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Title: Draft BS EN 50155 BS Railway applications - Rolling stock - Electronic equipment.

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- iii) requires additional national guidance or information

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Full document details: 24/30469113 DC

Introduction

This draft standard is based on national and international discussions. Your comments on this draft are invited and will assist in the preparation of the consequent standard.

For international standards, comments will be reviewed by the relevant UK national committee before sending the consensus UK vote and comments to the international committee, which will then decide appropriate action. If the international standard is approved, it is usual for the text to be published as a British Standard.

For national standards, comments will be reviewed by the relevant UK national committee and the resulting standards published as a British Standard.

UK Vote

Please indicate whether you consider the UK should submit a negative (with supporting technical reasons) or positive vote on this draft. Please indicate if you are aware of any reason why this draft standard should not be published as a British Standard.

Submission of Comments

- **Annotated drafts are not acceptable and will be rejected.**
- All comments should be submitted online at <https://standardsdevelopment.bsigroup.com/>. You will need to register in order to comment.

Template for comments and secretariat observations

Date: xx/xx/20xx	Document: ISO/DIS xxxx
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1	2	(3)	4	5	(6)	7
MB	Clause No./ Subclause No./Annex (e.g. 3.1)	Paragraph/ Figure/Table/Note	Type of comment	Comment (justification for change) by the MB	Proposed change by the MB	Secretariat observations on each comment submitted
	3.1	Definition 1	ed	Definition is ambiguous and needs clarifying.	Amend to read '...so that the mains connector to which no connection...'	
	6.4	Paragraph 2	te	The use of the UV photometer as an alternative cannot be supported as serious problems have been encountered in its use in the UK.	Delete reference to UV photometer.	

English Version

Railway applications - Rolling stock - Electronic equipment

Applications ferroviaires - Équipements électroniques
utilisés sur le matériel roulant

Bahnanwendungen - Elektronische Einrichtungen auf
Schienenfahrzeugen

This draft European Standard is submitted to CENELEC members for enquiry.
Deadline for CENELEC: 2024-11-29.

It has been drawn up by CLC/SC 9XB.

If this draft becomes a European Standard, CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

This draft European Standard was established by CENELEC in three official versions (English, French, German).
A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

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Recipients of this draft are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation.

Warning : This document is not a European Standard. It is distributed for review and comments. It is subject to change without notice and shall not be referred to as a European Standard.



European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels

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198 European foreword

199 This document (prEN 50155:2024) has been prepared by CLC/SC 9XB, “Electrical, electronic and
200 electromechanical material on-board rolling stock, including associated software”.

201 The following dates are proposed:

- latest date by which the existence of this document has to be announced at national level (doa) dor + 6 months
- latest date by which this document has to be implemented at national level by publication of an identical national standard or by endorsement (dop) dor + 12 months
- latest date by which the national standards conflicting with this document have to be withdrawn (dow) dor + 36 months (to be confirmed or modified when voting)

202 This document will supersede EN 50155:2021 and all of its amendments and corrigenda (if any).

203 prEN 50155:2024 includes the following significant technical changes with respect to EN 50155:2021:

204 a) Revision of Clause 1 Scope;

205 1) Scope regarding “Software requirements for on-board railway equipment” is covered by EN 50716.

206 b) Updating of Clause 2 Normative references;

207 c) Revision of Clause 3 Terms, definitions and abbreviations”, new definitions and reorganization of
208 subclauses;

209 1) Definition modified for “operating temperature”;

210 2) Definition added for “ancillary component”;

211 d) Improvement of Clause 4 General requirements, in terms of better wording, requirement expansion and
212 reorganization of subclauses;

213 1) Precision about concept of expected performance level for all operational conditions.

214 2) Wording improvements of 4.3.2 to 4.3.3 “Performance criterion A and B;

215 3) Wording improvements of 4.4.2 about “Operating temperature classes” and concept of temperature
216 (45 °C) to consider during service life with its effects on unit material ageing.

217 e) Improvement of Clause 5 Electrical service conditions, with reorganization of subclauses;

218 1) Subclause “5.1.1 General” is added before “5.1.2 DC supply system” and “5.1.3 AC supply system”;

219 2) Nominal voltage (Un) of the electronic equipment “should” be selected amongst the following values:
220 24 V, 28 V, 36 V, 48 V, 72 V, 96 V, 110 V;

221 3) Wording improvement of 5.2.2 “Equipment shall operate satisfactorily within the voltage range and
222 duration defined in Table 4, measured at its power input terminals”;

