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Railway applications — Electromagnetic compatibility —

Part 3-2: Rolling stock — Apparatus

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ICS 29.020; 29.280; 45.060.01

National foreword

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A list of organizations represented on GEL/9 can be obtained on request to its secretary.

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**Railway applications -
Electromagnetic compatibility
Part 3-2: Rolling stock -
Apparatus**

Applications ferroviaires -
Compatibilité électromagnétique
Partie 3-2: Matériel roulant -
Appareils

Bahnanwendungen -
Elektromagnetische Verträglichkeit
Teil 3-2: Bahnfahrzeuge -
Geräte

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CENELEC

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Foreword

This European Standard was prepared by Technical Committee TC 9X: Electrical and electronic applications for railways. The text of the draft was submitted to the formal vote and was approved by CENELEC as EN 50121-3-2 on 2006-07-01.

This European Standard supersedes EN 50121-3-2:2000.

This European Standard is to be read in conjunction with EN 50121-1.

This standard forms Part 3-2 of the European Standard series EN 50121, published under the general title "Railway applications - Electromagnetic compatibility". The series consists of:

- Part 1 : General
- Part 2 : Emission of the whole railway system to the outside world
- Part 3-1 : Rolling stock - Train and complete vehicle
- Part 3-2 : Rolling stock - Apparatus
- Part 4 : Emission and immunity of the signalling and telecommunications apparatus
- Part 5 : Emission and immunity of fixed power supply installations and apparatus

The following dates were fixed:

latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2007-07-01
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This European Standard has been prepared under a mandate given to CENELEC by the European Commission and the European Free Trade Association and covers essential requirements of EC Directive 89/336/EEC. See Annex ZZ.

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1 Scope

This European Standard applies to emission and immunity aspects of EMC for electrical and electronic apparatus intended for use on railway rolling stock. EN 50121-3-2 applies for the integration of apparatus on rolling stock.

The frequency range considered is from d.c. to 400 GHz. No measurements need to be performed at frequencies where no requirement is specified.

The application of tests shall depend on the particular apparatus, its configuration, its ports, its technology and its operating conditions.

This standard takes into account the internal environment of the railway rolling stock and the external environment of the railway, and interference to the apparatus from equipment such as hand-held radio transmitters.

If a port is intended to transmit or receive for the purpose of radio communication (intentional radiators, e.g. transponder systems), then the emission and immunity limits in this standard at the communication frequency do not apply.

This standard does not apply to transient emissions when starting or stopping the apparatus.

The objective of this standard is to define limits and test methods for electromagnetic emissions and immunity test requirements in relation to conducted and radiated disturbances.

These limits and tests represent essential electromagnetic compatibility requirements.

Emission requirements have been selected so as to ensure that disturbances generated by the apparatus operated normally on railway rolling stock do not exceed a level which could prevent other apparatus from operating as intended.

Likewise, the immunity requirements have been selected so as to ensure an adequate level of immunity for rolling stock apparatus.

The levels do not however cover extreme cases which may occur with an extremely low probability of occurrence in any location. Specific requirements which deviate from this standard shall be specified.

Test requirements are specified for each port considered.

These specific provisions are to be used in conjunction with the general provisions in EN 50121-1.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 50121-1	Railway applications – Electromagnetic compatibility Part 1: General
EN 50121-3-1	Railway applications – Electromagnetic compatibility Part 3-1: Rolling stock – Train and complete vehicle
EN 50155	Railway applications – Electronic equipment used on rolling stock
EN 55011	Industrial, scientific and medical (ISM) radio-frequency equipment – Radio disturbance characteristics – Limits and methods of measurement (CISPR 11, mod.)
EN 55016-1-1	Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-1: Radio disturbance and immunity measuring apparatus – Measuring apparatus (CISPR 16-1-1)

EN 55022	Information technology equipment – Radio disturbance characteristics – Limits and methods of measurement (CISPR 22, mod.)
EN 61000-4-2	Electromagnetic compatibility (EMC) Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test (IEC 61000-4-2)
EN 61000-4-3	Electromagnetic compatibility (EMC) Part 4-3: Testing and measurement techniques – Radiated, radio-frequency, electromagnetic field immunity test (IEC 61000-4-3)
EN 61000-4-4	Electromagnetic compatibility (EMC) Part 4-4: Testing and measurement techniques – Electrical fast transient/burst immunity test (IEC 61000-4-4)
EN 61000-4-5	Electromagnetic compatibility (EMC) Part 4-5: Testing and measurement techniques – Surge immunity test (IEC 61000-4-5)
EN 61000-4-6	Electromagnetic compatibility (EMC) Part 4-6: Testing and measurement techniques – Immunity to conducted disturbances, induced by radio-frequency fields (IEC 61000-4-6)
EN 61000-6-1	Electromagnetic compatibility (EMC) Part 6-1: Generic standards – Immunity for residential, commercial and light-industrial environments (IEC 61000-6-1, mod.)

