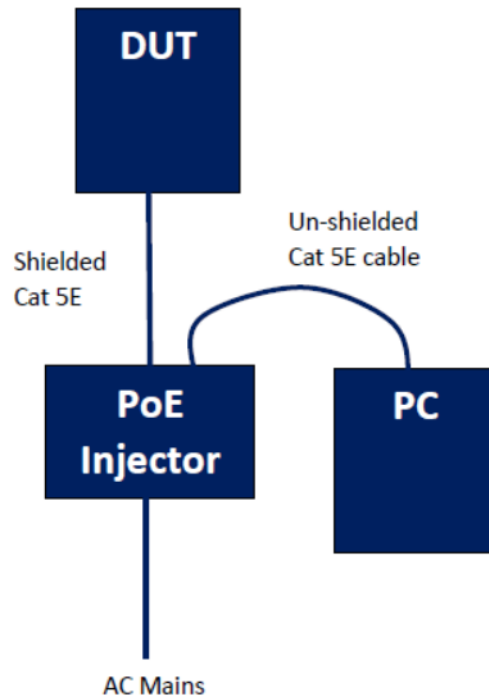


Diagram 1: Test Configuration Block Diagram

2.9 Modification Incorporated/Special Accessories on EUT

There were no modifications made to the EUT during testing to comply with the specification.

2.10 Deviation, Opinions Additional Information or Interpretations from Test Standard

There were no deviations, opinions, additional information or interpretations from the test specification.

3 Test Specification, Method and Procedures

3.1 Test Specification

Title	47 CFR FCC Part 15, Subpart C 15.203, 15.207 and 15.255 Limits and methods of measurement of radio interference characteristics of radio frequency devices. RSS-Gen, issue 5, General Requirements for Compliance of Radio Apparatus RSS-210, issue 10, License-Exempt Radio Apparatus: Category I Equipment
Purpose of Test	The tests were performed to demonstrate initial compliance

3.2 Methods & Procedures

3.2.1 47 CFR FCC Part 15 Section 15.203 / RSS-GEN

See test standard for details.

3.2.2 47 CFR FCC Part 15 Section 15.207 / RSS-GEN

See test standard for details.

3.2.3 47 CFR FCC Part 15 Section 15.255 / RSS-210

See test standard for details.

3.3 FCC Part 15, Subpart C

3.3.1 Summary of Tests

FCC Section	ISED Section	Environmental Phenomena	Frequency Range (MHZ)	Result
15.203	N/A	Antenna requirements	Structural Requirement	Compliant
15.207	RSS-Gen	Conducted Disturbance at Mains Port	0.15 to 30	N/A
15.255 (e)	RSS-210 § J.4	Bandwidth Requirement	57000 - 71000	Compliant
15.255 (c)	RSS-210 § J.4	Peak Output Power	57000 - 71000	Compliant
15.255 (d)	RSS-210 § J.3	Antenna Conducted Spurious Emissions	0.009 to 40000	N/A
15.255 (d)	RSS-210 § J.3	Radiated Spurious Emissions	0.009 to 200000	Compliant
15.255 (c)	RSS-210 § J.4	Peak Power Spectral Density	57000 - 71000	Compliant
15.255 (f)	RSS-210 § J.6	Frequency Stability	57000 - 71000	Compliant
The testing was performed according to the procedures in ANSI C63.10-2013, KDB 558074 and 47 CFR Part 15.				

3.4 Results

In the configuration tested, the EUT complied with the requirements of the specification.

3.5 Test Location

Testing was performed at the Unified Compliance Laboratory 3-Meter and 10-Meter chambers located at 427 West 12800 South, Draper, UT 84020. Unified Compliance Laboratory is accredited by National Voluntary Laboratory Accreditation Program (NVLAP); NVLAP Code 600241-0 which is effective until 30 June 2023. This site has also been registered with Innovations, Science and Economic Development (ISED) department as was accepted under Appendix B, Phase 1 procedures of the APEC Tel MRA for Canadian recognition. ISED No.: 25346, effective until 30 June 2023. Unified Compliance Laboratory has been assigned Conformity Assessment Number US0223 by ISED.

4 Test Equipment

4.1 Conducted Emissions at Mains Ports

Type of Equipment	Manufacturer	Model Number	Asset Number	Date of Last Calibration	Due Date of Calibration
EMI Receiver	AFJ	FFT3010	UCL-2500	6/27/2022	6/27/2023
LISN	AFJ	LS16C/10	UCL-6749	12/6/2021	12/6/2023
Cat6 ISN	Teseq	ISN T8-Cat6	UCL-2971	1/30/2022	1/30/2023
ISN	Teseq	ISN T800	UCL-2974	6/27/2022	6/27/2023
LISN	Com-Power	LIN-120C	UCL-2612	1/6/2022	1/6/2023
AC Power Source	Laplace Instruments	AC1000A	UCL-2857	N/A	N/A
Test Software	UCL	Revision 1	UCL-3107	N/A	N/A

Table 1: List of equipment used for Conducted Emissions Testing at Mains Port

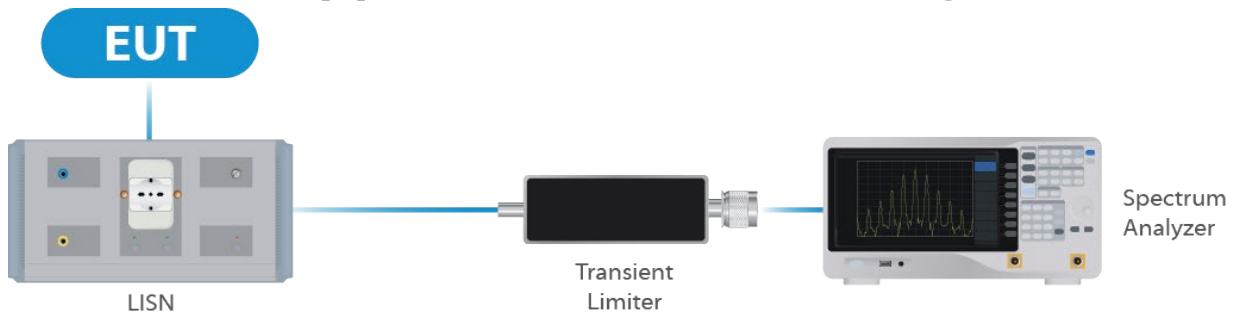


Figure 1: Conducted Emissions Test

4.2 Radiated Emissions

Type of Equipment	Manufacturer	Model Number	Asset Number	Date of Last Calibration	Due Date of Calibration
EMI Receiver	Keysight	N9038A	UCL-2778	1/4/2022	1/4/2023
Pre-Amplifier 9 kHz – 1 GHz	Sonoma Instruments	310N	UCL-2889	12/1/2022	12/1/2023
Double Ridge Horn Antenna	Com-Power	AH-118	UCL-5582	1/27/2023	1/27/2025
Log Periodic 15 - 40 GHz Horn Antenna	Scwarzbeck	STLP 9129	UCL-3068	1/27/2023	1/27/2025
Pre-Amplifier 9 kHz – 1 GHz	Sonoma Instruments	310N	UCL-4793	12/1/2022	12/1/2023
Pre-Amplifier 1 – 18 GHz	Com-Power	PAM 118A	UCL-3833	12/9/2022	12/9/2023

Type of Equipment	Manufacturer	Model Number	Asset Number	Date of Last Calibration	Due Date of Calibration
Pre-Amplifier 1 – 18 GHz	The EMC Shop	PA18G	UCL-5896	3/11/2022	3/11/2023
Pre-Amplifier 15 – 40 GHz	Mini-Circuits	ZVA-18403G+	UCL-7743	12/14/2022	12/14/2023
Test Software	UCL	Revision 1	UCL-3108	N/A	N/A
Conical Horn Antenna	VDI	WR15CH	UCL-5774	N/A	N/A
Conical Horn Antenna	VDI	WR12CH	UCL-4869	N/A	N/A
Conical Horn Antenna	VDI	WR19CH	UCL-4873	N/A	N/A
Conical Horn Antenna	VDI	WR5.1CH	UCL-4880	N/A	N/A
Conical Horn Antenna	VDI	WR8.0CH	UCL-4886	N/A	N/A
Spectrum Analyzer Extension Module	VDI	SAX 705	UCL-4887	N/A	N/A
Spectrum Analyzer Extension Module	VDI	SAX 706	UCL-4883	N/A	N/A
USB Switch	Keysight	U1816C	UCL-4957	N/A	N/A
Spectrum Analyzer	Keysight	N9041B	UCL-4964	1/28/2022	1/27/2023