- 223 4) Wording improvement of 5.2.3 "Electronic equipment shall also operate at the values of the DC supply
224 voltage, which are measured at the terminals of the equipment, within the entire range of temporary
225 supply voltage variation defined in Table 4.";
- 226 5) Wording improvement of 5.2.6 "EXAMPLE 3 Considering the maximum and minimum temporary
227 supply voltage for equipment designed to operate at nominal voltages from 24 V up to 110 V, the
228 minimum temporary voltage is $0,6 \times 24 \text{ V}$ and the maximum temporary voltage is $1,4 \times 110 \text{ V}$ ";
- 229 6) Wording improvement of 5.2.8 "Starting the combustion engine by a starter motor powered by the
230 battery voltage supply system can cause voltage drops and fluctuations on the battery voltage supply
231 system";
- 232 7) 5.3.1 "Supply by a specific source" is renamed 5.3.1 "Supply by a specific DC or AC source";
- 233 8) 5.3.2 "Supply by an AC auxiliary power converter", sentence "In some special cases more restrictive
234 requirements for the voltage characteristics can be specified between the involved parties." Is added;
- 235 9) 5.3.4 "Design and test requirements for AC supply" is added; with reference to informative Annex I;
- 236 f) Improvement of Clause 6 Reliability, maintainability and expected useful life;
- 237 1) 6.3.3.1, sentence "Maintenance or diagnostic procedures at this level shall not require the removal or
238 replacement of any part of the defective LRU" is added;
- 239 2) 6.5, sentence "The supplier shall provide information about purpose-built test equipment and/or special
240 tools are required to carry out the user's maintenance procedures.", is added;
- 241 3) 6.5, sentence "Purpose-built test equipment does not necessarily have to comply with this standard"
242 is changed by "Purpose-built test equipment does not necessarily need to be in accordance with the
243 requirements of this document."
- 244 g) Wording improvements and precision added to Clause 7 Design;
- 245 1) 7.2.4: Rewording of the sentence about reference potential of galvanically isolated power supplies
246 outputs.;
- 247 2) 7.2.6: The following sentence is added: "The equipment shall restart in normal operating mode when
248 the supply voltage is within the continuous voltage"
- 249 h) Clause 9 Components,
- 250 1) 9.1: The acronyms UPIC is used to identify the "user programmable integrated circuits";
- 251 2) 9.2: Improvement of the text related to requirements that can be required at tender stage by the user
252 about reliability, the life duration of components and the documentation of the electronic equipment.;
- 253 i) Wording improvements and precisions added for Clause 10 Construction
- 254 1) 10.2.5: Added recommendation: "It is recommended to avoid integrated circuit socket and/or edge
255 connectors as far as possible";
- 256 2) 10.6.5: Applicable standard about defined flammability of rigid PCB: "The base material of the rigid
257 PCB shall be epoxy and woven glass fabric laminated sheet of defined flammability in accordance with
258 EN 45545-2:2020+A1:2023.";
- 259 3) 10.8.2: Precision about identification of subracks and PBA: "Means shall be provided on the subracks
260 and PBAs to indicate any revision/change in design or manufacturing.";

- 261 4) 10.11: Precision about “Materials and finishes”: “Potting to provide additional protection should only
 262 be used if it is necessary for technical reasons” and “Coating and potting materials may not need to be
 263 dimensionally stable as long as their thermal coefficient is considered to avoid high stress on
 264 components or assemblies”.
- 265 j) Revision of Clause 12 Documentation;
- 266 1) 12.1: Added requirement about identification of “documents or drawings submitted to the user”: “shall
 267 be identified by an appropriate and unambiguous reference, a date, a version or revision index, a
 268 record of changes and an explanatory title of the presented item and of the type of document or
 269 drawing.”;
- 270 2) 12.3: Precision about the datasheet content: “This document shall contain all information which the
 271 user needs to evaluate whether the electronic equipment fulfils the requirements covered by the scope
 272 of this document.”
- 273 3) 12.7: The design documentation structure is reorganised on the main topics: Hardware, User
 274 Programmable Integrated Circuits (UPIC) and Software.
- 275 4) Subclauses that were previously in the topic “Repair documentation”: (e.g.: “12.7.10.2 Circuit
 276 diagrams”, “12.7.10.3 Component list (Bill of material)” and 12.7.10.4 Component layout”) are moved
 277 to the “Hardware” main documentation topic.;
- 278 5) 12.7.3: The new standard reference about “Requirements for software development” is used: “All
 279 identified information items (documentation) shall be in accordance with EN 50716:2023.”
- 280 EN 50716 specifies the documentation required for the software development process but does not specify
 281 the documentation to provide to the user. In the EN 50155 scope, the following requirement is kept: “the
 282 supplier shall determine and list which information items are deliverable documents, consultable documents
 283 and non-deliverable documents and which information items are to be archived.”, but the following sentence
 284 is deleted: “At least the highly recommended documents (HR) in EN 50657:2017, Table A.1 column basic
 285 integrity shall be provided for non-safety related on-board equipment.”
- 286 6) 12.9.1: Precisions about Repair documentation – General: “The equipment detailed repair
 287 documentation is delivered only under specific request of the user and is subject to a contractual
 288 agreement between supplier and user regarding the contents, the confidentiality and the rights of use
 289 of this documentation.”
- 290 “NOTE The list, the description, reference of special tools and the list of declared non-repairable
 291 items, are not subjected to contractual agreement, confidentiality and right of use. (See: 12.9.2 and
 292 12.9.3);
- 293 k) Improvements of Clause 13 Testing;
- 294 1) 13.1 General: Added precisions about the test specification: “A test specification defines the test
 295 procedures and the acceptance criteria of the individual tests and the test sequence, if relevant. The
 296 test specification shall be written by the supplier”.
- 297 “NOTE Additional information are provided by Annex B for the verification of equipment by the system
 298 integrator at system level.”
- 299 2) 13.2.2: Added precision about type tests and “production serial tests”: “Equipment used for type tests
 300 shall previously been subjected to routine test. If the production routine tests are not ready at this step,
 301 they may be replaced by equivalent tests.”
- 302 3) 13.4 title: “Test specification” is renamed “Description of the tests”;