3 Definitions

For the purpose of this Part 3-2 of the European Standard, the following definitions apply:

3.1

rolling stock apparatus

a finished product with an intrinsic function intended for implementation into the rolling stock installation

3.2

port

the particular interface of the specified apparatus with the external environment e.g. a.c. power port, d.c. power port, I/O (input/output) port

3.3

enclosure port

the physical boundary of the apparatus through which electromagnetic fields may radiate or impinge

The main categories of ports for rolling stock apparatus are presented in Figure 1.

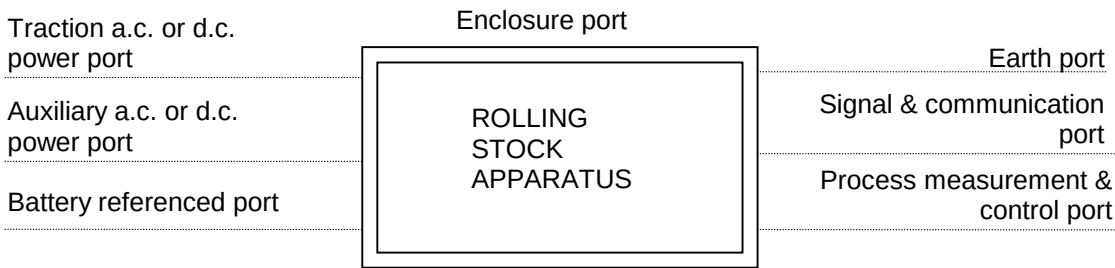


Figure 1 – Main categories of ports

Typical examples of rolling stock apparatus with their ports are listed in Annex A.

4 Performance criteria

The variety and the diversity of the apparatus within the scope of this standard make it difficult to define precise criteria for the evaluation of the immunity test results.

A functional description and a definition of performance criteria, during or as a consequence of the EMC testing, shall be provided by the manufacturer and noted in the test report, based on the criteria A, B, C defined in EN 50121-1.

5 Conditions during testing

It is not always possible to test every function of the apparatus. The tests shall be made at a typical operating mode considered by the manufacturer to produce the largest emission or maximum susceptibility to noise as appropriate in the frequency band being investigated consistent with normal applications. The manufacturer shall define the conditions during testing in a test plan.

If the apparatus is part of a system, or can be connected to auxiliary apparatus, then the apparatus shall be tested while connected to the minimum configuration of auxiliary apparatus necessary to exercise the ports in accordance with EN 55022.

The configuration and mode of operation shall be specified in the test plan and the actual conditions, during the tests, shall be precisely noted in the test report.

If the apparatus has a large number of similar ports or ports with many similar connections, then a sufficient number shall be selected to simulate actual operating conditions and to ensure that all the different types of termination are covered (e.g. 20 % of the ports or at least four ports).

The tests shall be carried out within the specified operating range for the apparatus and at its rated supply voltage, unless otherwise indicated in the Basic Standard.

6 Applicability

The measurements in this standard shall be made on the relevant ports of the apparatus.

It may be determined from consideration of the electrical characteristics, the connection and the usage of a particular apparatus that some of the tests are not applicable (e.g. radiated immunity of induction motors, transformers). In such cases, the decision not to test has to be recorded in the test plan or test report.

If not otherwise specified, the EMC tests shall be type tests.

7 Emission tests and limits

The emission tests and limits for apparatus covered by this standard are given on a port by port basis.

Measurements shall be performed in well-defined and reproducible conditions for each type of disturbance.

The description of the test, the test methods and the test set-up are given in Basic Standards which are referred to in Tables 1 to 6.

The contents of these Basic Standards are not repeated here, however modifications or additional information needed for the practical application of the tests are given in this standard.

NOTE The reference to "Basic Standard" is intended to be limited to those parts of the standard that give the description of the test, the test methods and the test set-up.

Table 1 – Emission – Traction a.c. power ports

	Port	Test specification		Basic standard	Test set-up	Remarks
1.1	High voltage connection, input side before filter (port 3 on Figures A.1, A.2, A.3)	Signalling and telecommunication frequencies	see EN 50121-3-1			
		9 kHz ... 30 MHz	No limits			See note 1 & 2
NOTE 1 No conducted radio frequency limits are applied. The apparatus when installed with other surrounding equipment shall satisfy the radiated emission limits of EN 50121-3-1 for trains.						
NOTE 2 It is desirable but not possible to apply conducted radio frequency limits. No practical test method exists and the relationship between conducted emissions and radiated emissions is not possible to define.						