Table 2: List of equipment used for Radiated Emissions

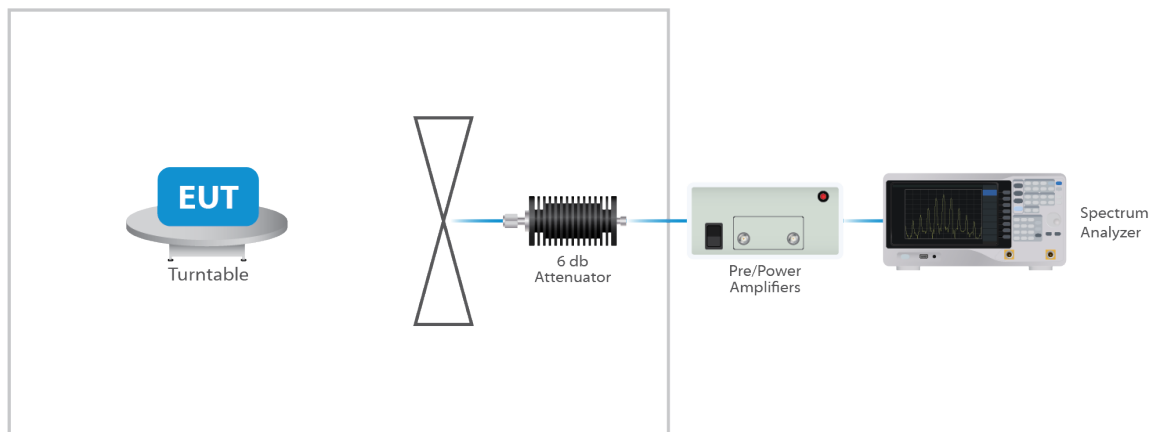


Figure 2: Radiated Emissions Test

4.3 Equipment Calibration

All applicable equipment is calibrated using either an independent calibration laboratory or Unified Compliance Laboratory personnel at intervals defined in ANSI C63.4:2014 following outlined calibration procedures. All measurement instrumentation is traceable to the National Institute of Standards and Technology (NIST). Supporting documentation relative to traceability is on file and is available for examination upon request.

4.4 Measurement Uncertainty

Test	Uncertainty ($\pm$ dB)	Confidence (%)
Conducted Emissions	1.44	95
Radiated Emissions (9 kHz to 30 MHz)	2.50	95
Radiated Emissions (30 MHz to 1 GHz)	4.38	95
Radiated Emissions (1 GHz to 18 GHz)	4.37	95
Radiated Emissions (18 GHz to 40 GHz)	3.93	95
Direct Connect Tests	K Factor	Value
Emissions Bandwidth	2	2.0%
Output Power	2	1.0 dB
Peak Power Spectral Density	2	1.3 dB
Band Edge	2	0.8 dB
Transmitter Spurious Emissions	2	1.8 dB

5 Test Results

5.1 §15.203 Antenna Requirements

The EUT uses a single integral antenna structure. The maximum gain of the antenna per chain is 46 dBi per manufacturer's datasheet. The antenna is not user replaceable.

Results

The EUT complied with the specification.

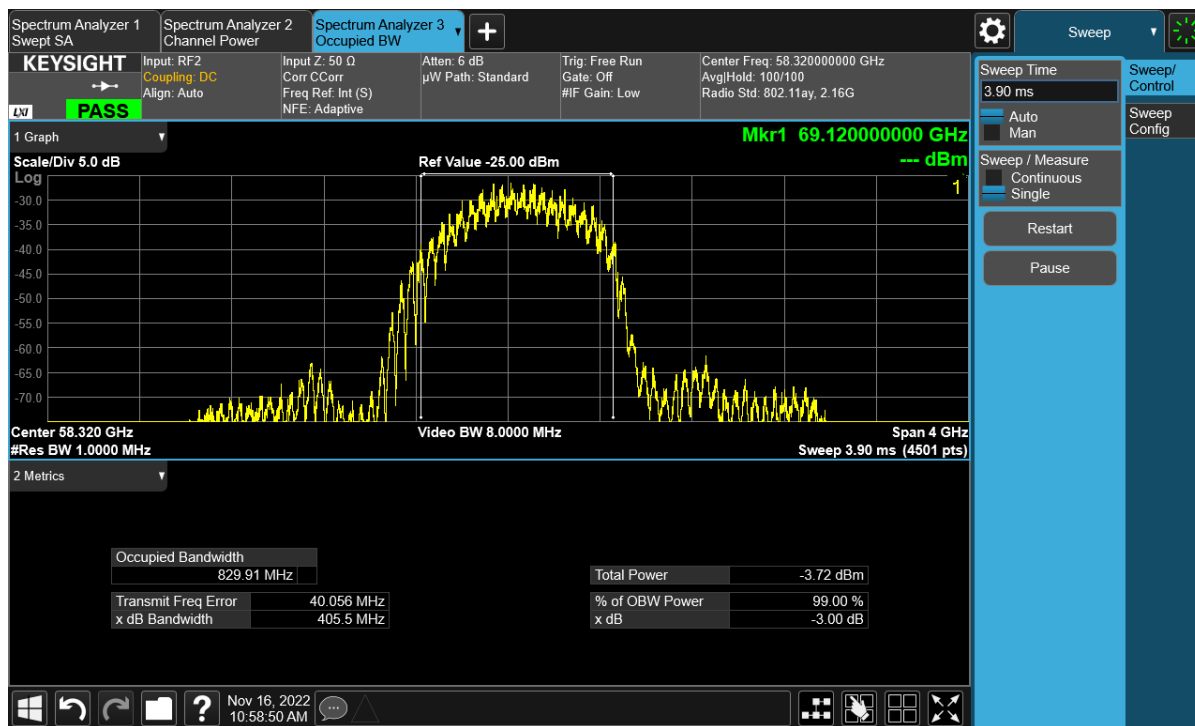
5.2 Emissions Bandwidth

Channel Width (GHz)	Frequency (MHz)	Emissions 99% Bandwidth (MHz)
1.06	58320	919.2
	63720	933.1
	70200	915.8
2.12	58320	1784.0
	63720	1812.0
	69120	1828.0

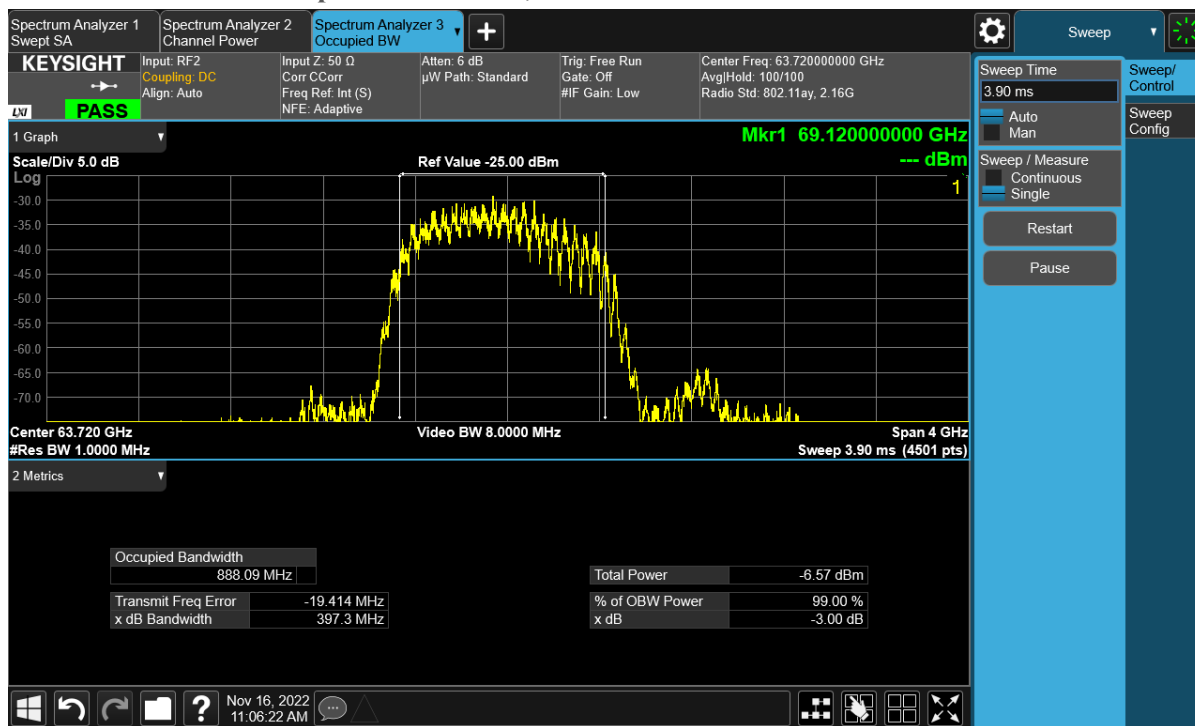
Result

All chains were tested and the highest bandwidth per chain is reported above.

