

EMC Test Report

According to

Title 47 CFR Part 15 Subpart B

ISED ICES-Gen Issue 1; Amendment 1 (February 2021)

ISED ICES-003 Issue 7

ANSI C63.4:2014+A1:2017

DUT Name: TR4111000
Model No. : 4111000
Customer: Treon Oy
Address: Visiokatu 3, 33720 Tampere, Finland
Summary: IN COMPLIANCE
Date of Reception: 15.3.2024
Date(s) of Test(s): 18.3.2024 – 3.4.2024

Tested by (Test Engineer)


Pekka Pulkkinen

Approved by (Technical Manager)


Jukka Rauma

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Document Version History	Date of issue	Comments	Approved by
v0.1	24.06.2024	Initial version	
v1.0	26.06.2024	Approved version	Jukka Rauma

1. General Information

Test Engineer: Pekka Pulkkinen

Location:

Test Firm Name	Eurofins Electric & Electronics Finland Oy (EEEF)
Test Site	Yrttipellontie, Peltola
Address of Test Site	Yrttipellonte 6, 90230 Oulu, Finland
FCC Designation number	FI0008
FCC site registration number	771880
ISED number	29576
CAB Identifier	T290

Customer: Treon Oy
Visiokatu 3, 33270 Tampere, Finland
Mika Sipola
tel: +358 40 750 4514
mika.sipola@treon.fi

Climate Conditions: Temperature: 15 - 35 °C
Air pressure: 860 - 1060 hPa
Humidity: 30-60 rH%
These limits were not exceeded during testing.

2. Test Samples

General description:

4111000 and 5111000 together form a comprehensive and versatile tracking device.

4111000 is responsible for providing local & wide area connectivity to a backend service using in-built antennas, monitoring selected metrics using in-built sensors and autonomous operation using an in-built battery.

5111000 has a powerful processing unit, plenty of RAM and data storage for the processing of data from the monitored object 4111000, and for running internal applications for various purposes.

5111000 has multiple different connectors for data transfer, power transfer and connection of external devices.

Test samples:

Sample number	Serial number	Manufacturer	DUT Type	Model	HW version	SW version	Comments
3955ER011	24034339500043 (CU EMC05 v2)	Treon Oy	Connectivity unit	4111000	05	5.3	

Accessories:

Sample number	Serial number	Manufacturer	DUT Type	Model	HW version	SW version	Comments
3955ER013	PU0BF6CEBF CW2350	Treon Oy	Processing unit + power cable	5111000	C	0.0.2	
3955ER015	5CD311DJZL	HP	Laptop	14s-fq0033no	NA	NA	EMC TEST PC
3955ER016	NA	Treon Oy	Power cable 5111000 to lab power	NA	NA	NA	
3955ER017	NA	Treon Oy	Cable 5111000 to laptop	NA	NA	NA	

3. Configuration and Operation Modes

Operation Mode	Description
OM1	EUT ON. Sensor reading 1 sec interval. GNSS active, nFC enabled, Quectel LTE Band 2 in IDLE mode, WLAN enabled. 4111000 – 5111000 data 1 sec interval transmission. Power Supply: 24 VAC/50 Hz

4. Test sample description

Model	4111000	
Additional model(s)	-	
Brand name	-	
FCC ID	2AR86-TR41	
IC	24716-TR41	
Class	Class B	
Radio 1	Type	Bluetooth Low Energy 5.0, ANT1
	Model	nRF52840
	Manufacturer	Nordic Semiconductor ASA
	FCC-ID	2AR86-TR41
	IC	24716-TR41
Antenna	Type	Integrated antenna, manufacturer: Treon, Gain 5.04 dBi (ANT1)
Radio 2	Type	Bluetooth Low Energy 5.0, ANT2
	Model	nRF52840
	Manufacturer	Nordic Semiconductor ASA
	FCC-ID	2AR86-TR41
	IC	24716-TR41
Antenna	Type	Integrated antenna, manufacturer: Treon, Gain 0.91 dBi (ANT2)
Radio module 1	Type	Cellular 1
	Model	nRF9160
	Manufacturer	Nordic Semiconductor ASA
	FCC-ID	2ANPO00NRF9160
	IC	24529-NRF9160
Antenna	Type	LTE Main antenna, manufacturer: Treon, gain 4.83 dBi
Radio module 2	Type	Cellular 2
	Model	EG21-G
	Manufacturer	Quectel
	FCC-ID	XMR201906EG21G
	IC	102224A-201906EG21G
Antenna	Type	LTE Main antenna, manufacturer: Treon, gain 4.83 dBi
Radio module 3	Type	WLAN
	Model	LILY-W131
	Manufacturer	u-blox
	FCC-ID	XPYLILYW1
	IC	8595A-LILYW1

Antenna	Type	Integrated antenna, manufacturer: Treon, Gain 0.97 dBi
Manufacturer	Treon Oy Visiokatu 3, 33720 Tampere, Finland	

Ports	Port		Cable					
	Name and description		Shielded	Specified max length [m]	Attached during test			
	4111000 – 5111000 cable port		☐	2.4	☒			
			☐		☐			
			☐		☐			
			☐		☐			
Supplementary information to the ports								
Rated power supply	Voltage and Frequency			Reference poles				
				L1	N	PE		
	☐	AC 230 V	☐ 50 Hz ☐ 60 Hz	☐	☐	☐		
	☐	AC 240 V	☐ 50 Hz ☐ 60 Hz	☐	☐	☐		
	☐	AC 110 V	☐ 50 Hz ☐ 60 Hz	☐	☐	☐		
	☐	AC 100 V	☐ 50 Hz ☐ 60 Hz	☐	☐	☐		
	☒	Other: internal battery, Nickel-Metal-Hydrid			☐	☐		
DC: 6 VDC								
Rated Power								
Clock frequencies								
CU-PU USB comm: 480 MHz, application processor : 64 MHz								
Other parameters								
Dimensions in cm (W x H x D)								
259,8 x 94 x 29.8 mm								
Weight								
731 gr								
Mounting position	☐	Table top equipment						
	☒	Wall/Ceiling mounted equipment						
	☐	Floor standing equipment						
	☐	Hand-held equipment						
	☐	Other:						