Table 2 – Emission – Traction d.c. power ports

	Port	Test specification		Basic standard	Test set-up	Remarks
2.1	High voltage connection, input side before filter (port 3 on Figure A.4)	Signalling and telecommunication frequencies	see EN 50121-3-1			
		9 kHz ... 30 MHz	No limits			See note 1 & 2
NOTE 1 No conducted radio frequency limits are applied. The apparatus when installed with other surrounding equipment shall satisfy the radiated emission limits of EN 50121-3-1 for trains.						
NOTE 2 At present there is no agreed method or limit for conducted emissions on the traction supply from 9 kHz to 30 MHz. Limiting conducted emissions from an apparatus connected to the traction supply will prevent excessive radiated emissions from the supply system. A method for measuring conducted emissions is proposed in Annex B. Experience in this technique and the relationship between conducted and radiated emissions is necessary in order to progress this standard in the future.						

Table 3 – Emission – Auxiliary a.c. or d.c. power ports

	Port	Test specification		Basic Standard	Test set-up	Remarks
		9 kHz ... 150 kHz	No limits			
3.1	Auxiliary supply sinusoidal a.c. or d.c. (port 9 on Figures A.1, A.2 and A.4)	150 kHz ... 500 kHz 500 kHz ... 30 MHz	99 dB μ V quasi-peak 93 dB μ V quasi-peak	EN 55011	EN 55011	See note 1 & 2 See note 3, 4 & 5 See note 3, 4 & 5
NOTE 1 At present there are no limits for conducted emissions from 9 kHz to 150 kHz. Limiting conducted emissions from an apparatus will prevent excessive radiated emissions. Experience in this technique and the relationship between conducted and radiated emissions is necessary in order to progress this standard in the future.						
NOTE 2 230 V AC power outlet ports for public use shall offer a power quality, which is sufficient for the use of intended equipment like PC and mobile telephone chargers. The harmonic distortion in differential and common mode shall be limited by a sine-filter to < 5 %. The burst and surge emissions of the outlet have to be limited to the levels of residential equipment according to EN 61000-6-1. AM radio receivers are not intended to be supplied by these power outlets.						
NOTE 3 Wherever applicable the method defined by EN 55011 is to be used. At present the existing method of measuring conducted emissions (EN 55011) 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.						
NOTE 4 This requirement refers to the industrial limit values but considering they have been defined to protect radio and TV sets 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.						
NOTE 5 This requirement is not applicable to power ports which are connected to other dedicated, compatible ports.						

Table 4 – Emission – Battery referenced ports

	Port	Test specification		Basic standard	Test set-up	Remarks
		9 kHz ... 150 kHz	No limits			
4.1	Battery power supply (port 10 on Figures A.1-A.5)	150 kHz ... 500 kHz 500 kHz ... 30 MHz	99 dB μ V quasi-peak 93 dB μ V quasi-peak	EN 55011	EN 55011	See note 1 See note 2 See note 2
NOTE 1 At present there are no limits for conducted emissions from 9 kHz to 150 kHz. Limiting conducted emissions from an apparatus will prevent excessive radiated emissions. Experience in this technique and the relationship between conducted and radiated emissions is necessary in order to progress this standard in the future.						
NOTE 2 This requirement refers to the industrial limit values but considering they have been defined to protect radio and TV sets 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.						

Table 5 – Emission – Process measurement and control ports

	Port	Test specification		Basic standard	Test set-up	Remarks
5.1	Electronic supply sinusoidal a.c. or d.c. (port 16 on Figure A.5)	9 kHz ... 150 kHz	No limits	EN 55011	EN 55011	See note 1
		150 kHz ... 500 kHz	99 dB μ V quasi-peak			See note 2
		500 kHz ... 30 MHz	93 dB μ V quasi-peak			See note 2
NOTE 1 At present there are no limits for conducted emissions from 9 kHz to 150 kHz. Limiting conducted emissions from an apparatus will prevent excessive radiated emissions. Experience in this technique and the relationship between conducted and radiated emissions is necessary in order to progress this standard in the future.						
NOTE 2 This requirement refers to the industrial limit values but considering they have been defined to protect radio and TV sets 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.						

Table 6 - Emission - Enclosure port

	Port	Test specification		Basic standard	Test set-up	Remarks
6.1	Enclosure	30 MHz ... 230 MHz	40 dB μ V/m quasi-peak	EN 55011	EN 55011	See note 1 & 2
		230 MHz ... 1 GHz	47 dB μ V/m quasi-peak			See note 1 & 2
NOTE 1 Measurement distance is 10 m. A measurement distance of 3 m may be used with the limit increased by 10 dB.						
NOTE 2 Traction converters and auxiliary converters over 50 kVA need not be tested individually but when the vehicle is tested as a whole in accordance with EN 50121-3-1.						

8 Immunity tests and limits

The immunity tests and limits for apparatus covered by this standard are given on a port by port basis.

To ensure the immunity of the complete vehicle, the limits shall be applicable to all relevant apparatus.

Tests shall be conducted in a well-defined and reproducible manner.

The tests shall be carried out as single tests in sequence. The sequence of testing is optional. The description of the test, the test generator, the test methods and the test set-up are given in Basic Standards which are referred to in Tables 7 to 9.