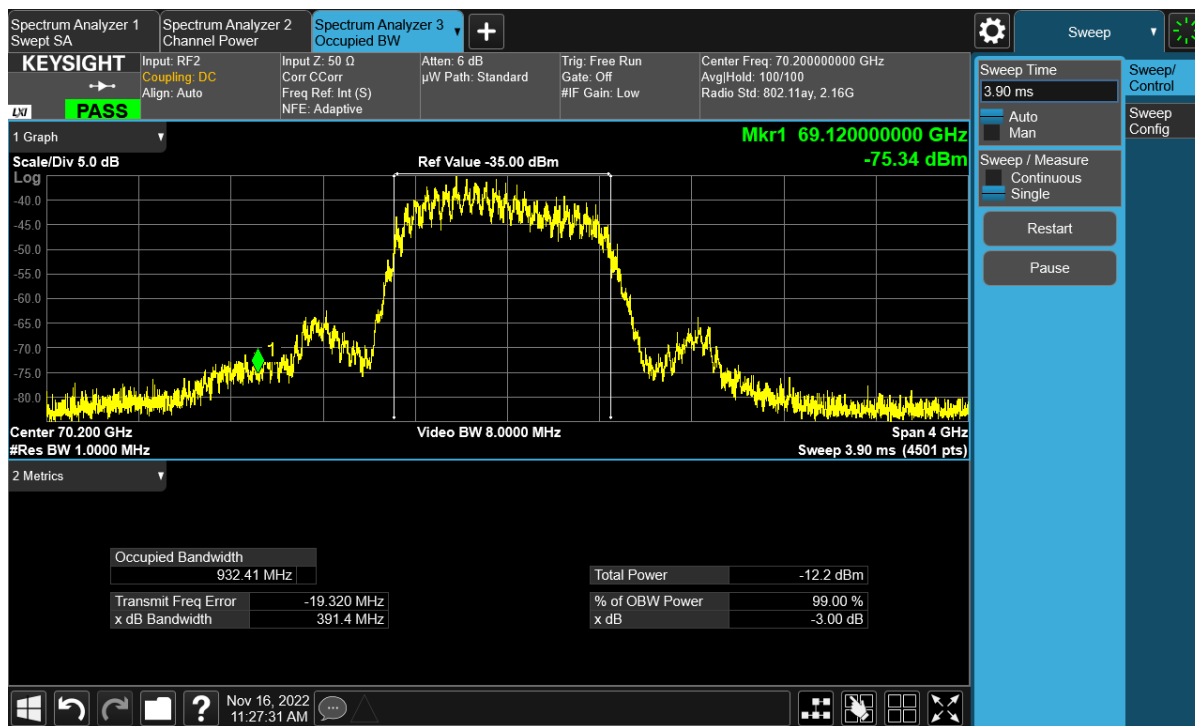
In the configuration tested, the 99% bandwidth was greater than 500 kHz; therefore, the EUT complied with the requirements of the specification (see spectrum analyzer plot below).



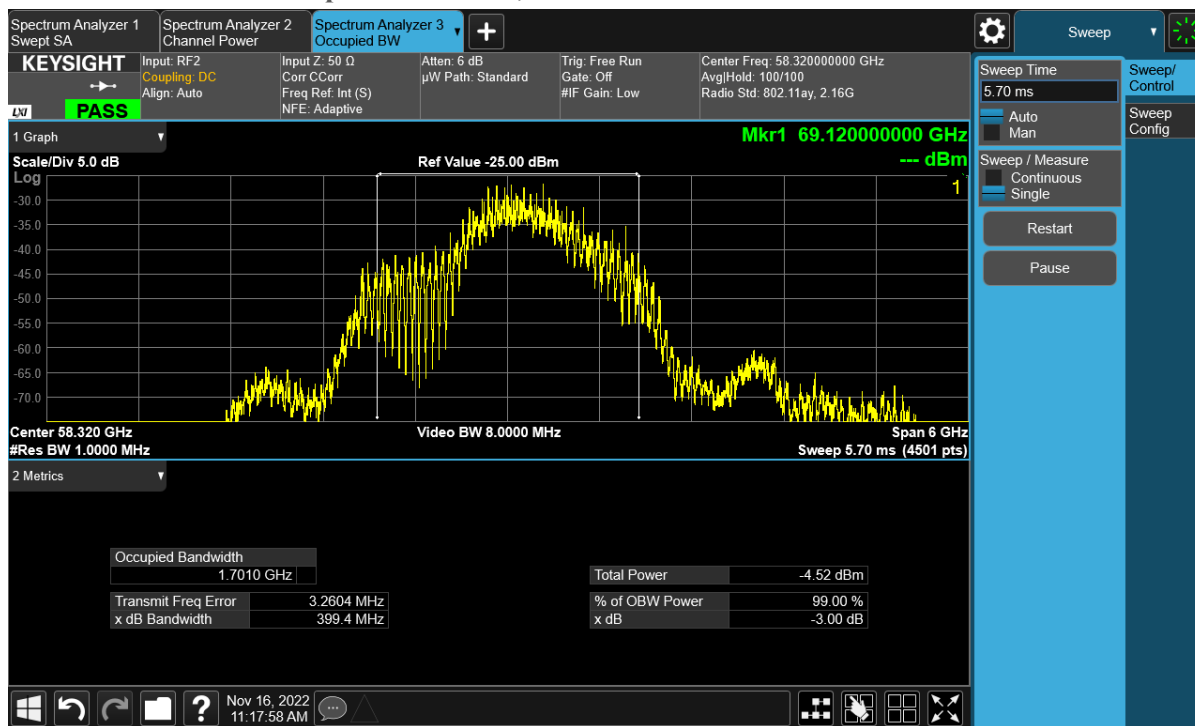
Graph 1: 58.32GHz, 1.06GHz Emissions Bandwidth



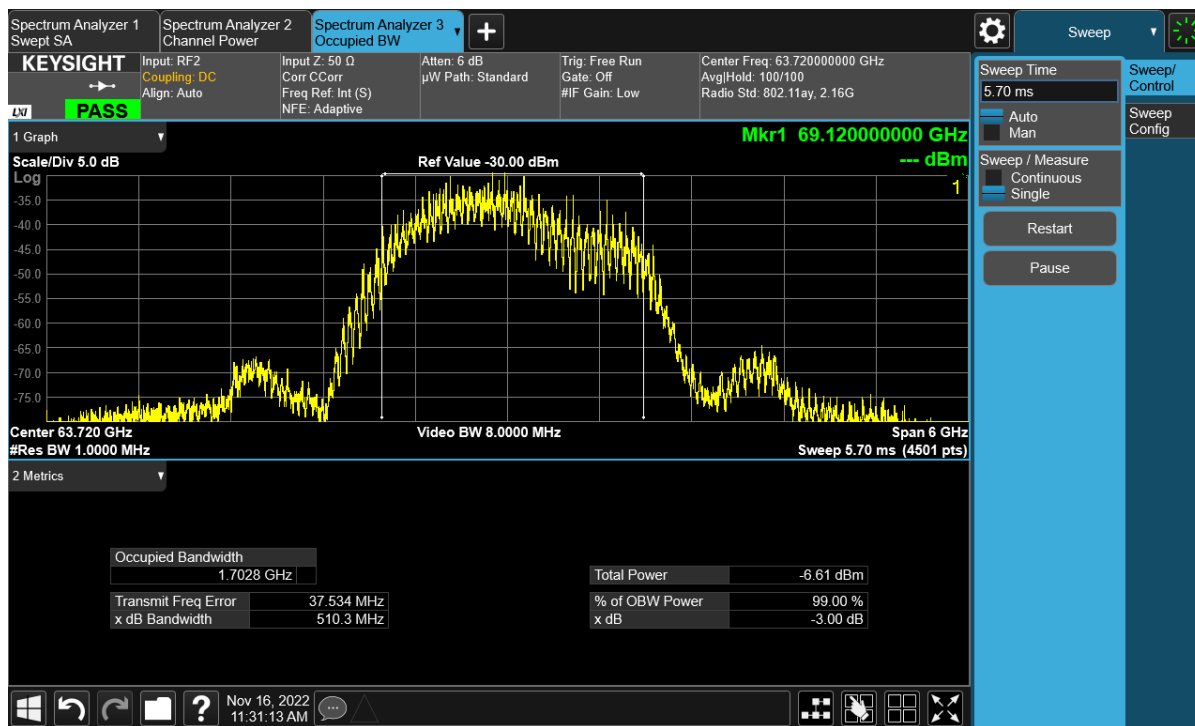
Graph 2: 63.72GHz, 1.06GHz Emissions Bandwidth



