

Test Report

HELEM2209000376-1



INTENTIONAL RADIATOR TESTS ACCORDING TO FCC PART 15 C AND ISED CANADA REQUIREMENTS

Equipment Under Test: Virtual Reality Headset

Model: Varjo Aero

Manufacturer: Varjo Technologies Oy
Vuorikatu 20
FI-00100, Helsinki
Finland

Customer: Varjo Technologies Oy
Vuorikatu 20
FI-00100, Helsinki
Finland

FCC Rule Part: 15.247
IC Rule Part: RSS-247, Issue 2, 2017
RSS-GEN Issue 5 Amendment 2, 2021

KDB: 558074 D01 15.247 Meas Guidance v05r02
Guidance for Compliance Measurements on Digital Transmission Systems,
Frequency Hopping Spread Spectrum System, and Hybrid System Devices
Operating Under §15.247 of the FCC rules (April 2, 2019)

- partial testing; see Summary of Testing for details

Date: 8 September 2022

Issued by:

A handwritten signature in blue ink, appearing to read 'R. Repo'.

Rauno Repo
Senior EMC Specialist

Date: 8 September 2022

Checked by:

A handwritten signature in blue ink, appearing to read 'Henri Mäki'.

Henri Mäki
Testing Engineer

TABLE OF CONTENTS

TABLE OF CONTENTS	2
GENERAL REMARKS.....	3
Disclaimer	3
RELEASE HISTORY	4
PRODUCT DESCRIPTION	5
Equipment Under Test	5
General Description.....	5
Ratings and declarations	5
Power Supply	5
Mechanical Size of the EUT	5
Peripherals	6
SUMMARY OF TESTING.....	7
EUT Test Conditions during Testing	7
Test Facility	8
TEST RESULTS	9
Antenna Requirement	9
Conducted Emissions In The Frequency Range 150 kHz - 30 MHz.....	10
Transmitter Radiated Spurious Emissions 9 kHz – 26.5 GHz	12
TEST EQUIPMENT	19

GENERAL REMARKS

Disclaimer

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Unless otherwise stated the results shown in this test report refer only to the sample(s) tested and such sample(s) are retained for 30 days only.

RELEASE HISTORY

Version	Changes	Issued
1.0	Initial release	8 September 2022

PRODUCT DESCRIPTION

Equipment Under Test

Equipment Under Test:	Virtual Reality Headset
Model:	Varjo Aero
Type:	-
Trademark:	Varjo
Serial no:	V0032E419A00211493
Main PCB version:	5LMP_05
Highest frequency:	4.1 GHz
FCC ID:	2AROD-004
IC:	24483-004
Radio module or chip:	Nordic Semiconductor nRF24L01 (two radio chips)

The EUT was tested as a tabletop unit. The equipment includes two Enhanced ShockBurst radio chips (Nordic Semiconductor nRF24L01), both of which have their own dedicated antennas.

General Description

The equipment under test is a virtual reality headset.

Classification

Fixed device	<input type="checkbox"/>
Mobile Device (Human body distance > 20cm)	<input type="checkbox"/>
Portable Device (Human body distance < 20cm)	<input checked="" type="checkbox"/>

Modifications Incorporated in the EUT

No modifications.

Ratings and declarations

Operating Frequency Range (OFR):	2402 - 2480 MHz
Channels:	40
Channel separation:	2 MHz
Transmission technique:	DSSS
Modulation:	GFSK
Antenna type:	Integrated ceramic chip antennas
Antenna count:	2
Integral Antenna gain:	1.1 dBi

Power Supply

Rated voltage:	12 V
Rated current:	3 A
Rated frequency:	DC

Mechanical Size of the EUT

Height: 170 mm	Width: 200 mm	Length: 300 mm
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Peripherals

VR adapter:	Power supply and data communication between laptop and EUT.
Laptop:	Razer Blade RZ09-0330. Device configuration.
AC/DC power supply:	Razer RC30-024801. Power supply to laptop.
AC/DC power supply:	Adapter Technology ATS036T-W120V. Power supply to EUT.

The peripherals were provided by the customer.