The contents of these “Basic Standards” are not repeated here, however modifications or additional information needed for the practical application of the tests are given in this standard.

Table 7 - Immunity - Battery referenced ports (except at the output of energy sources), auxiliary a.c. power input ports (rated voltage $\leq 400\text{ V}_{\text{rms}}$)

	Environmental phenomena	Test specification		Basic Standard	Test set-up	Remarks	Performance criteria
7.1	Radio-frequency common mode	0,15 MHz ... 80 MHz 10 V (r.m.s) 80 % AM, 1 kHz	Unmodulated carrier	EN 61000-4-6	EN 61000-4-6	See note 1 The test level specified is the r.m.s. value of the unmodulated carrier	A
7.2	Fast transients	$\pm 2\text{ kV}$ 5/50 ns 5 kHz	Peak T_r / T_h Repetition frequency	EN 61000-4-4	EN 61000-4-4	See note 2	A
7.3	Surges	1,2 / 50 μs $\pm 2\text{ kV}$ 42 Ω , 0,5 μF $\pm 1\text{ kV}$ 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 note 3	B
NOTE 1 The test level can also be defined as the equivalent current into a 150 Ω load							
NOTE 2 Direct coupling, positive and negative polarity.							
NOTE 3 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 recommended.							

Table 8 - Immunity - Signal & communication, process measurement & control ports

	Environmental phenomena	Test specification		Basic Standard	Test set-up	Remarks	Performance criteria
8.1	Radio-frequency common mode	0,15 MHz ... 80 MHz 10 V (r.m.s) 80 % AM, 1 kHz	Unmodulated carrier	EN 61000-4-6	EN 61000-4-6	See note 1 The test level specified is the r.m.s. value of the unmodulated carrier	A
8.2	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 note 2 Capacitive clamp used	A
NOTE 1 The test level can also be defined as the equivalent current into a 150 Ω load.							
NOTE 2 Capacitive coupling, positive and negative polarity.							

Table 9 - Immunity - Enclosure ports

	Environmental phenomena	Test specification		Basic Standard	Test set-up	Remarks	Performance criteria
9.1	Radio-frequency electromagnetic field. Amplitude modulated	80 MHz ... 1 000 MHz 20 V/m (r.m.s) 80 % AM, 1 kHz	Unmodulated carrier	EN 61000-4-3	EN 61000-4-3	See notes 1 & 2 The test level specified is the r.m.s. value of the unmodulated carrier	A
9.2	Radio-frequency electromagnetic field, from digital mobile telephones	800 MHz ... 1 000 MHz 20 V/m (r.m.s) 80 % AM, 1 kHz	Unmodulated carrier	EN 61000-4-3	EN 61000-4-3	See notes 2 & 3	A
		1 400 MHz... 2 100 MHz 10 V/m (r.m.s) 80 % AM, 1 kHz	Unmodulated carrier				
		2 100 MHz... 2 500 MHz 5 V/m (r.m.s) 80 % AM, 1 kHz	Unmodulated carrier				
9.3	Electrostatic discharge	± 6 kV ± 8 kV	Contact discharge Air discharge	EN 61000-4-2	EN 61000-4-2	See note 4	B
NOTE 1 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							
NOTE 2 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).							
NOTE 3 The immunity test levels may be reduced for equipment mounted in areas where the threat from mobile digital radio telephones has been demonstrated to be less severe.							
NOTE 4 Only applicable to equipment accessible to passengers and operational staff (not maintenance).							

Annex A (informative)

Examples of apparatus and ports

The purpose of this Annex is to provide examples of the different types of rolling stock apparatus together with their ports. Examples of apparatus which may be placed on the market as a single commercial unit are given in Table A.1. However these items of apparatus may also form a sub-system in a larger apparatus (e.g. control electronics in an auxiliary converter). In this case, the requirements of the standard apply only to the apparatus which is placed on the market. A port is defined in the standard as the interface of an apparatus with the external environment. The matrix in the table indicates whether the particular apparatus is relevant to emission, immunity or neither. This guidance is offered for the benefit of users of this standard, but it is not intended to be definitive. It is for the user of the standard to make the necessary technical judgements in determining whether or not a test is applicable.

The drawings on the following figures clarify the most essential ports. They show examples of different arrangements.

Figure A.1 applies for an a.c. fed locomotive with a.c. traction drive and psophometric filter on the line side.

Figure A.2 shows another a.c./a.c. system with power factor correction filter on the converter side and with d.c. or three-phase auxiliary and train power supply.

Figure A.3 shows a more conventional system with a.c. input and d.c. traction motors fed by phase control converter.

Figure A.4 is a d.c. fed system with a.c. traction drive.

Figure A.5 shows some additional ports of converter and control electronics.

Of course, many other different system arrangements are possible.

