TECHNICKÝ SKÚŠOBNÝ® ÚSTAV PIEŠŤANY, š.p.
Krajinská cesta 2929/9, 921 01 Piešťany, Slovak Republic

ilac-MRA SNAS Reg. No. 009/S-047

Test Laboratory TSÚ – Test Laboratory EMC a RED
Tel.: +421-33-7957 229 E-mail: obchodne@tsu.sk www.tsu.eu www.tsu.sk

TEST REPORT
No.: 220500318/EMC

Test name : Electromagnetic compatibility tests

Product name : Senseir

Model : Airlyse 100

Manufacturer : Sense IoT, s.r.o.
Mlynské Nivy 73
821 05 Bratislava
Slovak Republic

Applicant : COCV TSÚ Piešťany,
Krajinská cesta 2929/9
921 01 Piešťany
Slovak Republic

Testing location : Test Laboratory TSÚ Piešťany, š.p.,
Krajinská cesta 2929/9,
921 01 Piešťany,
Slovak Republic

Order no. : 220500318

Test procedure : See chap. 2

Date of test : See chap. 2

Distribution : Copy no.1 – manufacturer
Copy no.2 – TSU

Date of issue : 25.01.2023

TECHNICKÝ SKÚŠOBNÝ. ÚSTAV PIEŠŤANY, š.p.
SkúšobňaTSÚ
Krajinskácesta 2929/9
92101 PIEŠŤANY
-317-

Tested by: **Ing. Jakub Šiška**
Test engineer

Approved by: **Ing. Ľuboš Vančo**
Technical head of RED and EMC testing body

CONTENTS

1 GENERAL INFORMATION

EMC emissions and immunity tests were performed on the equipment under test (EUT) in the testing laboratory of TSÚ, š.p. Piešťany, Slovak Republic, accredited by the SNAS.

All tests were conducted in an environment which ensured that the measurable influence or interference (background noise) not generated by EUT, was below the threshold limits defined in the standards.

2 TEST METHODS AND CONDITIONS

Test methods used :	MPS 01/5.11/2018 Measurement of electromagnetic compatibility
Standards :	EN 301 489-1 V2.2.3 ElectroMagnetic Compatibility (EMC) standard for radio equipment and services; Part 1: Common technical requirements; Harmonised Standard for ElectroMagnetic Compatibility EN 301 489-52 V1.2.1 ElectroMagnetic Compatibility (EMC) standard for radio equipment and services; Part 52: Specific conditions for Cellular Communication User Equipment (UE) radio and ancillary equipment; Harmonised Standard for ElectroMagnetic Compatibility EN 50155:2017 Railway applications - Rolling stock - Electronic equipment EN 50121-3-2:2016/A1:2019 Railway applications - Electromagnetic compatibility - Part 3-2: Rolling stock - Apparatus
Place of testing :	☒ EMC testing laboratory TSÚ Piešťany, š.p. ☐ Laboratory Pobedim TSÚ Piešťany, š.p. ☐ on-site:
Place and date of sample delivery :	Samples delivered to TSÚ Piešťany, š.p. on 25.10.2022 and recorded under the registration number 220500318/317/5268
Start of test :	25.11.2022
End of test :	29.11.2022
Test procedure deviations :	Without test procedure deviation.
Tests conditions and results :	See chap. 3, 4, 7, 8

2.1 Environmental Conditions

Temperature :	19 - 20 °C
Relative Humidity :	37 - 40 %
Atmospheric Pressure :	102,1 - 103,1 kPa

3 SUMMARY OF TESTS AND TEST RESULTS

Possible test case verdicts:
- test not applicable…….....: N/A
- test not required by manufacturer……..: N/R
- test object does meet the requirement….....: PASS
- test object does not meet the requirement….....: FAIL

The tests were performed in accordance with the requirements of standards EN 301 489-52 V1.2.1, referenced EN 301 489-1 V2.2.3, EN 50155:2017 and EN 50121-3-2:2016/A1:2019. Basic standards referenced by EN 301 489-1 V2.2.3 as follows:

Harmonized Standard ETSI EN 301 489-52				
Classification of EUT: Measuring equipment with radio part for fixed use.				
Emissions				
Clause No. of EN 301 489-1	**Test Description**	**Referenced standard**	**Test Result**	**Condition**
8.2	Enclosure of ancillary equipment measured on a stand-alone basis	EN 55032	PASS	Only applicable to ancillary equipment not incorporated in the radio equipment and intended to be measured on a stand-alone basis.
8.3	DC power input/output ports	EN 55032	N/A (Note1)	Only where equipment has DC power input and/or output ports with a cable length greater than 3 m or from a vehicle power supply
8.4	AC mains power input/output ports	EN 55032	PASS	**Class B** Equipment intended primarily for use in a residential environment shall meet the Class B limits
8.5	Harmonic current emission (AC mains input port)	EN 61000-3-2 EN 61000-3-12	N/A (Note4)	**EN 61000-3-2 Class A** Equipment with input current ≤ 16 A per phase
8.6	Voltage fluctuations and flicker (AC mains input ports)	EN 61000-3-3 EN 61000-3-11	PASS	**EN 61000-3-3** Equipment with input current ≤ 16 A per phase
8.7	Wired network ports	EN 55032	N/A (Note3)	Only where equipment has wired network ports
Immunity				
Clause No. of EN 301 489-1	**Test Description**	**Referenced standard**	**Test Result**	**Condition**
9.2	Radio frequency electromagnetic field (80 MHz to 6 000 MHz)	EN 61000-4-3	PASS (Note5)	---
9.3	Electrostatic discharge	EN 61000-4-2	PASS (Note5)	---
9.4	Fast transients common mode	EN 61000-4-4	N/A	---
9.5	Radio frequency common mode	EN 61000-4-6	N/A	---
9.6	Transients and surges in the vehicular environment	ISO 7637-2	N/A (Note2)	Only where equipment is connected to vehicle power supply
9.7	Voltage dips and interruptions	EN 6000-4-11	N/A	---
9.8	Surges, line to line and line to ground	EN 61000-4-5	N/A	---

Note 1: The EUT is powered from internal rechargeable battery, charged from integrated photovoltaic panel or USB-C port with cable length less than 3 m. The EUT was being charged from AC/DC adapter (AE1, lab equipment) during the testing.
Note 2: The EUT is not intended for road vehicular environment.
Note 3: The EUT has no wired network ports.
Note 4: Limits are not specified for equipment with a rated power of 75 W or less.
Note 5: In addition, this test was also carried out at higher test limits according to EN 50121-3-2 standard.

Test cases according to EN 50155 and EN 50121-3-2:

EMISSION					
Test Carried Out	Test	**Standard**	Class	Test result	Note
☒	Railway applications - Rolling stock - Electronic equipment	**EN 50155:2017** **idt EN 50155:2017**	---	PASS	
☒	Railway applications - Electromagnetic compatibility - Part 3-2: Rolling stock - Apparatus	**EN 50121-3-2:2016/ A1:2019** **idt EN 50121-3-2:2016/ A1:2019**	---	PASS	1
☒	Specification for radio disturbance and immunity measuring apparatus and methods – Part 2-1: Methods of measurement of disturbances and immunity - Conducted disturbance measurements	**EN 55016-2-1:2014/ A1:2017** **CISPR 16-2-1:2014/ A1:2017**	---	---	2
☒	Specification for radio disturbance and immunity measuring apparatus and methods – Part 2-3: Methods of measurement of disturbances and immunity - Radiated disturbance measurements	**EN 55016-2-3:2017** **CISPR 16-2-3:2016**	---	---	3

SUSCEPTIBILITY					
Test Carried Out	Test	**Standard**	Performance Criteria	Test result	Note
☒	Railway applications - Rolling stock - Electronic equipment	**EN 50155:2017** **idt EN 50155:2017**	---	PASS	
☒	Railway applications - Electromagnetic compatibility - Part 3-2: Rolling stock - Apparatus	**EN 50121-3-2:2016/ A1:2019** **idt EN 50121-3-2:2016/ A1:2019**	---	PASS	
☒	Electromagnetic compatibility (EMC) - Part 4-2: Electrostatic discharge immunity test	**EN 61000-4-2:2009**	B	PASS	
☒	Electromagnetic compatibility (EMC). Part 4-3: Testing and measurement techniques. Radiated, radio-frequency, electromagnetic field immunity test	**EN 61000-4-3:2006/ A1:2008/A2:2010/ IS1:2009**	A	PASS	
☒	Electromagnetic compatibility (EMC) - Part 4-4: Electrical fast transient/burst immunity test	**EN 61000-4-4:2012**	B	N/A	4
☒	Electromagnetic compatibility (EMC) - Part 4-5: Surge immunity test	**EN 61000-4-5:2014**	C	N/A	4
☒	Electromagnetic compatibility (EMC). Part 4-6: Testing and measurement techniques Immunity to conducted disturbances, induced by radio-frequency fields	**EN 61000-4-6:2014**	A	N/A	4

Note 1: According to the standard EN 50121-3-2:2016/A1:2019, the emission limits defined in EN 61000-6-4:2007/A1:2011, Table 1 (Emission – enclosure port) shall be complied with.
Note 2: The standard EN 55016-2-1:2014/A1:2017 (CISPR 16-2-1:2014/A1:2017) is only standard for Specification for radio disturbance and immunity measuring apparatus and methods. Acceptance criterion (Test limits) is defined in the standard EN 50121-3-2:2016/A1:2019 (idt EN 50121-3-2:2016/A1:2019) Railway applications - Electromagnetic compatibility - Part 3-2: Rolling stock - Apparatus.
Note 3: The standard EN 55016-2-3:2017 (CISPR 16-2-3:2016) is only standard for Specification for radio disturbance and immunity measuring apparatus and methods. Acceptance criterion (Test limits) is defined in the standard EN 50121-3-2:2016/A1:2019 (idt EN 50121-3-2:2016/A1:2019) Railway applications - Electromagnetic compatibility - Part 3-2: Rolling stock - Apparatus.
Note 4: The EUT is powered from internal rechargeable battery, charged from integrated photovoltaic panel or USB-C port with cable length less than 3 m. The EUT was being charged from AC/DC adapter (AE1, lab equipment) during the testing.

4 EQUIPMENT UNDER TEST

4.1 Description of EUT

Prototype: ☐

Production Version: ☒

Manufacturer:	Sense IoT, s.r.o. Mlynské Nivy 73 821 05 Bratislava Slovak Republic
Product name:	Senseir
Model:	Airlyse 100
Serial number:	073B6A
Number of test samples:	1 pc.
Description:	Senseir Airlyse 100 is a device for monitoring indoor air pollution with remote control by transferring data using the NB-IoT communication network.
Tested sample description:	- power rating: Li-Fe battery 3.2 V DC, 3300 mAh; USB-C 5V DC, 3A or photovoltaic panel charging - EUT functional temperature range: not specified - RF operational frequencies: NB-IoT E-UTRA (uplink; downlink): 703 – 748; 758 – 803 MHz 832 – 862; 791 – 821 MHz 880 – 915; 925 – 960 MHz 1710 – 1785; 1805 – 1880 MHz 1920 – 1980; 2110 – 2170 MHz output power: 23 dBm conducted PCB antenna, gain unknown
Deviations from the Basic EMC standards:	none

4.2 Software and Firmware

The EUT was delivered in the configuration typical for its intended use.

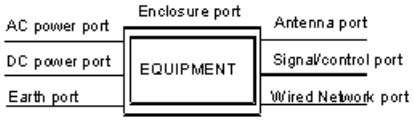
4.3 Test Modes

The tests were carried out on the sample operated in its typical operational mode. The EUT function was checked by data sent via mobile network on an app installed on AE1. The EUT was being charged from AE2 during testing.

AE1: Smartphone, model: Galaxy A12, manufacturer: Samsung Electronics Co., Ltd.
AE2: Travel adapter, model: EP-TA200, manufacturer: Samsung Electronics Co., Ltd., input: 100 – 240 V AC, 50-60 Hz, 0.5 A, output: 9 V DC, 1.67 A or 5 V DC, 2 A (laboratory equipment)

4.4 Input / Output Ports

Any connection point on an equipment intended for connection of cables to or from that equipment is considered as a port:



List of EUT ports:
- signal/control port (USB-C)

4.5 RF Exclusion Bands

The frequencies on which the EUT is intended to operate shall be excluded from the conducted and radiated RF emission and immunity tests.

4.5.1 Exclusion band for transmitters or the transmitter part of transceivers

Exclusion bands shall not be applied when measuring transmitters in standby mode.

For channelized equipment the exclusion band shall extend 250 % of the channel width either side of the transmitter centre frequency.

For non-channelized equipment the exclusion band shall extend 250 % of the occupied bandwidth either side of the transmitter centre frequency.

EUT transmitter part exclusion bands:

Operating frequency (MHz)	Channel width (MHz)	Exclusion Band (MHz)
703 - 748	20	653 - 798
832 - 862	20	782 - 912
880 - 915	20	830 - 965
1710 - 1785	20	1660 - 1835
1920 - 1980	20	1870 - 2030

4.5.2 Exclusion band for receivers or the receiver part of transceivers

Exclusion bands are not applied when testing emissions of receivers or receiver part of transceivers.

