

Test Report

Report Number:

F230142E5, 2nd version

Equipment under Test (EUT):

NICP-EM30-IOL-H1141 + NICS-EM30-IOL-HK1141

Applicant:

Turck Beierfeld GmbH

Manufacturer:

Turck Beierfeld GmbH



Deutsche
Akkreditierungsstelle
D-PL-17186-01-00

References

- [1] **FCC/OST MP-5 (1986)** FCC methods of measurement of radio noise emissions from industrial, scientific and medical equipment.
- [2] **FCC 47 CFR Part 2** General Rules and Regulations
- [3] **FCC 47 CFR Part 18** INDUSTRIAL, SCIENTIFIC, AND MEDICAL EQUIPMENT

Test Result

The requirements of the tests performed as shown in the overview (clause 4) were fulfilled by the equipment under test. The complete test results are presented in the following.

“Passed” indicates that the equipment under test conforms with the relevant limits of the testing standard without taking any measurement uncertainty into account. However, the measurement uncertainty is calculated and shown in this test report.

Tested and written
by:

Signature

Reviewed and
approved by:

Signature

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The test results herein refer only to the tested sample. PHOENIX TESTLAB GmbH is not responsible for any generalisations or conclusions drawn from these test results concerning further samples. Any modification of the tested samples is prohibited and leads to the invalidity of this test report. Each page necessarily contains the PHOENIX TESTLAB Logo and the TEST REPORT NUMBER.

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1 Identification

Name:	Turck Beierfeld GmbH
Address:	Am Bockwald 2, 08344 Grünhain-Beierfeld
Country:	Germany
Name for contact purposes:	Michael SIEGEL
Phone:	+49 3774-135-153
eMail address:	michael.siegel@turck.com
Applicant represented during the test by the following person:	None

1.1 Manufacturer

Name:	Turck Beierfeld GmbH
Address:	Am Bockwald 2, 08344 Grünhain-Beierfeld
Country:	Germany
Name for contact purposes:	Michael SIEGEL
Phone:	+49 3774-135-153
eMail address:	michael.siegel@turck.com
Manufacturer represented during the test by the following person:	None

1.2 Test Laboratory

The tests were carried out by: **PHOENIX TESTLAB GmbH**
Königswinkel 10
32825 Blomberg
Germany

accredited by Deutsche Akkreditierungsstelle GmbH (DAkkS) according to DIN EN ISO/IEC 17025:2018. The accreditation is only valid for the scope of accreditation listed in the annex of the certificate D-PL-17186-01-00. FCC Test Firm Designation Number DE0004, FCC Test Firm Registration Number 469623, CAB Identifier DE0003 and ISED# 3469A.

1.3 EUT (Equipment under Test)

Test object: *	Inductive coupler (base coupler)
Model name: *	NICP-EM30-IOL-H1141
Model number: *	-
Order number: *	100018258
FCC ID: *	YQ7-NICP-EM30
IC certification number: *	8821A-NICPEM30
PMN: *	NICP-EM30-IOL-H1141
HVIN: *	7630/08
FVIN: *	V1
HMN: *	NA

Test object: *	Inductive coupler (remote coupler)
Model name: *	NICS-EM30-IOL-HK1141
Model number: *	-
Order number: *	100018259
FCC ID: *	YQ7-NICS-EM30
IC certification number: *	8821A-NICSEM30
PMN: *	NICS-EM30-IOL-HK1141
HVIN: *	7631/07
FVIN: *	V1
HMN: *	NA

	EUT number		
	1 (NICP-EM30-IOL-H1141)	2 (NICS-EM30-IOL-HK1141)	3
Serial number: *	230714_16	230413_1	-
PCB identifier: *	07763008	07763107	-
Hardware version: *	2.1.0	2.0.0	-
Software version: *	1.0.14.2	1.0.1.0	-

* Declared by the applicant

1 set of EUTs base/remote coupler (primary and secondary part) were used for the WPT tests. In the overview (chapter 4) is shown which EUT was used for each test case.

Note: PHOENIX TESTLAB GmbH does not take samples. The samples used for tests are provided exclusively by the applicant.

1.4 Technical Data of Equipment

General:			
Power supply EUT 1: *	DC		
Supply voltage EUT 1: *	$U_{nom} = 24 \text{ V}_{DC}$	$U_{min} = 20.4 \text{ V}_{DC}$	$U_{max} = 28.8 \text{ V}_{DC}$
Temperature range: *	-25 °C to +55 °C		
Lowest / highest internal frequency: *	16 MHz / 2472 MHz		
Max. Distance EUT 1 to EUT 2: *	7 mm		
Min. Distance EUT 1 to EUT 2: *	Direct touch		

* Declared by the applicant

Energy power part:	
Frequency range: *	100 kHz – 148 kHz
Number of channels: *	-
Type of modulation: *	CW carrier only. No other data (information) is transmitted.
Data rate: *	-
Duty cycle: *	100%
Antenna type: *	Internal coil
Antenna connector: *	None

* Declared by the applicant

Proprietary radio communication part	
Operating frequency range: *	2.412 GHz – 2.472 GHz
Number of channels: *	13
Nominal channel bandwidth: *	4 MHz
Type of modulation: *	FSK
Antenna type: *	Internal
Antenna connector: *	None
Radio chip: *	Semtech SX1281

* Declared by the applicant

Ports / Connectors				
Identification	Connector		Length during test	Shielding (Yes / No)
	EUT	Ancillary		
NICP-EM30-IOL-H1141 24V SDCI	M12 - Code A	M12 - Code A	~ 3 m	yes
NICS-EM30-IOL-HK1141 24V SDCI	M12 - Code A	M12 - Code A	~ 3 m	yes

Ancillary equipment	
Laptop* ²	Siemens Fujitsu LifeBook E Series E780
Fieldbus master* ¹	TEBEN-L5-8ILO (Ident No.:6814017)
AC Adapter* ¹	MEAN WELL (Order No.: GST160A24-R7B)
bel Power Solutions & Protection* ²	HC24-2.4-AG
IO-Link Sensor* ¹	IO-Link Sensor CMTH-M12-IOL6X2-H1141
Resistor load* ¹	R47 / R33 (47 Ohm and 33 Ohm)

*¹ Provided by the applicant

*² Provided by the laboratory

1.5 Dates

Date of receipt of test sample:	18.08.2023
Start of test:	24.08.2023
End of test:	31.10.2023

2 Operational States

Description of function of the EUT:

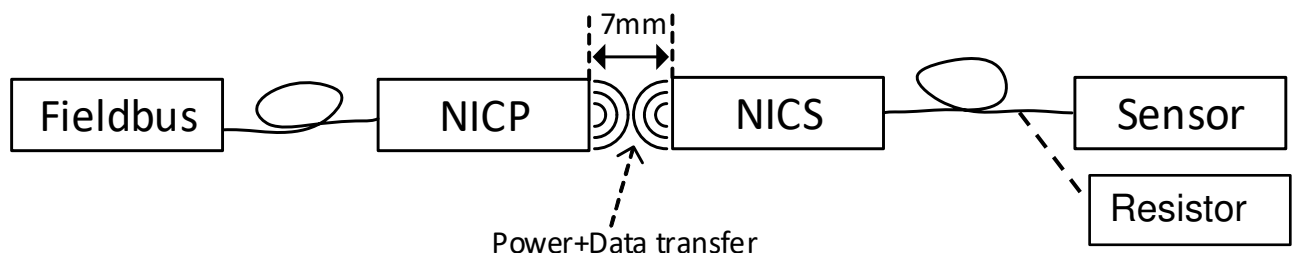
The NICP-EM30 coupler transmits power and data contact-free over an air gap of a few millimeters (0-7 mm). For contactless transmission at least two devices are needed: a primary part (NICP-EM30-IOL-H1141 - base coupler) and a secondary part (NICS-EM30-IOL-HK1141 - remote coupler). The primary part (base coupler) transfers the energy inductively to the secondary part (remote coupler) which could feed a sensor or another load.

The following states were defined as the operating conditions:

Operational Mode	Set-up	Remark
Mode 1 Primary part only in TX mode	Single device	EUT 1
Mode 2: Energy transmission in 7 mm distance	WPT system alignment	Distance between EUT 1 and EUT 2: 7 mm Secondary part load 1: Sensor approx. 150 mA Secondary part load 2: Resistor 47 Ohm approx. 500 mA Secondary part load 3: Resistor 33 Ohm approx. 800 mA
Mode 3: Energy transmission in 0 mm distance	WPT system alignment	Distance between EUT 1 and EUT 2: 0 mm Secondary part load 1 Sensor approx. 150 mA Secondary part load 2 Resistor 47 Ohm approx. 500 mA Secondary part load 3 Resistor 33 Ohm approx. 800 mA

The system was set up as follows:

During the tests the EUT was connected to a field bus of the type TBEN-L5-8IOL. The field bus was connected to a laptop computer via Ethernet. The correct function of the EUT assembly was monitored via a browser on the laptop computer, having access to the fieldbus.



3 Additional Information

The EUT was not labeled as required by FCC / IC. All tests were performed using an unmodified sample. This test report is for the WPT part of the EUT only. Further measurements are for the digital part and the wanted communication radio part around 2.45 GHz are stated in test report F230142E4 and F230142E2.

4 Overview

Conducted emissions FCC 47 CFR Part 18 section 18.307 (b) [3]					
Application	Frequency range	Limits	Reference standard	Remark	Status
AC supply line	0.15 to 0.5 MHz	66 to 56 dB(μV) (QP)*	FCC OST/MP-5 [1]	-	Passed
	0.5 to 5 MHz	56 to 46 dB(μV) (AV)*			
	5 to 30 MHz	56 dB(μV) (QP)			
		46 dB(μV) (AV)			
		60 dB(μV) (QP)			
		50 dB(μV) (AV)			
Radiated emissions FCC 47 CFR Part 18 section 18.305 (b) [3]					
Application	Frequency range	Limits	Reference standard	Remark	Status
Radiated Emission	0.009 to 30 MHz**	15 μV/m (23.5 dB(μV)/m) at 300 m	FCC OST/MP-5 [1]	-	Passed

*: Decreases with the logarithm of the frequency

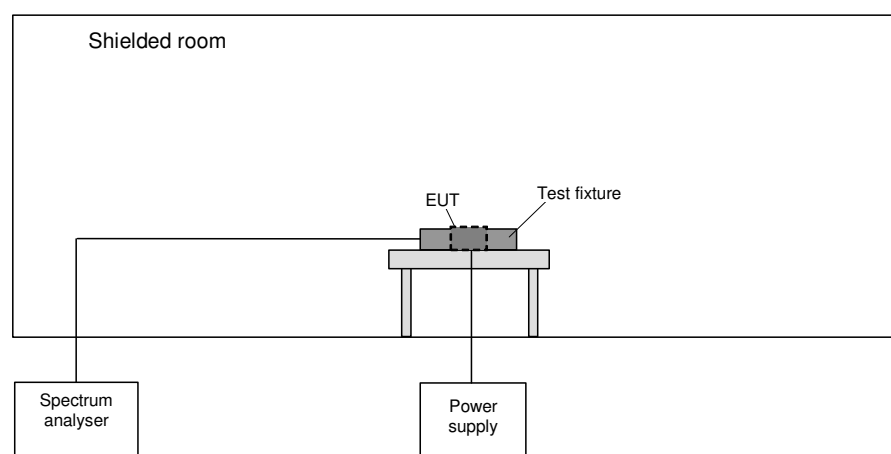
**:
As declared by the applicant the highest operating frequency of the power transfer WPT is 145 kHz and below 1.705 MHz. Therefore, the radiated emission measurement must be carried out up to 30 MHz. The wanted communication radio frequency around 2.45 GHz is excluded and documented in test report F230142E4.