SUMMARY OF TESTING

Test Specification	Description of Test	Result
§15.203	Antenna requirement	PASS
§15.207(a) / RSS-GEN 8.8	Conducted Emissions on Power Supply Lines	PASS
§15.247(b)(3) / RSS-247 5.4(d)	Maximum Peak Conducted Output Power	N/T ⁽¹⁾
§15.247(a)(2) / RSS-247 5.2(a)	6 dB Bandwidth	N/T ⁽¹⁾
§15.247(e) / RSS-247 5.2(b)	Power Spectral Density	N/T ⁽¹⁾
RSS-GEN 6.7	99% Occupied Bandwidth	N/T ⁽¹⁾
§15.247(d) / RSS-247 5.5	100 kHz Bandwidth of Frequency Band Edges and Conducted Spurious Emissions	N/T ⁽¹⁾
§15.209(a), §15.247(d) / RSS-247 5.5	Radiated Emissions Within the Restricted Bands	PASS

¹⁾ Not tested by the request of the customer

The decision rule applied for the tests results stated in this test report is according to the requirements of section 1.3 of ANSI C63.10-2013.

EUT Test Conditions during Testing

The EUT's radio was in continuous transmit mode during all the tests and was configured into the wanted channel using software provided by the manufacturer. During testing a test image was visible on the displays, the eye tracking cameras were running in test mode, Steam tracking was running, cooling fan was set to constant 10% running speed, white noise was played from the earphones, and internal logging of temperatures, voltage and current consumption was running.

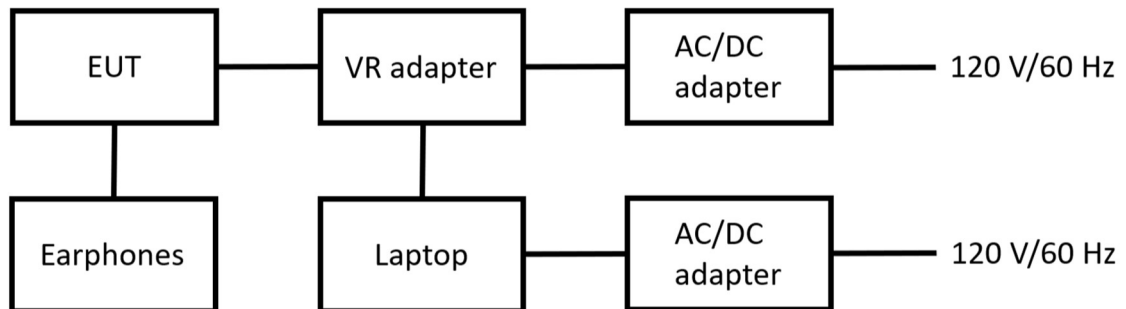


Figure 1: Test setup block diagram

Table 1: Test frequencies and settings

Channel	Frequency (MHz)
Low	2402
Mid	2440
High	2480

Test Facility

<p>Testing Laboratory / address: FCC designation number: FI0002 ISED CAB identifier: T004</p>	<p>SGS Fimko Ltd Takomotie 8 FI-00380, HELSINKI FINLAND</p>
<p>Test Site:</p>	<p><input type="checkbox"/> K10LAB, ISED Canada registration number: 8708A-1 <input checked="" type="checkbox"/> K5LAB, ISED Canada registration number: 8708A-2 <input type="checkbox"/> T10LAB</p>

TEST RESULTS

Antenna Requirement

Standard: FCC Rule §15.203
Tested by: RRE
Date: 6 September 2022

FCC Rule: 15.203

An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device.

Specification	Requirement (at least one of the following shall be applied)	Conclusion
§15.203	1. Permanently attached antenna 2. Unique coupling to the intentional radiator 3. Professionally installed radio. The installer shall be responsible for ensuring that the proper antenna is employed so that the limits in this part are not exceeded.	PASS
Note	Option1 is used	

Conducted Emissions In The Frequency Range 150 kHz - 30 MHz

Conducted Emissions In The Frequency Range 150 kHz - 30 MHz

Standard: ANSI C63.10 (2013)
Tested by: HEM
Date: 6 September 2022
Temperature: 23 ± 3 °C
Humidity: 20 - 75 % RH
Measurement uncertainty: ± 2.9 dB Level of confidence 95 % (k = 2)

FCC Rule: 15.207 (a)
RSS-GEN 8.8

Conducted disturbance voltage was measured with an artificial main network from 150 kHz to 30 MHz with 4.5 kHz steps and a resolution bandwidth of 9 kHz. Measurements were carried out with peak and average detectors.