5. Test description

5.1. FCC subpart 15B and ICES-003, radiated emission test procedure

Radiated tests were performed in a semi-anechoic chamber that has met NSA requirements (4 dB tolerance) according to

- CISPR 16-1-4 Ed. 4.0 2019-01 Validation of a SAC (6.8) using the Reference Site Method (RSM) (6.6);
- ANSI C63.4a -2017 Validation of radiated emission test sites (30MHz – 1 GHz) (Annex D)

sVSWR requirements (1 -18 GHz) are met according to

- CISPR 16-1-4 Ed. 4.0 2019-01 sVSWR site validation – standard test procedure (7, 7.6)

2 different measurement antenna was used, located at a distance of 3 m.

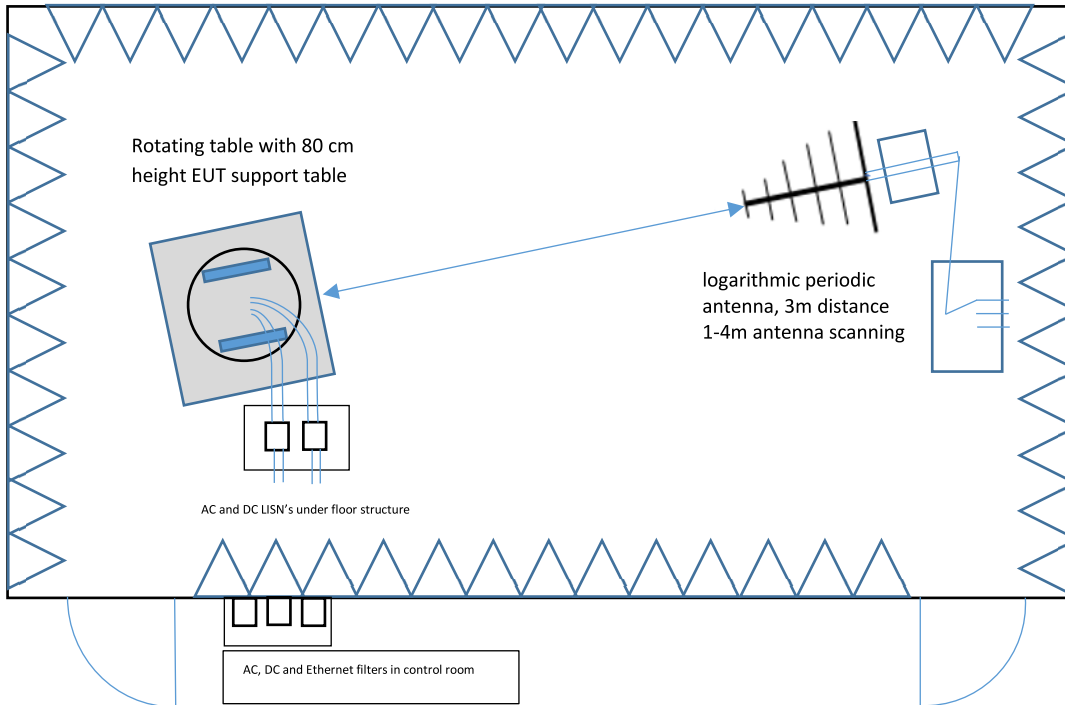
- linear polarized logarithmic periodic antenna for frequency range 30-1000 MHz
- and double-ridged horn antenna for the frequency range 1-18 GHz

The equipment under test was set up on a non-conductive support, 80 cm above the ground plane. EUT power supply LISN's for AC and DC were located under the ground reference plane. The field strength was calculated by adding correction factor to the measured level from the EMI receiver. This correction factor includes antenna factor, cable loss and pre-amplifier gain.