Table A.1 – Typical examples of apparatus

Apparatus	Test requirements
Traction convertor	Emission and immunity
Main circuit breaker	No test requirements
Traction transformers	No test requirements
Traction motor	No test requirements
Auxiliary motor	No test requirements
D.C. auxiliary supply (battery)	Emission and immunity
Electronic control supply	Emission and immunity
Signalling & communication equipment	Emission and immunity
Electronic man-machine interface	Emission and immunity
Environmental conditioning equipment	Emission and immunity
Passenger information equipment	Emission and immunity
Door control	Emission and immunity
Auxiliary equipment for train operation	Emission and immunity
Auxiliary equipment for passenger services	Emission and immunity
Train management systems	Emission and immunity
Electronic power supply	Emission and immunity
Braking control system	Emission and immunity

In Tables 1 to 9, tests are specified for application to a specific port (interface of an apparatus). Table A.2 lists some more typical descriptions used for these ports and the type of apparatus which may have such a port. Examples of these ports are given in the accompanying figures except for ports n° 11, 13 and 14.

Table A.2 – Typical port descriptions

Port No on figures	Typical port name	Typical apparatus
	Traction a.c. power ports	
1	Pantograph line terminal	Main circuit breaker
3	High voltage connection (before filter)	Filter
4	Connection filter-transformer, HV side	Filter
5	Train power line single phase	Auxiliary converter
6	Connection transformer-converter	Propulsion converter
7	Traction motor cables	Traction motors
8	Auxiliary feed windings of transformer	D.C. auxiliary supply
	Traction d.c. power ports	
2	D.C. conductor input	Main circuit breaker
3	High voltage connection (before filter)	Filter
6	Connection filter-converter	Propulsion converter
7	Traction motor cables	Traction motors
	Auxiliary a.c. ports	
9	Auxiliary a.c. supply	Environmental conditioning equipment
	Auxiliary d.c. ports	
9	Auxiliary d.c. supply	
	Battery referenced ports	
10	Battery power supply	Electronic power supply
11	Train control bus (conventional battery voltage)	Train management system
19	Relay logic input/output	Electronic control system
	Signal & communication ports	
12	Databus within vehicle	Electronic control system
13	Databus within train	Train management system
14	Passenger entertainment network	Passenger entertainment equipment
15	Firing control line	Electronic control system
17, 18	Sensor/transducer signal (digital or analog)	Electronic control system
20	Communication interface (maintenance)	Electronic control system
	Process measurement & control ports	
16	Internal electronic supply	Electronic control system
18	Sensor/transducer signal (analog)	Electronic control system
	Enclosure port	
21	Equipment enclosure	All apparatus
	Earth port	
22	Earth connection	All apparatus

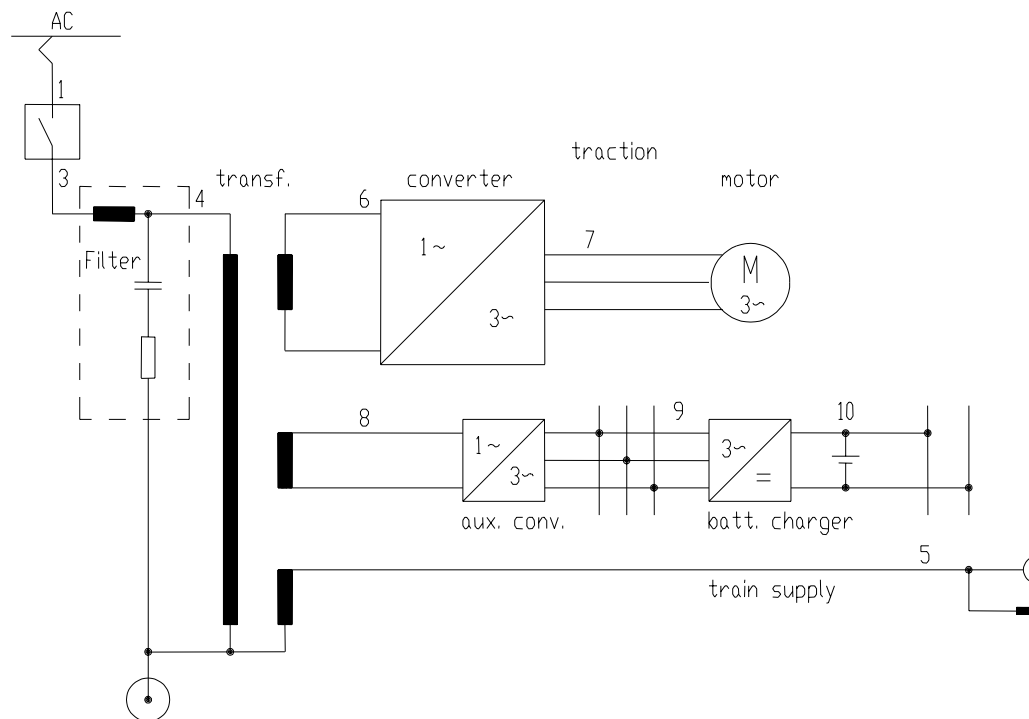


Figure A.1 – A.C. fed loco with a.c. traction drive and psophometric filter on the line side