- 4) 13.4.2: Added precision about the performance test: "The performance test is carried out according to the test specification, which contains the performance test procedure, written by the supplier either for type test or for routine test."
- 5) Test descriptions for 13.4.5.1, 13.4.5.2, 13.4.5.2 and 13.4.6 are improved.
- 6) 13.4.7.1: The following sentence is added for insulation test: "During the test all input / output of the same equipotential area should be connected together in order to avoid damages due to unwanted voltages within the equipotential area."
- 7) 13.4.7.2: Additional details are provided for Insulation resistance test acceptance requirements when high impedance bleeder resistors are inserted between adjacent equipotential areas or between an equipotential area and functional earth.;
- 8) 13.4.8: Cyclic damp heat test: Additional details are provided for final test acceptance requirements:
- l) Improvement of informative Annex A - List of default requirements of EN 50155 and related subclauses; Content is updated;
- m) Improvement of informative Annex B - System testing approach (In particular B.10)
- n) Improvement of informative Annex C - Severity level of service conditions in different vehicle locations. (Figure C.2)
- o) Improvement of informative Annex D - Example for an equipment tests compliance summary sheet.
- p) Informative Annex E User programmable integrated circuit life cycle example.
- q) Improvement of informative Annex F – Design suggestions for electronic hardware used on rolling stock
- 1) F.1: Added precision: "The values given in Tables F.2 to F.19 are examples of typical use and can vary from one design to another."
- 2) F.2.2 Added precision: "Between battery referenced ports and earth, the use of voltage suppressors is not recommended to ensure high dielectric isolation between battery referenced ports and earth."
- 3) F.2.6 Prototype testing:
- "At prototype stage, all functions should be verified according to the specification. It is also recommended that the integrity of signals between parts of the circuit be investigated. Furthermore, it is strongly recommended to carry out the tests following the type test specification."
- "These tests are intended as investigation tests, but they cannot be used to produce a type test report. One of the reasons is that, normally, the prototype equipment is not manufactured according to the same manufacturing process as a series equipment."
- 4) F.2.7 Interfacing: About analogue and digital interfaces:
- "They should be designed as differential inputs and/or outputs to ensure adequate common-mode noise rejection."
- r) Improvement of informative Annex G - Electronic equipment not designed for use on rolling stock;
- 1) New text about "Applicability conditions for use of electronic equipment not designed for rolling stock";
- 2) New text about "electronic equipment properties list" that should be comparable to the requirements in this document.

- 340 3) New text about “Possible deviations or mitigations for the suitability evaluation”;
- 341 s) Improvement of informative Annex H – Paragraphs with agreements between the involved parties.
- 342 1) Added Note:
- 343 “NOTE Agreements between the involved parties (e.g. user and supplier) are not applicable to electronic
344 equipment that can be purchased as catalogue parts with qualification according to EN 50155. Since these
345 have been developed as generic products for a market, but not for a specific user”
- 346 t) Improvement of informative Annex I – Electronic equipment supplied from AC supply system;
- 347 1) Paragraph “I.1 General” is moved to 5.3.4.
- 348 2) New paragraph I.1 is renamed “Design and test provisions”
- 349 3) Table I.1 is completed by a new note:
- 350 If AC voltage is derived from an “AC Auxiliary Power converter” refer to EN 50533 for static voltage
351 tolerances and for short dips/interruptions.
- 352 If AC voltage is derived from any other AC source the technical specification of this local source, regarding
353 tolerances and short dips/interruptions, should be met. In the absence of information EN 50160 for static
354 voltage tolerances and EN IEC 61000-6-2 for short dips/interruptions should be used as a guide.
- 355 u) Improvement of informative Annex J - Typical content of datasheets
- 356 v) Improvement of informative Annex K - Insulation test and testing matrix example
- 357 w) Updated informative Annex ZZ - Relationship between this European Standard and the Essential
358 Requirements of EU Directive.
- 359 x) Updated Bibliography.
- 360 This document has been prepared under a standardization request addressed to CENELEC by the European
361 Commission. The Standing Committee of the EFTA States subsequently approves these requests for its
362 Member States.
- 363 For the relationship with EU Legislation, see informative Annex ZZ, which is an integral part of this document.

Introduction

This document specifies the requirements for design, manufacturing, documentation and testing of any electronic equipment installed on-board of rolling stock.

It also describes the electrical and environmental operating conditions.