For channelized equipment the exclusion band shall be calculated by using the following formulae:
For the lower edge for the exclusion band:
$EXband(lower) = Band_{RX}(lower) - nChW_{RX}$
and for the upper edge of the exclusion band:
$EXband(upper) = Band_{RX}(upper) + nChW_{RX}$

Where n = number of channel widths required for exclusion band.

> NOTE: For equipment that support multiple channel widths the Channel Width used is the widest supported by the EUT.

Where the present document is being used in a stand-alone basis, the value of n shall be 1.

For non-channelized equipment the exclusion band shall be calculated by using the following formula:
For the lower edge for the exclusion band:
$EXband(lower) = Band_{RX}(lower) - nBW_{RX}$
and for the upper edge of the exclusion band:
$EXband(upper) = Band_{RX}(upper) + nBW_{RX}$

Where n = multiple of whole bandwidths required to define exclusion band.

Bandwidth of Receiver is the occupied bandwidth of the corresponding transmitter signal.
Where the present document is being used in a stand-alone basis, the value of n shall be 1.
EUT receiver part exclusion bands:

Operating frequency (MHz)	Channel width (MHz)	Exclusion Band (MHz)
758 - 803	20	738 - 823
791 - 821	20	771 - 841
925 - 960	20	905 - 980
1805 - 1880	20	1785 - 1900
2110 - 2170	20	2090 - 2190

5 PERFORMANCE CRITERIA

The performance criteria are used to take a decision whether a radio equipment passes or fails immunity tests.

Performance criteria defined in clause 6 of EN 301 489-1 V2.2.3 apply:

		Performance criterion
1	Performance criteria for continuous phenomena	During the test, the equipment shall: • continue to operate as intended; • not unintentionally transmit; • not unintentionally change its operating state; • not unintentionally change critical stored data.
2	Performance criteria for transient phenomena	For all ports and transient phenomena with the exception described below, the following applies: • The application of the transient phenomena shall not result in a change of the mode of operation (e.g. unintended transmission) or the loss of critical stored data. • After application of the transient phenomena, the equipment shall operate as intended. For surges applied to symmetrically operated wired network ports intended to be connected directly to outdoor lines the following criteria applies: • For products with only one symmetrical port intended for connection to outdoor lines, loss of function is allowed, provided the function is self-recoverable, or can be otherwise restored. Information stored in non-volatile memory, or protected by a battery backup, shall not be lost. • For products with more than one symmetrical port intended for connection to outdoor lines, loss of function on the port under test is allowed, provided the function is self-recoverable. Information stored in non-volatile memory, or protected by a battery backup, shall not be lost.

Performance criteria defined in clause 6 of EN 301 489-52 V1.2.1 apply:

		Performance criterion
1	Performance criteria for continuous phenomena	E-UTRA, E-UTRA with LAA, inband or guard band NB-IoT, Standalone NB-IoT: In data transfer mode, the data throughput of the EUT shall not fall below 95 % of the maximum data throughput. Details are specified in annex C. In the case of narrow band responses, the procedure in clause 4.4.2.2 shall be followed. When testing a voice call, the performance criteria in clause 6.1.1 shall apply.
2	Performance criteria for transient phenomena	At the conclusion of each exposure of the transient phenomena, the EUT shall operate without loss of the communication link. At the conclusion of the total test comprising the series of individual exposures, the EUT shall operate as intended without loss of user control functions or critical stored data. In addition where the EUT supports idle mode it should be verified that the transmitter shall not unintentionally operate when transient phenomena are applied.

The results of applicable immunity tests based on these criteria are given in respective chapters.

6 TEST EQUIPMENT USED

Measurement of emissions						
Used eq.	Name	Manufacturer	Type	S/N	Registration no.	Date of calibration validity
☒	EMI test receiver	Rohde & Schwarz	ESR7	1316.30003K07	540-316-022	29.03.2023
☒	LISN type V	PMM Italy	PMM L3-32	122WT50407	540-316-018	24.04.2023
☐	LISN type V	Hameg	HM6050-2	025880024	540-316-026	02.03.2023
☐	BiConiLog Antenna	A.H. Systems	SAS-521F-2	272	540-317-097	24.08.2023
☒	BiConiLog Antenna	ETS Lindgren	3143B	00157570	540-316-017	23.11.2023
☒	Horn Antenna	ETS Lindgren	3119	00157903	540-316-016	16.12.2023
☐	Three-phase network analyzer	Fluke	Fluke 435	DM9631006	130-316-85	17.05.2023
☒	Mains network analyzer	Spitzenberger	B10	G80588	540-316-025	11.11.2023
☒	LISN - 16A	Spitzenberger	Line - 16A	A2793 07/0 0701	540-316-023	11.11.2023
☒	AC/ DC Power source	Spitzenberger	PAS 5000	A2793 01/0 0701	540-316-024	11.11.2023
☒	Antenna mast	ETS Lindgren	2175		---	No cal due
☒	Turntable	ETS Lindgren	2188		---	No cal due
☒	Anechoic chamber	ETS Lindgren	FACT 3		---	No cal due
☒	Atmosphere recorder	Comet System	C4130	13900371	412-316-001	04.04.2024

Measurement of susceptibility						
Used eq.	Name	Manufacturer	Type	S/N	Registration no.	Date of calibration validity
☐	Multifunctional test generator for transients	EM test	UCS500 N5	07430/06	540-323-77	07.07.2023
☐	Compact NX Generator	AMETEK CTS	NX5	1824221146	540-317-091	04.03.2024
☐	ESD Simulator	Schaffner	NSG 432	1450	540-316-019	17.08.2023
☒	Generator - ESD NX 30.1	emtest	ESD NX 30.1	11944	540-317-098	05.03.2026
☐	Compact simulator conducted immunity	EM test	CWS500 N1	P1315117094	540-316-001	08.08.2024
☐	Coupling and Decoupling network	EM test	CDN M1-32A	P1326119725	540-316-002	21.11.2023
☐	Coupling and Decoupling network	EM test	CDN M2/M3	P1343125199	540-316-003	21.11.2023
☐	Coupling and Decoupling network	EM test	CDN M5-32A	P1317117980	540-316-004	21.11.2023
☐	Coupling and Decoupling network	EM test	CDN S4 USB	P1315117419	540-316-005	21.11.2023
☐	Coupling and Decoupling network	EM test	CDN AF3	P1315117307	540-316-006	21.11.2023
☐	Coupling and Decoupling network	EM test	CDN AF5	P1316117719	540-316-007	21.11.2023
☐	Coupling and Decoupling network	EM test	CDN AF8	P1318118482	540-316-008	21.11.2023
☐	Coupling and Decoupling network	EM test	CDN T4 RJ45	P1344125509	540-316-009	21.11.2023
☐	Coupling and Decoupling network	EM test	CDN S19 HDMI	P1529161237	540-316-020	05.08.2023
☐	Coupling and Decoupling network	EM test	CDN T8 RJ45	P1510151693	540-316-021	05.08.2023
☐	Coupling and Decoupling network	Schaffner	CDN 117	17395	540-323-83	No cal. due
☐	Coupling and Decoupling network	AMETEK CTS	CNI 508N2	P1907226998	540-317-090	27.02.2024
☒	RF Amplifier	Prana	MT-200		1312-1464	No cal.due
☒	RF Amplifier	Prana	SV-40DC		1312-1465	No cal.due
☒	RF Amplifier	Prana	UX-30DC		1312-1466	No cal.due
☒	Attenuator 6dB	EM test	ATT 6 / 75	P1306112990	540-316-010	21.11.2023
☒	Adapter - R100N	EM test	R100N	P1324119059	540-316-011	21.11.2023
☒	Field Probe	PMM Italy	EP 601	511WX30645	540-316-014	05.12.2023
☒	Signal Generator	Rohde&Schwarz	SMB100A03	180253	540-316-027	02.05.2023
☒	AC/ DC Power source	Spitzenberger	PAS 5000	A2793 01/0 0701	540-316-024	11.11.2023
☐	Set to measurement of immunity to the magnetic field	TSU Piešťany, š.p.	9.15	201501	540-317-084	No cal.due
☐	BiConiLog Antenna	A.H. Systems	SAS-521F-2	272	540-317-097	24.08.2023
☒	BiConiLog Antenna	ETS Lindgren	3143B	00157570	540-316-017	23.11.2023
☒	Horn Antenna	ETS Lindgren	3119	00157903	540-316-016	16.12.2023
☒	Antenna mast	ETS Lindgren	2175		---	No cal due
☒	Turntable	ETS Lindgren	2188		---	No cal due
☒	Anechoic chamber	ETS Lindgren	FACT 3		---	No cal due
☒	Atmosphere recorder	Comet System	C4130	13900371	412-316-001	04.04.2024

7 EMISSIONS TESTS DESCRIPTION AND RESULTS

Where the test limits and frequency ranges of the tests are equal in radio and non-radio standards, the tests were performed simultaneously. The test limits of measurements of Radiated emissions (enclosure port of ancillary equipment) and Conducted emissions (AC mains power input/output port) were applied according to the standard EN 55032, class B limits as referenced in EN 301 489-1 V2.2.3.

7.1 Radiated emissions (enclosure port of ancillary equipment)

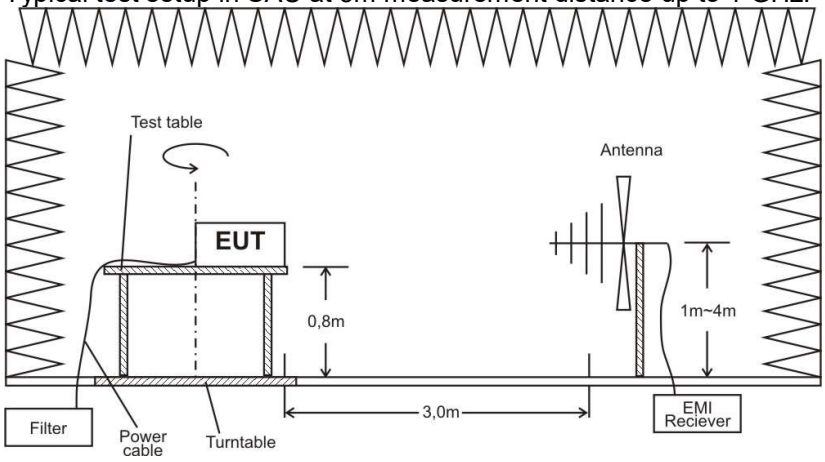
General description:

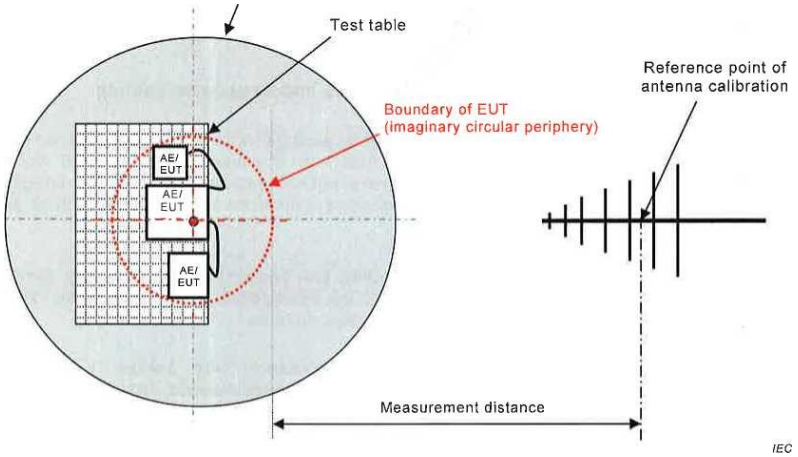
This test is only applicable to ancillary equipment not incorporated in the radio equipment and assessed separately from its associated radio equipment.
This test shall be performed on a representative configuration of the ancillary equipment.

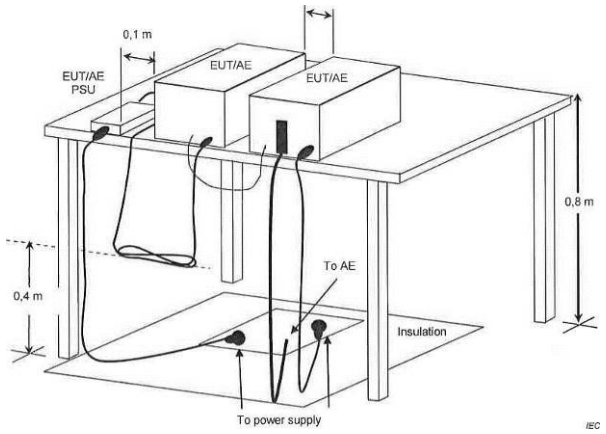
Test method:

The test method shall be in accordance with CENELEC EN 55032.

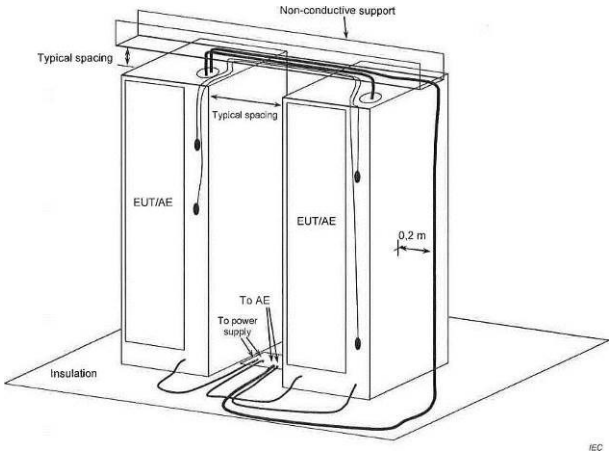
Typical test setup in SAC at 3m measurement distance up to 1 GHz:







Example measurement arrangement for table-top EUT
(radiated emission measurement)



Example measurement arrangement for floor standing EUT
(radiated emission measurement)

A facility validated against the FSOATS requirements shall be used for measurements above 1 GHz. An FSOATS may be a SAC/OATS with RF absorber on the RGP or a FAR.