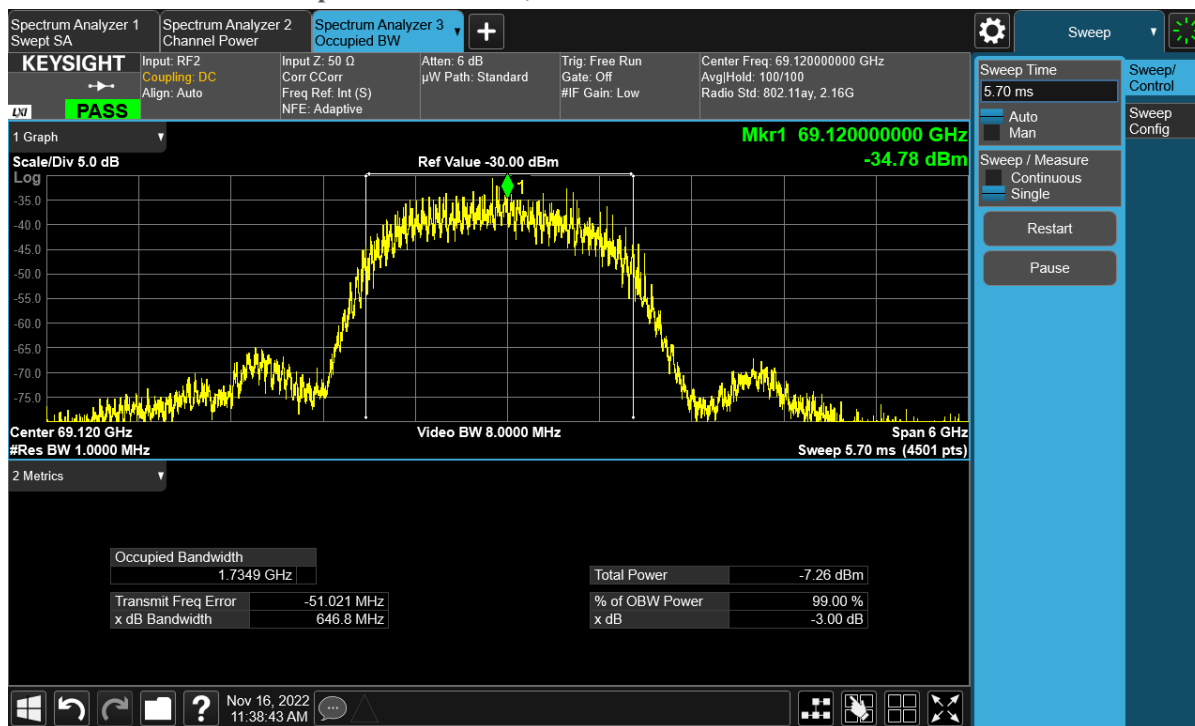
Graph 3: 70.2GHz, 1.06GHz Emissions Bandwidth



Graph 4: 58.32GHz, 2.12GHz Emissions Bandwidth



Graph 5: 63.72GHz, 2.12GHz Emissions Bandwidth



Graph 6: 69.12GHz, 2.12GHz Emissions Bandwidth

5.3 §15.255(c)(1)(i) Maximum Average Output Power

All chains were measured and summed under the guidance of KDB 558074 Section 8.3.2.3. and KDB 66291 D01. Please see associated annex for details on instrument settings.

The maximum average RF EIRP measured for this device was 54.2 dBm or 263 Watts.

For fixed point-to-point transmitters located outdoors, the average power of any emission shall not exceed 82 dBm, and shall be reduced by 2 dB for every dB that the antenna gain is less than 51 dBi. The peak power of any emission shall not exceed 85 dBm, and shall be reduced by 2 dB for every dB that the antenna gain is less than 51 dBi.). The antenna gain is 46dBi therefore the limit of 72 and 75 take precedence.

Nominal BW	Freq. (MHz)	Air Path Loss (dB)	Total Correction (dBm)	Peak SA Reading (dBm)	EIRP Peak (dBm)	Peak EIRP Limit (dBm)	Peak Delta (dBm)
1.08	58320	77.3	56.1	5.36	61.5	75	-13.5
	63720	78.1	56.5	4.65	61.1	75	-13.9
	70200	78.9	57.0	-26.5	58.3	75	-16.7
2.12	58320	77.3	56.1	-21.2	63.0	75	-12.0
	63720	78.1	56.5	-20.9	61.6	75	-13.4
	69120	78.8	57.0	-22.2	60.2	75	-14.8

Nominal BW	Freq. (MHz)	Air Path Loss (dB)	Total Correction (dBm)	AvG SA Reading (dBm)	EIRP Avg (dBm)	Avg EIRP Limit (dBm)	Avg Delta (dBm)
1.08	58320	77.3	56.1	-2.7	53.4	72	-18.6
	63720	78.1	56.5	-3.5	52.9	72	-19.1
	70200	78.9	57.0	-6.8	50.3	72	-21.7
2.12	58320	77.3	56.1	-1.9	54.2	72	-17.8
	63720	78.1	56.5	-3.6	52.9	72	-19.1
	69120	78.8	57.0	-5.7	51.3	72	-20.7

Result

In the configuration tested, the maximum average RF EIRP was less than 40 dBm; therefore, the EUT complied with the requirements of the specification. (see spectrum analyzer plot below/within the Annex).

5.4 §15.255(d) Spurious Emissions

5.4.1 Radiated Spurious Emissions in the Restricted Bands of §15.205

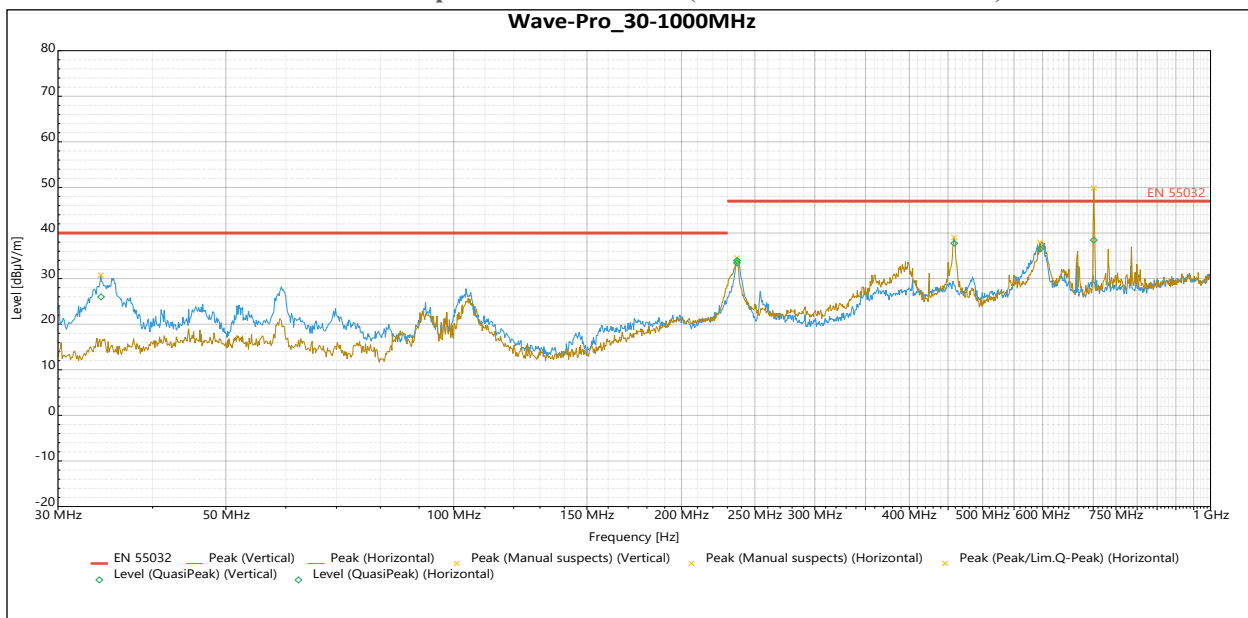
The frequency range from the lowest frequency generated or used in the device to the tenth harmonic of the highest fundamental emissions was investigated to measure any radiated emissions in the restricted bands. The following tables show measurements of any emissions that fell into the restricted bands of §15.205. The tables show the worst-case emissions measured from the EUT. For frequencies between 18.0 and 40 GHz, a measurement distance of 1 meter was used. The noise floor was a minimum of 6 dB below the limits. The emissions in the restricted bands must meet the limits specified in §15.209. Tabular data for each of the spurious emissions is shown below for each of the units. The BLE radio and 60 GHz radio are active during all plots. The limit above 40 GHz is 90pW/cm². The measurement distance above 40 GHz was 3 meters.

Result

All emissions in the restricted bands of §15.205 met the limits specified in §15.209. All emissions met the limits set out in 15.255(d) therefore, the EUT complies with the specification.