5 Results

5.1 Test setups

5.1.1 Radiated: Test fixture

The test is carried out in a shielded chamber. Table-top devices are set up on a table and the spectrum analyser is connected to a test fixture / loop antenna, which is placed around / on top of the EUT.



5.1.2 Radiated: 9 kHz to 30 MHz

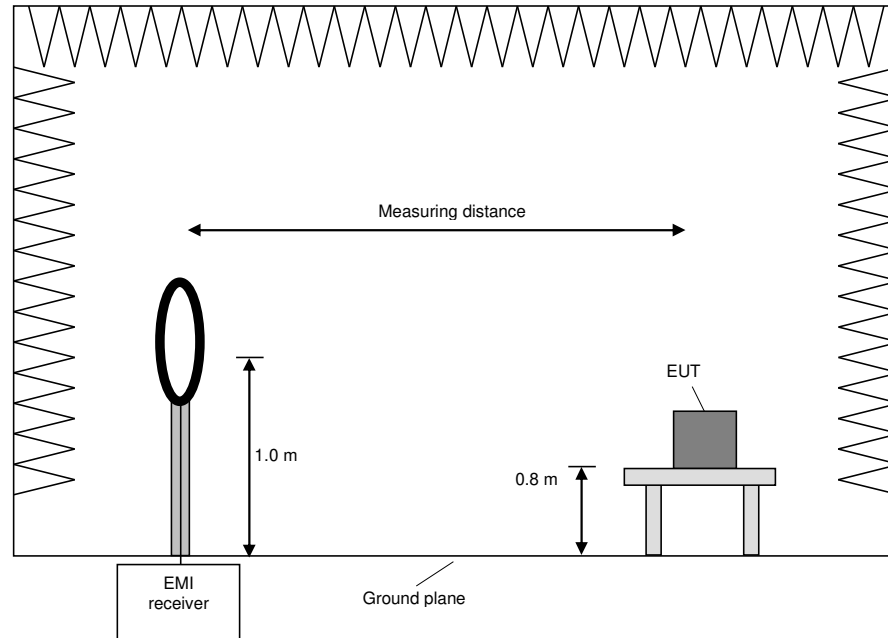
5.1.2.1 Preliminary measurement 9 kHz to 30 MHz

In the first stage a preliminary measurement is performed in a semi-anechoic chamber at a measuring distance of 3 meters. Table-top devices are set up on a non-conducting support with a size of 1 m by 1.5 m and a height of 80 cm. Floor-standing devices are placed directly on the turntable / ground plane. The setup of the equipment under test is in accordance with [1].

The frequency range 9 kHz to 30 MHz is monitored with an EMI receiver while the system and its cables are manipulated to find out the configuration with the maximum emission levels if applicable. The EMI receiver is set to MAX hold mode. The EUT and the measuring antenna are rotated around their vertical axis to find the maximum emission levels.

The resolution bandwidth of the EMI receiver is set to the following values:

Frequency range	Resolution bandwidth
9 kHz to 150 kHz	200 Hz
150 kHz to 30 MHz	9 kHz



Procedure preliminary measurement:

Pre-scans are performed in the frequency range 9 kHz to 150 kHz and 150 kHz to 30 MHz.

The following procedure is used:

- 1) Monitor the frequency range with the measuring antenna facing the EUT and an EUT / turntable azimuth of 0 °.
- 2) Manipulate the system cables to produce the maximum levels of emissions.
- 3) Rotate the EUT by 360 ° to maximize the detected signals.
- 4) Measure the frequencies of the highest detected emissions with a lower span and resolution bandwidth to increase the accuracy and note the frequency values.
- 5) If the EUT is portable or ceiling mounted, repeat steps 1 to 4 with other orientations (x,y,z) of the EUT.
- 6) Rotate the measuring antenna and repeat steps 1 to 5.

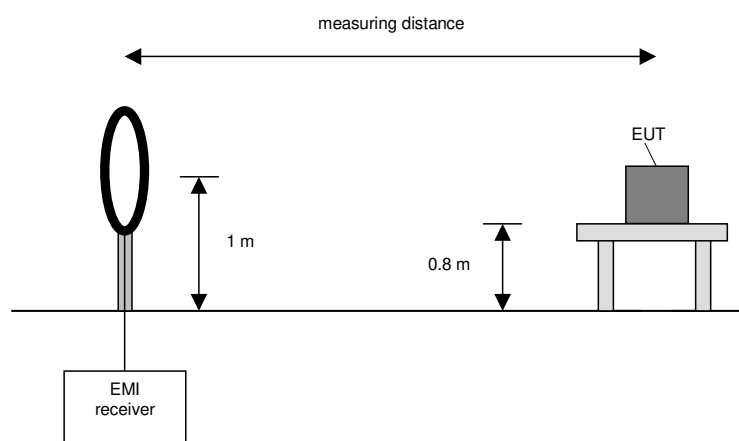
5.1.2.2 Final measurement 9 kHz to 30 MHz

In the second stage a final measurement is performed on an open area test site with no conducting ground plane at a measuring distance of 3 m, 10 m, 30 m or 300 m. If the standard requires larger measuring distances for a given frequency, the results are extrapolated with $1/d$, as stated in MP-5 [1]. The final measurement is performed with an EMI receiver set to average detector for FCC measurements and Quasi-Peak for RSS measurements.

At the frequencies, which were detected during the preliminary measurements, the final measurement is performed while rotating the EUT and the measuring antenna in the range of 0° to 360° around their vertical axis until the maximum level value is found.

The resolution bandwidth of the EMI receiver is set to the following values:

Frequency range	Resolution bandwidth	Measuring time
9 kHz to 150 kHz	200 Hz	1 s
150 kHz to 30 MHz	9 kHz	1 s



Procedure final measurement:

The following procedure is used:

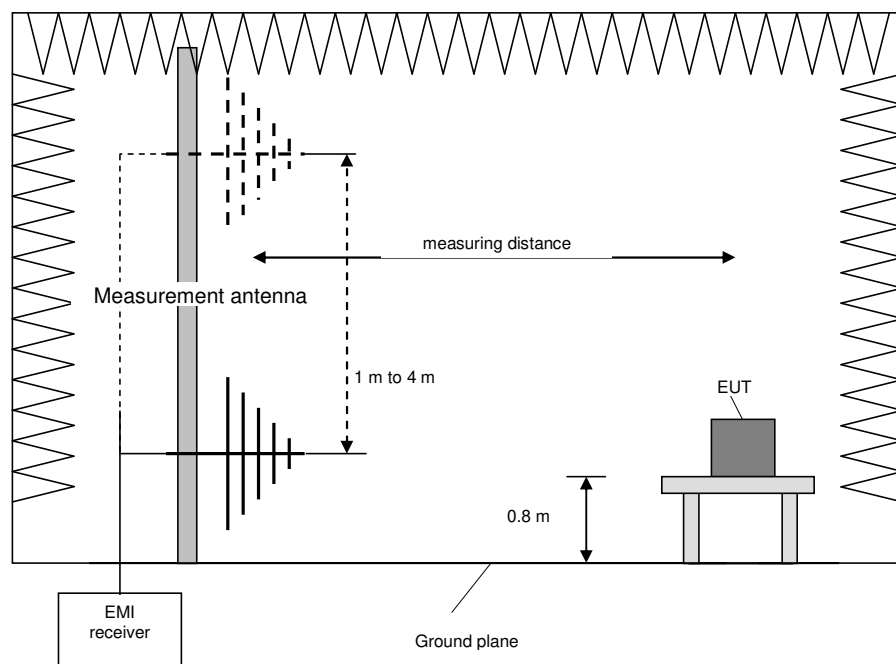
- 1) Monitor the selected frequencies from the preliminary measurement with the measuring antenna facing the EUT and an EUT azimuth of 0° .
- 2) Rotate the EUT by 360° to maximize the detected signals.
- 3) Rotate the measuring antenna and repeat steps 1 to 2 until the maximum value is found and note it.
- 4) If the EUT is portable or ceiling mounted, repeat steps 1 to 3 with other orientations (x,y,z) of the EUT.

5.1.3 Preliminary and final measurement (30 MHz to 1 GHz)

The preliminary and final measurements were conducted in a semi-anechoic chamber with a metal ground plane. During the test the EUT will be rotated in the range of 0 ° to 360 °, the measuring antenna will be set to horizontal and vertical polarization and raised and lowered in the range from 1 m to 4 m to find the maximum level of emissions.

The resolution bandwidth of the EMI Receiver will be set to the following values:

Test	Frequency range	Resolution bandwidth
Preliminary measurement	30 MHz to 1 GHz	100 kHz
Frequency peak search	+ / - 1 MHz	10 kHz
Final measurement	30 MHz to 1 GHz	120 kHz



Procedure preliminary measurement:

The following procedure is used:

1. Set the measurement antenna to 1 m height.
2. Monitor the frequency range at vertical polarisation and a EUT azimuth of 0 °.
3. Rotate the EUT by 360° to maximize the detected signals.
4. Repeat 1) to 2) with the vertical polarisation of the measuring antenna.
5. Increase the height of the antenna for 0.5 m and repeat steps 2 – 4 until the final height of 4 m is reached.
6. The highest values for each frequency will be saved by the software, including the antenna height, measurement antenna polarization and turntable azimuth for that value.

Procedure final measurement:

The following procedure is used:

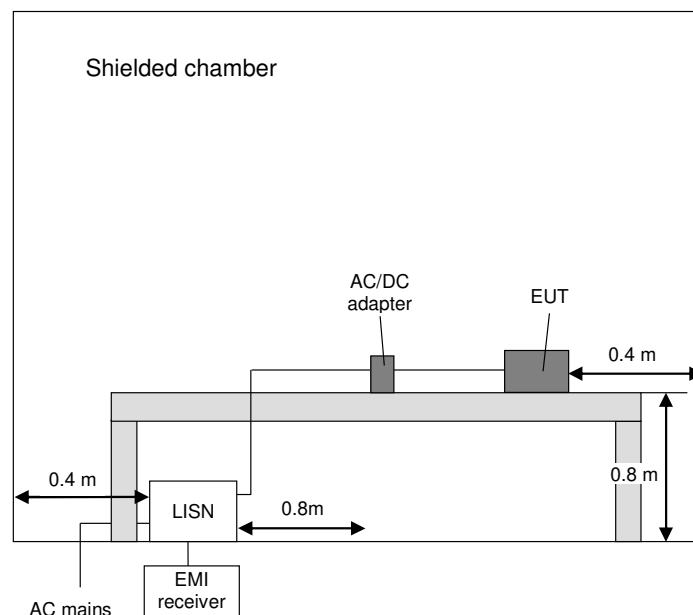
1. Select the highest frequency peaks to the limit for the final measurement.
2. The software will determine the exact peak frequencies by doing a partial scan with reduced RBW with ± 10 times the RBW of the pre-scan of the selected peaks.
3. If the EUT is portable or ceiling mounted, find the worst case EUT position (x,y,z) for the final test.
4. The worst measurement antenna height is found by the measurement software by varying the measurement antenna height by ± 0.5 m from the value obtained in the preliminary measurement, and to monitor the emission level.
5. The worst azimuth turntable position is found by varying the turntable azimuth by $\pm 30^\circ$ from the value obtained in the preliminary measurement, and to monitor the emission level.
6. The final measurement is performed at the worst case antenna height and the worst case turntable azimuth
7. Steps 2 – 6 will be repeated for each frequency peak selected in step 1.

5.1.4 Conducted emission: AC power line

The test is carried out in a shielded chamber. Table-top devices are set up on a non-conducting support with a size of 1 m by 1.5 m and a height of 80 cm above the ground plane. Floor-standing devices are placed directly on the ground plane. In case of DC powered equipment, which is not exclusively powered by a battery, it is connected to the LISN via a suitable AC/DC adaptor. The setup of the equipment under test is in accordance with [1].