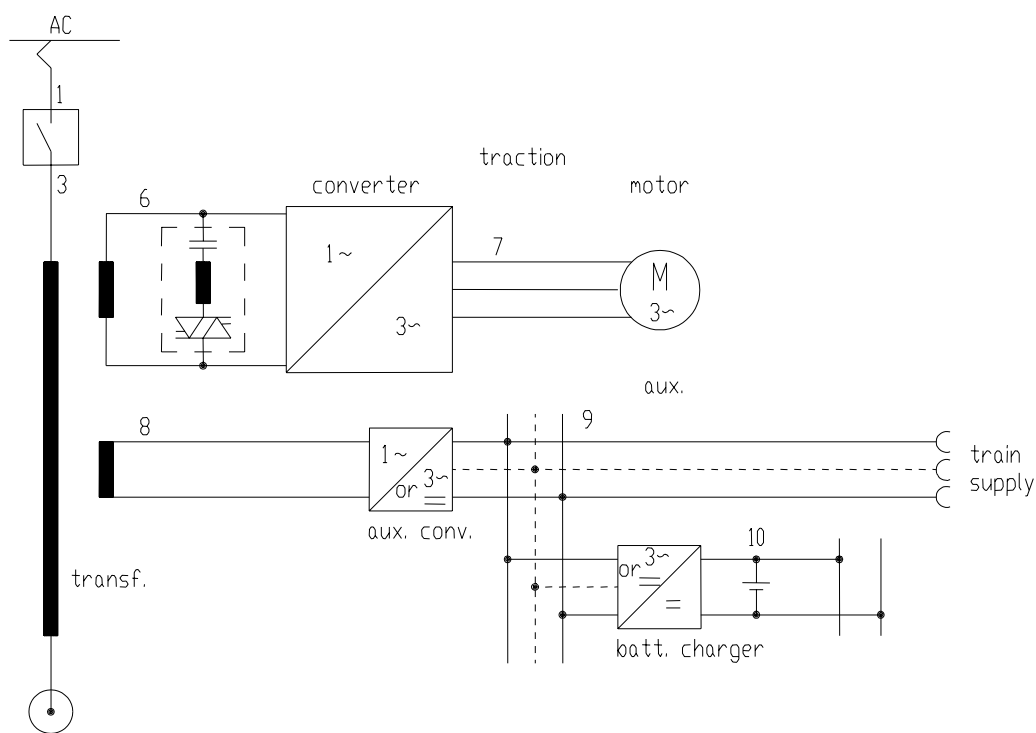


Figure A.2 – A.C./A.C. system with power factor correction filter on the converter side and with d.c. or three-phase auxiliary and train power supply

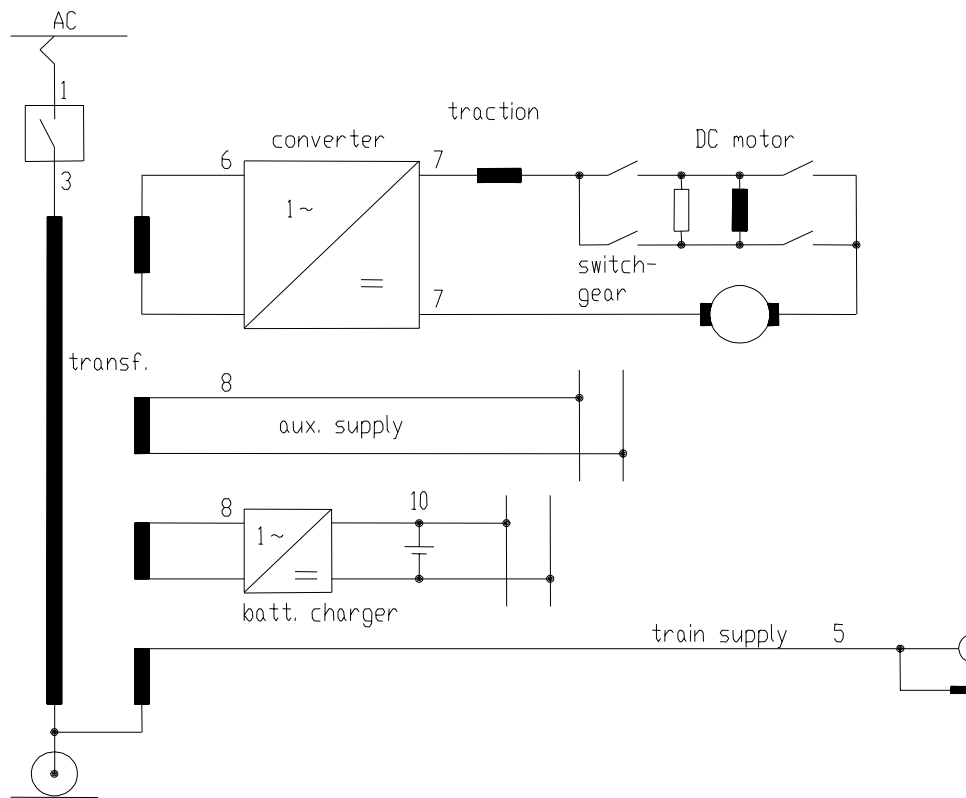


Figure A.3 – Conventional system with a.c. input and d.c. traction motors fed by phase control converter