Frequency of emission (MHz)	Conducted limit (dBµV)	
	Quasi-peak	Average
0.15-0.5	66 to 56*	56 to 46*
0.5-5	56	46
5-30	60	50

*Decreases with the logarithm of the frequency.

Full Spectrum

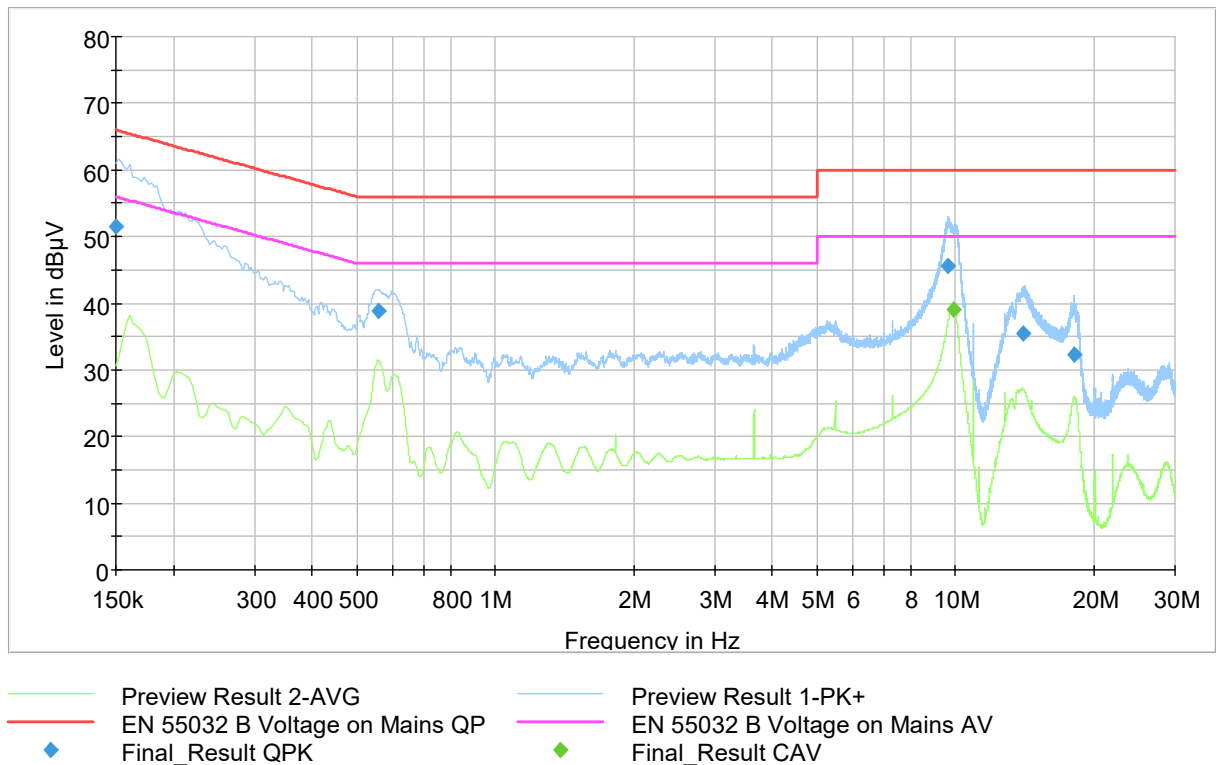


Figure 2: The measured curves with peak- and average detector (low channel)

Conducted Emissions In The Frequency Range 150 kHz - 30 MHz

Final measurements from the worst frequencies

Table 2: Final results

Frequency (MHz)	QuasiPeak (dB μ V)	CAverage (dB μ V)	Limit (dB μ V)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	Corr. (dB)
0.150000	51.50	---	66.00	14.50	15x1000.0	9.000	N	9.7
0.557500	38.74	---	56.00	17.26	15x1000.0	9.000	L1	9.7
9.634000	45.50	---	60.00	14.50	15x1000.0	9.000	L1	10.2
9.877000	---	39.08	50.00	10.92	15x1000.0	9.000	L1	10.2
14.079250	35.40	---	60.00	24.60	15x1000.0	9.000	N	10.4
18.104250	32.36	---	60.00	27.64	15x1000.0	9.000	N	10.5

The correction factor in the final result table contains the sum of the transducers (cables + LISN). The result value is the measured value corrected with the correction factor.