Note: Abbreviations:
FSOATS - Free Space Open Area Test Site
FAR - Fully Anechoic Room
OATS - Open Area Test Site
SAC - Semi Anechoic Chamber

Limits:
The ancillary equipment shall meet the class B limits given in CENELEC EN 55032.
Alternatively, for ancillary equipment intended to be used exclusively in an industrial environment or telecommunication centers, the class A limits given in CENELEC EN 55032 may be used.

Frequency range MHz	**Measurement**			**Class A limits** dB(µV/m)	**Class B limits** dB(µV/m)
	Facility	**Distance (m)**	**Detector type / bandwidth**		
30 to 230	OATS/SAC	10	Quasi Peak / 120 kHz	40	30
230 to 1 000				47	37
30 to 230	OATS/SAC	3		50	40
230 to 1 000				57	47
30 to 230	FAR	10	Quasi Peak / 120 kHz	42 to 35	32 to 25
230 to 1 000				42	32
30 to 230	FAR	3		52 to 45	42 to 35
230 to 1 000				52	42
1 000 to 3 000	FSOATS	3	Average / 1 MHz	56	50
3 000 to 6 000				60	54
1 000 to 3 000			Peak / 1 MHz	76	70
3 000 to 6 000				80	74

Requirements for radiated emissions according to EN 61000-6-4:2007/A1:2011, as referenced in EN 50121-3-2:2016/A1:2019:

Frequency range MHz	**Measurement**			**Limits** dB(µV/m)
	Facility	**Distance (m)**	**Detector type / bandwidth**	
30 to 230	OATS or SAC	10	Quasi Peak / 120 kHz	40
230 to 1 000				47
30 to 230	OATS or SAC	3		50
230 to 1 000				57
30 to 230	FAR	3	Quasi Peak / 120 kHz	52 to 45
230 to 1 000				52
30 to 230	TEM Waveguide	-	Quasi Peak / 120 kHz	40
230 to 1 000				47
1 000 to 3 000	OATS, SAC or FAR	3	Average / 1 MHz	56
3 000 to 6 000				60
1 000 to 3 000			Peak / 1 MHz	76
3 000 to 6 000				80

Measurement data:
Results of tests of radio disturbance emission – frequency range from 30 MHz to 1000 MHz:

Polarization: **Vertical**

Scan Table

Scan Start	30.000000000 MHz
Scan Stop	1.000000000 GHz
Scan Type	TD Scan
Transducer	Antenna 3143B new cal + cable

Detector Trace 1: Quasi Peak

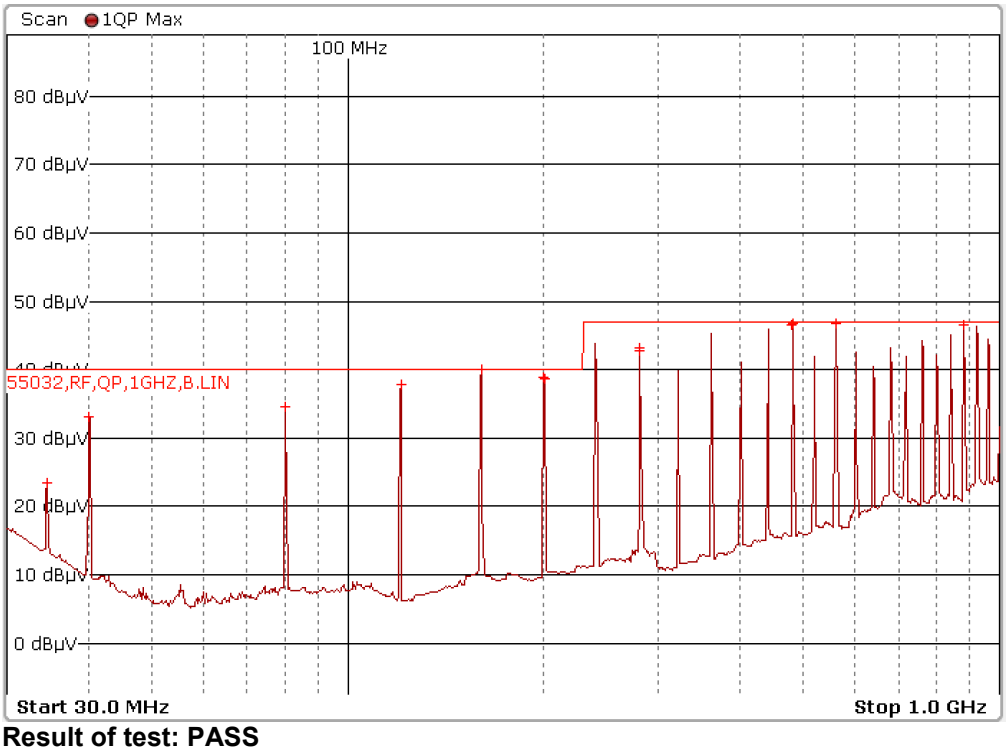
Start Frequency	Stop Frequency	Step Size	RBW	RF Atten	Preamp	Input
30.000 MHz	1.000 GHz	30.000 kHz	120.0 kHz	10.0 dB	30.0 dB	INPUT1

Peak List

Margin	30.0 dB
Peaks	25

Trace	Frequency	Level (dBµV)	Phase	Detector	Delta Limit/dB
1	34.500000000 MHz	23.40		Quasi Peak	-16.60
1	40.140000000 MHz	33.16		Quasi Peak	-6.84
1	80.280000000 MHz	34.60		Quasi Peak	-5.40
1	120.600000000 MHz	37.53		Quasi Peak	-2.47
1	160.740000000 MHz	39.89		Quasi Peak	-0.11
1	200.100000000 MHz	38.18		Quasi Peak	-1.82
1	200.940000000 MHz	38.01		Quasi Peak	-1.99
1	280.140000000 MHz	43.25		Quasi Peak	-3.75
1	280.830000000 MHz	42.74		Quasi Peak	-4.26
1	480.750000000 MHz	46.58		Quasi Peak	-0.42
1	481.770000000 MHz	46.76		Quasi Peak	-0.24
1	560.220000000 MHz	46.83		Quasi Peak	-0.17
1	880.710000000 MHz	46.47		Quasi Peak	-0.53

Scan Diagram



Result of test: PASS

Polarization: **Horizontal**

Scan Table

Scan Start	30.000000000 MHz
Scan Stop	1.000000000 GHz
Scan Type	TD Scan
Transducer	Antenna 3143B new cal + cable

Detector Trace 1: Quasi Peak

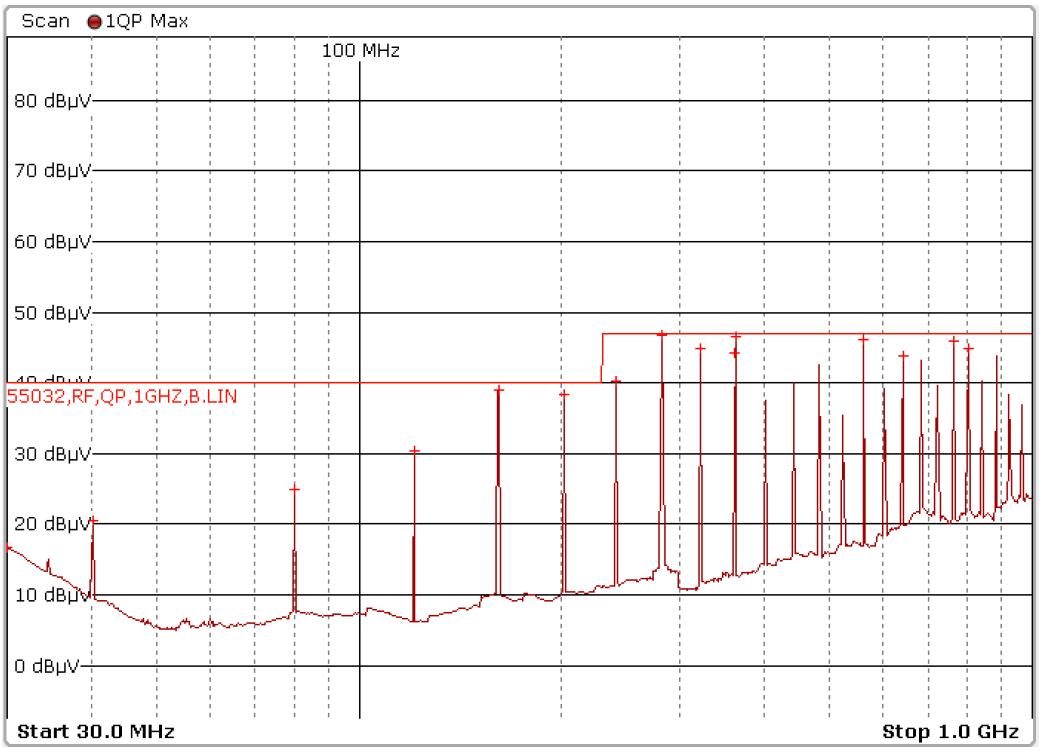
Start Frequency	Stop Frequency	Step Size	RBW	RF Atten	Preamp	Input
30.000 MHz	1.000 GHz	30.000 kHz	120.0 kHz	10.0 dB	30.0 dB	INPUT1

Peak List

Margin	30.0 dB
Peaks	25

Trace	Frequency	Level (dBµV)	Phase	Detector	Delta Limit/dB
1	30.030000000 MHz	16.73		Quasi Peak	-23.27
1	40.200000000 MHz	20.61		Quasi Peak	-19.39
1	80.370000000 MHz	24.82		Quasi Peak	-15.18
1	120.660000000 MHz	30.36		Quasi Peak	-9.64
1	160.980000000 MHz	39.26		Quasi Peak	-0.74
1	201.240000000 MHz	38.39		Quasi Peak	-1.61
1	241.110000000 MHz	40.33		Quasi Peak	-6.67
1	281.640000000 MHz	46.83		Quasi Peak	-0.17
1	321.900000000 MHz	44.96		Quasi Peak	-2.04
1	361.920000000 MHz	44.25		Quasi Peak	-2.75
1	362.250000000 MHz	46.72		Quasi Peak	-0.28
1	562.560000000 MHz	46.55		Quasi Peak	-0.45
1	643.680000000 MHz	43.73		Quasi Peak	-3.27
1	764.340000000 MHz	45.98		Quasi Peak	-1.02
1	804.540000000 MHz	44.81		Quasi Peak	-2.19

Scan Diagram



Result of test: PASS

Results of tests of radio disturbance emission – frequency range from 1 GHz to 6 GHz:

Polarization: **Vertical**

Scan Table

Scan Start	1.000000000 GHz
Scan Stop	6.000000000 GHz
Scan Type	TD Scan
Transducer	Antenna 3119 + cable

Detector Trace 1: Max Peak Trace 2: CISPR AV

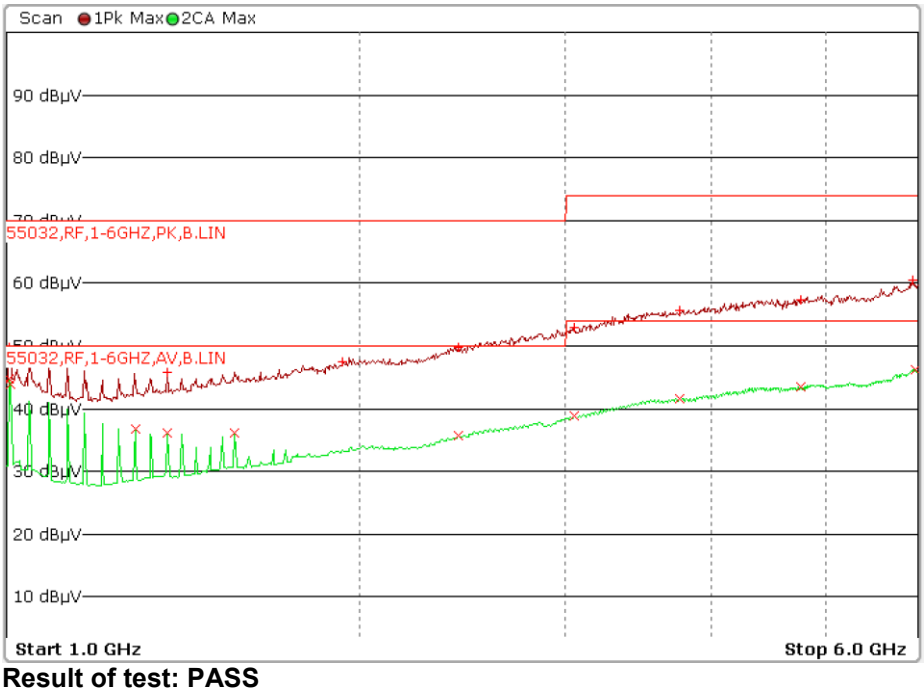
Start Frequency	Stop Frequency	Step Size	RBW	RF Atten	Preamp	Input
1.000 GHz	6.000 GHz	250.000 kHz	1.0 MHz	10.0 dB	30.0 dB	INPUT1