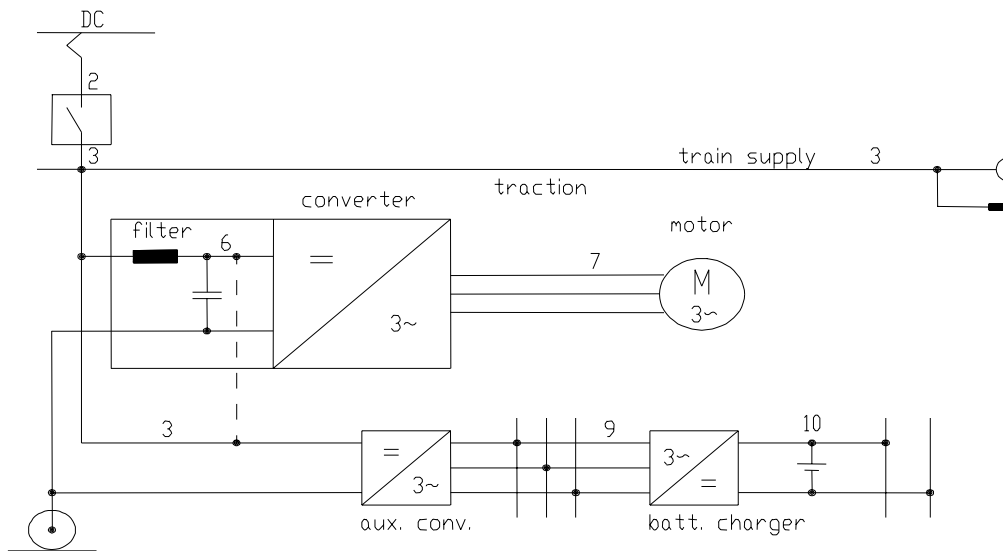


Figure A.4 – D.C. fed system with a.c. traction drive

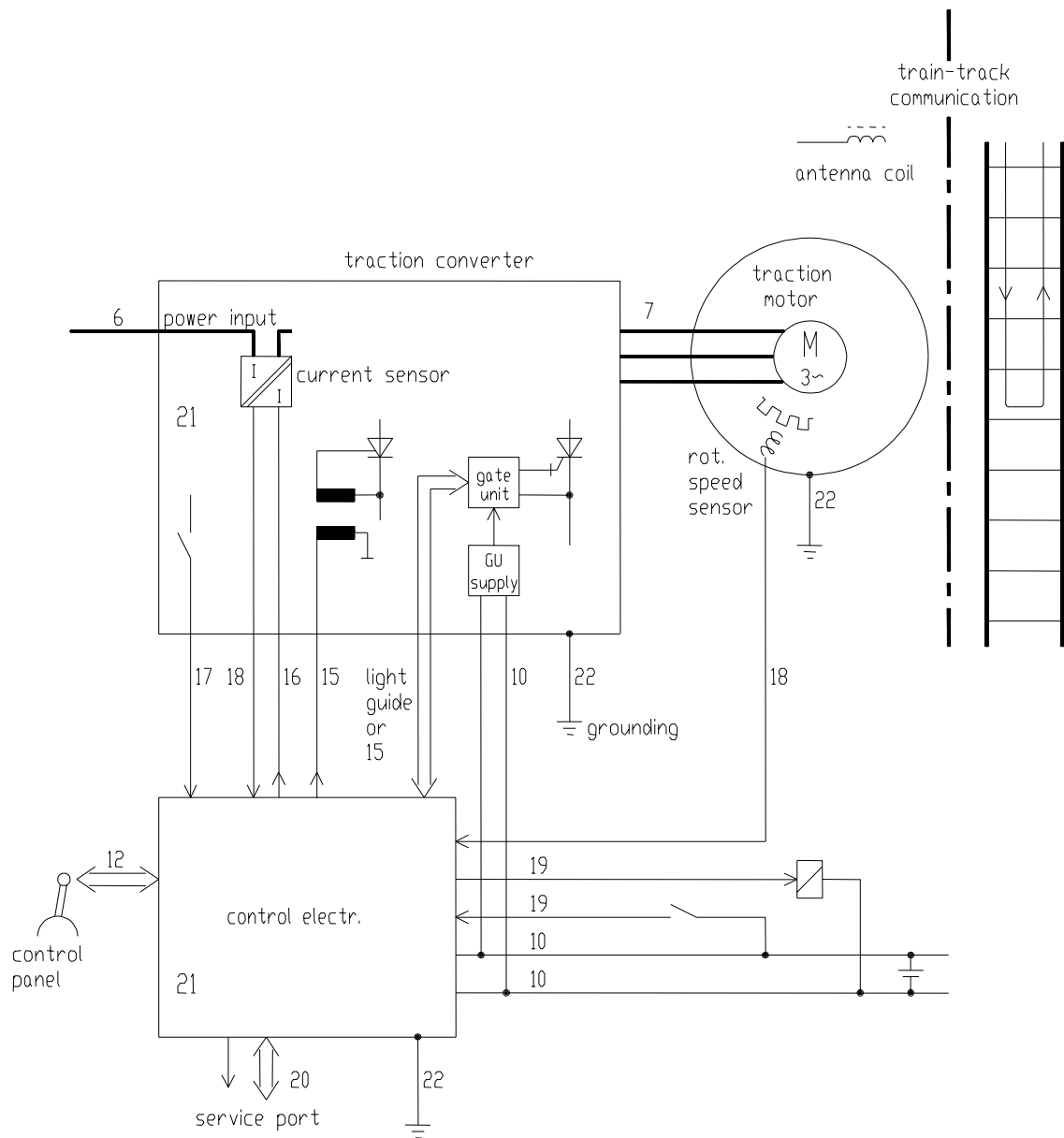


Figure A.5 – Additional ports of converter and control electronics

Annex B (informative)

Conducted disturbances generated by power converters in the range of 9 kHz to 30 MHz

B.1 Scope

This procedure concerns switched mode power conversion devices connected to the main traction d.c. port (catenary or conductor rail) with or without a main line filter.

B.2 Measuring method

The measurements should be carried out using the EN 55016 Series. The following adjustments should be set:

- 200 Hz 6 dB bandwidth, in the range 9 kHz - 150 kHz;
- 9 kHz 6 dB bandwidth, in the range 150 kHz - 30 MHz;
- quasi-peak detection with appropriate weighting for each frequency range.

Care should be taken of possible saturation caused by the main current which may affect the probe transfer characteristics. Correct impedance matching should be ensured from the probe to the measuring apparatus.

B.3 Test procedure

The organisation of the test is presented in Figure B.1 with appropriate recommendations.

The common mode impedance and grounding conditions should be as close as possible to the actual conditions on both input and output of the converter.