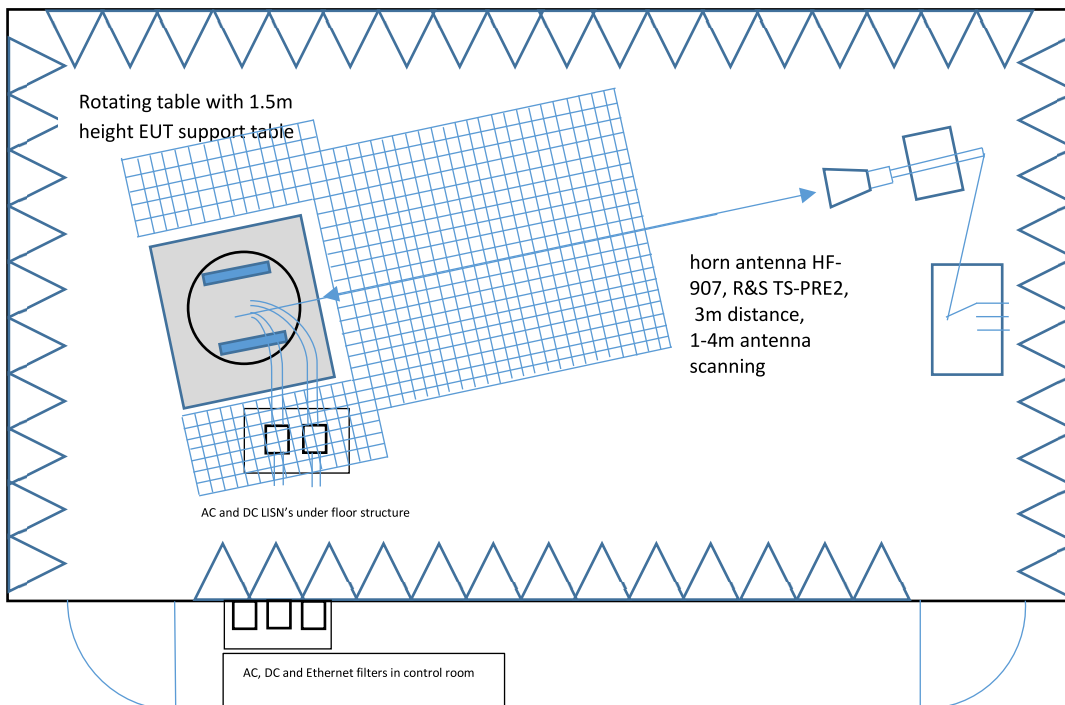
Measurement procedure

- EUT was set in a manner that is most representative of the equipment as typically used (i.e., as specified in the EUT instruction manual)
 - o In making any tests involving handheld, body-worn, or ceiling-mounted equipment, it is essential to recognize that the measured levels may be dependent on the orientation (attitude) of the three orthogonal axes of the EUT. Thus, exploratory tests as specified in 8.3.1 shall be carried out for various axes orientations to determine the orientation (attitude) having maximum or near-maximum emission level.
- in exploratory measurements for full frequency range
 - o turntable was rotated with 45° steps (from 0° to 315°)
 - o measurement was done in both vertical and horizontal antenna polarization with antenna height of 1m
 - o measurement was done with peak detector to find the frequencies of maximum emissions and at least six highest peaks related to the limits were chosen
- these peak values were further maximized by scanning the turntable position 0 to 360 degrees and the antenna height 1 to 4m
- for maximized values, final measurement was done with
 - o quasi-peak detector for 30MHz to 1GHz frequency range
 - o with Average detector for 1GHz to 18GHz frequency range

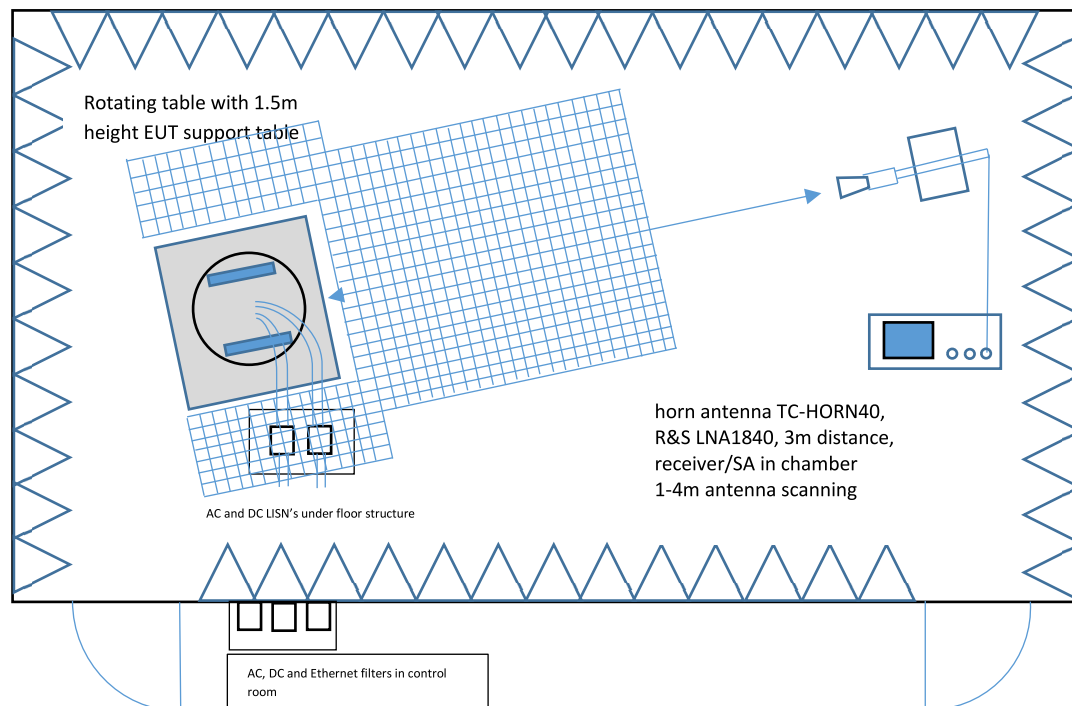
Radiated measurements setup from 30 MHz to 1 GHz:



Radiated measurements setup from 1 GHz to 18 GHz:



Radiated measurements setup from 18 GHz to 26 / 40 GHz:



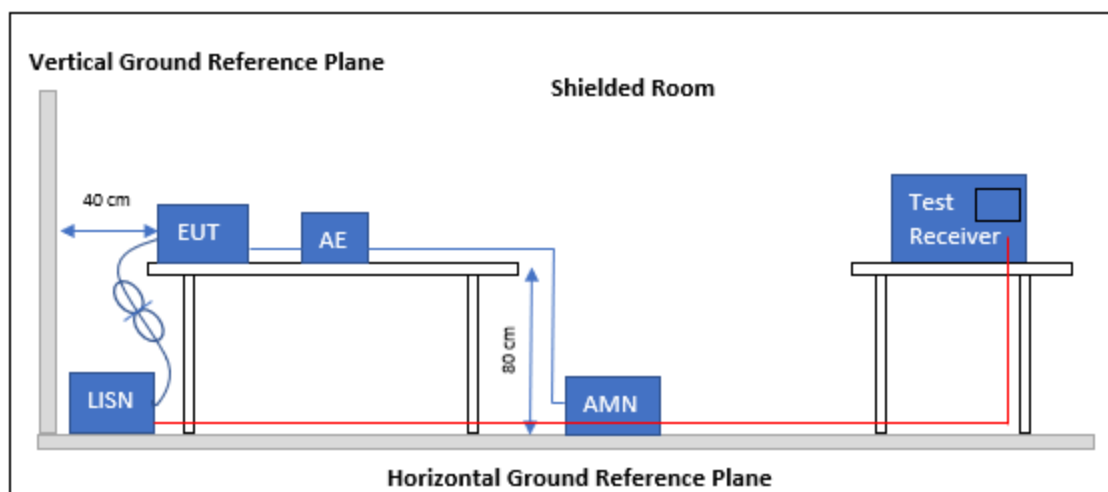
5.2. FCC subpart 15B and ICES-003, conducted emission test procedure

The equipment under test was set up on a non-conductive support, 80 cm above the ground plane and 40 cm distance of vertical ground plane. Test setup is described in pictures below.