The aim of this document is not to be a detailed guideline for the design of the electronic equipment. The design is the supplier's responsibility. However, some recommendations are given in informative annexes in order to draw the attention of the designer on known design aspects. The supplier should take into account the requirements resulting from the specific location of the on-board installation (see Annex C).

The roles of user and/or supplier are shown in Figure 1 below.

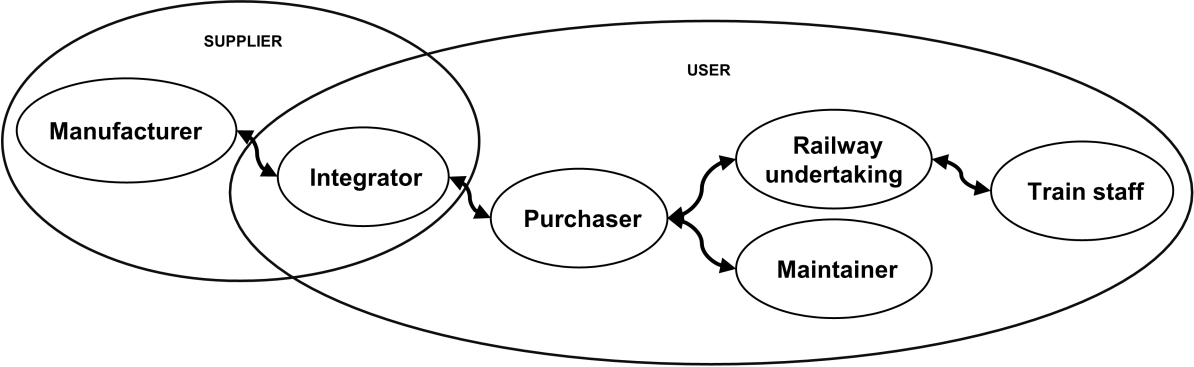


Figure 1 — Roles and relationship of user and/or supplier

This **document** primarily specifies requirements for electronic equipment that is developed and manufactured according to user specifications.

The requirements also apply to electronic equipment that can be purchased as catalogue parts with qualification in accordance with EN 50155. Since these have already been developed before purchase, the agreements between the involved parties (e.g. user and supplier) described in this document (see Annex H) are not applicable.

1 Scope

This document is applicable to all electronic equipment for control, regulation, protection, diagnostic, energy supply, etc. installed on rail vehicles.

For the purpose of this document, electronic equipment is defined as equipment composed of electronic components (e.g. resistors, capacitors, transistors, diodes, integrated circuits, hybrids, application specific integrated circuits, wound components and relays), and recognized associated components (e.g. connectors, mechanical parts). These components are mainly mounted on printed circuit boards.

Sensors (e.g. current, voltage, speed) and semiconductor drive units for power electronic devices are covered by this document. Complete semiconductor drive units and power converters are covered by EN 61287-1.

This document covers the requirements for operating conditions, design, documentation, testing and integration of electronic equipment, as well as hardware and software requirements considered necessary for compliant and reliable equipment.

Specific requirements related to practices necessary to ensure defined safety integrity level or functional safety are not covered by this document. Nevertheless, this document is applicable to the hardware of all rolling stock electronic equipment or systems performing safety-related functions.

The software development requirements for on-board railway equipment are specified by EN 50716.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

NOTE The version of IPC normative references, herein after listed, is identified by the last letter of the identification code, e.g. the letter K in IPC-A-600K identify the version K which was published in July 2020. However, the publication date is reported, even though implicit in the last letter. Consequently, the date is not repeated in the text of this document when the IPC normative references appear.

EN 45545-1:2013, *Railway applications - Fire protection on railway vehicles - Part 1: General*

EN 45545-2:2020+A1:2023, *Railway applications - Fire protection on railway vehicles - Part 2: Requirements for fire behaviour of materials and components*

EN 45545-5:2013+A1:2015, *Railway applications - Fire protection on railway vehicles - Part 5: Fire safety requirements for electrical equipment including that of trolley buses, track guided buses and magnetic levitation vehicles*

EN 50121-3-2:2016,¹ *Railway applications - Electromagnetic compatibility - Part 3-2: Rolling stock - Apparatus*

EN 50124-1:2017, *Railway applications - Insulation coordination - Part 1: Basic requirements - Clearances and creepage distances for all electrical and electronic equipment*

EN 50125-1:2014, *Railway applications - Environmental conditions for equipment - Part 1: Rolling stock and on-board equipment*

EN 50126-1:2017, *Railway Applications - The Specification and Demonstration of Reliability, Availability, Maintainability and Safety (RAMS) - Part 1: Generic RAMS Process*

¹ As impacted by EN 50121-3-2:2016/A1:2019.