The frequency range 150 kHz to 30 MHz is measured with an EMI receiver set to MAX hold mode with Peak and Average detectors and a resolution bandwidth of 9 kHz. A scan is carried out on the phase and neutral line of the AC mains network. If emissions less than 10 dB below the appropriate limit are detected, these emissions are measured with an Average and Quasi-peak detector on all lines.

Frequency range	Resolution bandwidth	Measuring time
150 kHz to 30 MHz	9 kHz	5 s



5.1.5 Test setup (99 % bandwidth)

Test setup (99 % bandwidth)			
Used	Setup	See sub-clause	Comment
☒	Radiated: Test fixture	5.1.1	-
☐	Test setup (antenna port conducted)	-	-

5.1.1 Test method (99 % bandwidth)

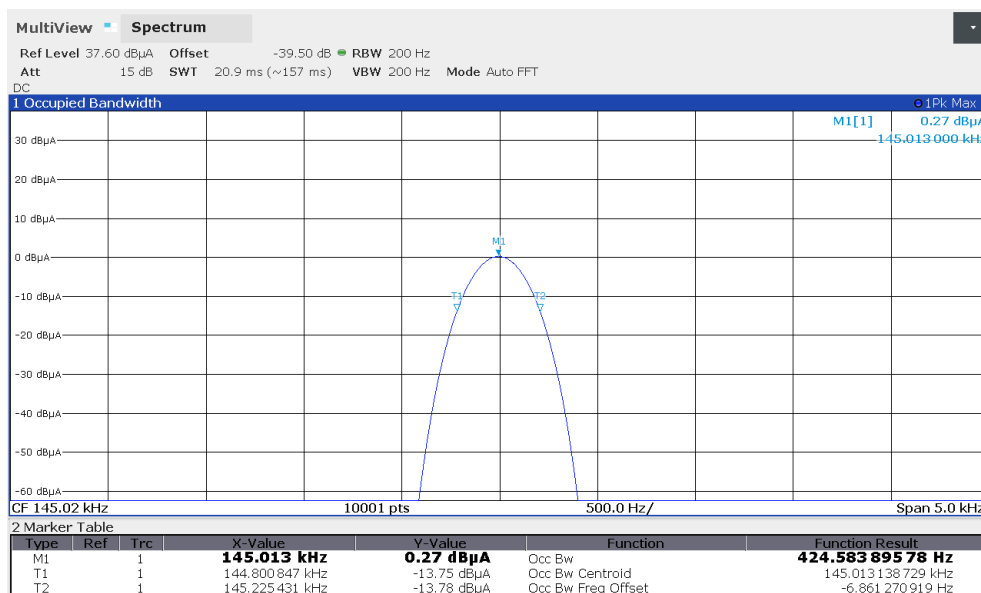
Test method (99 % bandwidth)				
Used	Sub-Clause [1]	Name of method	Applicability	Comment
☒	6.9.2	Occupied bandwidth – power bandwidth (99%) measurement procedure	-	-

5.1.2 Test results (99 % bandwidth)

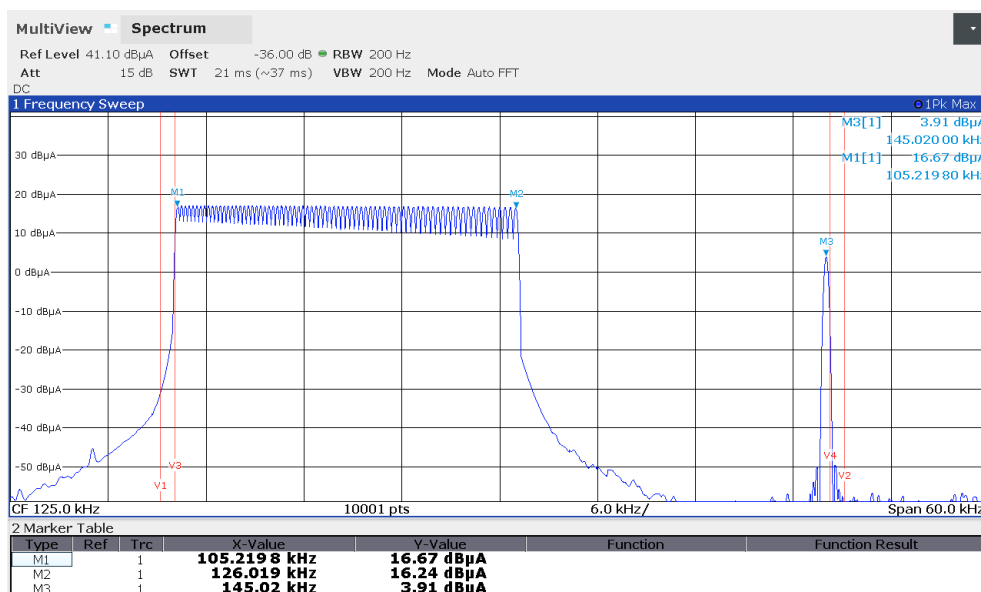
Ambient temperature:	22 °C
Relative humidity:	56 %

Date:	24.10.2023
Tested by:	M. DINTER

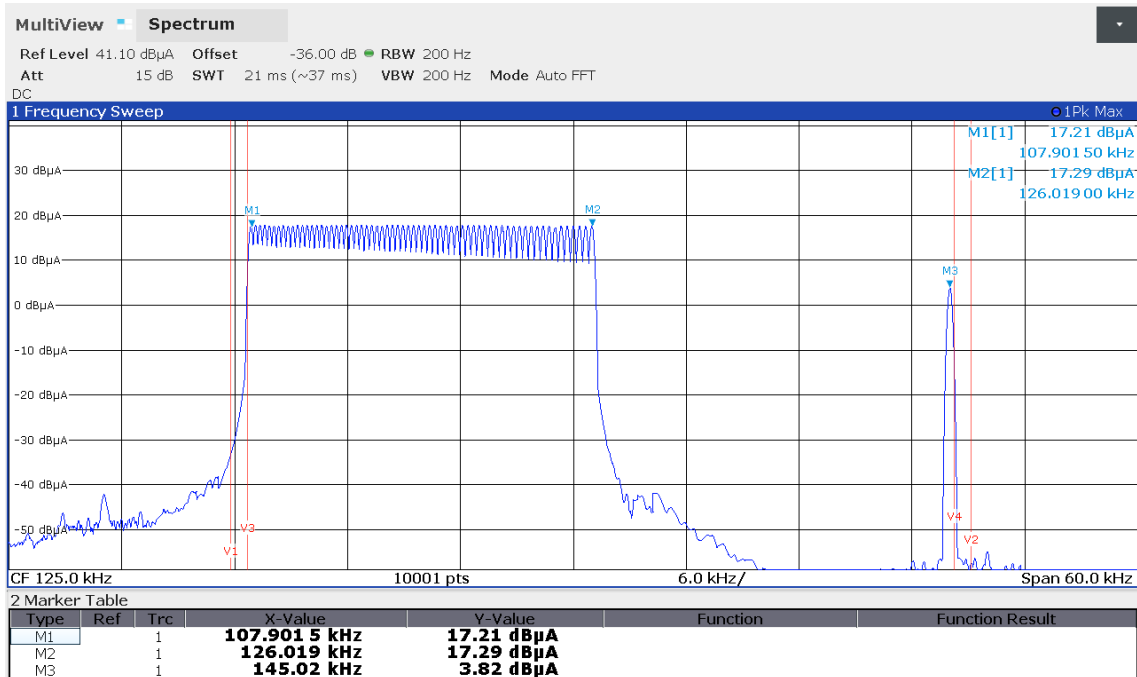
Mode1 / primary part only



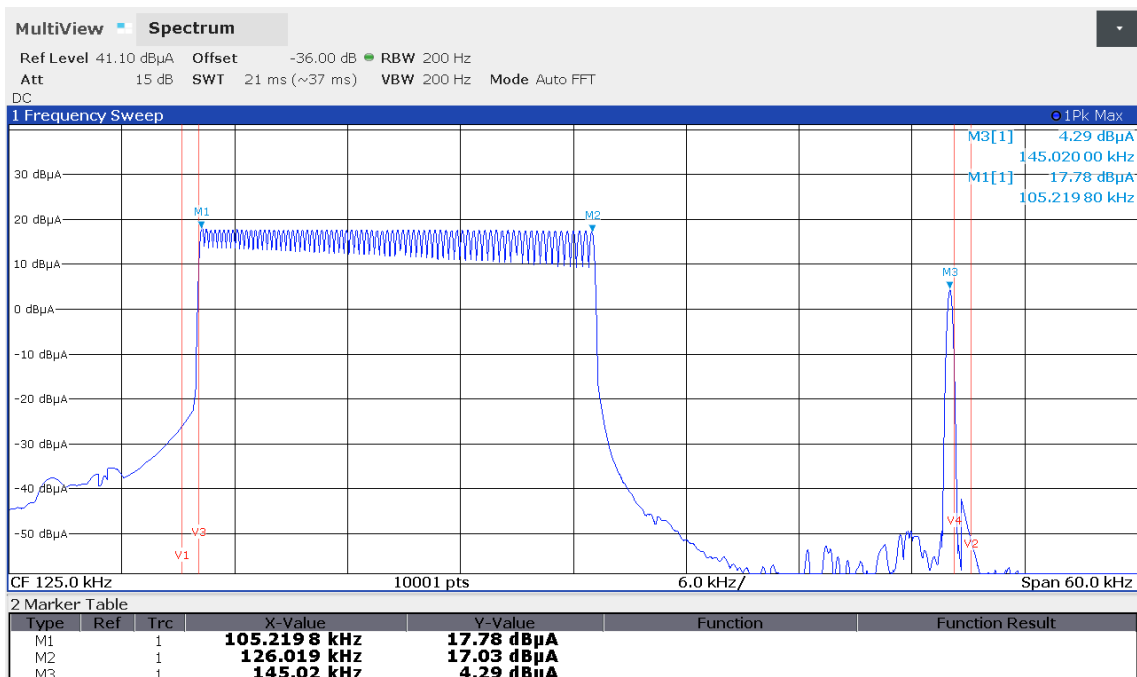
Mode 1 - 3 Distance variation, Sensor supply (Primary and Secondary part with Sensor load)



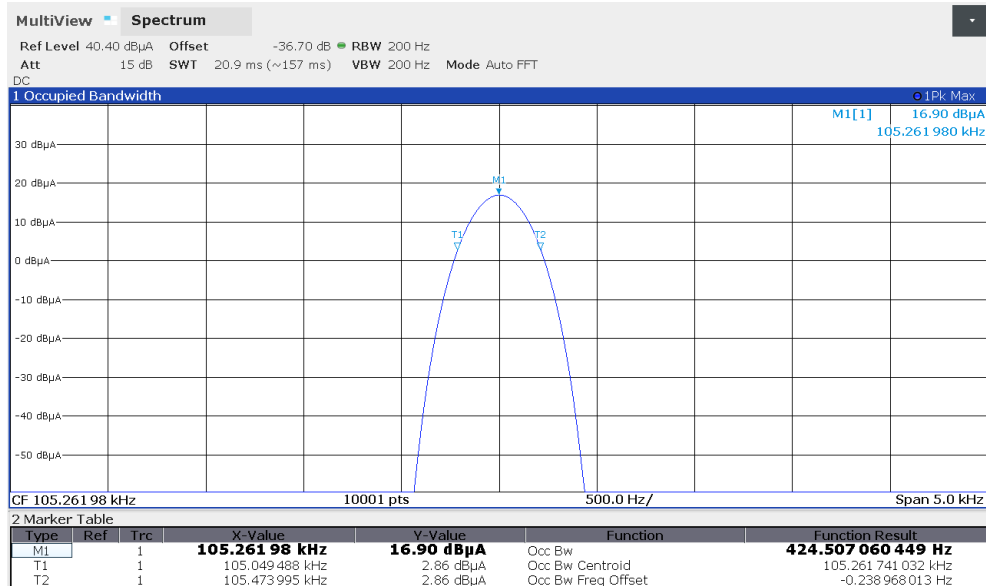
Mode 1 - 3 Distance variation, Sensor supply (Primary and Secondary part with R 33 Ohm Resistor load)