Peak List

Margin	27.0 dB
Peaks	5

Trace	Frequency	Level (dBµV)	Phase	Detector	Delta Limit/dB
1	1.005500000 GHz	49.87		Positive Peak	-20.13
2	1.005500000 GHz	44.76		CISPR AV	-5.24
2	1.008000000 GHz	43.85		CISPR AV	-6.15
2	1.287250000 GHz	36.75		CISPR AV	-13.25
1	1.371000000 GHz	45.71		Positive Peak	-24.29
2	1.371000000 GHz	36.12		CISPR AV	-13.88
2	1.566750000 GHz	36.12		CISPR AV	-13.88
1	1.937750000 GHz	47.55		Positive Peak	-22.45
2	2.430750000 GHz	35.67		CISPR AV	-14.33
1	2.433000000 GHz	49.81		Positive Peak	-20.19
2	3.054500000 GHz	38.80		CISPR AV	-15.20
1	3.055250000 GHz	52.85		Positive Peak	-21.15
1	3.756500000 GHz	55.69		Positive Peak	-18.31
2	3.756750000 GHz	41.66		CISPR AV	-12.34
2	4.770500000 GHz	43.50		CISPR AV	-10.50
1	4.770750000 GHz	57.41		Positive Peak	-16.59
1	5.942750000 GHz	60.42		Positive Peak	-13.58
2	5.966500000 GHz	46.29		CISPR AV	-7.71

Scan Diagram



Result of test: PASS

Polarization: **Horizontal**

Scan Table

Scan Start	1.000000000 GHz
Scan Stop	6.000000000 GHz
Scan Type	TD Scan
Transducer	Antenna 3119 + cable

Detector Trace 1: Max Peak Trace 2: CISPR AV

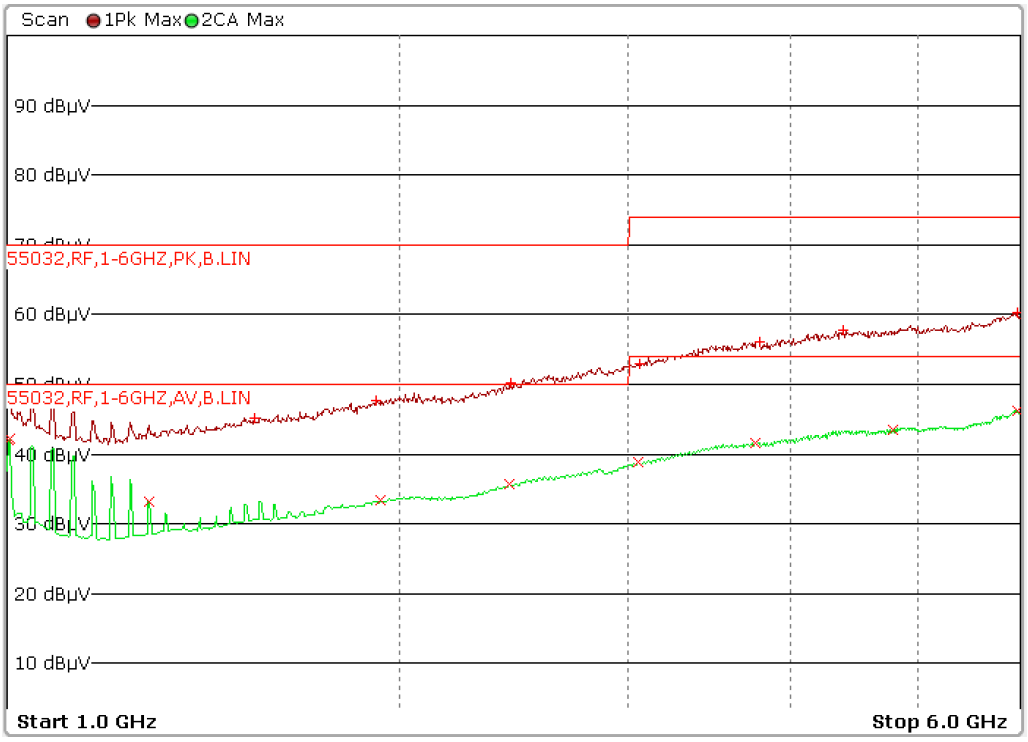
Start Frequency	Stop Frequency	Step Size	RBW	RF Atten	Preamp	Input
1.000 GHz	6.000 GHz	250.000 kHz	1.0 MHz	10.0 dB	30.0 dB	INPUT1

Peak List

Margin	27.0 dB
Peaks	5

Trace	Frequency	Level (dBµV)	Phase	Detector	Delta Limit/dB
1	1.002250000 GHz	48.79		Positive Peak	-21.21
2	1.002250000 GHz	42.11		CISPR AV	-7.89
2	1.005000000 GHz	42.21		CISPR AV	-7.79
2	1.285500000 GHz	33.20		CISPR AV	-16.80
1	1.547750000 GHz	45.23		Positive Peak	-24.77
1	1.918250000 GHz	47.72		Positive Peak	-22.28
2	1.936750000 GHz	33.30		CISPR AV	-16.70
2	2.430750000 GHz	35.66		CISPR AV	-14.34
1	2.435500000 GHz	50.24		Positive Peak	-19.76
2	3.054500000 GHz	38.79		CISPR AV	-15.21
1	3.058500000 GHz	52.84		Positive Peak	-21.16
2	3.756500000 GHz	41.67		CISPR AV	-12.33
1	3.783500000 GHz	56.10		Positive Peak	-17.90
1	4.380750000 GHz	57.80		Positive Peak	-16.20
2	4.796000000 GHz	43.49		CISPR AV	-10.51
2	5.966250000 GHz	46.27		CISPR AV	-7.73
1	5.966500000 GHz	60.25		Positive Peak	-13.75

Scan Diagram



Result of test: PASS

7.2 Conducted emissions (DC power input/output ports)

General description:

This test is applicable for radio equipment and ancillary equipment for fixed use that are intended to be connected to a local DC power network or to local battery with connecting cables longer than 3 m.
If the DC power cable of the radio and/or the ancillary equipment is less than or equal to 3 m in length, and intended for direct connection to a dedicated AC/DC power supply, then the measurement shall be performed on the AC power input port of that power supply. If the DC power cable is longer than 3 m, then the measurement shall additionally be performed on the DC power port of the radio and/or ancillary equipment.
If the DC power cable between the mobile radio and/or ancillary equipment and the dedicated DC/DC power converter is less than or equal to 3 m in length, then the measurement can be limited to the DC power input port of that power converter only. If this DC power cable is longer than 3 m, then the measurement shall additionally be performed on the DC power port of the mobile radio and/or ancillary equipment.
This test shall be performed on a representative configuration of the radio equipment, the associated ancillary equipment, or a representative configuration of the combination of radio and ancillary equipment.
This test assesses the level of internally generated electrical noise present on the DC power input/output ports.

Test method:

For mobile radio and ancillary equipment intended to be connected to the vehicle's onboard DC mains, an Artificial Network (AN) as specified in CISPR 25 shall be used and be connected to a DC power source.
For all other equipment the test method for AC mains power port specified in CENELEC EN 55032 shall be used.
The measurement frequency range extends from 150 kHz to 30 MHz. When the EUT is a transmitter operating at frequencies below 30 MHz, then the exclusion band for transmitters applies for measurements in the transmit mode of operation.
For emission measurements on DC output ports the relevant port shall be connected via an AMN/AN to a load drawing the rated current of the source.

Limits:

The equipment shall meet the limits below including the average limit and the quasi-peak limit when using, respectively, an average detector receiver and a quasi-peak detector receiver and measured in accordance with the method described above. If the average limit is met when using a quasi-peak detector, the equipment shall be deemed to meet both limits and measurement with the average detector is unnecessary.

The equipment shall meet the limits:

Frequency range MHz	**Coupling device**	**Detector type / bandwidth**	**Class A limits** dB(µV)	**Class B limits** dB(µV)
0.15 to 0.50	AMN/AN	Quasi Peak / 9 kHz	79	66 to 56
0.50 to 5			73	56
5 to 30			73	60
0.15 to 0.50	AMN/AN	Average / 9 kHz	66	56 to 46
0.50 to 5			60	46
5 to 30			60	50

Requirements for conducted emissions from the auxiliary AC or DC power ports and battery power supply according to the standard EN 50121-3-2:2016/A1:2019:

	Port	Test specification		Basic Standard	Test set-up	Applicability note	Remarks
1.1	**Auxiliary supply sinusoidal AC or DC** (port 9 on Figures A.1, A.2 and A.4)	150 kHz to 500 kHz 500 kHz to 30 MHz	99 dBµV quasi-peak 93 dBµV quasi-peak	EN 55016–2–1	EN 55016–2–1	See [a] [b] and [c]	For the time being there are no limits for shore supply mode. Therefore the limits given in this table are valid. Other limits may apply if connected e.g. to the public low voltage power supply and should be specified by the train operator.

[a] Wherever applicable the method defined by EN 55016–2–1 is to be used. At present the existing method of measuring conducted emissions (EN 55016–2–1) has limitations in terms of voltage and current rating of coupling networks. In addition the method of measuring voltage has safety implications for testing high power systems. Limiting conducted emissions from apparatus connected to external cable systems will prevent excessive radiated emissions.

[b] This requirement refers to the industrial limit values but considering they have been defined to protect radio and TV services and as the objective is not the same here, the applicable limit for railway applications have been relaxed by 20 dB to be more representative of potential problems.

[c] This requirement is not applicable to power ports which are connected to other dedicated, compatible ports.

	Port	Test specification		Basic standard	Test set-up	Applicability note	Remarks
2.1	**Battery power supply** (port 10 on Figures A.1-A.5)	150 kHz to 500 kHz 500 kHz to 30 MHz	99 dBµV quasi-peak 93 dBµV quasi-peak	EN 55016–2–1	EN 55016–2–1	See [a]	

[a] This requirement refers to the industrial limit values but considering they have been defined to protect radio and TV services and as the objective is not the same here, the applicable limit for railway applications have been relaxed by 20 dB to be more representative of potential problems.

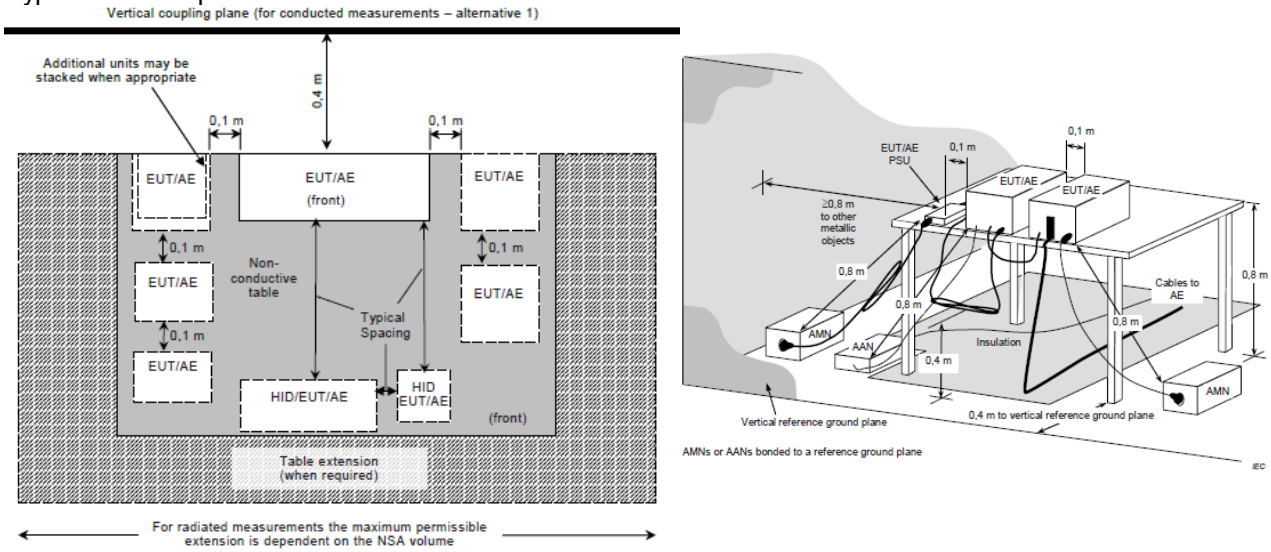
Measurement data:
Test not applicable to the EUT.

7.3 Conducted emissions (AC mains power ports)

General description:
This test is applicable for radio equipment and/or ancillary equipment for fixed use powered by the AC mains.
This test shall be performed on a representative configuration of the radio equipment, the associated ancillary equipment, or a representative configuration of the combination of radio and ancillary equipment.
This test assesses the level of internally generated electrical noise present on the AC power input/output ports.

Test method:
The test method shall be in accordance with CENELEC EN 55032 and the Artificial Mains Networks (AMNs) shall be connected to the AC mains power source.
The measurement frequency range extends from 150 kHz to 30 MHz. When the EUT is a transmitter operating at frequencies below 30 MHz, then the exclusion band for transmitters applies for measurements in the transmit mode of operation.
For emission measurements on AC output ports of the EUT the relevant port shall be connected via an AMN to a load drawing the rated current of the source. In case where the AC output port is directly connected (or via a circuit breaker) to the AC power input port of the EUT the AC power output port need not to be tested.