The levels should be measured for each measuring point and for each working condition recognised as providing the maximum disturbing currents.

B.4 Limits

No conducted radio frequency limits are applied. The apparatus when installed with other surrounding equipment must satisfy the radiated emission limits of EN 50121-3-1 for trains. This test is offered to quantify the emission of apparatus, e.g. for data sheets.

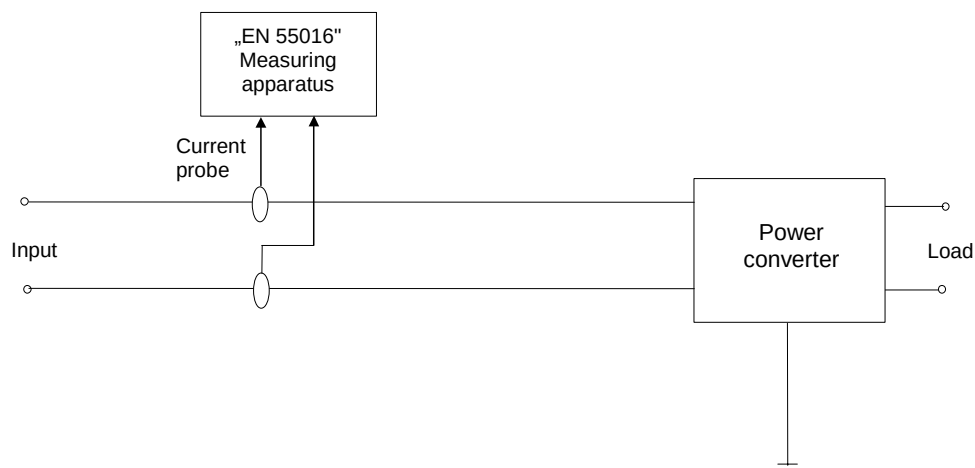


Figure B.1 – Test set-up

Annex ZZ (informative)

Coverage of Essential Requirements of EC Directives

This European Standard has been prepared under a mandate given to CENELEC by the European Commission and the European Free Trade Association and within its scope the standard covers all relevant essential requirements as given in Article 4 of the EC Directive 89/336/EEC.

Compliance with this standard provides one means of conformity with the specified essential requirements of the Directive concerned.

WARNING: Other requirements and other EC Directives may be applicable to the products falling within the scope of this standard.

blank

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