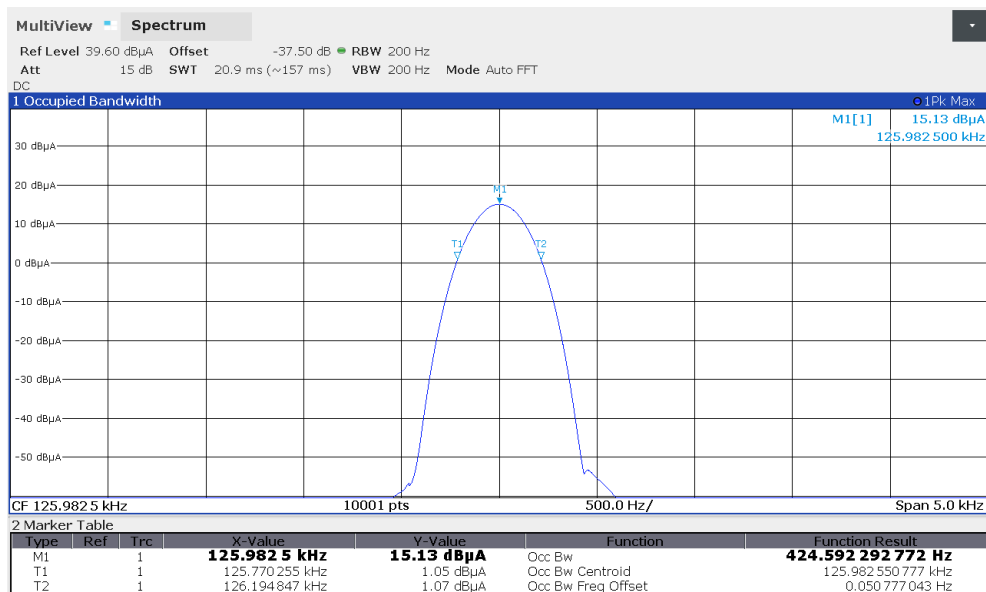
Mode 1 - 3 Distance variation, Sensor supply (Primary and Secondary part with R 47 Ohm Resistor load)



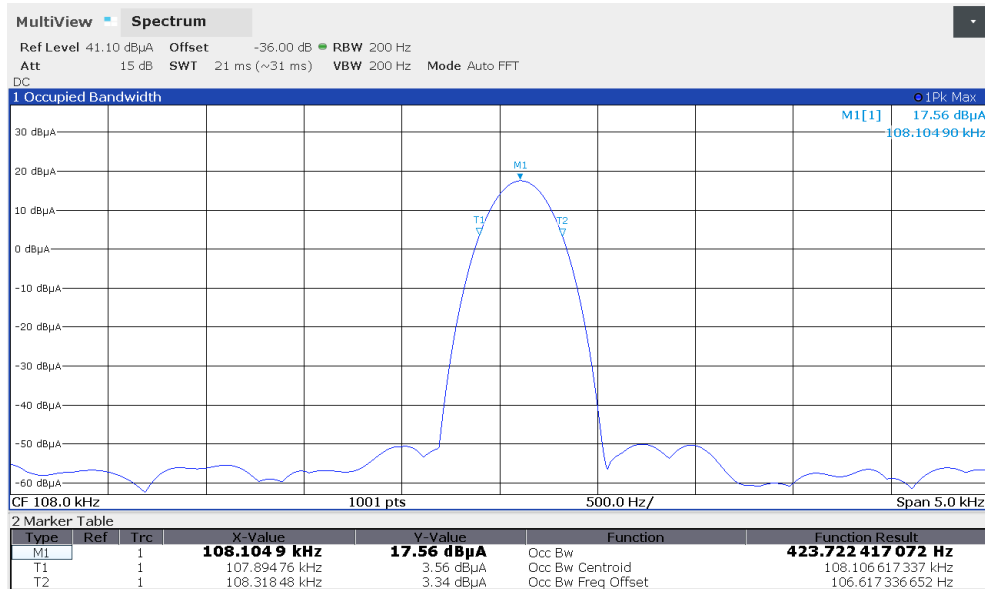
Mode 3
Sensor load, distance 0 mm



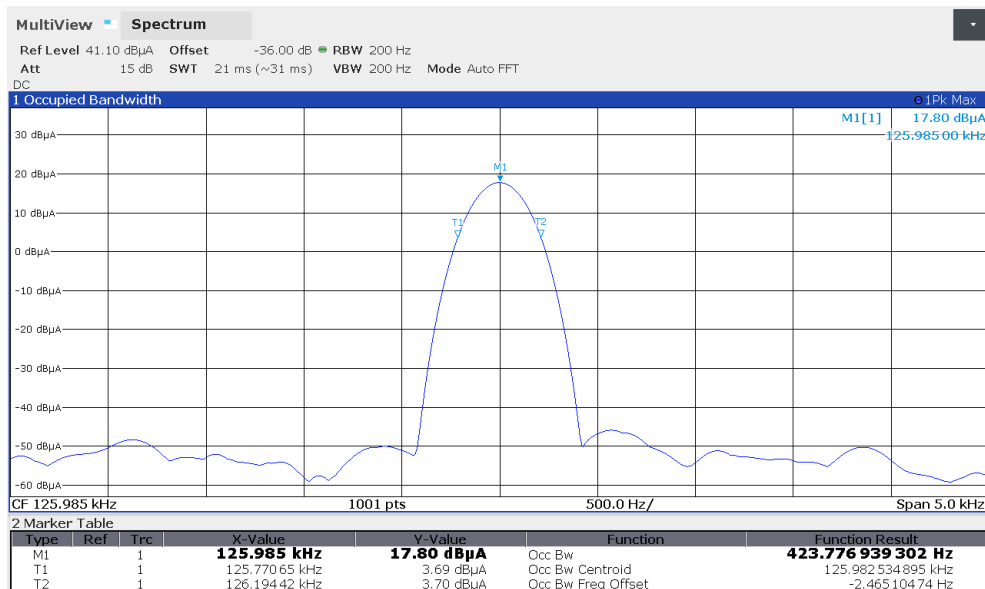
Mode 2
Sensor load, distance 7 mm



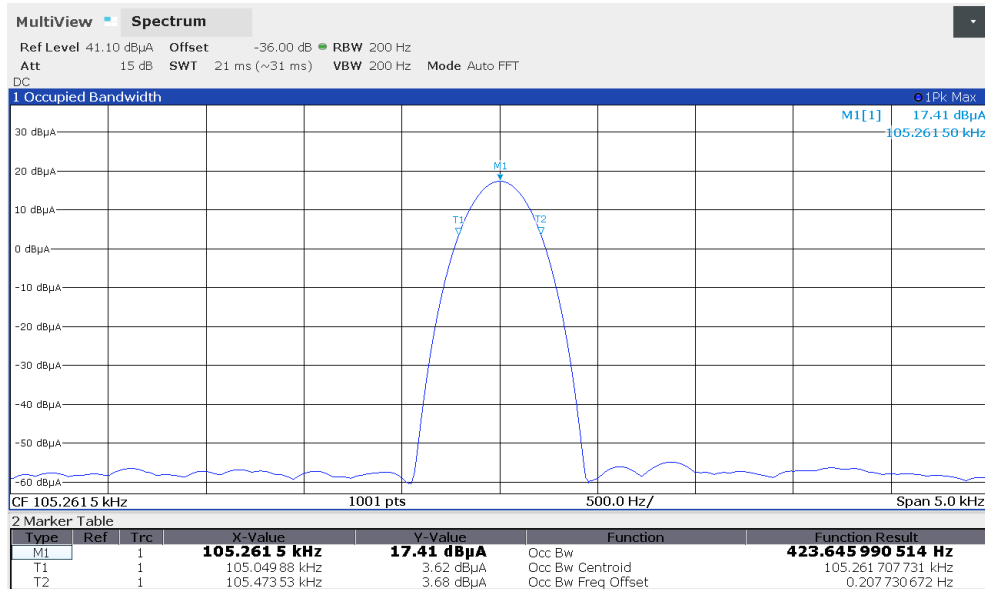
Mode 3
R33 Ohm Resistor load, distance 0 mm



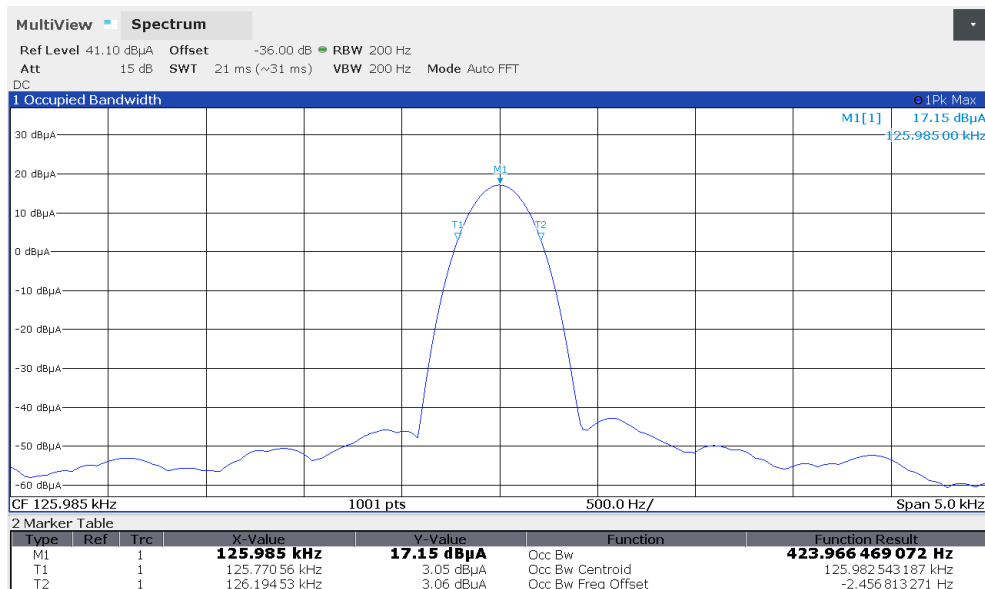
Mode 2
R33 Ohm Resistor load, distance 7 mm



Mode 3
R47 Ohm Resistor load, distance 0 mm



Mode 2
R47 Ohm Resistor load, distance 7 mm



Operation mode: Mode 1, Mode 2 and Mode 3

Test conditions Mode	Distance EUT 1 to EUT 2 in mm	Load	f_L in kHz	f_U in kHz	$f_C = (f_U + f_L)/2$ in kHz	OFR= $f_U - f_L$ in kHz
1	-	-	144.801	145.225	145.013	0.424
2	7	Sensor	125.770	126.194	125.982	0.424
3	0	Sensor	105.049	105.474	105.2615	0.425
2	7	R33 Ohm	125.770	126.194	125.982	0.424
3	0	R33 Ohm	107.895	108.318	108.1065	0.423
2	7	R47 Ohm	125.771	126.195	125.983	0.424
3	0	R47 Ohm	105.050	105.474	105.262	0.424
1, 2 & 3 (max.)			105.049	145.225	125.137	40.176

Test result: Passed

Test equipment (please refer to chapter 7 for details)
1 - 3

5.2 AC power line conducted emissions

5.2.1 Test setup (AC power line conducted emissions)

Test setup (Conducted emissions on power supply lines)			
Used	Setup	See sub-clause	Comment
☒	Conducted: AC power line	5.1.4	-
☐	Not applicable, because ...	-	-

5.2.2 Test method (AC power line conducted emissions)

Test setup (Conducted emissions on power supply lines)				
Used	Clause [1]	Name of method	Sub-clause	Comment
☒	6.2	Tabletop equipment testing	5.1.3	Provided AC switching power adaptor
☐	6.2	Floor-standing equipment testing	-	-

The AC power adaptor provided by the applicant was used for the tests:
 HC24-2.4-AG from bel power solutions.
 The power adaptor itself was supplied by 120 V_{AC} 60 Hz.