Frequency	Det	Level (dBμV/m)	Limit (dBμV/m)	Margin	Azimuth (°)	Height	Pol.	Correction (dB)
34.199 MHz	QP	26.004	40	-13.996	79	1.063	Vertical	-14.947
236.8 MHz	QP	33.945	47	-13.055	115	1.004	Vertical	-12.533
595.17 MHz	QP	36.5	47	-10.5	137	2.317	Vertical	-4.79
236.75 MHz	QP	33.447	47	-13.553	166	3.863	Horizontal	-12.536
458.53 MHz	QP	37.758	47	-9.242	118	1.849	Horizontal	-7.95
700.94 MHz	QP	38.441	47	-8.559	153	1.218	Horizontal	-3.922

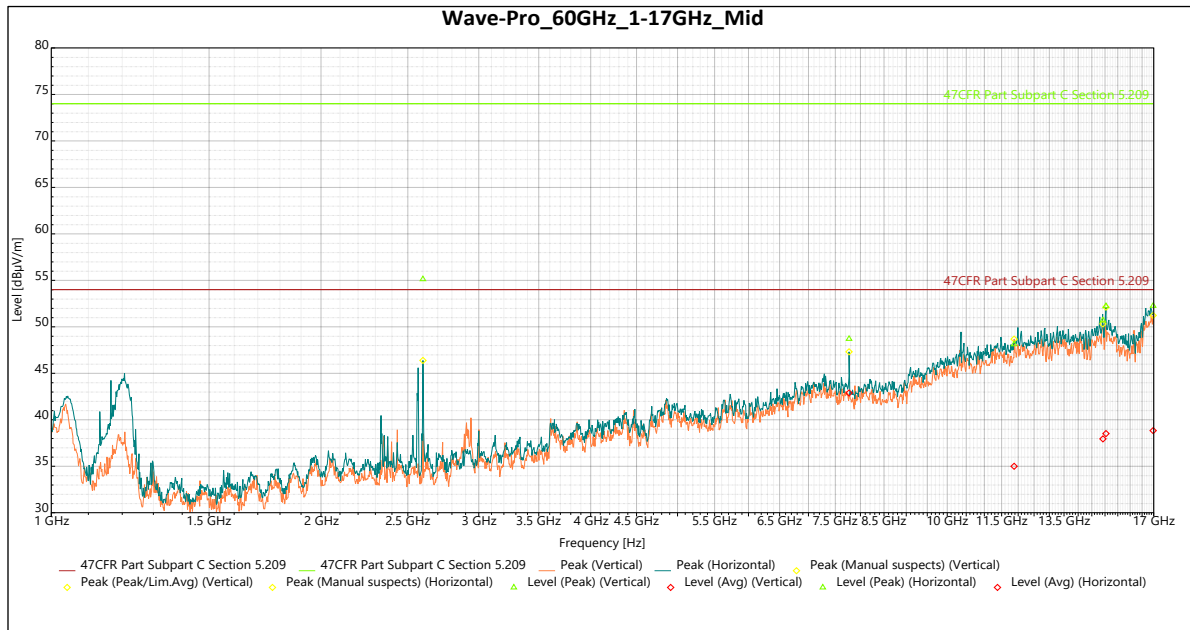
30-100MHz Spurious Emissions (all transmitters Active)



Graph 7 30-100MHz Spurious Emissions (all transmitters Active)

Frequency	Det.	Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	Correction (dB)
1.1665 GHz	PK	45.869	74	-28.131	153	3.798	Vertical	-21.352
14.91 GHz	PK	50.1	74	-23.9	35	1.5	Vertical	7.305
16.975 GHz	PK	52.445	74	-21.555	38	4	Vertical	9.168
1.1665 GHz	AV	21.671	54	-32.329	153	3.798	Vertical	-21.352
14.91 GHz	AV	37.606	54	-16.394	35	1.5	Vertical	7.305
16.975 GHz	AV	38.83	54	-15.17	38	4	Vertical	9.168
10.36 GHz	PK	50.819	74	-23.181	112	3.311	Horizontal	1.024
15.22 GHz	PK	51.091	74	-22.909	357	3.798	Horizontal	6.737
16.757 GHz	PK	51.521	74	-22.479	48	3.798	Horizontal	8.932
10.36 GHz	AV	44.119	54	-9.881	112	3.311	Horizontal	1.024
15.22 GHz	AV	38.053	54	-15.947	357	3.798	Horizontal	6.737
16.757 GHz	AV	39.132	54	-14.868	48	3.798	Horizontal	8.932
15.016 GHz	PK	51.62	74	-22.38	197	3.798	Vertical	7.765
16.676 GHz	PK	49.425	74	-24.575	167	2.812	Vertical	8.916
15.016 GHz	AV	38	54	-16	197	3.798	Vertical	7.765
16.676 GHz	AV	36.992	54	-17.008	167	2.812	Vertical	8.916
10.36 GHz	PK	51.866	74	-22.134	106	1.5	Horizontal	1.024
15.003 GHz	PK	49.683	74	-24.317	132	2.645	Horizontal	7.221
16.769 GHz	PK	50.884	74	-23.116	243	4	Horizontal	9.07
10.36 GHz	AV	46.265	54	-7.735	106	1.5	Horizontal	1.024
15.003 GHz	AV	36.771	54	-17.229	132	2.645	Horizontal	7.221
16.769 GHz	AV	37.153	54	-16.847	243	4	Horizontal	9.07
11.875 GHz	PK	48.121	74	-25.879	240	2.146	Vertical	4.382
14.92 GHz	PK	50.694	74	-23.306	272	3.798	Vertical	7.174
16.976 GHz	PK	52.257	74	-21.743	271	3.307	Vertical	9.19
11.875 GHz	AV	34.993	54	-19.007	240	2.146	Vertical	4.382
14.92 GHz	AV	37.939	54	-16.061	272	3.798	Vertical	7.174
16.976 GHz	AV	38.833	54	-15.167	271	3.307	Vertical	9.19
11.875 GHz	AV	34.993	54	-19.007	240	2.146	Vertical	4.382
14.92 GHz	AV	37.939	54	-16.061	272	3.798	Vertical	7.174
2.5987 GHz	PK	55.125	74	-18.875	260	1.638	Horizontal	-15.894
7.7698 GHz	PK	48.702	74	-25.298	107	1.5	Horizontal	-3.666
15.037 GHz	PK	52.225	74	-21.775	9	4	Horizontal	7.47
16.976 GHz	AV	38.833	54	-15.167	271	3.307	Vertical	9.19
2.5987 GHz	AV	22.488	54	-31.512	260	1.638	Horizontal	-15.894
7.7698 GHz	AV	42.879	54	-11.121	107	1.5	Horizontal	-3.666
15.037 GHz	AV	38.508	54	-15.492	9	4	Horizontal	7.47