Transmitter Radiated Spurious Emissions 9 kHz – 26.5 GHz
Transmitter Radiated Spurious Emissions 9 kHz – 26.5 GHz

Standard: ANSI C63.10 (2013)
Tested by: RRE, HEM
Date: 8 September 2022
Temperature: 23 ± 3 °C
Humidity: 20 - 75 % RH
Measurement uncertainty: ± 4.51 dB Level of confidence 95 % (k = 2)

FCC Rule: 15.247(d), 15.209(a)

RSS-247 5.5

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power. In addition, radiated emissions which fall in the restricted bands, as defined in Section 15.205(a), must also comply with the radiated emission limits specified in Section 15.209(a).

At the request of the customer the emissions below 1000 MHz are additionally compared to the general limits specified in Section 15.209(a), whether or not they fall in the restricted bands.

The correction factor in the final result table contains the sum of the transducers (antenna + amplifier + cables).

Frequency range [MHz]	Limit [$\mu\text{V/m}$]	Limit [$\text{dB}\mu\text{V/m}$]	Detector
0.009-0.490	2400/F(kHz)	48.5-13.8	Quasi-peak
0.490-1.705	24000/F(kHz)	33.8-22.97	Quasi-peak
1.705-30.0	30	29.54	Quasi-peak
30 - 80	100	40.0	Quasi-peak
88 - 216	150	43.5	Quasi-peak
216 - 960	200	46.0	Quasi-peak
960 - 1000	500	53.9	Quasi-peak
Above 1000	500	53.9	Average
Above 1000	5000	73.9	Peak

Transmitter Radiated Spurious Emissions 9 kHz – 26.5 GHz

Results LOW channel

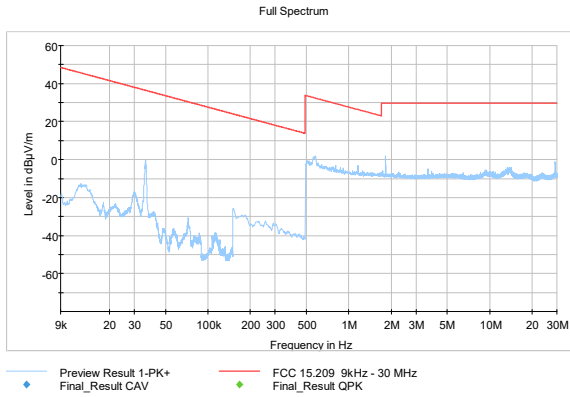


Figure 3: LOW channel (9 kHz – 30 MHz)

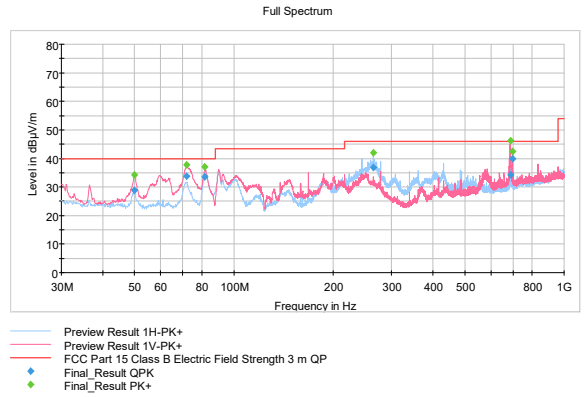


Figure 4: LOW channel (30 MHz – 1000 MHz)

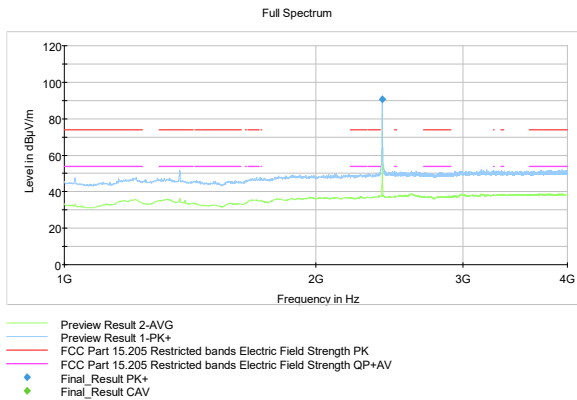


Figure 5: LOW channel (1 GHz – 4 GHz)