- 418 EN 50153:2014,² *Railway applications - Rolling stock - Protective provisions relating to electrical hazards*
- 419 EN 50163:2004,³ *Railway applications - Supply voltages of traction systems*
- 420 EN 50343:2014,⁴ *Railway applications - Rolling stock - Rules for installation of cabling*
- 421 EN 50533:2011,⁵ *Railway applications - Three-phase train line voltage characteristics*
- 422 EN 50716:2023, *Railway Applications - Requirements for software development*
- 423 EN 60068-2-1:2007, *Environmental testing - Part 2-1: Tests - Test A: Cold*
- 424 EN 60068-2-2:2007, *Environmental testing - Part 2-2: Tests - Test B: Dry heat*
- 425 EN IEC 60068-2-11:2021, *Environmental testing - Part 2-11: Tests - Test Ka: Salt mist*
- 426 EN 60068-2-30:2005, *Environmental testing - Part 2-30: Tests - Test Db: Damp heat, cyclic (12 h + 12 h cycle)*
- 427 EN 60297-3-100:2009, *Mechanical structures for electronic equipment - Dimensions of mechanical structures*
428 *of the 482,6 mm (19 in) series - Part 3-100: Basic dimensions of front panels, subracks, chassis, racks and*
429 *cabinets*
- 430 EN 60297-3-101:2004, *Mechanical structures for electronic equipment - Dimensions of mechanical structures*
431 *of the 482,6 mm (19 in) series - Part 3-101: Subracks and associated plug-in units*
- 432 EN 60529:1991,⁶ *Degrees of protection provided by enclosures (IP Code)*
- 433 EN 61373:2010,⁷ *Railway applications - Rolling stock equipment - Shock and vibration tests*
- 434 EN ISO 13732-1:2008, *Ergonomics of the thermal environment - Methods for the assessment of human*
435 *responses to contact with surfaces - Part 1: Hot surfaces (ISO 13732-1:2006)*
- 436 ISO/IEC/IEEE 15289:2019, *Systems and software engineering — Content of life-cycle information items*
437 *(documentation)*
- 438 IPC-A-600K,⁸ *Acceptability of Printed Boards (Published date: 2020-07-01)*
- 439 IPC-A-610J,⁹ *Acceptability of Electronic Assemblies (Published date: 2024-04-04)*

² As impacted by EN 50153:2014/A1:2017 and EN 50153:2014/A2:2020.

³ As impacted by EN 50163:2004/A1:2007, EN 50163:2004/corrigendum May 2010, EN 50163:2004/A2:2020, EN 50163:2004/A3:2022 and EN 50163:2004/AC:2013.

⁴ As impacted by EN 50343:2014/A1:2017.

⁵ As impacted by EN 50533:2011/A1:2016.

⁶ As impacted by EN 60529:1991/corrigendum May 1993, EN 60529:1991/A1:2000, EN 60529:1991/A2:2013, EN 60529:1991/A2:2013/AC:2019-02, and EN 60529:1991/AC:2016-12.

⁷ As impacted by EN 61373:2010/AC:2017-09.

⁸ Equivalent standards published by an official international or European standardization body could in the future become available, covering the same requirements now covered by this IPC standard.

⁹ Equivalent standards published by an official international or European standardization body could in the future become available, covering the same requirements now covered by this IPC standard.

440 IPC-7711/21D,¹⁰ *Rework, Modification and Repair of Electronic Assemblies* (Published date: 2024-01-01)

441 3 Terms, definitions and abbreviations

442 3.1 Terms and definitions

443 For the purposes of this document, the following terms and definitions apply.

444 ISO and IEC maintain terminology databases for use in standardization at the following addresses:

445 — IEC Electropedia: available at <https://www.electropedia.org/>

446 — ISO Online browsing platform: available at <https://www.iso.org/obp>

447 3.1.1

448 **printed board**

449 **printed circuit board**

450 **PCB**

451 base material which is cut to size containing all required holes and incorporating at least one conductive layer

452 Note 1 to entry: Printed circuit boards are typically subdivided according to:

453 — their structure (e.g. single and double sided, multilayers);

454 — the nature of the base material (e.g. rigid, flexible).

455 Note 2 to entry: In some standards instead of printed circuit board the synonym printed board is used.

456 [SOURCE: IEC 60050-541:1990, 541-01-03, modified – “printed circuit board” has been added as synonym of
457 the entry. “which is” has been added. “bearing” has been replaced by “incorporating”. “pattern” has been
458 replaced by “layer”. Note 1 to entry has been added.]

459 3.1.2

460 **printed board assembly**

461 **PBA**

462 printed circuit board with electrical and mechanical components and/or other printed board assemblies attached
463 to it with all manufacturing processes, soldering, coating, etc., completed

464 3.1.3

465 **operating temperature**

466 <of electronic equipment> temperature range in which the electronic equipment is operating as specified (e.g.
467 temperature inside cubicle, temperature inside rack, temperature inside roof box, temperature surrounding
468 cubicle inside vehicle)

469 Note 1 to entry: Outside of the operating temperature range there can be temporary or permanent degradation of the
470 equipment performances.

471 3.1.4

472 **plug-in unit**

473 unit which plugs into a subrack and is supported by guides

474 Note 1 to entry: Plug-in units can be of various types, e.g. a PBA with or without enclosure designed with a plug-in
475 connection to be inserted into a subrack.

¹⁰ Equivalent standards published by an official international or European standardization body could in the future become available, covering the same requirements now covered by this IPC standard.