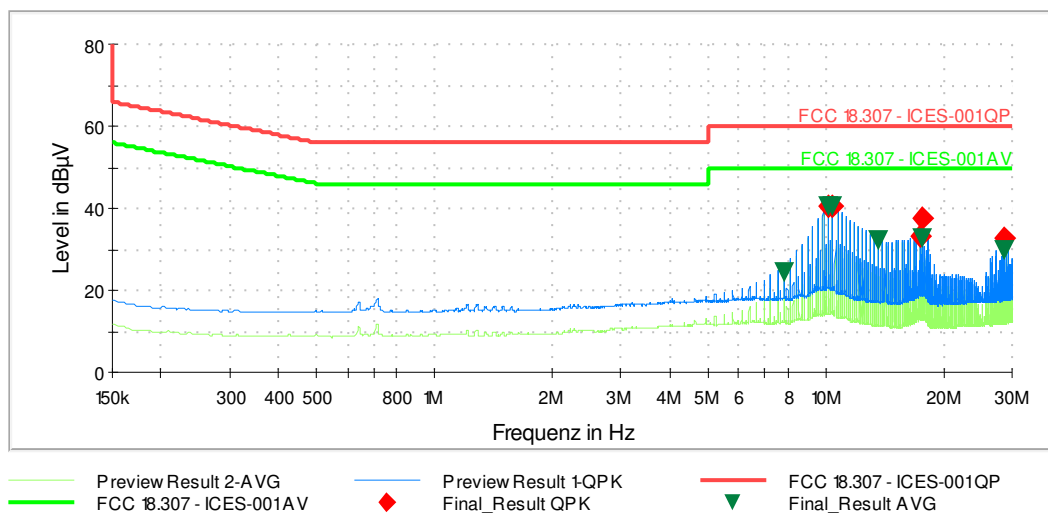
5.2.3 Results of conducted emission measurement on AC mains

Ambient temperature:	22 °C
Relative humidity:	44 %

Date:	25.09.2023
Tested by:	Michael Dinter

Mode1 / only Primary part

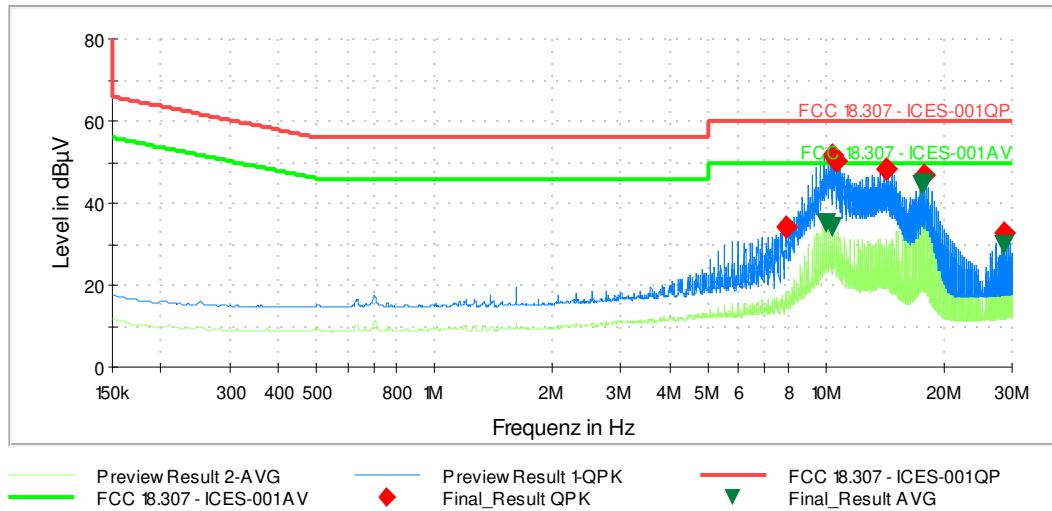
The curves in the diagrams below only represent for each frequency point the maximum measured value of all preliminary measurements which were made for each power supply line. The top measured curve represents the peak measurement and the bottom measured curve the average measurement. The quasi-peak measured points are marked by ◆ and the average measured points by ▼.



Frequency [MHz]	QuasiPeak [dB(μV)]	Average [dB(μV)]	Limit [dB(μV)]	Margin [dB]	Line	PE	Corr. [dB]
7.831500	---	24.29	50.00	25.71	L1	FLO	20.4
10.151250	40.56	---	60.00	19.44	L1	GND	20.5
10.151250	---	40.32	50.00	9.68	L1	GND	20.5
10.441500	40.67	---	60.00	19.34	L1	GND	20.5
10.441500	---	40.43	50.00	9.57	L1	GND	20.5
13.632000	---	32.12	50.00	17.88	L1	GND	20.5
17.400750	33.26	---	60.00	26.74	N	GND	20.6
17.693250	37.33	---	60.00	22.67	N	FLO	20.6
17.693250	---	32.88	50.00	17.12	N	FLO	20.6
28.686750	---	29.68	50.00	20.32	N	GND	20.7
28.686750	32.73	---	60.00	27.27	N	GND	20.7

Test result: Passed

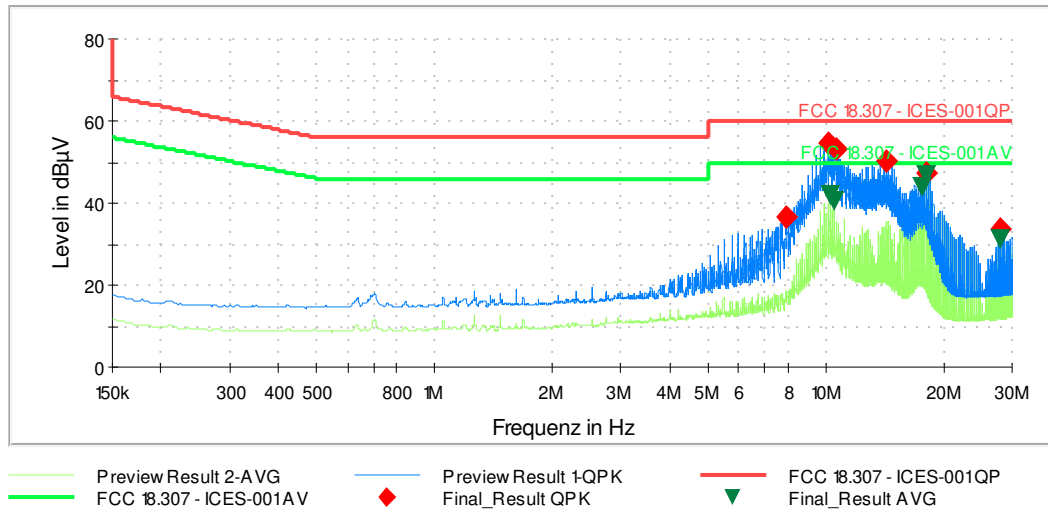
Mode 2 (Distance 7 mm, Sensor load)



Frequency [MHz]	QuasiPeak [dB(μ V)]	Average [dB(μ V)]	Limit [dB(μ V)]	Margin [dB]	Line	PE	Corr. [dB]
7.953000	34.31	---	60.00	25.69	L1	GND	20.4
10.079250	---	34.96	50.00	15.04	L1	GND	20.5
10.376250	51.51	---	60.00	8.49	L1	GND	20.5
10.457250	---	34.01	50.00	15.99	L1	FLO	20.5
10.603500	50.37	---	60.00	9.63	L1	GND	20.5
14.291250	48.46	---	60.00	11.54	N	FLO	20.5
17.637000	---	44.26	50.00	5.74	L1	GND	20.6
17.889000	46.62	---	60.00	13.38	N	GND	20.6
17.889000	---	45.10	50.00	4.90	N	GND	20.6
28.686750	32.86	---	60.00	27.14	N	GND	20.7
28.686750	---	29.82	50.00	20.18	N	GND	20.7

Test result: Passed

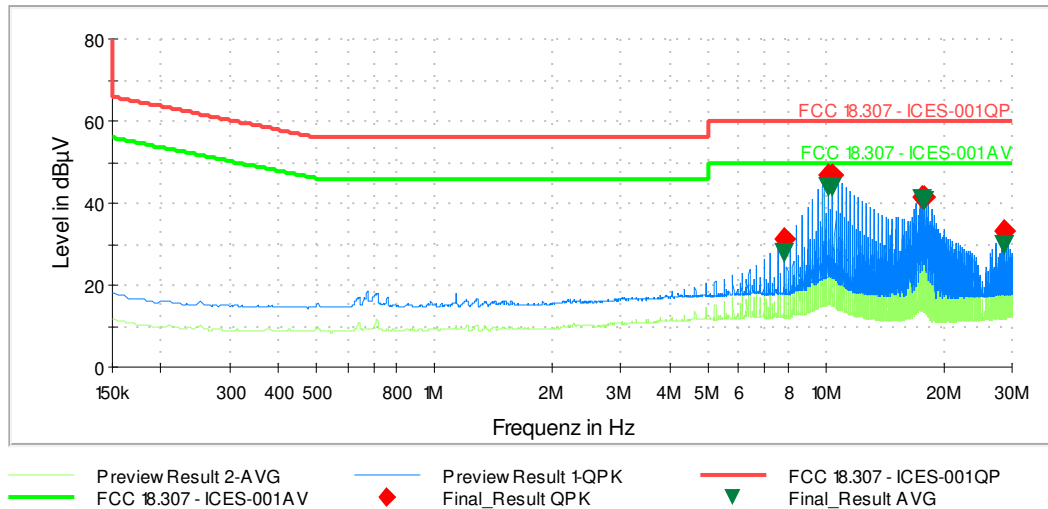
Mode 3 (Distance 0 mm, Sensor load)



Frequency [MHz]	QuasiPeak [dB(µV)]	Average [dB(µV)]	Limit [dB(µV)]	Margin [dB]	Line	PE	Corr. [dB]
7.901250	36.51	---	60.00	23.49	L1	GND	20.4
10.131000	54.58	---	60.00	5.42	L1	FLO	20.5
10.315500	---	41.82	50.00	8.18	L1	GND	20.5
10.527000	---	40.45	50.00	9.55	L1	GND	20.5
10.603500	53.16	---	60.00	6.84	L1	FLO	20.5
14.291250	50.09	---	60.00	9.91	L1	FLO	20.5
17.578500	---	43.67	50.00	6.33	L1	GND	20.6
17.999250	---	47.06	50.00	2.94	L1	GND	20.6
17.999250	47.49	---	60.00	12.51	L1	GND	20.6
27.894750	---	31.43	50.00	18.57	L1	FLO	20.7
27.894750	33.48	---	60.00	26.52	L1	GND	20.7