Typical test setup



Limits:
The equipment shall meet the limits below including the average limit and the quasi-peak limit when using, respectively, an average detector receiver and a quasi-peak detector receiver and measured in accordance with the method described above. If the average limit is met when using a quasi-peak detector, the equipment shall be deemed to meet both limits and measurement with the average detector is unnecessary.

The equipment shall meet the class B limits given in CENELEC EN 55032.
Alternatively, for ancillary equipment intended to be used exclusively in an industrial environment or telecommunication centers, the class A limits given in CENELEC EN 55032 may be used.

Frequency range MHz	**Coupling device**	**Detector type / bandwidth**	**Class A limits** dB(µV)	**Class B limits** dB(µV)
0.15 to 0.50	AMN	Quasi Peak / 9 kHz	79	66 to 56
0.50 to 5			73	56
5 to 30			73	60
0.15 to 0.50	AMN	Average / 9 kHz	66	56 to 46
0.50 to 5			60	46
5 to 30			60	50

Requirements for conducted emissions from the auxiliary AC or DC power ports according to the standard EN 50121-3-2:2016/A1:2019:

	Port	Test specification		Basic Standard	Test set-up	Applicability note	Remarks
1.1	**Auxiliary supply sinusoidal AC or DC** (port 9 on Figures A.1, A.2 and A.4)	150 kHz to 500 kHz 500 kHz to 30 MHz	99 dBµV quasi-peak 93 dBµV quasi-peak	EN 55016–2–1	EN 55016–2–1	See [a] [b] and [c]	For the time being there are no limits for shore supply mode. Therefore the limits given in this table are valid. Other limits may apply if connected e.g. to the public low voltage power supply and should be specified by the train operator.

[a] Wherever applicable the method defined by EN 55016–2–1 is to be used. At present the existing method of measuring conducted emissions (EN 55016–2–1) has limitations in terms of voltage and current rating of coupling networks. In addition the method of measuring voltage has safety implications for testing high power systems. Limiting conducted emissions from apparatus connected to external cable systems will prevent excessive radiated emissions.

[b] This requirement refers to the industrial limit values but considering they have been defined to protect radio and TV services and as the objective is not the same here, the applicable limit for railway applications have been relaxed by 20 dB to be more representative of potential problems.

[c] This requirement is not applicable to power ports which are connected to other dedicated, compatible ports.

Results of conducted emission measured on mains terminals:

Phase **L1**

Scan Table

Scan Start	150.000000000 kHz
Scan Stop	30.000000000 MHz
Scan Type	TD Scan
Transducer	PMM L3-32 L1(16).TDF

Detector Trace 1: Quasi Peak Trace 2: CISPR AV

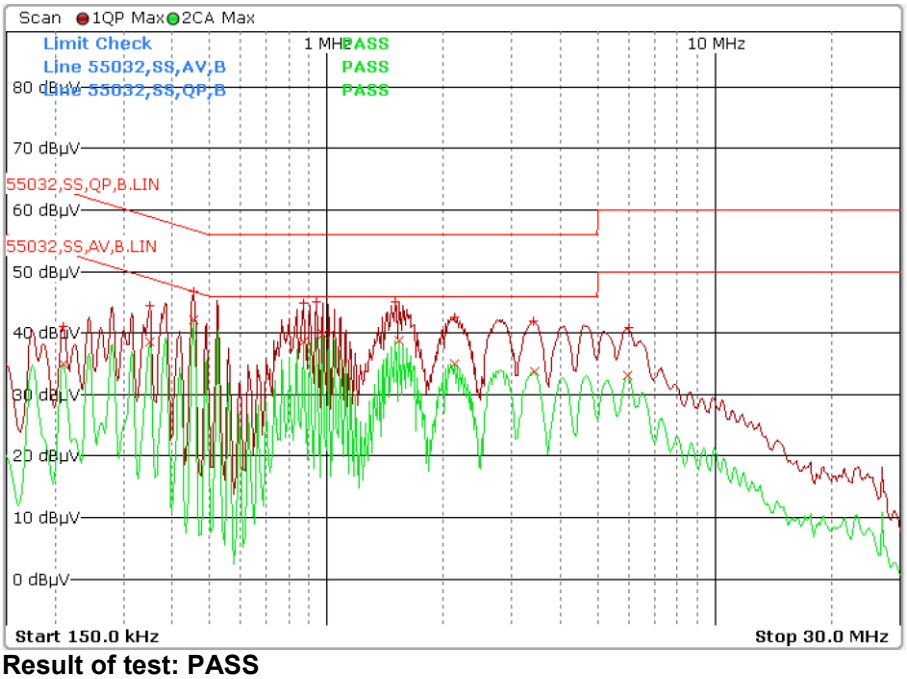
Start Frequency	Stop Frequency	Step Size	RBW	RF Atten	Preamp	Input
150.000 kHz	30.000 MHz	2.250 kHz	9.0 kHz	10.0 dB	0.0 dB	INPUT1

Peak List

Margin	25.0 dB
Peaks	25

Trace	Frequency	Level (dBµV)	Phase	Detector	Delta Limit/dB
1	210.750000000 kHz	41.07		Quasi Peak	-22.11
2	210.750000000 kHz	34.98		CISPR AV	-18.20
1	350.250000000 kHz	44.51		Quasi Peak	-14.45
2	350.250000000 kHz	38.58		CISPR AV	-10.38
1	453.750000000 kHz	46.86		Quasi Peak	-9.95
2	453.750000000 kHz	42.20		CISPR AV	-4.61
1	874.500000000 kHz	44.83		Quasi Peak	-11.17
2	874.500000000 kHz	38.65		CISPR AV	-7.35
1	942.000000000 kHz	45.18		Quasi Peak	-10.82
2	978.000000000 kHz	39.81		CISPR AV	-6.19
1	1.500000000 MHz	45.03		Quasi Peak	-10.97
2	1.538250000 MHz	38.76		CISPR AV	-7.24
1	2.132250000 MHz	42.48		Quasi Peak	-13.52
2	2.132250000 MHz	35.08		CISPR AV	-10.92
1	3.401250000 MHz	41.94		Quasi Peak	-14.06
2	3.426000000 MHz	33.81		CISPR AV	-12.19
2	5.957250000 MHz	33.15		CISPR AV	-16.85
1	5.995500000 MHz	40.90		Quasi Peak	-19.10

Scan Diagram



Result of test: PASS

Neutral **N**

Scan Table

Scan Start	150.000000000 kHz
Scan Stop	30.000000000 MHz
Scan Type	TD Scan
Transducer	PMM L3-32 N(16).TDF

Detector Trace 1: Quasi Peak Trace 2: CISPR AV

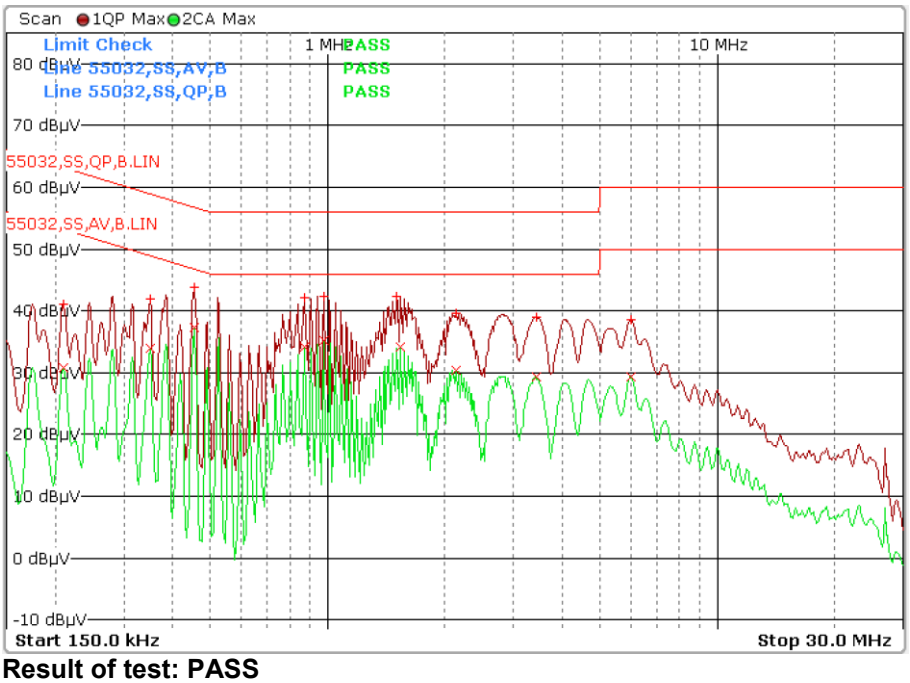
Start Frequency	Stop Frequency	Step Size	RBW	RF Atten	Preamp	Input
150.000 kHz	30.000 MHz	2.250 kHz	9.0 kHz	10.0 dB	0.0 dB	INPUT1

Peak List

Margin	25.0 dB
Peaks	25

Trace	Frequency	Level (dBµV)	Phase	Detector	Delta Limit/dB
1	210.750000000 kHz	41.03		Quasi Peak	-22.15
2	210.750000000 kHz	30.80		CISPR AV	-22.38
1	350.250000000 kHz	41.93		Quasi Peak	-17.03
2	350.250000000 kHz	33.92		CISPR AV	-15.04
1	453.750000000 kHz	43.77		Quasi Peak	-13.04
2	453.750000000 kHz	37.25		CISPR AV	-9.56
1	874.500000000 kHz	42.05		Quasi Peak	-13.95
2	874.500000000 kHz	34.11		CISPR AV	-11.89
1	978.000000000 kHz	42.37		Quasi Peak	-13.63
2	978.000000000 kHz	35.23		CISPR AV	-10.77
1	1.500000000 MHz	42.31		Quasi Peak	-13.69
2	1.538250000 MHz	34.07		CISPR AV	-11.93
1	2.132250000 MHz	39.61		Quasi Peak	-16.39
2	2.132250000 MHz	30.43		CISPR AV	-15.57
2	3.426000000 MHz	29.34		CISPR AV	-16.66
1	3.437250000 MHz	38.91		Quasi Peak	-17.09
2	5.993250000 MHz	29.29		CISPR AV	-20.71
1	6.031500000 MHz	38.59		Quasi Peak	-21.41

Scan Diagram



Result of test: PASS

7.4 Harmonic current emissions (AC mains input port)

General description:

For equipment with an input current up to and including 16A per phase, the classification from CENELEC EN 61000-3-2 shall apply together with the limits from CENELEC EN 61000-3-2, and the evaluation requirements of CENELEC EN 61000-3-2.
For equipment with an input current of greater than 16A per phase the limits from CENELEC EN 61000-3-12 shall apply together with the evaluation requirements of CENELEC EN 61000-3-12.

Test method:

The test procedure as described in CENELEC EN 61000-3-2 or EN 61000-3-12 if applicable shall be used.

Limits:

For the purpose of harmonic current limitation, the equipment is classified according EN 61000-3-2 as follows:

Class A:
– balanced three-phase equipment; household appliances, excluding equipment identified as Class D; tools, excluding portable tools; dimmers for incandescent lamps; audio equipment.

Equipment not specified in one of the three other classes shall be considered as Class A equipment.

Class B:
– portable tools; arc welding equipment which is not professional equipment.

Class C:
– lighting equipment.

Class D:
Equipment having a specified power less than or equal to 600 W, of the following types:
– personal computers and personal computer monitors;

Limits defined in chapter 7 of EN 61000-3-2 or, for the EUT of input current over 16 A per phase limits in chapter 5 of EN 61000-3-12, applies

Limits for Class A equipment	
Harmonics Order no.	Max. permissible harmonics current (A)
Odd harmonics	
3	2,30
5	1,14
7	0,77
9	0,4
11	0,33
13	0,21
15<=n<=39	0,15x15/n
Even harmonics	
2	1,08
4	0,43
6	0,30
8<=n<=40	0,23x8/n

Measurement data:

Test not applicable to the EUT.

7.5 Voltage fluctuations and flicker (AC mains input port)

General description:
For equipment with an input current up to and including 16A per phase, if no conditional connection is needed, the limits from CENELEC EN 61000-3-3 shall apply together with the evaluation requirements of CENELEC EN 61000-3-3.
For equipment with an input current up to and including 16A per phase, where a conditional connection is required, and for equipment with an input current of greater than 16A up to and including 75A per phase, the limits from CENELEC EN 61000-3-11 shall apply together with the evaluation requirements of CENELEC EN 61000-3-11.

Test method:
All types of voltage fluctuations may be assessed by direct measurement using a flickermeter which complies with the specification given in IEC 61000-4-15:2010. This is the reference method for application of the limits.

Tests to prove the compliance of the equipment with the limits shall be made using the test conditions defined in chapter 6 of EN 61000-3-3 and EN 61000-3-11 if applicable.

Limits:
Limits defined in chapter 5 of EN 61000-3-3 or, for the EUT of input current over 16 A per phase or/and where conditional connection is needed limits defined in chapter 5 of EN 61000-3-12, applies.