[SOURCE: IEC 60050-581:2008, 581-25-04, modified – The Note 1 to entry has been modified.]

3.1.5

subrack

structural unit for housing PBA/PBAs and plug-in units

[SOURCE: IEC 60050-581:2008, 581-25-01, modified – The terminological entry “rack” has been replaced by “subrack”, “printed boards with components inserted” has been replaced with “PBA/PBAs“.]

3.1.6

rack

free-standing or fixed structure for housing electrical and electronic equipment

[SOURCE: IEC 60050-581:2008, 581-25-03]

3.1.7

enclosure

<of electrical or electronic equipment> adequate housing provided by the equipment manufacturer to mount the equipment and to protect it from accidental damage, and occasionally from electromagnetic fields or environmental effects

Note 1 to entry: The equipment housing can offer protection to personnel, e.g. from electric shock.

Note 2 to entry: Several enclosure types are given in Figure 2

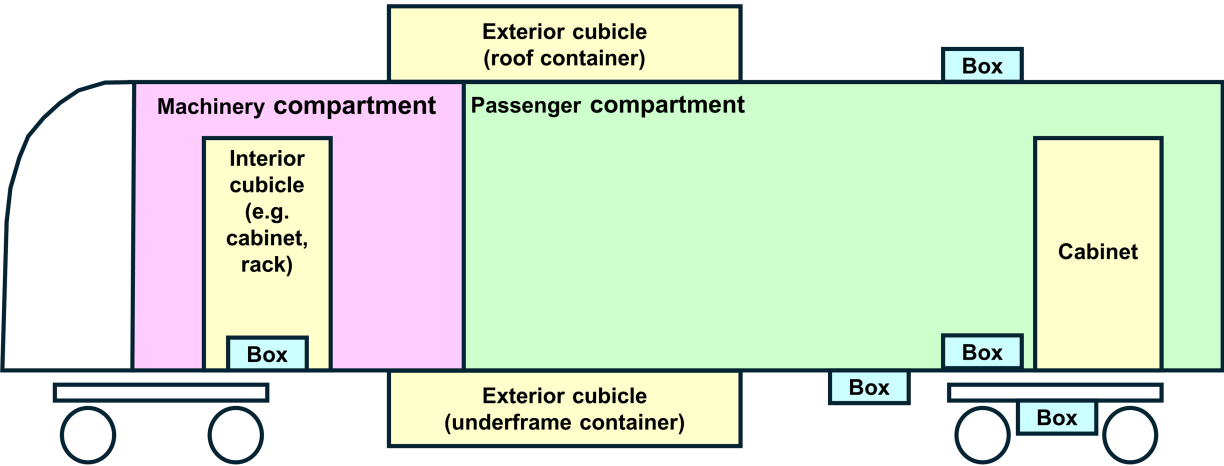


Figure 2 — Types of enclosures

[SOURCE: IEV 821-01-54, modified – The term “equipment housing” has been replaced by “enclosure”. In the definition the words “case, or other protective housing,” has been replaced by “adequate housing for electrical and/or electronic equipment,“. The 2nd and 3rd sentence of the Note 1 to entry has been omitted.]

3.1.8

cubicle

enclosure for whole equipment, including electrical, electronic and mechanical parts (e.g. converter, inverter)

EXAMPLE cabinet, roof container, underframe container

3.1.9

box

enclosure for smaller equipment, including electrical, electronic and mechanical parts

- 505 **3.1.10**
 506 **line replaceable unit**
 507 **LRU**
 508 unit which can be removed from a railway system and replaced by an operating unit with the same function in
 509 order to restore the operational capability of the system
- 510 **3.1.11**
 511 **performance test**
 512 test in which all functions of the equipment are stimulated and verified in accordance with the specified functional
 513 requirements
- 514 Note 1 to entry: The performance test is carried out according to the test specification which describes the performance
 515 test procedure and is provided by the supplier.
- 516 **3.1.12**
 517 **operational check**
 518 tailored performance test which is carried out during and/or after environmental tests or stress screening
 519 sufficient to prove that the equipment is still functioning within its operational limits
- 520 Note 1 to entry: Each environmental test or stress screening can use a different operational check.
- 521 Note 2 to entry: Operational checks are carried out according to operational check specifications and operational check
 522 procedures provided by the supplier.
- 523 **3.1.13**
 524 **system power supply**
 525 combination of vehicle battery and battery charger to provide the DC on-board supply voltage
- 526 Note 1 to entry: see Figure 3.
- 527 **3.1.14**
 528 **power supply**
 529 <of electronic equipment> unit used to supply the electronic equipment with electrical energy
- 530 Note 1 to entry: The power supply can be also part of the equipment.
- 531 Note 2 to entry: See Figure 3 and Figure 4.
- 532 **3.1.15**
 533 **supply voltage**
 534 <of electronic equipment> voltage at the supply terminals of the electronic equipment
- 535 **3.1.16**
 536 **vehicle cabling**
 537 all cabling which can be connected to the power supply, and all other cabling outside of the electronic equipment
- 538 **3.1.17**
 539 **supply overvoltage**
 540 disturbance to the system power supply (e.g. caused by battery charger malfunction or by load drop)
- 541 Note 1 to entry: A supply overvoltage will occur as an increase in the level of the supply voltage.
- 542 **3.1.18**
 543 **energetic transient pulses**
 544 non-periodic and relatively short positive and negative pulse or sequence of pulses of voltage and/or current

3.1.19

failure

<of an item> loss of ability to perform as required

Note 1 to entry: "Failure" is an event, as distinguished from "fault", which is a state.