Test result: Passed

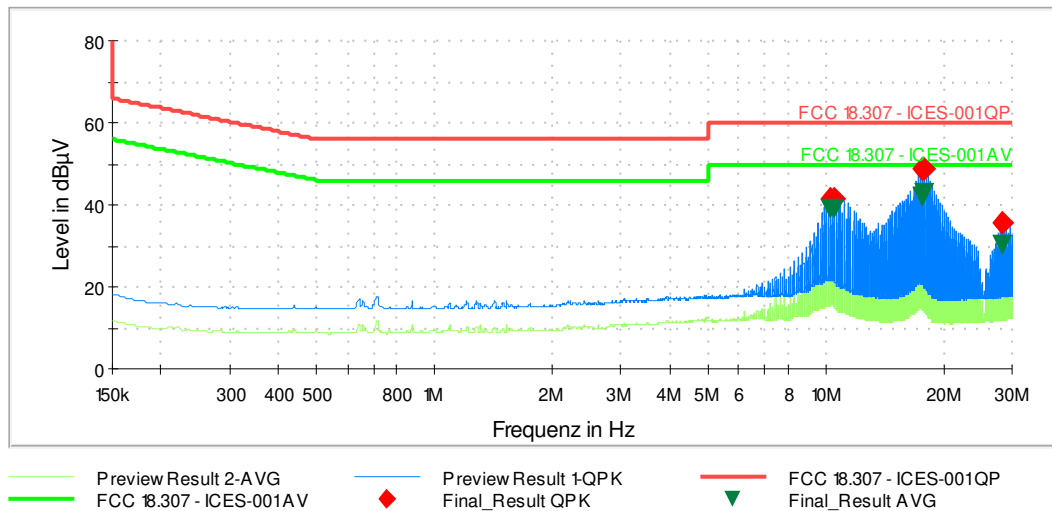
Mode 2 (Distance 7 mm, Load R33 Ohm 800mA)



Frequency [MHz]	QuasiPeak [dB(μ V)]	Average [dB(μ V)]	Limit [dB(μ V)]	Margin [dB]	Line	PE	Corr. [dB]
7.831500	---	27.80	50.00	22.20	L1	GND	20.4
7.831500	31.20	---	60.00	28.80	L1	GND	20.4
10.151250	---	43.91	50.00	6.09	L1	GND	20.5
10.151250	46.82	---	60.00	13.18	L1	GND	20.5
10.441500	---	44.02	50.00	5.98	L1	GND	20.5
10.441500	46.98	---	60.00	13.02	L1	GND	20.5
17.637000	---	40.78	50.00	9.22	N	FLO	20.6
17.637000	41.50	---	60.00	18.50	N	GND	20.6
17.889000	41.61	---	60.00	18.39	N	GND	20.6
17.889000	---	40.42	50.00	9.58	N	FLO	20.6
28.686750	---	29.85	50.00	20.15	N	GND	20.7

Test result: Passed

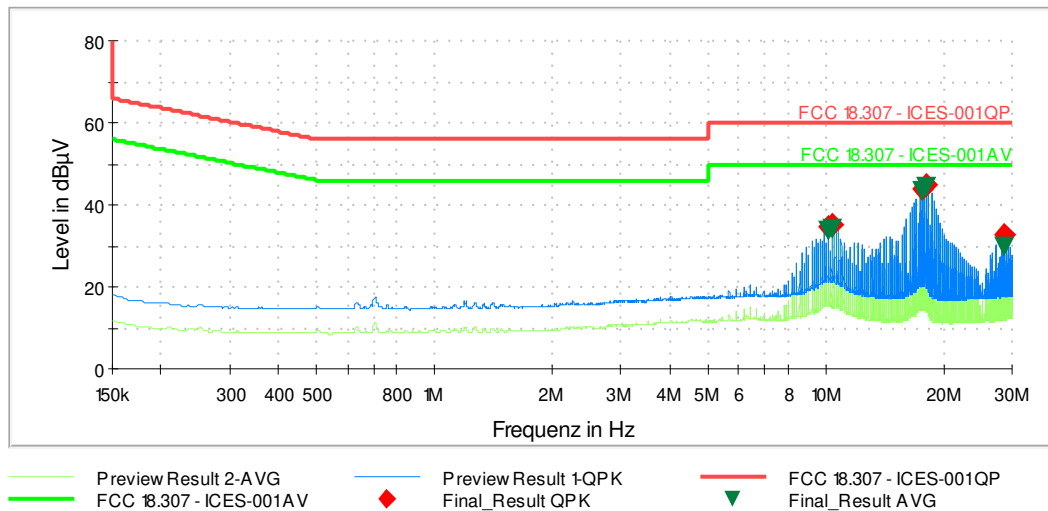
Mode 3 (Distance 0 mm, Load R33 Ohm 800mA)



Frequency [MHz]	QuasiPeak [dB(µV)]	Average [dB(µV)]	Limit [dB(µV)]	Margin [dB]	Line	PE	Corr. [dB]
10.277250	41.52	---	60.00	18.48	L1	GND	20.4
10.277250	---	38.93	50.00	11.07	L1	GND	20.4
10.495500	41.70	---	60.00	18.30	L1	GND	20.5
10.495500	---	39.11	50.00	10.89	L1	GND	20.5
17.603250	---	41.85	50.00	8.15	L1	GND	20.5
17.643750	48.76	---	60.00	11.24	L1	GND	20.5
17.862000	48.58	---	60.00	11.42	N	FLO	20.6
17.931750	---	42.86	50.00	7.14	N	GND	20.6
28.317750	---	30.13	50.00	19.87	N	GND	20.6
28.383000	35.75	---	60.00	24.25	N	FLO	20.6

Test result: Passed

Mode 2 (Distance 7 mm, Load R47 Ohm 500mA)



Frequency [MHz]	QuasiPeak [dB(µV)]	Average [dB(µV)]	Limit [dB(µV)]	Margin [dB]	Line	PE	Corr. [dB]
10.205250	34.48	---	60.00	25.52	L1	GND	20.5
10.205250	---	33.62	50.00	16.38	L1	GND	20.5
10.457250	35.06	---	60.00	24.94	L1	GND	20.5
10.457250	---	34.28	50.00	15.72	L1	GND	20.5
17.637000	---	43.57	50.00	6.43	L1	GND	20.6
17.637000	43.81	---	60.00	16.19	L1	GND	20.6
18.141000	---	44.45	50.00	5.55	N	GND	20.6
18.141000	44.65	---	60.00	15.35	N	GND	20.6
28.686750	32.92	---	60.00	27.08	N	GND	20.7
28.686750	---	29.85	50.00	20.15	N	GND	20.7

Test result: Passed

5.3 Radiated emissions

5.3.1 Test setup (Maximum unwanted emissions)

Test setup (Maximum unwanted emissions)			
Used	Setup	See sub-clause	Comment
☒	Radiated: 9 kHz to 30 MHz / 30 MHz to 1 GHz	5.1.2 / 5.1.3	-

5.3.2 Test method (Maximum unwanted emissions)

Used	Sub-Clause	Name of method	Applicability	Comment
☒	5.1.2 to 5.1.3	Unwanted radiated emissions	No limitations	-

5.3.3 Test results (Maximum unwanted emissions)

5.3.3.1 Test results preliminary measurement 9 kHz to 30 MHz

Ambient temperature:	22 °C
Relative humidity:	38 %

Date:	25.10.2023
Tested by:	M. DINTER

Position of EUT: For tests for f between 9 kHz to 30 MHz, the EUT was set-up on a table with a height of 80 cm. The distance between EUT and antenna was 3 m.

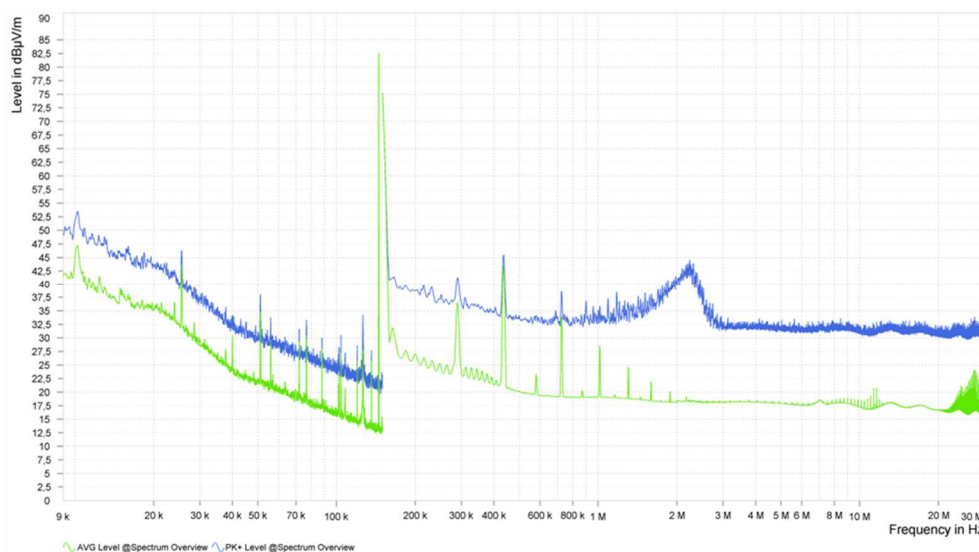
Cable guide: For detail information of test set-up and the cable guide refer to the pictures in the annex A in the test report.

Remark: All 3 orthogonal planes were tested separately, the plots below a showing the maximum of all positions.

Worst case plots:

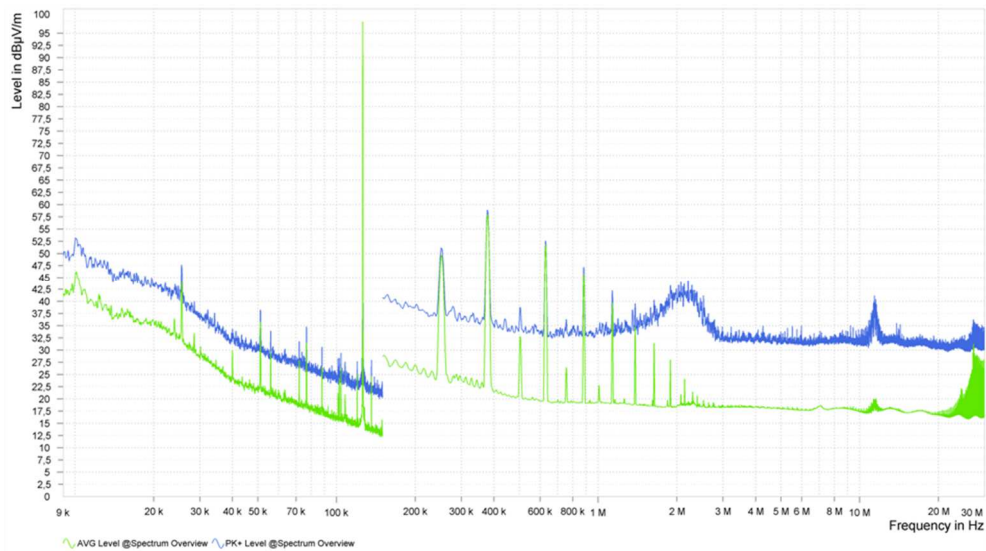
Spurious emissions from 9 kHz to 30 MHz:

Mode1 / only Primary part

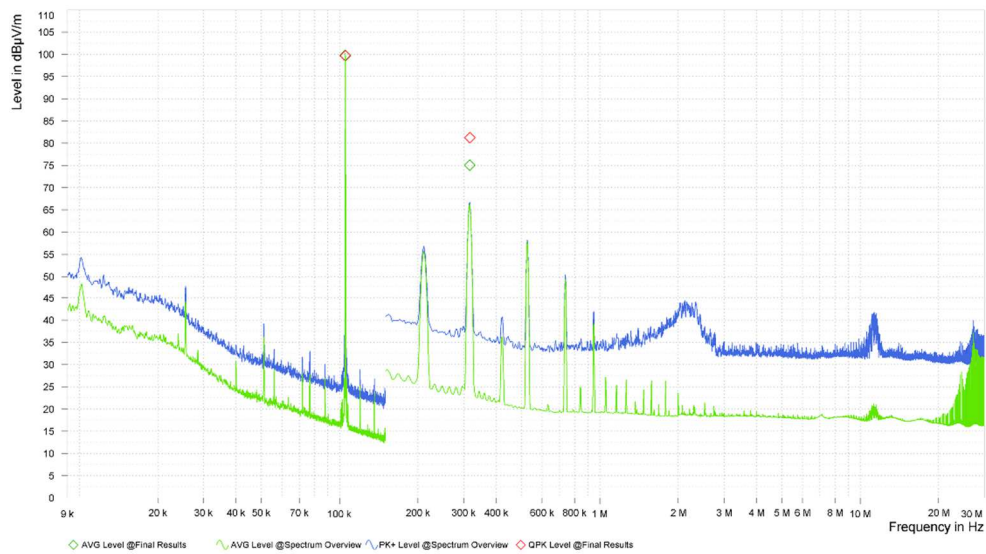


Remark: The peak at 150 kHz is caused by the resolution bandwidth changing from 200 Hz to 9 kHz nearby the wanted signal at 145 kHz. A measurement with 200 Hz resolution bandwidth has shown that the emission at 150 kHz is nearby the noise floor of the system. Therefore, the shown peak in the preliminary measurement needn't to be considered for the final measurement.