Measurement procedure

- EUT was operated in a range of typical modes of operation, with typical cable positions, and with a typical system equipment configuration and arrangement
- in exploratory measurements for full frequency range
 - o measurement was done with peak and average detector to find the frequencies of maximum emissions for each current-carrying conductor of each power cord associated with the EUT and at least six highest peaks related to the limits were chosen per conductor
 - o the one configuration and arrangement and mode of operation that produces the highest emissions related to the limit across all the measured conductors was recorded.
- for this configuration and its maximized values, final measurement for each current-carrying conductor was done with quasi-peak detector and average detector

Conducted emission test setup



6. Uncertainties

6.1. Emission measurement uncertainties

Description	Expanded Uncertainty (k=2)
AC conducted emission	2,24
Radiated emission ≤ 1 GHz	4,62
Radiated emission > 1 GHz	5,72

7. Summary

Title 47 CFR 15B, ISSED ICES-003 Issue 7			
Reference	Requirement – Test case	Verdict	Remark
FCC 15.109 ICES-003, 3.2.2	Radiated emission. Electromagnetic field measure (30 MHz – 1000 MHz)	PASS	
FCC 15.109 ICES-003, 3.2.2	Radiated emission. Electromagnetic field measure (1 GHz – 18 GHz)	PASS	
FCC 15.107 ICES-003, 3.2.1	Continuous conducted emission (150 kHz – 30 MHz)	PASS	
The DUT has been tested and passes the FCC Part 15 Subpart B without any modifications.		Yes	
Possible test case verdicts PASS = Test object meet the requirements FAIL = Test object does not meet the requirements N/T = Required by standard but not tested N/R = Not required by standard for the test object			

8. Radiated Emissions

Reference: FCC 15.109, ICES-003, 3.2.2
Test method: ANSI C63.4:2014+A1:2017 Section 8

The applied limit for radiated emissions, 3 m distance, according with the requirements of FCC Rules and Regulations 47 CFR Part 15, Subpart B, Secs. 15.109 & ICES-003 Issue 7, section 3.2.2.

FCC part 15, subpart B

Limits, Class B	Quasi-peak Limit for 3m	
Frequency of emission MHz)	(microvolt/meter)	(dBuV/m)
30-88	100	40
88-216	150	43.5
216-960	200	46
Above 960	500	54

ICES-003, Issue 7

Limits, Class B	Quasi-peak Limit for 3m	
Frequency of emission MHz)	(microvolt/meter)	(dBuV/m)
30-88	100	40
88-216	150	43.5
216-230	200	46
230-960	223	47
Above 960	500	54

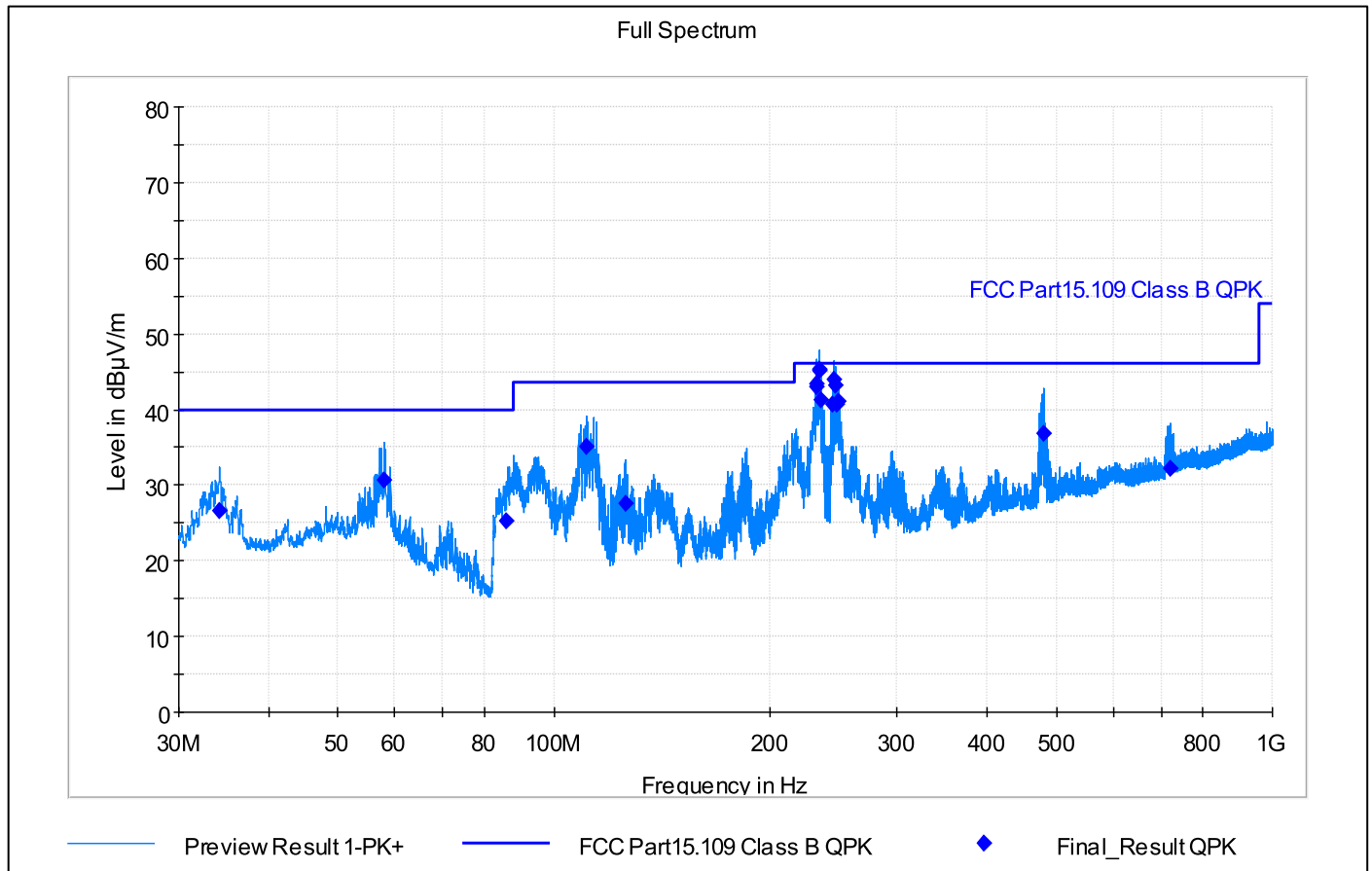
FCC part 15, subpart B and ICES-003, Issue 7