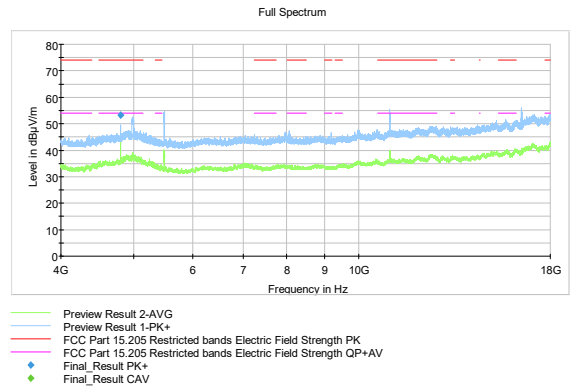


Figure 6: LOW channel (4 GHz – 18 GHz)

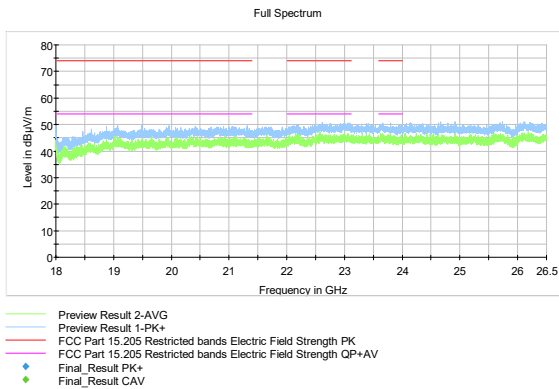


Figure 7: LOW channel (18 GHz – 26.5 GHz)

Transmitter Radiated Spurious Emissions 9 kHz – 26.5 GHz
Table 3: Quasi-peak results LOW channel

Frequency (MHz)	QuasiPeak (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	PoI	Azimuth (deg)	Corr. (dB/m)
49.995000	28.86	40.00	11.14	15x1000.0	120.000	105.0	V	246.0	17.8
71.995000	33.87	40.00	6.13	15x1000.0	120.000	105.0	V	348.0	15.7
81.665000	33.44	40.00	6.56	15x1000.0	120.000	100.0	V	260.0	12.8
263.975000	36.81	46.00	9.19	15x1000.0	120.000	129.0	H	191.0	18.1
687.525000	34.14	46.00	11.86	15x1000.0	120.000	105.0	V	0.0	28.1
697.465000	39.88	46.00	6.12	15x1000.0	120.000	100.0	V	348.0	28.2

Table 4: Peak results LOW channel

Frequency (MHz)	MaxPeak (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	PoI	Azimuth (deg)	Corr. (dB/m)
2401.600000*	90.75	---	---	15x1000.0	1000.000	116.0	V	19.0	13.8
4803.900000	53.27	74.00	20.73	15x1000.0	1000.000	154.0	V	11.0	7.5

* Fundamental frequency

Transmitter Radiated Spurious Emissions 9 kHz – 26.5 GHz

Results MID channel

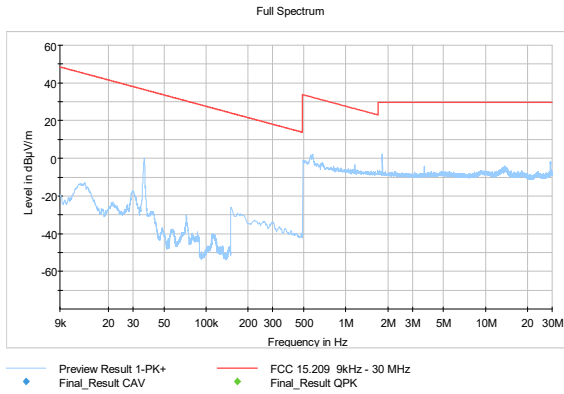


Figure 8: MID channel (9 kHz – 30 MHz)