Measurement data:

Spitzenberger & Spies GmbH & Co. KG
Viechtach

Name:		Serial no:	
Department:	317	Operating modes:	normal
Company:	TSU	Comment1:	--
Test report no:	1	Comment2:	--
Device:		Comment3:	--
Specimen:		Comment4:	--
Manufacturer:		Date:	25.11.2022
Type:		Test date:	25.11.2022

Test conditions: EN 61000-3-3:2013 / 230 V / 50 Hz / Phase L1
EN 61000-4-15:2011 / Obs 12 x 1 min / Ztest (0.400+j0.250) Ohm
Ra+jXa (0.2400+j0.1500) Ohm / Rn+jXn (0.1600+j0.1000) Ohm

FLICKER: Test PASS!

Time	Pmax	Pst	Sliding Plt	Tmax [s]	dmax [%]	dc [%]	PASS	FAIL
14:10:05	0.000	0.0030	-.----	0.000	+0.000	-.---	X	
14:11:05	0.000	0.0030	-.----	0.000	+0.000	-.---	X	
14:12:05	0.000	0.0030	-.----	0.000	+0.000	-.---	X	
14:13:05	0.000	0.0020	-.----	0.000	+0.000	-.---	X	
14:14:05	0.000	0.0020	-.----	0.000	+0.000	-.---	X	
14:15:05	0.000	0.0020	0.0026	0.000	+0.000	-.---	X	
14:16:05	0.000	0.0020	0.0024	0.000	+0.000	-.---	X	
14:17:05	0.000	0.0020	0.0022	0.000	+0.000	-.---	X	
14:18:05	0.000	0.0020	0.0020	0.000	+0.000	-.---	X	
14:19:05	0.000	0.0030	0.0022	0.000	+0.000	-.---	X	
14:20:05	0.000	0.0020	0.0022	0.000	+0.000	-.---	X	
14:21:05	0.000	0.0020	0.0022	0.000	+0.000	-.---	X	
Limits:		1.000	0.650	0.500	4.000	3.300		
Plt: 0.002429 (calculated over 12 periods)							X	
Evaluated: PST, PLT, Sliding PLT, dc, dmax, Tmax								

FLICKER: Source test PASS!

Time	Pmax	Pst	Sliding Plt	Tmax [s]	dmax [%]	dc [%]	PASS	FAIL
14:10:05	0.000	0.0020	-.----	0.000	+0.000	-.---	X	
14:11:05	0.000	0.0010	-.----	0.000	+0.000	-.---	X	
14:12:05	0.000	0.0020	-.----	0.000	+0.000	-.---	X	
14:13:05	0.000	0.0010	-.----	0.000	+0.000	-.---	X	
14:14:05	0.000	0.0010	-.----	0.000	+0.000	-.---	X	
14:15:05	0.000	0.0020	-.----	0.000	+0.000	-.---	X	
14:16:05	0.000	0.0020	-.----	0.000	+0.000	-.---	X	
14:17:05	0.000	0.0020	-.----	0.000	+0.000	-.---	X	
14:18:05	0.000	0.0020	-.----	0.000	+0.000	-.---	X	
14:19:05	0.000	0.0020	-.----	0.000	+0.000	-.---	X	
14:20:05	0.000	0.0020	-.----	0.000	+0.000	-.---	X	
14:21:05	0.000	0.0020	-.----	0.000	+0.000	-.---	X	
Plt: 0.001842 (calculated over 12 periods)								
Evaluated: PST <= 0.4 dmax < 20 % dmax1								

Result of test: PASS

7.6 Conducted emissions (wired network ports)

General description:

This test is applicable for radio equipment and/or ancillary equipment for fixed use which have wired network ports.
This test shall be performed on a representative configuration of the radio equipment, the associated ancillary equipment, or a representative configuration of the combination of radio and ancillary equipment.

This test assesses the level of unwanted emissions present at the wired network ports.

Test method:

The test method shall be in accordance with CENELEC EN 55032.

The measurement frequency range extends from 150 kHz to 30 MHz. When the EUT is a transmitter operating at frequencies below 30 MHz, then the exclusion band for transmitters applies for measurements in the transmit mode of operation.

Limits:

The wired network ports shall meet the class B limits given in CENELEC EN 55032.

Alternatively, for equipment intended to be used exclusively in an industrial environment or telecommunication centres, the class A limits given in CENELEC EN 55032 may be used.

Frequency range MHz	**Coupling device**	**Detector type / bandwidth**	**Class A limits** dB(µV)	**Class B limits** dB(µV)
0.15 to 0.50	AAN	Quasi Peak / 9 kHz	97 to 87	84 to 74
0.50 to 30			87	74
0.15 to 0.50	AAN	Average / 9 kHz	84 to 74	74 to 64
0.50 to 30			74	64

.

Measurement data:

Test not applicable to the EUT.

8 IMMUNITY TESTS DESCRIPTION AND RESULTS

Where the test levels and frequency ranges of the tests are equal in radio and non-radio standards, the tests were performed simultaneously. The test levels of measurement of Radio frequency electromagnetic field (80 MHz to 6 000 MHz) were applied according to the combination of standards EN 50121-3-2:2016/A1:2019 and EN 301 489-1 V2.2.3. The test levels of measurement of Electrostatic discharge were applied according to the standard EN 50121-3-2:2016/A1:2019.

8.1 Radio frequency electromagnetic field (80 MHz to 6 000 MHz)

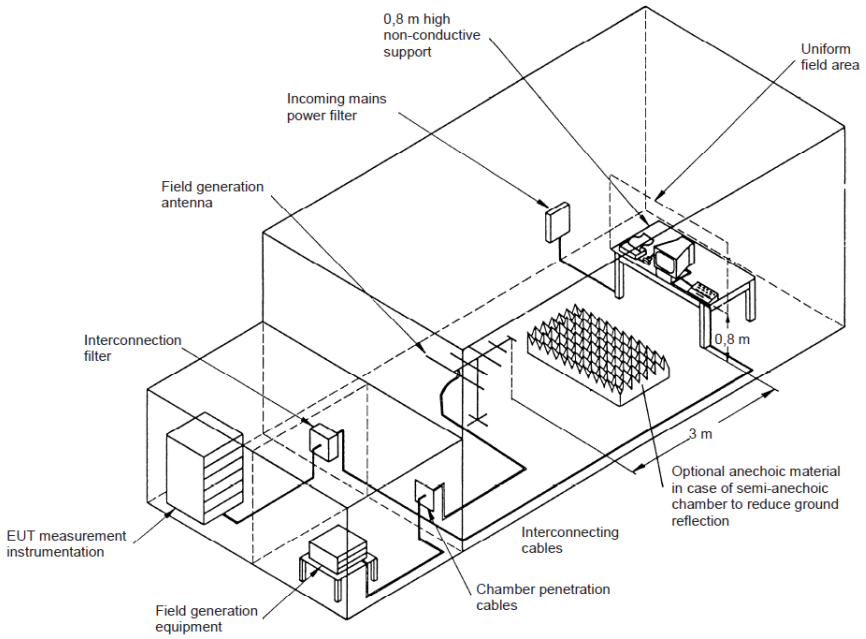
General description:

This test is applicable for radio equipment and associated ancillary equipment.
This test shall be performed on a representative configuration of the radio equipment, the associated ancillary equipment, or a representative configuration of the combination of radio and ancillary equipment.
This test assesses the ability of the EUT to operate as intended in the presence of a radio frequency electromagnetic field disturbance.

Test method:

The test method shall be in accordance with CENELEC EN 61000-4-3.
The following requirements and evaluation of test results shall apply:

- the test level shall be 3 V/m (measured unmodulated). The test signal shall be amplitude modulated to a depth of 80 % by a sinusoidal audio signal of 1 000 Hz. If the wanted signal is modulated at 1 000 Hz, then an audio signal of 400 Hz shall be used;
- the test shall be performed over the frequency range 80 MHz to 6000 MHz with the exception of the exclusion band for transmitters, receivers and duplex transceivers (see chapter 4.7), as appropriate;
- for receivers and transmitters the stepped frequency increments shall be 1 % frequency increment of the momentary used frequency, unless specified otherwise in the relevant part of ETSI EN 301 489 series;
- the dwell time of the test phenomena at each frequency shall not be less than the time necessary for the EUT to be exercised and to be able to respond.
- further product related spot frequency tests may be specified in the relevant part of ETSI EN 301 489 series;
- responses on receivers occurring at discrete frequencies, which are narrow band responses, shall be disregarded from the test;
- the frequencies selected and used during the test shall be recorded in the test report.



Example of suitable test facility

Requirements according to the standard EN 50121-3-2:2016/A1:2019:

	Environmental phenomena	Test specification		Basic Standard	Test set-up	Applicability note	Remarks	Performance criteria
5.1	**Radio-frequency electromagnetic field. Amplitude modulated**	80 MHz to 800 MHz 20 V/m (rms) 80 % AM, 1 kHz	Unmodulated carrier	EN 61000–4–3	EN 61000–4–3	See [a] [b]	The test level specified is the rms value of the unmodulated carrier	**A**
5.2	**Radio-frequency electromagnetic field**	800 MHz to 1 000 MHz 20 V/m (rms) 80 % AM, 1 kHz	Unmodulated carrier	EN 61000–4–3	EN 61000–4–3	See [b]	The test level specified is the rms value of the unmodulated carrier. These tests are intended to simulate disturbances from digital communication devices	**A**
		1 400 MHz to 2 000 MHz 10 V/m (rms) 80 % AM, 1 kHz	Unmodulated carrier					
		2 000 MHz to 2 700 MHz 5 V/m (rms) 80 % AM, 1 kHz	Unmodulated carrier					
		5 100 MHz to 6 000 MHz 3 V/m (rms) 80 % AM, 1 kHz	Unmodulated carrier					

[a] This limit applies to equipment mounted in the passenger compartments, drivers cab or external to the rolling stock (roof, underframe). For equipment mounted in all other areas a severity level of 10 V/m may be used

[b] For large apparatus (e.g. traction drives, auxiliary converters) it is often not practical to perform the immunity test to radiated electromagnetic fields on the complete unit. In such cases the manufacturer should test susceptible sub-systems (e.g. control electronics). The test report should justify the selection or not of sub-systems and any assumptions made (e.g. reduction of field due to case shielding).

[c] Only applicable to equipment accessible to passengers and operational staff (not maintenance).

Performance criteria:

The performance criteria for continuous phenomena shall apply.

Measurement data:

Test specifications:

Test location	Semi anechoic chamber with floor absorbers
Frequency range (MHz)	80 to 6000
Test signal level (V/m)	According to the table above, and 3 V/m for all other frequency bands in the test range
Exclusion Bands (MHz)	(see chap. 4)
Frequency step	1%
Dwell time	1 s
Performance criterion	A

Test results:

Modulation: AM 80%, 1kHz sine wave, Dwell time: 1000ms Frequency step size: 1% of preceding frequency value Test location: Anechoic chamber, Distance of antenna – EUT: 1,0 - 3,0m				
Frequency (MHz)	Antenna polarization	Field strength	Required criteria	Test result
80 ÷ 800 (*)	Vertical	20 V/m	A	PASS
80 ÷ 800 (*)	Horizontal	20 V/m	A	PASS
800 ÷ 1000 (*)	Vertical	20 V/m	A	PASS
800 ÷ 1000 (*)	Horizontal	20 V/m	A	PASS
1000 ÷ 1400	Vertical	3 V/m	A	PASS
1000 ÷ 1400	Horizontal	3 V/m	A	PASS
1400 ÷ 2000 (*)	Vertical	10 V/m	A	PASS
1400 ÷ 2000 (*)	Horizontal	10 V/m	A	PASS
2000 ÷ 2700 (*)	Vertical	5 V/m	A	PASS
2000 ÷ 2700 (*)	Horizontal	5 V/m	A	PASS
2700 ÷ 6000	Vertical	3 V/m	A	PASS
2700 ÷ 6000	Horizontal	3 V/m	A	PASS
5100 ÷ 6000	Vertical	3 V/m	A	PASS
5100 ÷ 6000	Horizontal	3 V/m	A	PASS

Remarks: No failure according to the performance criteria in the used standard was observed during or after the test.

Note (*): The exclusion bands are applicable in this frequency range.

Result of test: PASS.