Frequency of emission MHz)	Average Limit for 3m		Peak Limit for 3m
	(microvolt/meter)	(dBuV/m)	(dBuV/m)
Above 1000	500	54	74
Frequencies above 1 GHz, the limit on peak radio frequency emissions is 20 dB above the maximum permitted average emission limit applicable to the equipment under test, as per §15.35(b)			

Tested samples: 3955ER011
Operation mode(s) tested: OM1
Test results: PASS
Note:

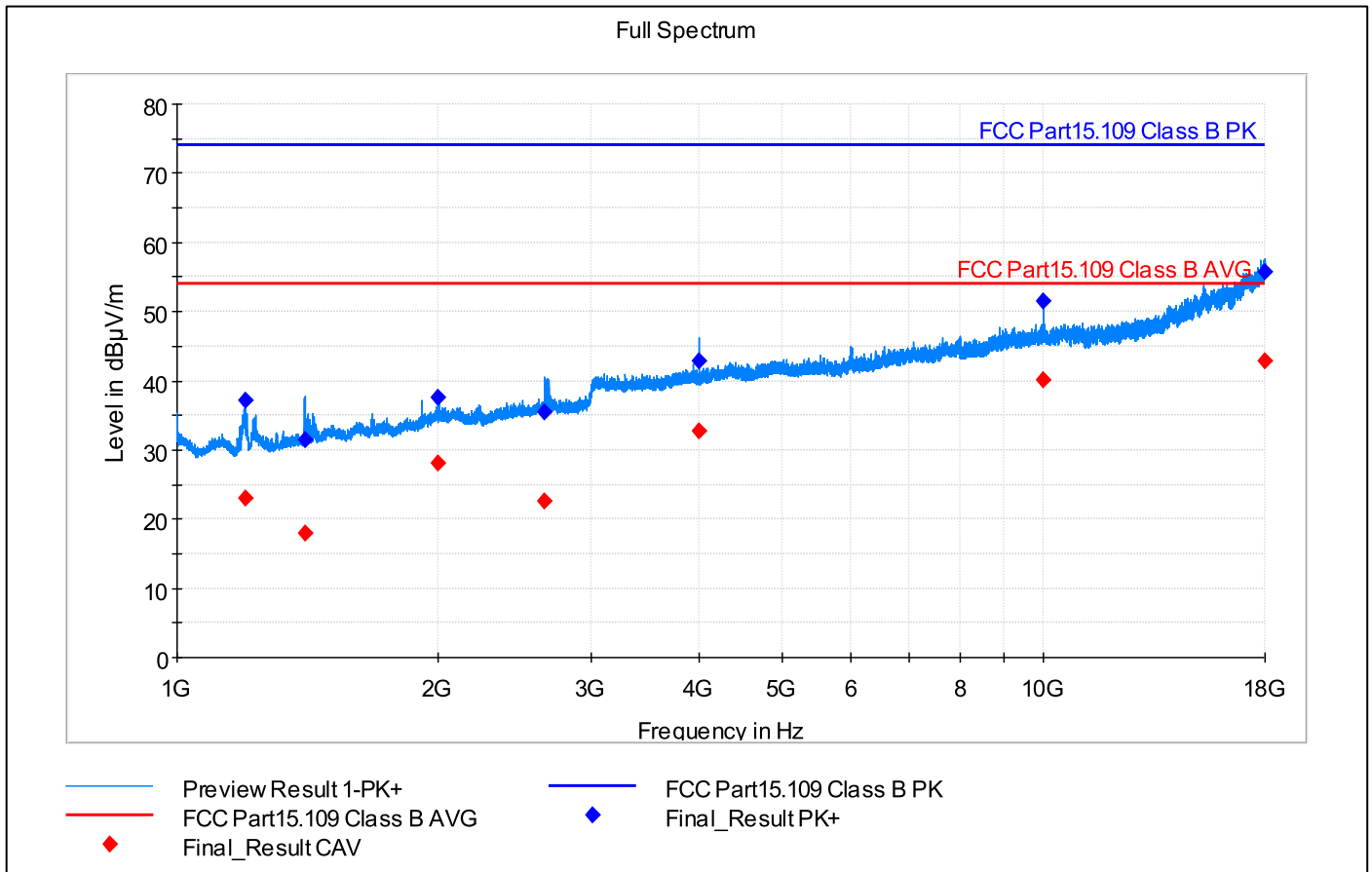
Test data:

Operation mode(s)	Configuration	Test Verdict
OM1	Worst case, Frequency Range: 30 MHz – 1GHz	PASS
OM1	Worst case, Frequency Range: 1 – 18 GHz	PASS

FCC part 15, subpart B and ICES-003, Graph and final result table for 30 MHz – 1 GHz, OM1:

Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Elevation (deg)	Corr. (dB/m)	Comment
34.200000	26.70	40.00	13.30	15000.0	120.000	116.0	V	292.0	0.0	17.3	PASS
57.990000	30.73	40.00	9.27	15000.0	120.000	105.0	V	216.0	0.0	20.3	PASS
85.800000	25.19	40.00	14.81	15000.0	120.000	121.0	V	-13.0	0.0	15.8	PASS
110.760000	35.05	43.50	8.45	15000.0	120.000	100.0	V	4.0	0.0	19.1	PASS
125.580000	27.64	43.50	15.86	15000.0	120.000	110.0	V	-12.0	0.0	17.0	PASS
231.510000	42.98	46.00	3.02	15000.0	120.000	134.0	H	335.0	0.0	20.6	PASS
232.410000	43.47	46.00	2.53	15000.0	120.000	102.0	V	222.0	0.0	20.7	PASS
233.640000	45.35	46.00	0.65	15000.0	120.000	100.0	V	227.0	0.0	20.7	PASS
234.480000	45.16	46.00	0.84	15000.0	120.000	103.0	V	242.0	0.0	20.8	PASS
235.320000	41.17	46.00	4.83	15000.0	120.000	101.0	V	240.0	0.0	20.8	PASS
244.650000	40.77	46.00	5.23	15000.0	120.000	100.0	V	334.0	0.0	21.2	PASS
245.520000	44.03	46.00	1.97	15000.0	120.000	100.0	V	323.0	0.0	21.2	PASS
246.390000	43.23	46.00	2.77	15000.0	120.000	100.0	V	316.0	0.0	21.2	PASS
247.590000	40.75	46.00	5.25	15000.0	120.000	102.0	V	323.0	0.0	21.3	PASS
248.460000	41.03	46.00	4.97	15000.0	120.000	100.0	V	321.0	0.0	21.3	PASS
480.000000	36.79	46.00	9.21	15000.0	120.000	171.0	H	164.0	0.0	26.7	PASS
720.000000	32.13	46.00	13.88	15000.0	120.000	102.0	H	0.0	0.0	30.7	PASS

FCC part 15 subpart B and ICES-003, Graph and final result table for 1 GHz – 18 GHz, OM1:



Final_Result

Frequency (MHz)	MaxPeak (dBμV/m)	CAverage (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)	Comment
1200.000000	---	23.07	54.00	30.93	500.0	1000.000	126.0	V	0.0	-7.6	PASS
1200.000000	37.22	---	74.00	36.78	500.0	1000.000	126.0	V	0.0	-7.6	PASS
1403.750000	31.44	---	74.00	42.56	500.0	1000.000	175.0	H	322.0	-6.4	PASS
1403.750000	---	17.85	54.00	36.15	500.0	1000.000	175.0	H	322.0	-6.4	PASS
2000.250000	37.62	---	74.00	36.38	500.0	1000.000	278.0	H	335.0	-1.5	PASS
2000.250000	---	28.08	54.00	25.92	500.0	1000.000	278.0	H	335.0	-1.5	PASS
2650.250000	35.52	---	74.00	38.48	500.0	1000.000	364.0	H	309.0	1.4	PASS
2650.250000	---	22.50	54.00	31.50	500.0	1000.000	364.0	H	309.0	1.4	PASS
4000.250000	42.75	---	74.00	31.25	500.0	1000.000	187.0	V	307.0	7.9	PASS
4000.250000	---	32.78	54.00	21.22	500.0	1000.000	187.0	V	307.0	7.9	PASS
10000.750000	---	40.09	54.00	13.91	500.0	1000.000	100.0	V	43.0	20.0	PASS
10000.750000	51.58	---	74.00	22.42	500.0	1000.000	100.0	V	43.0	20.0	PASS
17987.250000	---	42.81	54.00	11.19	500.0	1000.000	334.0	H	213.0	39.1	PASS
17987.250000	55.82	---	74.00	18.18	500.0	1000.000	334.0	H	213.0	39.1	PASS

9. Conducted Emissions, AC mains power port

Reference: FCC 15.107, ICES-003, 3.2.1
Test method: ANSI C63.4:2014+A1:2017 Section 12

The applied limit for continuous conducted emission in power leads, according with the requirements of FCC Rules and Regulations 47 CFR Part 15, Subpart B, Secs. 15.107 & ICES-003 Issue 7