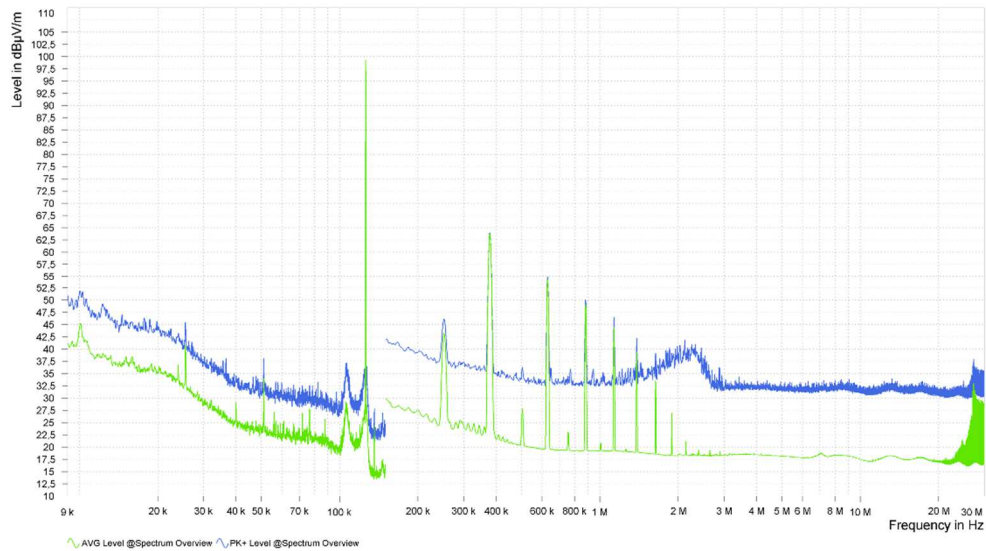
Mode 2 (Distance 7 mm, Sensor load)



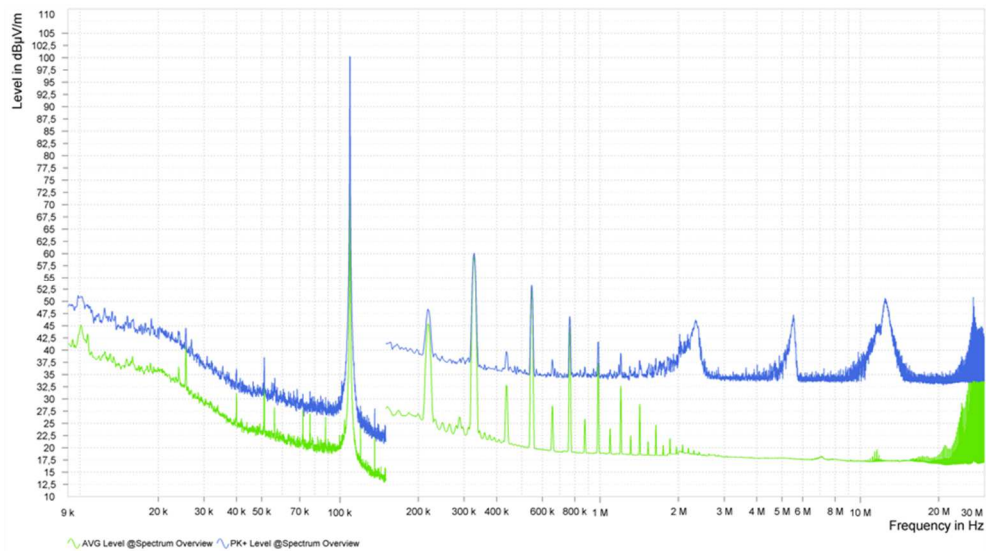
Mode 3 (Distance 0 mm, Sensor load)



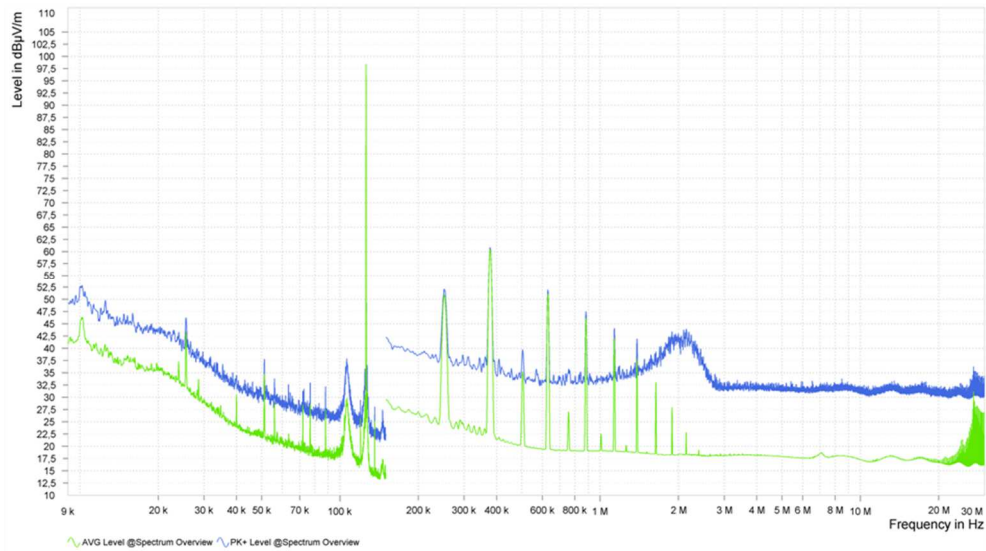
Mode 2 (Distance 7 mm, Load R33 Ohm 800mA)



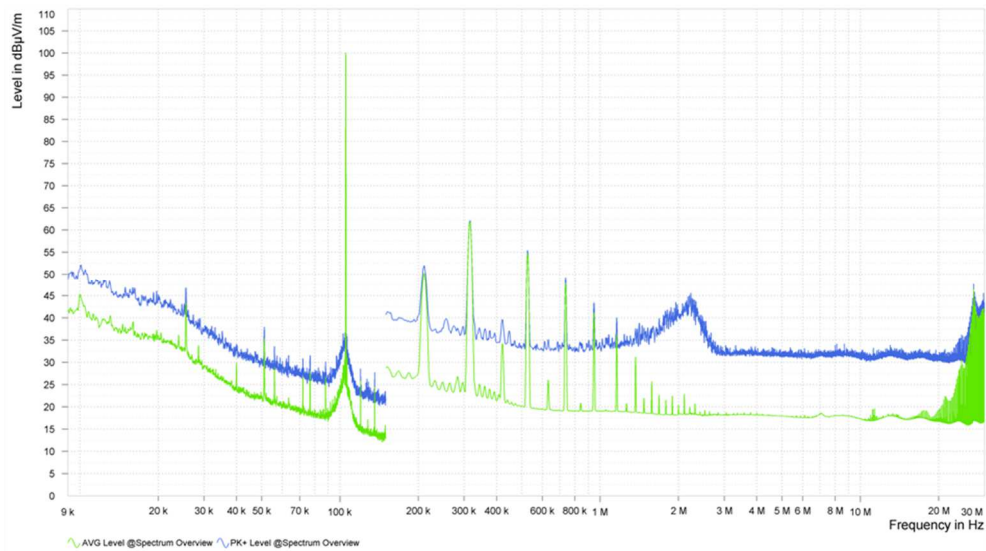
Mode 3 (Distance 0 mm, Load R33 Ohm 800mA)



Mode 2 (Distance 7 mm, Load R47 Ohm 500mA)



Mode 3 (Distance 0 mm, Load R47 Ohm 500mA)



During the preliminary measurement, the following emissions as stated in the final measurement were found:

On these frequencies a final measurement on an outdoor test site has to be carried out. The results of this final measurement are presented in 5.3.3.2 of this test report.

Test equipment (please refer to chapter 7 for details)
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5.3.3.2 Test results final measurement 9 kHz to 30 MHz

Ambient temperature:	10 °C
Relative humidity:	56 %

Date:	31.10.2023
Tested by:	M. DINTER

The results of the standard subsequent measurement at the outdoor test site are indicated in the tables below.

Calculations:

Result @ norm. dist. [dB(μV/m)] = Reading [dB(μV)] + AF [dB/m] + Distance corr. fact. (if applicable) [dB]

Result @ norm. dist. [dB(μA/m)] = Result @ norm. dist. [dB(μV/m)] – 20 x log₁₀ (377 Ω)

Margin [dB] = Limit [dB(μV|μA/m)] - Result [dB(μV|μA/m)]

Mode 1 , 2 and 3 according to 47 CFR 18.305 (b):

The wanted signal was measured with two different measuring distances in order to calculate a distance correction factor. For all other distances a distance correction factor of 20 dB / decade (1/d) was used.

Mode	Distance EUT 1 to EUT 2 in mm	Load	Frequency in kHz	Level at 3 m distance (AV) [dB(μV/m)]	Level at 10 m distance (AV) [dB(μV/m)]	Difference from 3 to 10 m [dB]	Distance correction factor [dB/decade]
1	-	-	145.03	80.2	52	28.2	56.4
2	7	Sensor	126.01	94.8	66.6	28.2	56.4
3	0	Sensor	105.3	100.2	68.4	31.8	63.6
2	7	R33 Ohm	126.05	97.0	68.1	28.9	57.8
3	0	R33 Ohm	108.8	99.6	68.9	30.7	61.4
2	7	R47 Ohm	126.05	96.9	67.6	29.3	58.6
3	0	R47 Ohm	105.33	100.1	68.9	31.2	62.4

The limits as well as the measured results (levels) refer to 47 CFR 18.305 (b) while taking in account the specified requirements for a 3 | 300 m measuring distance.