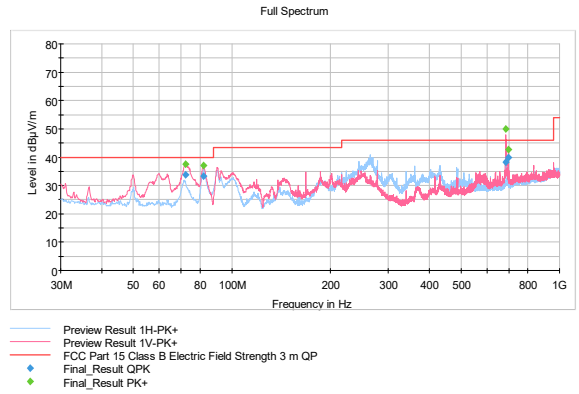


Figure 9: MID channel (30 MHz – 1000 MHz)

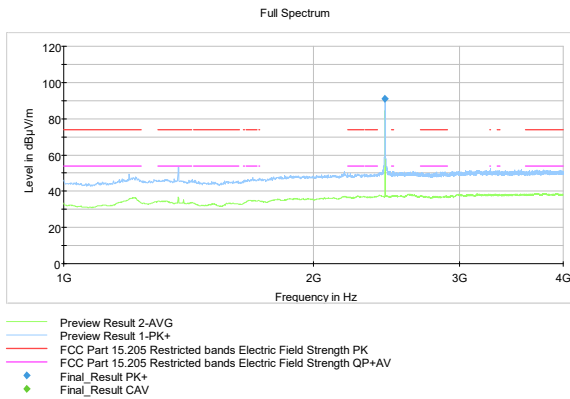


Figure 10: MID channel (1 GHz – 4 GHz)

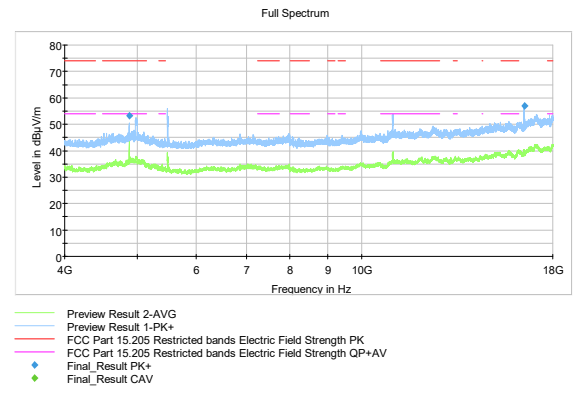


Figure 11: MID channel (4 GHz – 18 GHz)

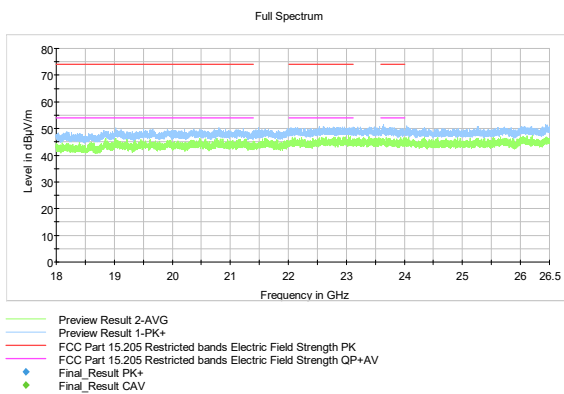


Figure 12: MID channel (18 GHz – 26.5 GHz)

Transmitter Radiated Spurious Emissions 9 kHz – 26.5 GHz
Table 5: Quasi-peak results MID channel

Frequency (MHz)	QuasiPeak (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
72.015000	33.80	40.00	6.20	15x1000.0	120.000	100.0	V	354.0	15.7
81.955000	33.36	40.00	6.64	15x1000.0	120.000	100.0	V	252.0	12.7
686.385000	38.35	46.00	7.65	15x1000.0	120.000	175.0	V	75.0	28.1
697.485000	39.85	46.00	6.15	15x1000.0	120.000	100.0	V	351.0	28.3

Table 6: Peak results MID channel

Frequency (MHz)	MaxPeak (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
2439.600000	90.95*	---	---	15x1000.0	1000.000	112.0	V	15.0	13.8
4879.800000	53.25	74.00	20.75	15x1000.0	1000.000	169.0	V	4.0	7.5
16491.100000	56.99	-20 dBc	33.96	15x1000.0	1000.000	232.0	V	200.0	22.4