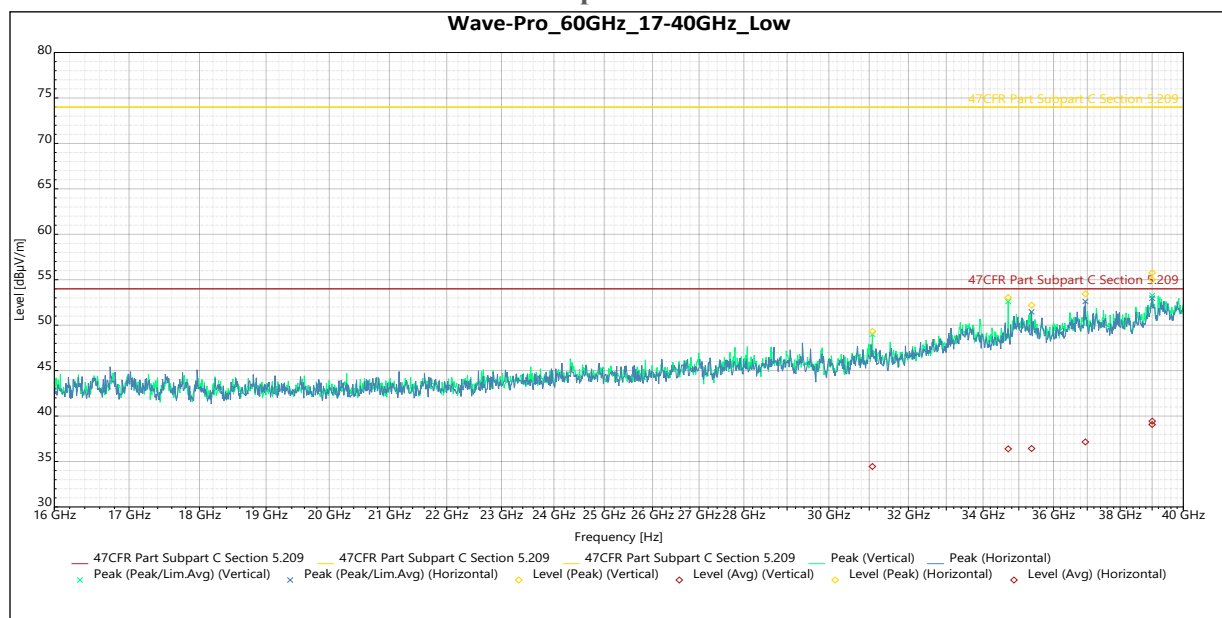
1-17GHz Spurious Emissions



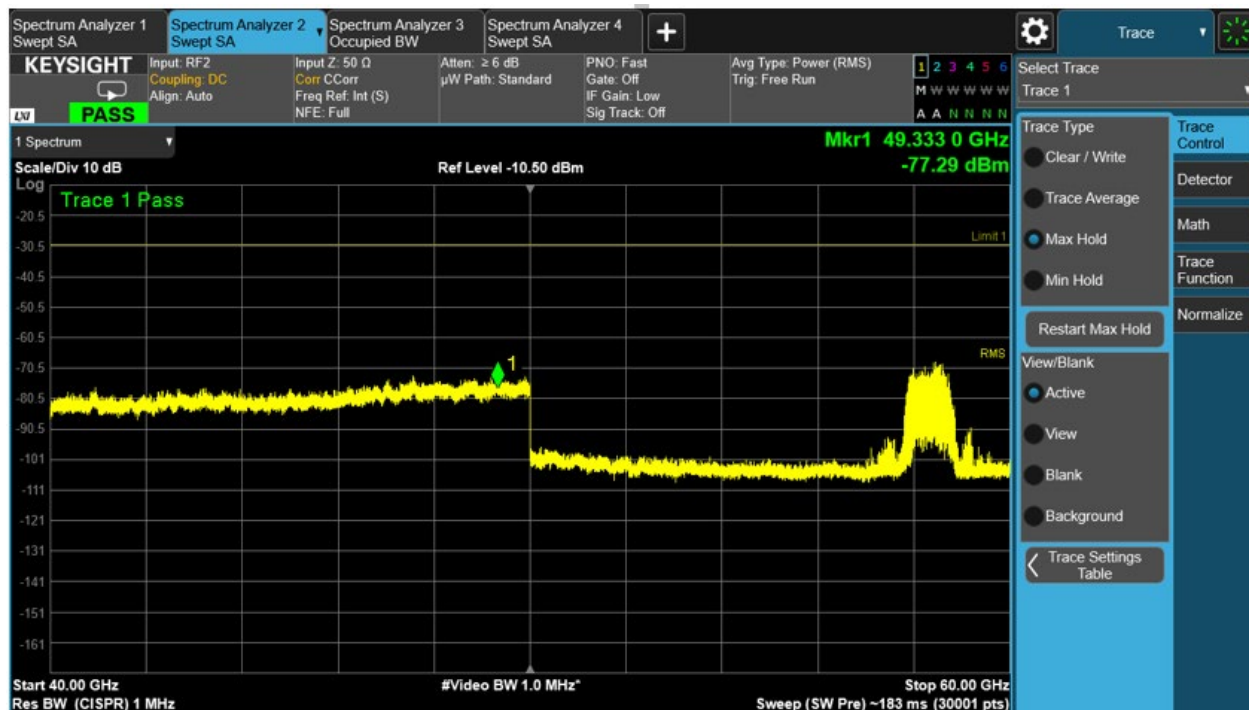
Graph 8 1-17GHz Spurious Emissions (Mid Channel - Worst Case)

Frequency	Det	Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Azimuth (°)	Pol.	Correction (dB)
24.168 GHz	PK	46.063	74	-27.937	6	Vertical	-5.042
36.742 GHz	PK	53.264	74	-20.736	349	Vertical	1.533
39.564 GHz	PK	55.497	74	-18.503	219	Vertical	3.998
24.168 GHz	AV	32.406	54	-21.594	6	Vertical	-5.042
36.742 GHz	AV	37.317	54	-16.683	349	Vertical	1.533
39.564 GHz	AV	38.533	54	-15.467	219	Vertical	3.998
39.013 GHz	PK	55.628	74	-18.372	9	Horizontal	4.015
39.013 GHz	AV	39.094	54	-14.906	9	Horizontal	4.015
31.079 GHz	PK	49.323	74	-24.677	69	Vertical	-0.219
34.701 GHz	PK	53.05	74	-20.95	259	Vertical	1.456
39.003 GHz	PK	55.007	74	-18.993	357	Vertical	4.031
31.079 GHz	AV	34.452	54	-19.548	69	Vertical	-0.219
34.701 GHz	AV	36.39	54	-17.61	259	Vertical	1.456
39.003 GHz	AV	39.439	54	-14.561	357	Vertical	4.031
35.365 GHz	PK	52.189	74	-21.811	320	Horizontal	1.515
36.943 GHz	PK	53.451	74	-20.549	284	Horizontal	2
39.001 GHz	PK	55.771	74	-18.229	98	Horizontal	4.034
35.365 GHz	AV	36.434	54	-17.566	320	Horizontal	1.515
36.943 GHz	AV	37.149	54	-16.851	284	Horizontal	2
39.001 GHz	AV	39.071	54	-14.929	98	Horizontal	4.034
39.006 GHz	PK	55.452	74	-18.548	294	Vertical	4.026
39.006 GHz	AV	39.407	54	-14.593	294	Vertical	4.026
39.012 GHz	PK	54.724	74	-19.276	341	Horizontal	4.017
39.012 GHz	AV	39.054	54	-14.946	341	Horizontal	4.017

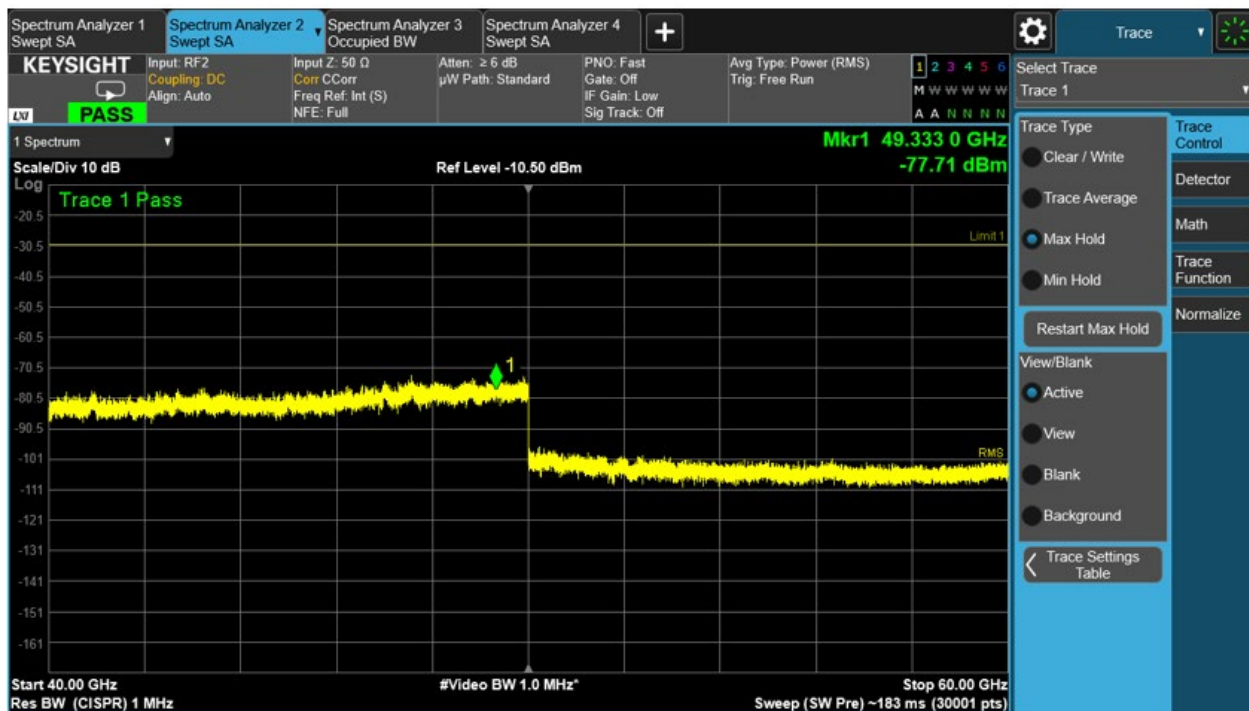
17-40GHz Spurious Emissions



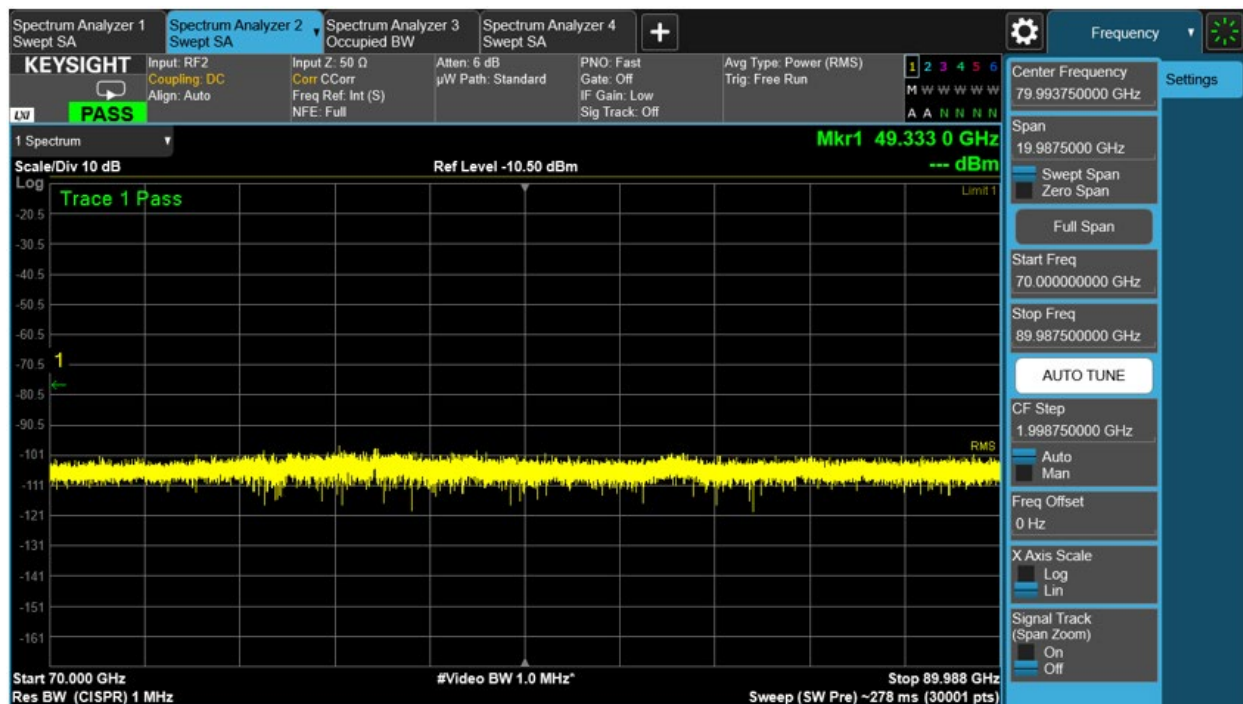
Graph 9 17-40GHz Spurious Emissions (Low Channel - Worst Case)