Mode1 / only Primary part

Results 9 kHz - 30 MHz										
Frequency [MHz]	Reading @ measuring distance [dB(μV)]	Result @ norm. distance [dB(μV/m)]	Limit acc. 18.305 [dB(μV/m)]	Margin [dB]	Detector	Antenna factor [dB/m]	Measuring distance [m]	Normative distance [m]	Distance correction factor * [dB]	Position #
0.145	60.3	-32.7 @ 300m	23.5	56.2	CAV	19.9	3	300	112.8	1
0.438	23.2	3.8 @ 300m	23.5	19.8	CAV	20.2	3	300	40.0	1
2.236	23.7	4.3 @ 300m	23.5	19.2	CAV	20.3	3	300	40.0	1
27.843	12.9	-6.5 @ 300m	23.5	30.1	CAV	20.3	3	300	40.0	1

*: Distance correction according to 47 CFR 18.305 (b) [3].

Mode 2 (Distance 7 mm, Sensor load)

Results 9 kHz - 30 MHz										
Frequency [MHz]	Reading @ measuring distance [dB(μV)]	Result @ norm. distance [dB(μV/m)]	Limit acc. 18.305 [dB(μV/m)]	Margin [dB]	Detector	Antenna factor [dB/m]	Measuring distance [m]	Normative distance [m]	Distance correction factor * [dB]	Position #
0.126	74.9	-18.1 @ 300m	23.5	41.6	CAV	19.9	3	300	112.8	1
0.254	30.6	11 @ 300m	23.5	12.5	CAV	20.2	3	300	40.0	1
0.377	38.6	19.2 @ 300m	23.5	4.3	CAV	20.3	3	300	40.0	1
0.629	32.3	12.9 @ 300m	23.5	10.6	CAV	20.3	3	300	40.0	1
0.881	26.9	7.5 @ 300m	23.5	16.0	CAV	20.3	3	300	40.0	1
2.072	23.7	4.3 @ 300m	23.5	19.2	CAV	20.3	3	300	40.0	1
2.207	24.0	4 @ 300m	23.5	19.5	CAV	20.0	3	300	40.0	1
27.463	15.2	-4.8 @ 300m	23.5	28.4	CAV	20.0	3	300	40.0	1

*: Distance correction according to 47 CFR 18.305 (b) [3].

Mode 3 (Distance 0 mm, Sensor load)

Results 9 kHz - 30 MHz										
Frequency [MHz]	Reading @ measuring distance [dB(μV)]	Result @ norm. distance [dB(μV/m)]	Limit acc. 18.305 [dB(μV/m)]	Margin [dB]	Detector	Antenna factor [dB/m]	Measuring distance [m]	Normative distance [m]	Distance correction factor * [dB]	Position #
0.105	80.3	-27.0 @ 300m	23.5	50.5	CAV	19.9	3	300	127.2	1
0.211	36.6	17 @ 300m	23.5	6.5	CAV	20.2	3	300	40.0	1
0.317	46.4	22 @ 300m	23.5	1.5	CAV	20.3	3	300	40.0	1
0.526	38.0	18.6 @ 300m	23.5	5.0	CAV	20.3	3	300	40.0	1
0.737	30.2	10.8 @ 300m	23.5	12.8	CAV	20.3	3	300	40.0	1
2.150	23.9	4.5 @ 300m	23.5	19.0	CAV	20.3	3	300	40.0	1
11.517	21.5	1.5 @ 300m	23.5	22.0	CAV	20.0	3	300	40.0	1
27.472	18.1	-1.9 @ 300m	23.5	25.4	CAV	20.0	3	300	40.0	1

*: Distance correction according to 47 CFR 18.305 (b) [3].

Mode 2 (Distance 7 mm, Load R33 Ohm 800mA)

Results 9 kHz - 30 MHz										
Frequency [MHz]	Reading @ measuring distance [dB(μV)]	Result @ norm. distance [dB(μV/m)]	Limit acc. 18.305 [dB(μV/m)]	Margin [dB]	Detector	Antenna factor [dB/m]	Measuring distance [m]	Normative distance [m]	Distance correction factor * [dB]	Position #
0.126	77,1	-18.6 @ 300m	23.5	42.1	CAV	19.9	3	300	115.6	1
0.377	43,8	22.1 @ 300m	23.5	1.4	CAV	20.2	3	300	40.0	1
27.339	17,7	-1.7 @ 300m	23.5	25.2	CAV	20.0	3	300	40.0	1

*: Distance correction according to 47 CFR 18.305 (b) [3].

Mode 3 (Distance 0 mm, Load R33 Ohm 800mA)

Results 9 kHz - 30 MHz										
Frequency [MHz]	Reading @ measuring distance [dB(μV)]	Result @ norm. distance [dB(μV/m)]	Limit acc. 18.305 [dB(μV/m)]	Margin [dB]	Detector	Antenna factor [dB/m]	Measuring distance [m]	Normative distance [m]	Distance correction factor * [dB]	Position #
0.109	79.7	-23.2 @ 300m	23.5	46.7	CAV	19.9	3	300	122.8	1
0.218	25.3	5.7 @ 300m	23.5	17.9	CAV	20.2	3	300	40.0	1
0.328	39.8	20.4 @ 300m	23.5	3.1	CAV	20.3	3	300	40.0	1
0.546	33.1	13.7 @ 300m	23.5	9.8	CAV	20.3	3	300	40.0	1
0.764	24.4	5 @ 300m	23.5	18.6	CAV	20.3	3	300	40.0	1
12.370	30.1	10.4 @ 300m	23.5	13.1	CAV	20.0	3	300	40.0	1
12.453	30.7	10.7 @ 300m	23.5	12.8	CAV	20.0	3	300	40.0	1
27.164	30.9	10.9 @ 300m	23.5	12.6	CAV	20.0	3	300	40.0	1

*: Distance correction according to 47 CFR 18.305 (b) [3].

Mode 2 (Distance 7 mm, Load R47 Ohm 500mA)

Results 9 kHz - 30 MHz										
Frequency [MHz]	Reading @ measuring distance [dB(μV)]	Result @ norm. distance [dB(μV/m)]	Limit acc. 18.305 [dB(μV/m)]	Margin [dB]	Detector	Antenna factor [dB/m]	Measuring distance [m]	Normative distance [m]	Distance correction factor * [dB]	Position #
0.126	77.0	-20.3 @ 300m	23.5	43.8	CAV	19.9	3	300	117.2	1
0.254	31.6	12 @ 300m	23.5	11.6	CAV	20.2	3	300	40.0	1
0.377	40.5	21.1 @ 300m	23.5	2.4	CAV	20.3	3	300	40.0	1
0.627	29.6	10.2 @ 300m	23.5	13.4	CAV	20.3	3	300	40.0	1
0.629	31.7	12.3 @ 300m	23.5	11.2	CAV	20.3	3	300	40.0	1
27.211	16.1	-3.6 @ 300m	23.5	27.1	CAV	20.0	3	300	40.0	1

*: Distance correction according to 47 CFR 18.305 (b) [3].

Mode 3 (Distance 0 mm, Load R47 Ohm 500mA)

Results 9 kHz - 30 MHz										
Frequency	Reading @ measuring distance	Result @ norm. distance	Limit acc. 18.305	Margin	Detector	Antenna factor	Measuring distance	Normative distance	Distance correction factor *	Position
[MHz]	[dB(μV)]	[dB(μV/m)]	[dB(μV/m)]	[dB]		[dB/m]	[m]	[m]	[dB]	#
0.105	80.2	-24.7 @ 300m	23.5	48.2	CAV	19.9	3	300	124.8	1
0.314	41.5	21.9 @ 300m	23.5	1.6	CAV	20.2	3	300	40.0	1
27.051	24.4	4.7 @ 300m	23.5	18.9	CAV	20.0	3	300	40.0	1
27.263	27.6	7.9 @ 300m	23.5	15.6	CAV	20.0	3	300	40.0	1
29.787	24.9	5.2 @ 300m	23.5	18.3	CAV	20.0	3	300	40.0	1

*: Distance correction according to 47 CFR 18.305 (b) [3].

Test result: Passed

Test equipment (please refer to chapter 7 for details)

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6 Measurement Uncertainties

Conducted measurements		
Measurement method	Standard used for calculating measurement uncertainty	Expanded measurement uncertainty (95 %) U_{lab}
Bandwidth measurements	-	9.0×10^{-8}
Conducted emissions from 9 kHz to 150 MHz with LISN	CISPR 16-4-2	3.8 dB
Conducted emissions from 150 kHz to 30 MHz with LISN	CISPR 16-4-2	2.8 dB

Radiated measurements		
Bandwidth measurements		
(Semi-) Anechoic chamber	-	9.0×10^{-8}
OATS	-	9.0×10^{-8}
Test fixture	-	9.1×10^{-8}
Radiated field strength M276		
R&S HL562E @ 3 m 30 MHz – 1 GHz	CISPR 16-4-2	4.8 dB
OATS		
Field strength measurements below 30 MHz on OATS without ground plane	-	4.4 dB

7 Test Equipment used for Tests

No.	Test equipment	Type	Manufacturer	Serial No.	PM. No.	Cal. Date	Cal Due
1	Loop antenna	22.5 cm	PHOENIX TESTLAB GmbH	-	410085	Calibration not necessary	
2	Power Supply	TOE8852 (DC)	Toellner Electronic Inst.	51712	480233	Calibration not necessary	
3	Signal & Spectrum Analyzer	FSW43	Rohde & Schwarz	100586 & 100926	481720	17.03.2023	03.2025
4	V-LISN	NSLK8128RC	Schwarzbeck	0412	483186	15.02.2022	02.2024
5	Shielded chamber M155	SK3	Albatross Projects		482786	Calibration not necessary	
6	Software	EMC32	Rohde & Schwarz	100619	483182	Calibration not necessary	
7	EMI Testreceiver	ESR7	Rohde & Schwarz	101939	482558	15.02.2022	02.2024
8	SPS_EMV	Software	Spitzenberger & Spies	A7078 B22 M1	480114	Calibration not necessary	
9	EMC test system	EMC D 30000 / PAS	Spitzenberger & Spies	A4507 00/1 1110	481301	Calibration not necessary	
10	Contol unit	SyCore 1k4	Spitzenberger & Spies	A4507 12/0 1110	481302	21.11.2022	11.2024
11	Loop antenna	HFH2-Z2	Rohde & Schwarz	832609/014	480059	22.02.2022	02.2024
12	Software M276	Elektra	Rohde&Schwarz	101381	483755	Calibration not necessary	
13	RF Switch Matrix	OSP220	Rohde & Schwarz		482976	Calibration not necessary	
14	Turntable	TT3.0-3t	Maturo	825/2612/.01	483224	Calibration not necessary	
15	Controller	NCD	Maturo	474/2612.01	483226	Calibration not necessary	
16	Semi Anechoic Chamber M276	SAC5-2	Albatross Projects	C62128-A540-A138-10-0006	483227	Calibration not necessary	
17	EMI Testreceiver	ESW44	Rohde & Schwarz	101828	482979	08.12.2021	12.2023
18	Outdoor test site	-	PHOENIX TESTLAB GmbH	-	480293	Calibration not necessary	
19	EMI Receiver / Spectrum Analyser	ESI 40	Rohde & Schwarz	100064/040	480355	18.02.2022	02.2024
20	DC Power Supply	TOE8951	Toellner Electronic Inst.	81995	481252	Calibration not necessary	

8 Test site Verification

Test equipment	PM. No.	Frequency range	Type of validation	According to	Val. Date	Val Due
Shielded chamber M155	482784	9 kHz – 30 MHz	GND-Plane	ANSI C63.4-2014	14.11.2022	13.11.2025
OATS Outdoor	480293	9 kHz – 30 MHz	-	ANSI C63.4-2014	-	-

9 Report History

Report Number	Date	Comment
F230142E5	06.03.2024	Initial Test Report
F230142E5, 2 nd version	30.09.2025	Remove RSS216 and ICES 001 results and standards
-	-	-

10 List of Annexes

Annex A	Test setup photos	10 pages
Annex B	External photos	7 pages
Annex C	External photos	4 pages