FCC part 15, subpart B and ICES-003, Issue 7

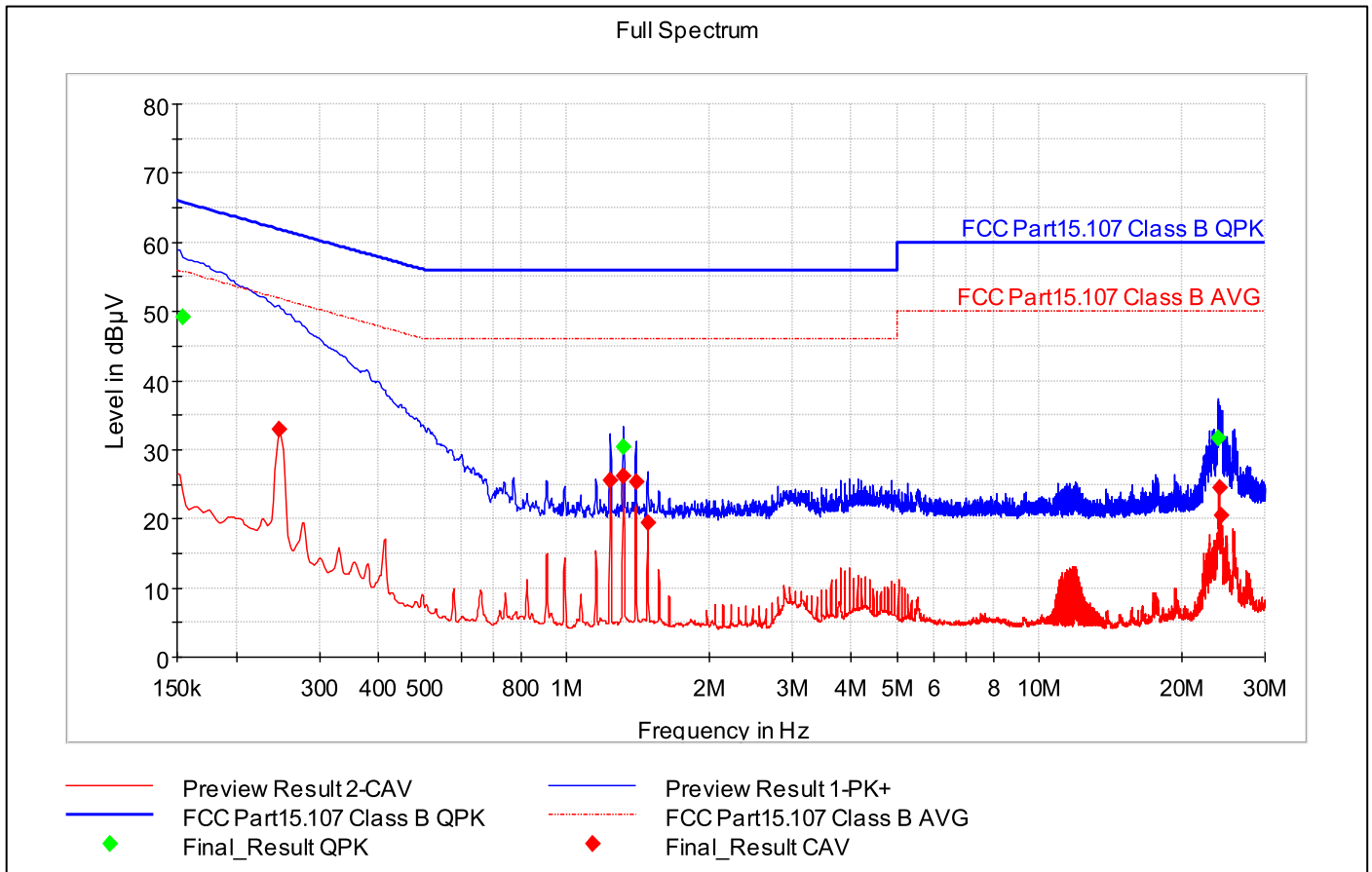
Limits:	Class B (dBuV)	
Frequency	Quasi peak limit	Average limit
0.15 – 0.50 MHz	66 to 56	56 to 46
0.50 – 5 MHz	56	46
5 – 30 MHz	60	50

Tested sample(s): 3955ER011
Operation mode(s) tested: OM1
Test results: PASS
Note:

Test data:

Operation mode(s)	Configuration	Test Verdict
OM1	Neutral wire noise.	PASS
OM1	Phase wire noise.	PASS

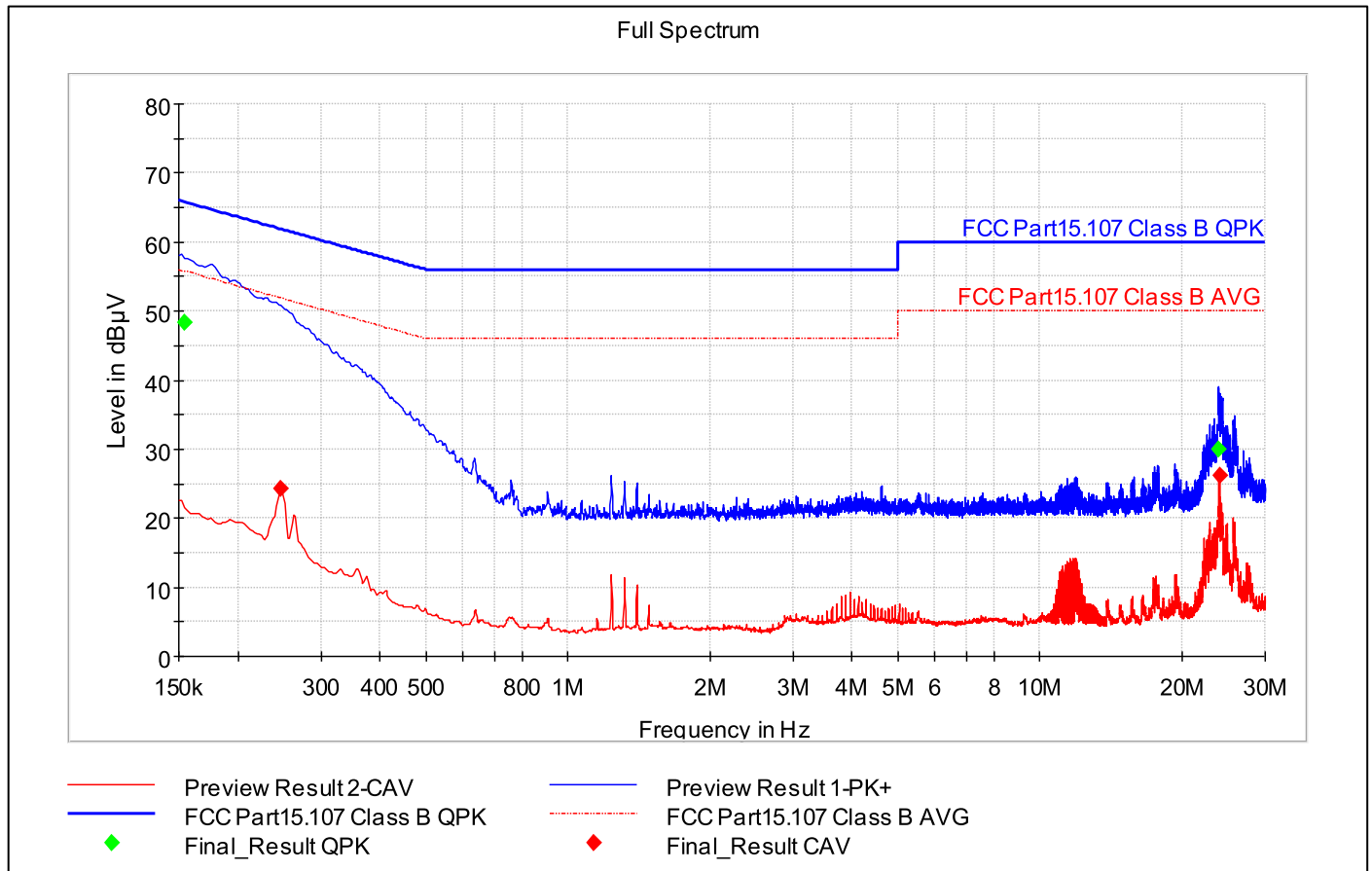
FCC part 15, subpart B and ICES-003, Graph and final result for frequency range 150kHz-30MHz, Neutral, OM1