Note 2 to entry: Attention is drawn to the possibility of a consequential failure of a second item of equipment resulting from a temporary malfunction of an item of equipment connected to it.

Note 3 to entry: A temporary malfunction will not be considered as a failure provided that the equipment recovers normal operation automatically following malfunction.

[SOURCE: IEC 60050-192:2015, 192-03-01, modified – different notes to entry]

3.1.20

damage

<to an electronic equipment> change in visual appearance or alteration of electrical or mechanical integrity

3.1.21

useful life

<of an item> time interval, from first use until user requirements are no longer met, due to economics of operation and maintenance, or obsolescence

Note 1 to entry: In this context, "first use" excludes testing activities prior to hand-over of the item to the end-user.

Note 2 to entry: For a repairable item the individual useful life can be ended by a failure which is not considered as repairable for any reason.

[SOURCE: IEC 60050-192:2015, 192-02-27, modified – Note 2 to entry has been added]

3.1.22

fault

<of an item> inability to perform as required, due to an internal state

Note 1 to entry: A fault of an item results from a failure, either of the item itself, or from a deficiency in an earlier stage of the life cycle, such as specification, design, manufacture or maintenance. See latent fault (IEV 192-04-08).

Note 2 to entry: Qualifiers, such as specification, design, manufacture, maintenance or misuse, may be used to indicate the cause of a fault.

Note 3 to entry: The type of fault can be associated with the type of associated failure, e.g. wear-out fault and wear-out failure.

Note 4 to entry: The adjective "faulty" designates an item having one or more faults.

[SOURCE: IEC 60050-192:2015, 192-04-01]

3.1.23

performance

characteristics defining the ability of an equipment to achieve the intended functions

[SOURCE: IEC 60050-311:2001, 311-06-11, modified – "quantitative" has been added. "a measuring instrument" has been replaced with "an equipment".]

3.1.24

performance criterion

<for electronic equipment> criterion specified for validation of the operation of the electronic equipment throughout the test conditions

- 585 **3.1.25**
 586 **user**
 587 <of electronic equipment> person or organization that receives and specifies equipment or software for further
 588 use, and that can be:
- 589 — a system integrator in relationship to the manufacturer;
 - 590 — a purchaser;
 - 591 — a maintainer;
 - 592 — a railway undertaking.
- 593 **3.1.26**
 594 **manufacturer**
 595 <of electronic equipment> party who develops and manufactures the electronic equipment
- 596 **3.1.27**
 597 **system integrator**
 598 party who is responsible for the specification and/or the integration of the electronic equipment into the railway
 599 vehicle or vehicle subsystem
- 600 **3.1.28**
 601 **system**
 602 set of interrelated elements considered in a defined context as a whole and separated from their environment
- 603 [SOURCE: IEC 60050-351:2013, 351-42-08, modified — The notes to entry have been omitted.]
- 604 **3.1.29**
 605 **equipment**
 606 single device or set of devices, or the set of main devices of an installation, or all devices necessary to perform
 607 a specific task
- 608 [SOURCE: IEC 60050-151:2001, 151-11-25, modified — The note to entry and the term apparatus have been
 609 omitted.]
- 610 **3.1.30**
 611 **component**
 612 constituent part of a device which cannot be physically divided into smaller parts without losing its particular
 613 function
- 614 [SOURCE: IEC 60050-151:2001, 151-11-21]
- 615 **3.1.31**
 616 **device**
 617 material element or assembly of such elements intended to perform a required function
- 618 Note 1 to entry: A device can form part of a larger device.
- 619 [SOURCE: IEC 60050-151:2001, 151-11-20]
- 620 **3.1.32**
 621 **package**
 622 **case**
 623 enclosure for one or more chips, film elements or other components, that allows electrical connection and
 624 provides mechanical and environmental protection
- 625 [SOURCE: IEC 60050-521:2002, 521-05-31, modified — “case” has been added as synonym.]

626 **3.1.33**

627 **item**

628 <electronic equipment on rolling stock> part, component, device, subsystem, functional unit, equipment or
629 system that can be individually considered

630 **3.1.34**

631 **event**

632 <electronic equipment on rolling stock> something that occurs in a certain place during a particular interval of
633 time

634 **3.1.35**

635 **supplier**

636 <electronic equipment on rolling stock> organization which has the responsibility for the supply of an individual
637 item of equipment or groups of the equipment to the user

638 Note 1 to entry: This can be:

639 — a manufacturer;

640 — a system integrator in relation to railway undertaking or maintainer.