* Fundamental frequency

Transmitter Radiated Spurious Emissions 9 kHz – 26.5 GHz

Results HIGH channel

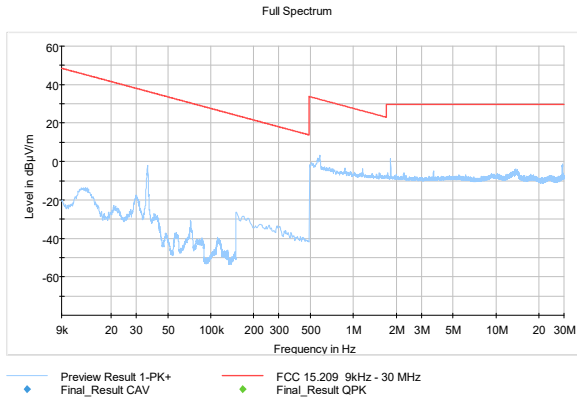


Figure 13: HIGH channel (9 kHz – 30 MHz)

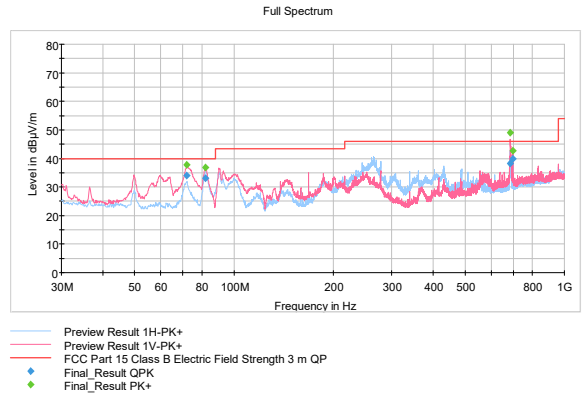


Figure 14: HIGH channel (30 MHz – 1000 MHz)

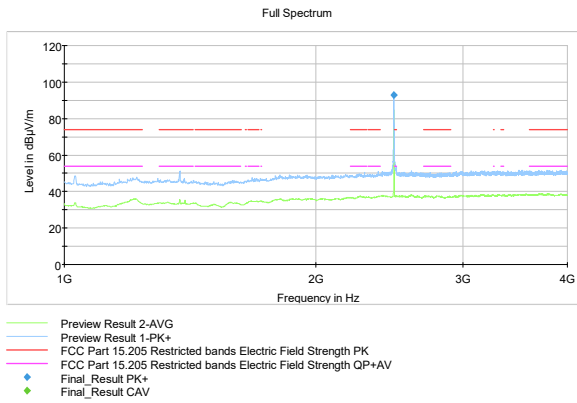


Figure 15: HIGH channel (1 GHz – 4 GHz)

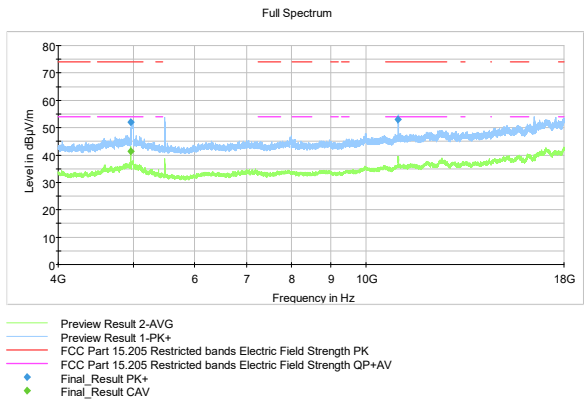


Figure 16: HIGH channel (4 GHz – 18 GHz)

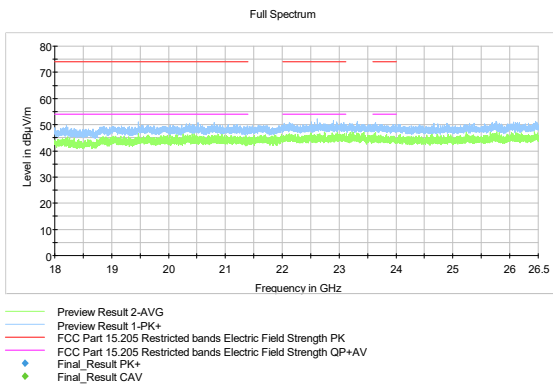


Figure 17: HIGH channel (18 GHz – 26.5 GHz)