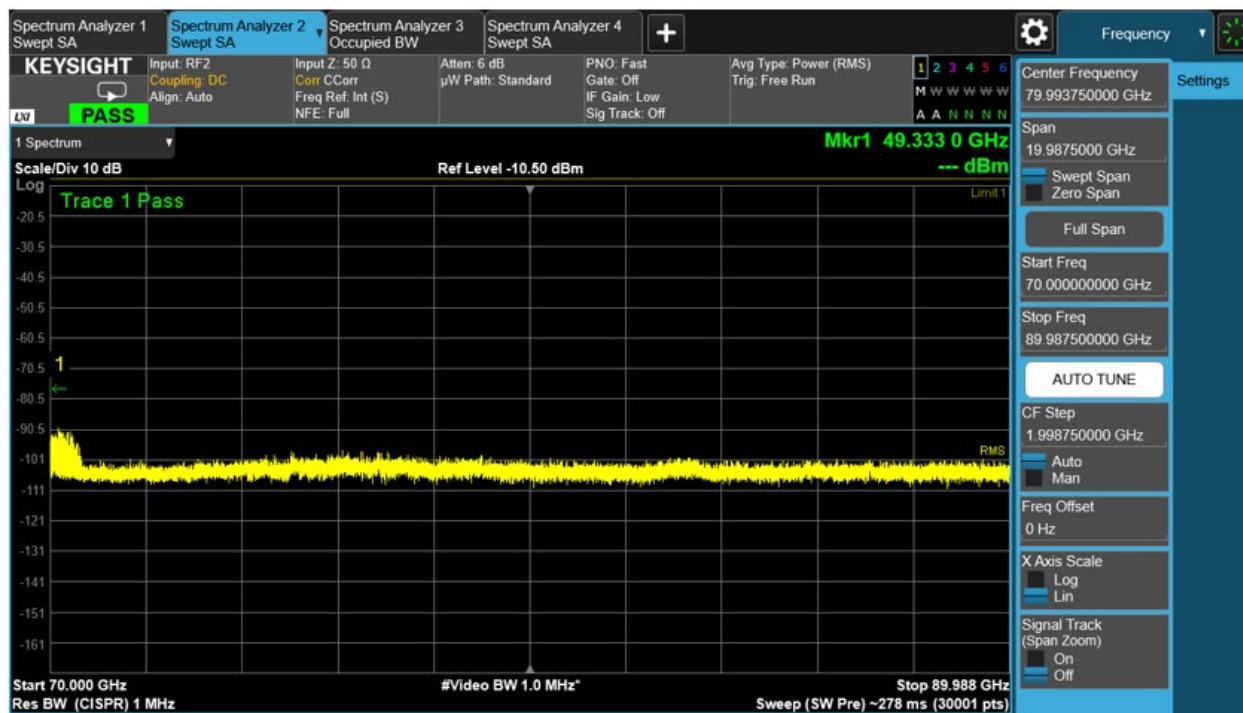
Low Channel 40 – 60 GHz



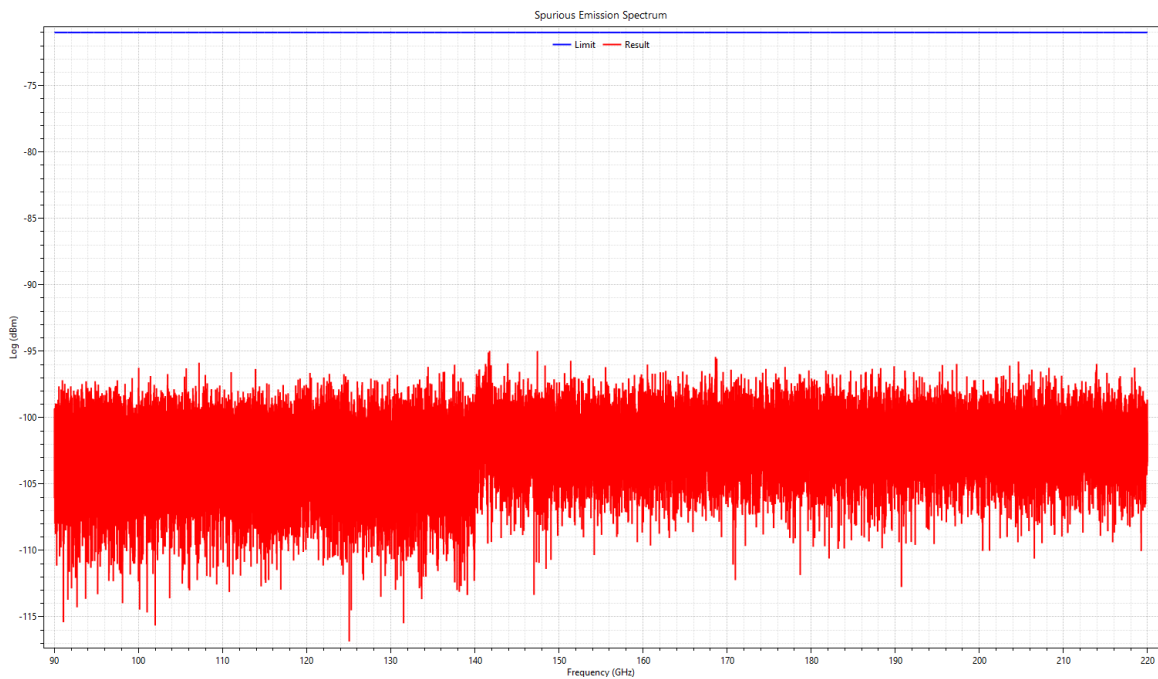
High Channel 40 – 60 GHz



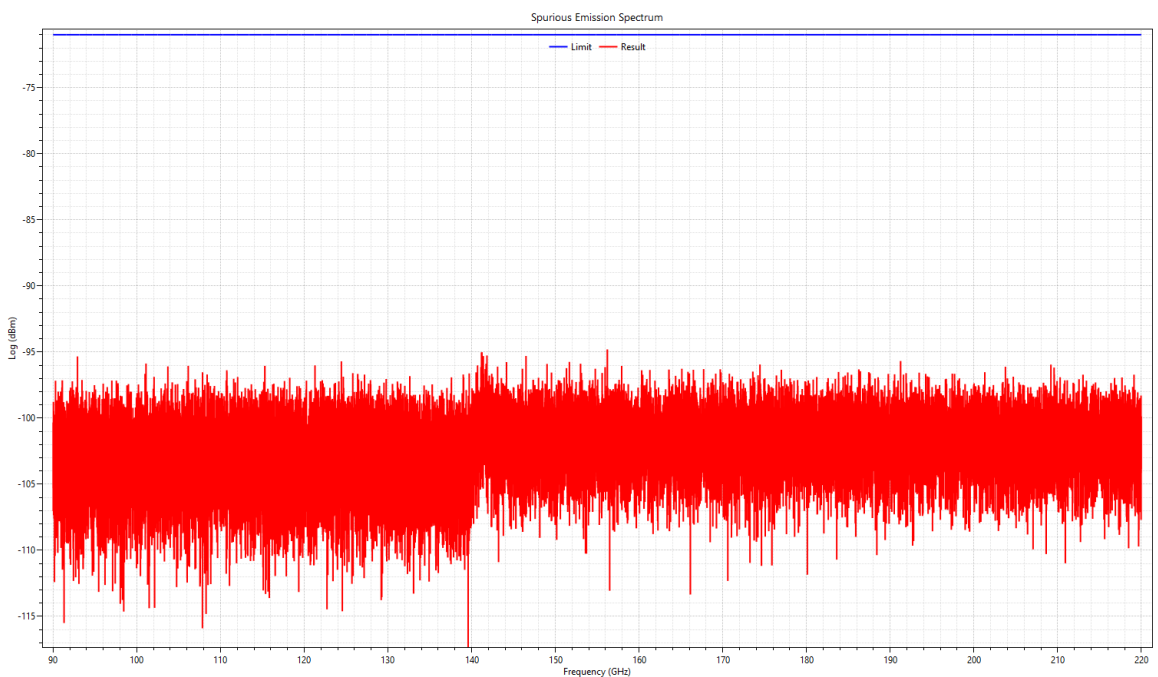
Low Channel 70 – 90 GHz



High Channel 70-90 GHz

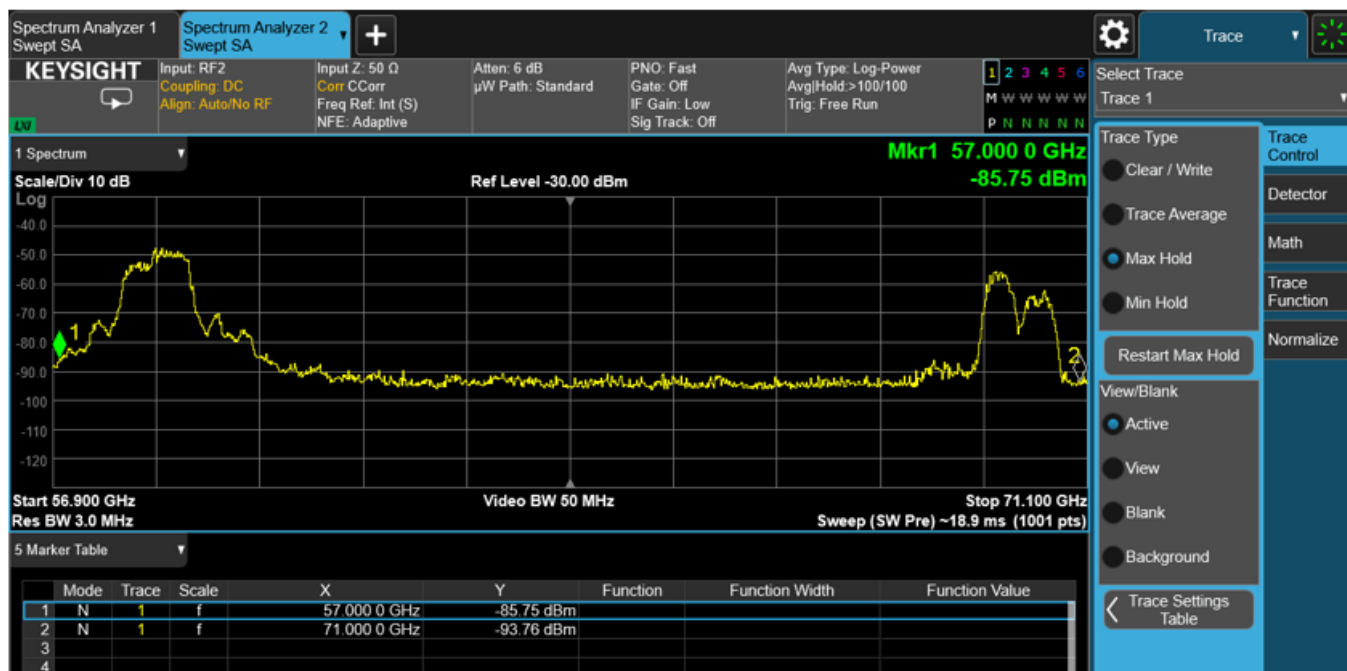


Low Channel 90 – 220 GHz