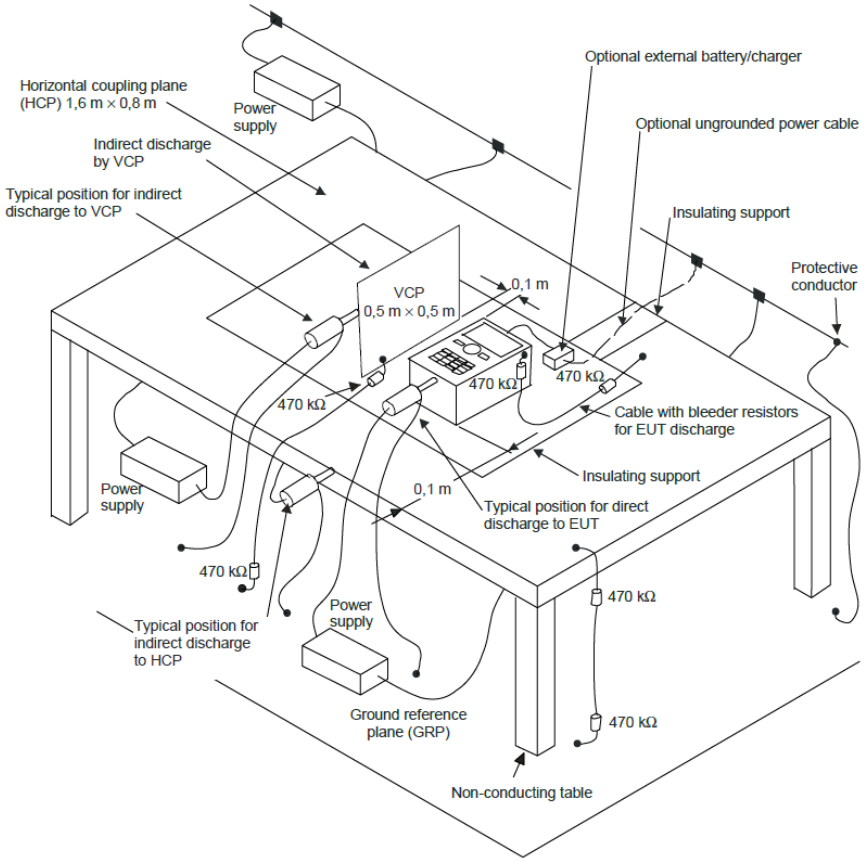
8.2 Electrostatic discharge

General description:

This test is applicable for radio equipment and associated ancillary equipment.
This test shall be performed on a representative configuration of the radio equipment, the associated ancillary equipment, or a representative configuration of the combination of radio and ancillary equipment.
This test assesses the ability of the EUT to operate as intended in the event of an electrostatic discharge.

Test method:

The test method shall be in accordance with CENELEC EN 61000-6-2 .
For radio equipment and ancillary equipment the following requirements and evaluation of test results shall apply.
The test severity level for contact discharge shall be ±4 kV and for air discharge ±8 kV. All other details, including intermediate test levels, are contained within CENELEC EN 61000-4-2 .
Electrostatic discharges shall be applied to all exposed surfaces of the EUT except where the user documentation specifically indicates a requirement for appropriate protective measures.



Example of test set-up for table-top equipment, laboratory tests:

Requirements according to the standard EN 50121-3-2:2016/A1:2019:

	Environmental phenomena	Test specification		Basic Standard	Test set-up	Applicability note	Remarks	Performance criteria
5.3	**Electrostatic discharge**	±6 kV ±8 kV	Contact discharge Air discharge	EN 61000–4–2	EN 61000–4–2	See [c]		**B**

[a] This limit applies to equipment mounted in the passenger compartments, drivers cab or external to the rolling stock (roof, underframe). For equipment mounted in all other areas a severity level of 10 V/m may be used

[b] For large apparatus (e.g. traction drives, auxiliary converters) it is often not practical to perform the immunity test to radiated electromagnetic fields on the complete unit. In such cases the manufacturer should test susceptible sub-systems (e.g. control electronics). The test report should justify the selection or not of sub-systems and any assumptions made (e.g. reduction of field due to case shielding).

[c] Only applicable to equipment accessible to passengers and operational staff (not maintenance).

Performance criteria:

The performance criteria for transient phenomena shall apply.

Measurement data:

The EUT was tested as a table-top device.

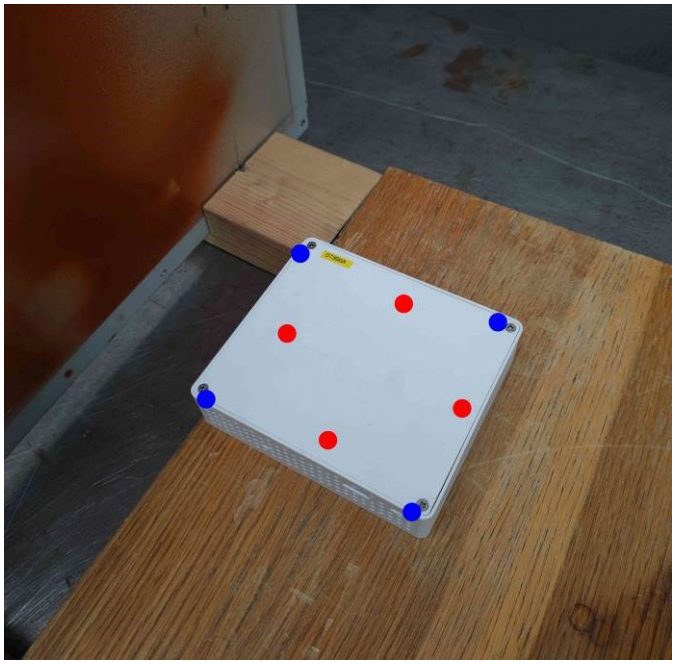
Test specifications and results:

Discharge type	Discharge level (kV)	Discharge location	Number of discharges per location (each polarity)	Performance criterion	Test result
Direct air discharge	±8	Non metallic parts	26*10	B	PASS
Direct contact discharge	±6	Metallic parts	4*10	B	PASS
Indirect contact discharge	±6	HCP - Front	10	B	PASS
Indirect contact discharge	±6	HCP - Left	10	B	PASS
Indirect contact discharge	±6	HCP - Right	10	B	PASS
Indirect contact discharge	±6	HCP - Rear	10	B	PASS
Indirect contact discharge	±6	VCP - Front	10	B	PASS
Indirect contact discharge	±6	VCP - Left	10	B	PASS
Indirect contact discharge	±6	VCP - Right	10	B	PASS
Indirect contact discharge	±6	VCP - Rear	10	B	PASS

Note: The EUT was without exposed conductive surfaces.
HCP - Horizontal coupling plane
VCP – Vertical coupling plane

Points of ESD Test:

Air discharge
Contact discharge



Result of test: PASS

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8.3 Fast transient common mode

General description:

This test shall be performed on the AC mains power port (if any) of radio equipment and associated ancillary equipment.
This test shall be additionally performed on signal ports, wired network ports, control ports, and DC power ports, of radio equipment and associated ancillary equipment, if the cables may be longer than 3 m.
Where this test is not carried out on any port because the manufacturer declares that it is not intended to be used with cables longer than 3 m, a list of ports, which were not tested for this reason, shall be included in the test report.
This test shall be performed on a representative configuration of the radio equipment or a representative configuration of the combination of radio and ancillary equipment.
This test assesses the ability of the EUT to operate as intended in the event of fast transients present on one of the input/output ports.

Test method:

The test method shall be in accordance with CENELEC EN 61000-4-4.
The following requirements and evaluation of test results shall apply:

- the test level for signal ports, wired network ports (excluding xDSL), and control ports shall be 0,5 kV open circuit voltage at a repetition rate of 5 kHz as given in CENELEC EN 61000-4-4;
- the test level for xDSL wired network ports shall be 0,5 kV open circuit voltage at a repetition rate of 100 kHz as given in CENELEC EN 61000-4-4;
- the test level for DC power input ports shall be 0,5 kV open circuit voltage at a repetition rate of 5 kHz as given CENELEC EN 61000-4-4;
- the test level for AC mains power input ports shall be 1 kV open circuit voltage at a repetition rate of 5 kHz as given CENELEC EN 61000-4-4

Requirements according to the standard EN 50121-3-2:2016/A1:2019:

Table 3 — Immunity - Battery referenced ports (except at the output of energy sources), auxiliary AC power input ports (rated voltage ≤ 400 V_{rms})

3.2	**Fast transients**	±2 kV 5/50 ns 5 kHz	Peak T_r / T_h Repetition frequency	EN 61000–4–4	EN 61000–4–4	see [b]	Direct coupling	**A**

[a] The test level can also be defined as the equivalent current into a 150 Ω load.
[b] The test applies to the power supply ports and the battery control input output ports, with direct coupling, positive and negative polarity.
[c] The test applies to the power supply ports and the battery control input output ports. This test is intended to replicate the phenomenon known as direct coupling; hence an output impedance of 42 Ω (40 Ω and 2 Ω generator) and a coupling capacitance of 0,5 µF is specified. This value is accepted as a compromise as the impedance of battery referenced network inside a rolling stock can vary up to a few hundred ohms depending on their length.

Table 4 — Immunity - Signal and communication, process measurement and control ports

4.2	**Fast transients**	±2 kV 5/50 ns 5 kHz	Peak T_r / T_h Repetition frequency	EN 61000–4–4	EN 61000–4–4	See [a b]	Capacitive clamp used	**A**

[a] Capacitive coupling, positive and negative polarity. Battery referenced control ports are covered by requirements in Table 3.
[b] Applicable only to ports interfacing with cables whose total length according to the manufacturer's functional specification may exceed 3m.
[c] The test level can also be defined as the equivalent current into a 150 Ω load.

Performance criteria*:*

The performance criteria for transient phenomena shall apply.

Measurement data:

Test not applicable to the EUT.

8.4 Radio frequency common mode

General description:

This test shall be performed on the AC mains power port (if any) of radio equipment and associated ancillary equipment.
This test shall be additionally performed on signal ports, wired network ports, control ports, and DC power ports, of radio equipment and associated ancillary equipment, if the cables may be longer than 3 m.
Where this test is not carried out on any port because the manufacturer declares that it is not intended to be used with cables longer than 3 m, a list of ports, which were not tested for this reason, shall be included in the test report.
This test shall be performed on a representative configuration of the radio equipment, the associated ancillary equipment, or a representative configuration of the combination of radio and ancillary equipment.
This test assesses the ability of the EUT to operate as intended in the presence of a radio frequency disturbance on the input/output ports.

Test method:

The test method shall be in accordance with CENELEC EN 61000-4-6.
The following requirements and evaluation of test results shall apply:

- the test level shall be severity level 2 as given in CENELEC EN 61000-4-6 corresponding to 3 V rms unmodulated. The test signal shall then be amplitude modulated to a depth of 80 % by a sinusoidal audio signal of 1 000 Hz. If the wanted signal is modulated at 1 000 Hz, then the test signal of 400 Hz shall be used;
- the test shall be performed over the frequency range 150 kHz to 80 MHz with the exception of an exclusion band for transmitters, and for receivers and duplex transceivers;
- for receivers and transmitters the stepped frequency increments shall be 1 % frequency increment of the momentary frequency in the frequency range 150 kHz to 80 MHz;
- the injection method to be used shall be selected according to the basic standard CENELEC EN 61000-4-6;
- responses on receivers or receiver parts of transceivers occurring at discrete frequencies which are narrow band responses (spurious responses), are disregarded from the test;
  the dwell time of the test phenomena at each frequency shall not be less than the time necessary for the EUT to be exercised and to be able to respond;
- the frequencies of the immunity test signal selected and used during the test shall be recorded.

Requirements according to the standard EN 50121-3-2:2016/A1:2019:

Table 3 — Immunity - Battery referenced ports (except at the output of energy sources), auxiliary AC power input ports (rated voltage ≤ 400 V_{rms})

	Environmental phenomena	Test specification		Basic Standard	Test set-up	Applicability note	Remarks	Performance criteria
3.1	Radio-frequency common mode	0,15 MHz to 80 MHz 10 V (rms) 80 % AM, 1 kHz	Unmodulated carrier	EN 61000–4–6	EN 61000–4–6	See [a]	The test level specified is the rms value of the unmodulated carrier	A

[a] The test level can also be defined as the equivalent current into a 150 Ω load.
[b] The test applies to the power supply ports and the battery control input output ports, with direct coupling, positive and negative polarity.
[c] The test applies to the power supply ports and the battery control input output ports. This test is intended to replicate the phenomenon known as direct coupling; hence an output impedance of 42 Ω (40 Ω and 2 Ω generator) and a coupling capacitance of 0,5 µF is specified. This value is accepted as a compromise as the impedance of battery referenced network inside a rolling stock can vary up to a few hundred ohms depending on their length.

Table 4 — Immunity - Signal and communication, process measurement and control ports

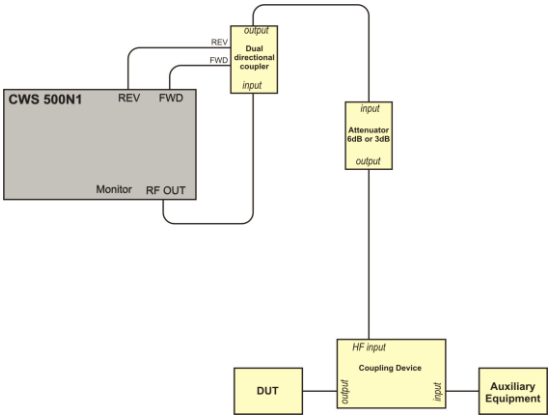
	Environmental phenomena	Test specification		Basic Standard	Test set-up	Applicability note	Remarks	Performance criteria
4.1	Radio-frequency common mode	0,15 MHz to 80 MHz 10 V (rms) 80 % AM, 1 kHz	Unmodulated carrier	EN 61000–4–6	EN 61000–4–6	See [b] [c]	The test level specified is the rms value of the unmodulated carrier	A

[a] Capacitive coupling, positive and negative polarity. Battery referenced control ports are covered by requirements in Table 3.
[b] Applicable only to ports interfacing with cables whose total length according to the manufacturer's functional specification may exceed 3m.
[c] The test level can also be defined as the equivalent current into a 150 Ω load.

Performance criteria*:*

The performance criteria for continuous phenomena shall apply.