Final_Result

Frequency (MHz)	QuasiPeak (dBµV)	CAverage (dBµV)	Limit (dBµV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	Filter	Corr. (dB)	Comment
0.154500	49.11	---	65.75	16.64	15000.0	9.000	N	ON	9.8	PASS
0.246750	---	32.98	51.87	18.88	15000.0	9.000	N	ON	9.8	PASS
1.236750	---	25.45	46.00	20.55	15000.0	9.000	N	ON	9.8	PASS
1.320000	---	26.28	46.00	19.72	15000.0	9.000	N	ON	9.8	PASS
1.320000	30.33	---	56.00	25.67	15000.0	9.000	N	ON	9.8	PASS
1.401000	---	25.33	46.00	20.67	15000.0	9.000	N	ON	9.8	PASS
1.484250	---	19.43	46.00	26.57	15000.0	9.000	N	ON	9.8	PASS
23.977500	31.70	---	60.00	28.30	15000.0	9.000	N	ON	10.5	PASS
23.988750	---	24.51	50.00	25.49	15000.0	9.000	N	ON	10.5	PASS
24.216000	---	20.57	50.00	29.43	15000.0	9.000	N	ON	10.5	PASS

FCC part 15, subpart B and ICES-003, Graph and final result for frequency range 150kHz-30MHz, Phase, OM1



Final_Result

Frequency (MHz)	QuasiPeak (dBµV)	CAverage (dBµV)	Limit (dBµV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	Filter	Corr. (dB)	Comment
0.154500	48.40	---	65.75	17.35	15000.0	9.000	L1	ON	9.8	PASS
0.246750	---	24.31	51.87	27.56	15000.0	9.000	L1	ON	9.8	PASS
23.887500	30.00	---	60.00	30.00	15000.0	9.000	L1	ON	10.4	PASS
23.986500	---	26.24	50.00	23.76	15000.0	9.000	L1	ON	10.4	PASS

10. Test Equipment List

Radiated emission test equipment

New ID	Manufacturer	Equipment type	Description	Serial	Calibration information	Next calibration
G4C265	Rohde & Schwarz	ESW26	EMI test receiver	101324	6.7.2023	6.7.2024
G4C273	Frankonia	ALX-4000E	Broadband Antenna, 25MHz-4GHz with 6dB (50-A-MFN-06) att.	00816+1531	22.1.2024	22.1.2027
G4C292	Rohde & Schwarz	TS-LNA 1840	RF Preamplifier 18 to 40 GHz	100841	9.6.2022	9.6.2024
G4C298	Rohde & Schwarz	CMW500	Wideband radio communication tester	170980	29.6.2023	29.6.2024
G4C469	Rohde & Schwarz	TS_PRE2	RF Preamplifier	101541	9.6.2022	9.6.2024
G4C294	Rohde & Schwarz	Antenna	Horn Antenna -> 40GHz	101067	4.11.2022	4.11.2025
G4C576	Rohde & Schwarz	HF907	Double-Ridged Waveguide Horn Antenna 800MHz-18GHz	100163	9.8.2022	9.8.2025

Conducted emission test equipment

New ID	Manufacturer	Equipment type	Description	Serial	Calibration information	Next calibration
G4C265	Rohde & Schwarz	ESW26	EMI test receiver	101324	6.7.2023	6.7.2024
G4C266	Rohde & Schwarz	ESH3-Z6	Single-Line V-Network, 150 A 100 kHz to 200 MHz	101516	12.9.2023	12.9.2024
G4C267	Rohde & Schwarz	ESH3-Z6	Single-Line V-Network, 150 A 100 kHz to 200 MHz	101404	12.9.2023	12.9.2024
G4C268	Rohde & Schwarz	ENY81-CA6	Coupling Networks	101657	23.8.2023	23.8.2024
G4C269	Rohde & Schwarz	ENY81	Coupling Networks	100172	23.8.2023	23.8.2024
G4C273	Frankonia	ALX-4000E	Broadband Antenna, 25MHz-4GHz with 6dB (50-A-MFN-06) att.	00816+1531	22.1.2024	22.1.2027
G4C298	Rohde & Schwarz	CMW500	Wideband radio communication tester	170980	29.6.2023	29.6.2024
G4C476	Teseq	ST08-10	Coupling/Decoupling Network	54466	11.9.2023	11.9.2024
G4C503	Rohde & Schwarz	ESIB26	EMI Test Receiver 20Hz...26.5GHz	100263	7.11.2023	7.11.2025
G4C515	Rohde & Schwarz	ENV216	Two-line V-Network LISN	101472	15.5.2023	15.5.2024
G4C516	Rohde & Schwarz	ENV216	Two-line V-Network LISN	100078	17.8.2023	17.8.2024
G4C572	Schaffner	CBL 6143	Bilog Antenna 30MHz-3GHz	5071	7.9.2022	7.9.2025
G4C576	Rohde & Schwarz	HF907	Double-Ridged Waveguide Horn Antenna 800MHz-18GHz	100163	9.8.2022	9.8.2025