High Channel 90 – 220 GHz

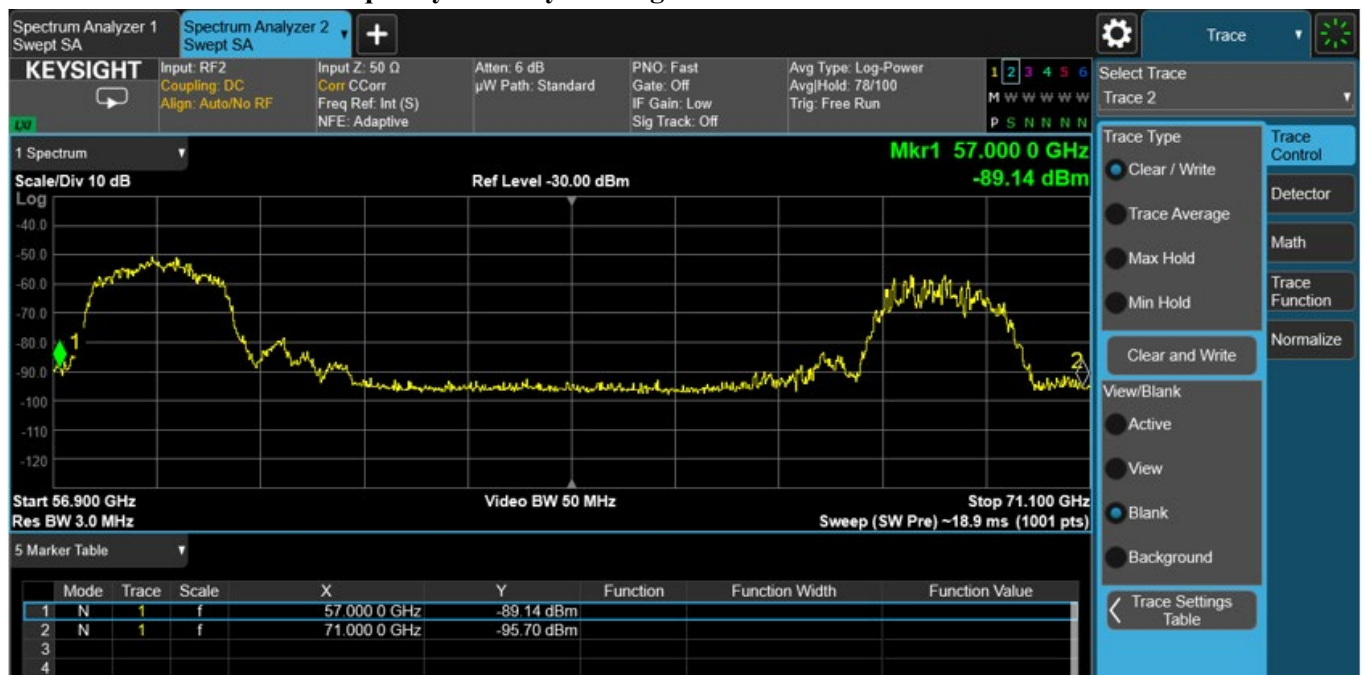
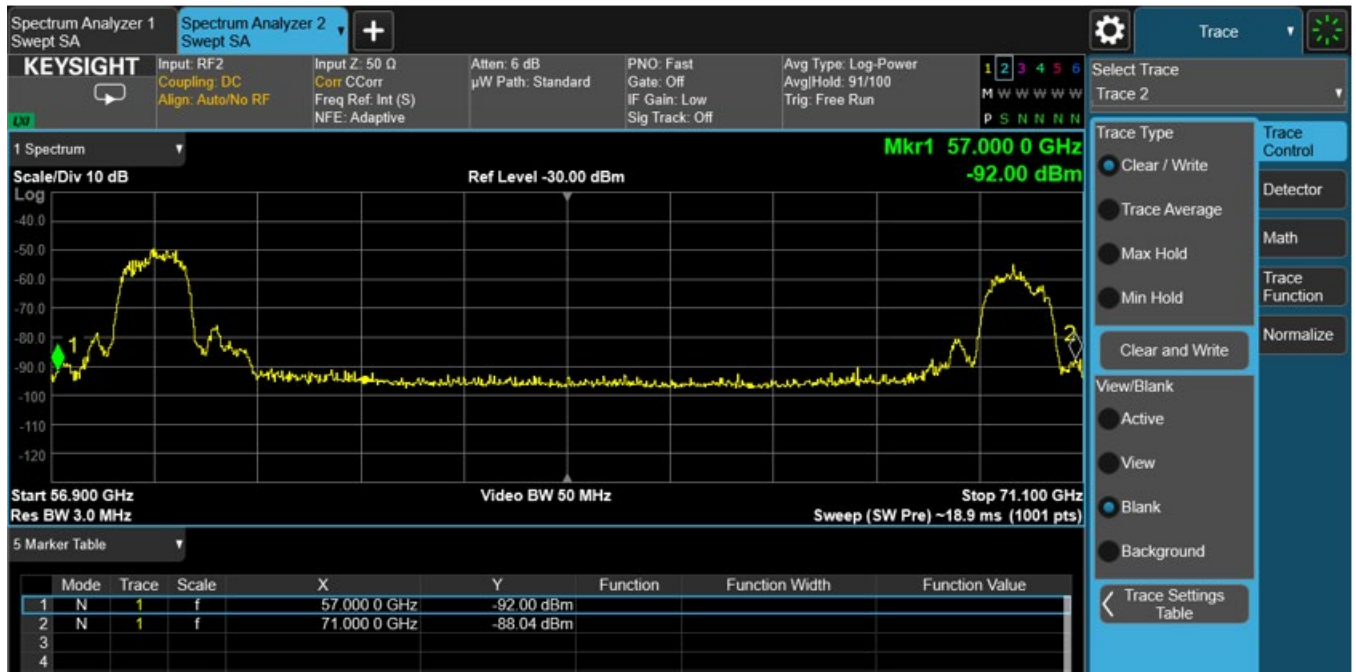
5.5 §15.255(f) Frequency Stability



Frequency Stability -40 degrees 1 GHz Bandwidth



Frequency Stability -40 degrees 2 GHz Bandwidth



-- End of Test Report --