Typical test Setup:



Measurement data:

Test not applicable to the EUT.

8.5 Transients and surges in the vehicular environment

General description:

These tests are applicable to radio and ancillary equipment intended for vehicular use.
These tests shall be performed on nominal 12V and 24V DC supply voltage input ports of mobile radio and ancillary equipment, which are also intended for mobile use in vehicles.
These tests shall be performed on a representative configuration of the mobile radio equipment, the associated ancillary equipment, or a representative configuration of the combination of radio and ancillary equipment.
These tests assess the ability of the EUT to operate as intended in the event of transients and surges present on their DC power input ports in a vehicular environment.

Test method:

The test method shall be in accordance with ISO 7637-2 for 12V DC and 24V DC powered equipment.
The test method shall be in accordance with ISO 7637-2, applying pulses 1, 2a, 2b, 3a, 3b, and 4, using immunity test level III. For the purpose of EMC testing it is sufficient to apply pulses 1, 2a, 2b and 4, 10 times each, and apply the test pulses 3a and 3b for 20 minutes each.

Performance criteria:

Where, pulse 3a and 3b are applied, the performance criteria for continuous phenomena shall apply.

Where pulse 1, 2a, 2b, and 4 are applied, the performance criteria for transient phenomena shall apply, with the exception that a communication link need not to be maintained during the EMC exposure and may have to be re-established.

Measurement data:

Test not applicable to the EUT.

8.6 Voltage dips and interruptions

General description:

This test shall be performed on the AC mains power port (if any) of radio equipment and associated ancillary equipment.
These tests shall be performed on a representative configuration of the radio equipment, the associated ancillary equipment, or a representative configuration of the combination of radio and ancillary equipment.
These tests assess the ability of the EUT to operate as intended in the event of voltage dips and interruptions present on the AC mains power input ports.

Test method:

The following requirements and evaluation of test results shall apply.
The test method shall be in accordance with CENELEC EN 61000-4-11 or for equipment requiring a mains current of greater than 16 A CENELEC EN 61000-4-34 shall be used.

The test levels shall be:

- voltage dip: 0 % residual voltage for 0,5 cycle;
- voltage dip: 0 % residual voltage for 1 cycle;
- voltage dip: 70 % residual voltage for 25 cycles (at 50 Hz);
- voltage interruption: 0 % residual voltage for 250 cycles (at 50 Hz).

Performance criteria:

For a 0 % residual voltage dip tests the following performance criteria apply:

- The performance criteria for transient phenomena shall apply.

For a 70 % residual voltage dip and voltage interruption tests, the following performance criteria apply:

- in the case where the equipment is fitted with or connected to a battery back-up, the performance criteria for transient phenomena shall apply.
- in the case where the equipment is powered solely from the AC mains supply (without the use of a parallel battery back-up) volatile user data may have been lost and if applicable the communication link need not to be maintained and lost functions should be recoverable by user or operator;
- no unintentional responses shall occur at the end of the test, when the voltage is restored to nominal;
- in the event of loss of function(s) or in the event of loss of user stored data, this fact shall be recorded.

Measurement data:

Test not applicable to the EUT.

8.7 Surges

General description:

This test shall be performed on the AC mains power input port (if any) of radio equipment and associated ancillary equipment.
This test shall be additionally performed on wired network ports, if any.
These tests shall be performed on a representative configuration of the radio equipment, the associated ancillary equipment, or a representative configuration of the combination of radio and ancillary equipment.
These tests assess the ability of the EUT to operate as intended in the event of surges present on the AC mains power input ports and wired network ports.

Test method:

The test method shall be in accordance with CENELEC EN 61000-4-5.
The requirements and evaluation of test results given in clause 9.8.2.1 of EN 301 489-1 (wired network ports, outdoor cables), clause 9.8.2.2 of EN 301 489-1 (wired network ports, indoor cables) and clause 9.8.2.3 of EN 301 489-1 (mains ports) shall apply, but no test shall be required where normal functioning cannot be achieved, because of the impact of the CDN on the EUT.

Test method for mains ports:

The test level for AC mains power input ports shall be 2 kV line to ground, and 1 kV line to line, with the output impedance of the surge generator including the CDN as given in CENELEC EN 61000-4-5.
In telecom centres 1 kV line to ground and 0,5 kV line to line shall be used.
The test generator shall provide the 1,2/50 µs pulse as defined in CENELEC EN 61000-4-5.

Requirements according to the standard EN 50121-3-2:2016/A1:2019:

Table 3 — Immunity - Battery referenced ports (except at the output of energy sources), auxiliary AC power input ports (rated voltage ≤ 400 V_{rms})

3.3	**Surges**	1,2 / 50 µs ±2 kV 42 Ω, 0,5 µF ±1 kV 42 Ω, 0,5 µF	Open circuit test voltage, line to ground Open circuit test voltage, line to line	EN 61000–4–5	EN 61000–4–5	see [b] [c]	All severity levels below the given severity level shall be tested with each 5 pulses and a test sequence not alternating but first one polarity, then the other polarity Test with maximum permanent supply voltage as defined in EN 50155	B

[a] The test level can also be defined as the equivalent current into a 150 Ω load.
[b] The test applies to the power supply ports and the battery control input output ports, with direct coupling, positive and negative polarity.
[c] The test applies to the power supply ports and the battery control input output ports. This test is intended to replicate the phenomenon known as direct coupling; hence an output impedance of 42 Ω (40 Ω and 2 Ω generator) and a coupling capacitance of 0,5 µF is specified. This value is accepted as a compromise as the impedance of battery referenced network inside a rolling stock can vary up to a few hundred ohms depending on their length.

Performance criteria:

The performance criteria for transient phenomena shall apply.

Measurement data:

Test not applicable to the EUT.

9 MEASUREMENT UNCERTAINTIES

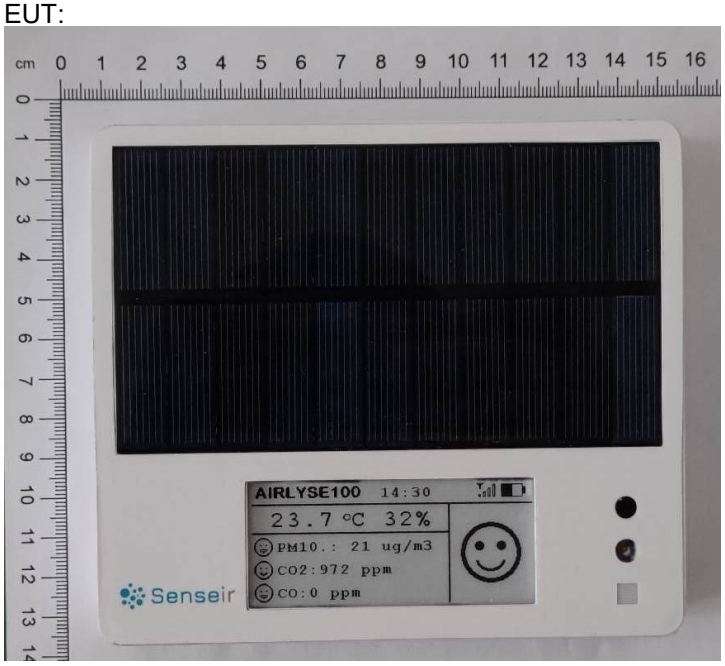
The measurement uncertainties are based on a 95% confidence level (based on the coverage factor k = 2) and calculated according to CISPR 16-4 and internal document 2017/1/316/NM of TSÚ Piešťany, š.p. The recorded value of measurement uncertainty is, for each measurement result, equal to or lower than the values required by the test-related standard.

If there are some measured values of the tested parameters in the measurement uncertainty band with their respective limits, there is the possibility that this sample or similar, selected out of production, may not meet the required limit if tested by another laboratory.

Uncertainty		
Conducted RF Emissions	<3,36 dB	
Radiated RF Emissions	<5,71 dB	
Harmonic Distortion per EN 61000-3-2	< 5 %	
Voltage Fluctuations and Flicker per EN 61000-3-3	< 8 %	
Electrostatic Discharges EN 61000-4-2	< 0,3kV for ± 4 kV < 0,4kV for ± 8 kV < 0,6kV for ± 15 kV	
Radiated RF EM Fields and Proximity Wireless fields EN 61000-4-3	< 1,67 dB	
Electrical Fast Transients and bursts EN 61000-4-4	Pulse rise time	< 6,2 %
	Peak voltage level	8,64 % (related to 3,75 kV)
	Pulse width	< 5,9 %
Surges EN 61000-4-5	Pulse rise time	< 13,3 %
	Peak voltage level	8,63 % (related to 3,85 kV)
	Pulse width	< 5,9 %
Conducted Disturbances, induced by RF fields EN 61000-4-6	< 1,25 dB	
Voltage Dips and Interruptions EN 61000-4-11	<3 dB	

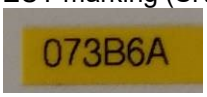
10 PHOTOGRAPHS FROM TEST SITE

EUT:

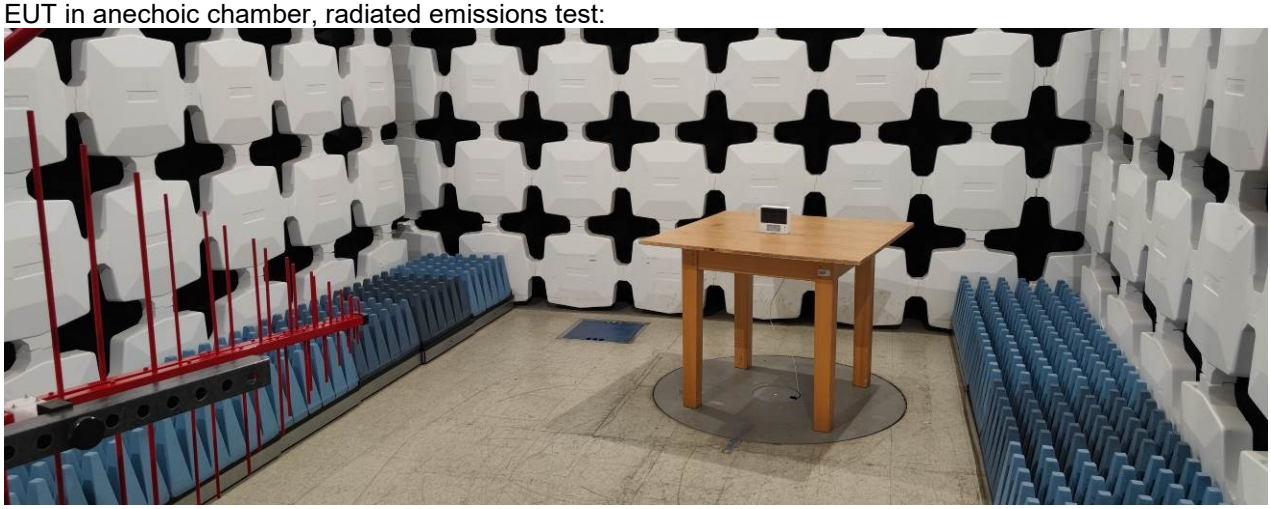


EUT product label:

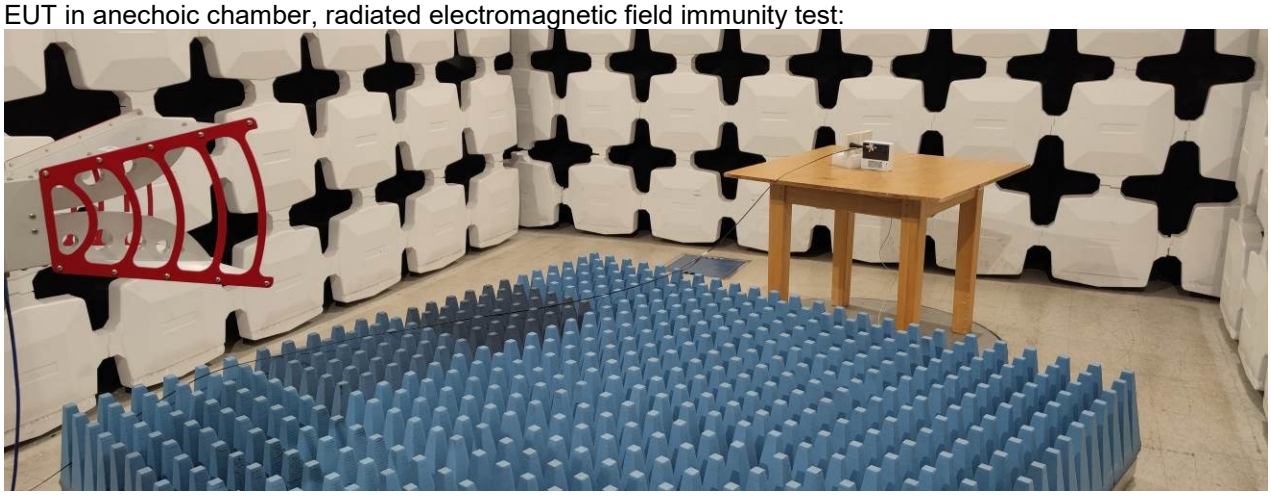
EUT marking (SN):



EUT in anechoic chamber, radiated emissions test:



EUT in anechoic chamber, radiated electromagnetic field immunity test:



End of test report