Transmitter Radiated Spurious Emissions 9 kHz – 26.5 GHz
Table 7: Quasi-peak results HIGH channel

Frequency (MHz)	QuasiPeak (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
71.995000	33.97	40.00	6.03	15x1000.0	120.000	100.0	V	345.0	15.7
81.925000	33.17	40.00	6.83	15x1000.0	120.000	105.0	V	263.0	12.7
686.405000	38.13	46.00	7.87	15x1000.0	120.000	175.0	V	90.0	28.1
697.465000	39.93	46.00	6.07	15x1000.0	120.000	100.0	V	350.0	28.2

Table 8: Average results HIGH channel

Frequency (MHz)	CAverage (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
4959.900000	41.31	54.00	12.69	15x1000.0	1000.000	143.0	V	4.0	7.3

Table 9: Peak results HIGH channel

Frequency (MHz)	MaxPeak (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
2480.000000	92.74*	---	---	15x1000.0	1000.000	148.0	V	26.0	13.8
4959.300000	52.08	74.00	21.92	15x1000.0	1000.000	154.0	V	0.0	7.3
10993.800000	52.91	74.00	21.09	15x1000.0	1000.000	217.0	V	122.0	15.9

* Fundamental frequency

TEST EQUIPMENT
Conducted Emissions

Equipment	Manufacturer	Type	Inv or serial	Prev Calib	Next Calib
TEST SOFTWARE	ROHDE & SCHWARZ	EMC-32	-	NCR	NCR
LISN	ROHDE & SCHWARZ	ENV216	inv:9611	2022-02-02	2023-02-02
LISN	ROHDE & SCHWARZ	ESH3-Z5	inv. 8019	2022-06-01	2023-06-01
EMI TEST RECEIVER	ROHDE & SCHWARZ	ESW26	inv:10679	2022-06-20	2023-06-20
POWER SUPPLY	CALIFORNIA INSTR.	5001 iX Series II	inv:7826	NCR	NCR

Radiated Emissions

Equipment	Manufacturer	Type	Inv or serial	Prev Calib	Next Calib
ANTENNA	ROHDE & SCHWARZ	HFH2-Z2 , 335.4711.52	inv. 8013	2020-10-28	2022-10-28
ANTENNA	SCHWARZBECK	VULB 9168	inv. 8911	2020-11-04	2022-11-04
ANTENNA	EMCO	3160-09, emi 18-26.5GHz	inv. 7294	2022-02-22	2023-02-22
ANTENNA	EMCO	3117, emi 1-18GHz	inv. 7293	2022-06-12	2024-06-16
ANTENNA MAST	MATURO	TAM 4.0E	inv. 10181	NCR	NCR
ATTENUATOR	INMET	10 dB, DC-40 GHz	sn. A2	2021-04-20	2023-04-20
ATTENUATOR	PASTERNAK	PE 7004-4 (4dB)	inv. 10126	2021-03-30	2023-03-30
EMI TEST RECEIVER	ROHDE & SCHWARZ	ESW26	inv. 10679	2022-06-20	2023-06-20
FILTER	WAINWRIGHT	WHKX4.0/18G-10SS	inv. 10403	2021-01-29	2023-01-29
MAST & TURNTABLE CONTROLLER	MATURO	NCD	inv. 10183	NCR	NCR
POWER SUPPLY	CALIFORNIA INSTR.	5001 iX Series II	inv. 7826	NCR	NCR
RF PREAMPLIFIER	CIAO	CA118-3123	inv. 10278	2021-10-05	2022-10-05
RF PREAMPLIFIER	CIAO	CA1840-5019	inv. 10593	2021-10-05	2022-10-05
TEST SOFTWARE	ROHDE & SCHWARZ	EMC-32	-	-	-
TURNTABLE	MATURO	DS430 UPGRADED	inv. 10182	NCR	NCR

NCR = No calibration required

END OF REPORT