641 **3.1.36**

642 **commercial off-the-shelf equipment/components**

643 item purchased from a supplier's catalogue, commercially available on the market, according to a supplier
644 reference, and for which the user has no control over the design definition or on the production

645 Note 1 to entry: The item can be modified, and manufacturing or maintenance can be discontinued without the user being
646 notified.

647 **3.1.37**

648 **equipotential area**

649 area of electronic components and electric connections referenced to the same potential and without insulation
650 between the electronic components

651 **3.1.38**

652 **DC ripple factor**

653 ratio of half the difference between the maximum and minimum value of a pulsating voltage to the mean value
654 of this voltage

655 Note 1 to entry: With low values of the DC ripple factor this quantity is approximately equal to the ratio of the difference to
656 the sum of the maximum and the minimum values.

657 [SOURCE: IEC 60050-551:1998, 551-17-29, modified – “direct current” has been replaced by “voltage”]

658 **3.1.39**

659 **Extra Low Voltage circuit**

660 **ELV circuit**

661 secondary circuit with voltages between any two conductors of the circuit, and between any one such conductor
662 and earth, not exceeding AC 25 V or DC 60 V, under normal operating conditions, which is separated from
663 hazardous voltage by basic insulation

664 Note 1 to entry: The values AC 25 V and DC 60 V are taken from band I of EN 50153:2014.

665 **3.1.40**

666 **functional earth**

667 terminal for earthing in a system or in an installation or in equipment, for purposes other than electrical safety

668 [SOURCE: IEC 60050-195:2001, 195-01-13, modified – the term “functional earthing” has been replaced by
669 “functional earth”, “earthing a point or points” has been replaced by “terminal for earthing”]

670 **3.1.41**

671 **terminal**

672 conductive part of a device, electric circuit or electric network, provided for connecting that device, electric circuit
673 or electric network to one or more external conductors

674 [SOURCE: IEC 60050-151:2001, 151-12-12, modified – Note which is not relevant in the context of this standard
675 omitted]

676 **3.1.42**

677 **adjacent circuit**

678 circuit next to the circuit under consideration having a requirement for functional, simple or protective insulation

679 [SOURCE: IEC 62477-1, ed. 1.0 (2012-07)]

680 **3.1.43**

681 **specification**

682 document stating requirements

683 Note 1 to entry: A specification can be related to activities (e.g. test specification) or products (e.g. product specification,
684 interface specification, performance specification).

685 [SOURCE: ISO 9000 2015, 3.8.7, modified – Example and Note 2 which are not relevant in the context of this
686 standard omitted, Note1 modified]

687 **3.1.44**

688 **procedure**

689 specified way to carry out an activity or a process

690 [SOURCE: ISO 9000:2015, 3.4.5 - modified – Note which is not relevant in the context of this standard omitted]

691 **3.1.45**

692 **ancillary component**

693 <of electronic equipment> component providing something additional to a main part or function .e.g. casing,
694 cabling, mechanical fixing part, insulation components

695 **3.2 Abbreviations**

696 For the purposes of this document, the following abbreviations apply.

AC	Alternating Current
ASIC	Application Specific Integrated Circuit
ATE	Automatic Test Equipment
CAN	Controller Area Network bus
CMRR	Common Mode Rejection Ratio
CPLD	Complex Programmable Logic Device
CPU	Central Processing Unit
CTR	Current Transfer Ratio
DC	Direct Current
ELV	Extra Low Voltage
EMC	Electromagnetic Compatibility

ESD	Electrostatic Discharge
FPGA	Field Programmable Gate Array
GBWP	Gain–Bandwidth Product
IEV	International Electrotechnical Vocabulary
I/O	Input Output
IP Code	International Protection Code
LED	Light Emitting Diode
LRU	Line Replaceable Unit
MTBF	Mean Time Between Failures
MVB	Multifunction Vehicle Bus
NA	Not Applicable
PBA	Printed Board Assembly
PCB	Printed Circuit Board
PLD	Programmable Logic Device
PPS	Polyphenylene Sulfide
PTE	Portable Test Equipment
RAMS	Reliability Availability, Maintainability and Safety
RF	Radio Frequency
RH	Relative Humidity
RMS	Root Mean Square (value of a quantity)
TCMS	Train Control and Management System
TFT	Thin-Film-Transistor (display)
UPIC	User Programmable Integrated Circuit
UV	Ultraviolet

4 General requirements

4.1 Requirement for equipment characteristics

The requirements for equipment characteristics (e.g. functional, electrical, mechanical, appearance, interfaces) shall be defined by the user or derived from market needs for a generic equipment.

The supplier will generate a technical specification how to fulfil these requirements.

4.2 Classes of environmental, constructional and service conditions

This document specifies a set of default classes of requirements; different classes may be requested at tender stage.

The summary of default requirements is given in Annex A.

4.3 Performance criteria

4.3.1 General

The expected performance (i.e. the equipment is functioning as specified), from the equipment under test, shall be specified for all operational conditions.

710 No damage to any connected equipment is allowed when the electronic equipment does not operate as intended
 711 during or after the test.

712 **4.3.2 Performance criterion A**

713 The equipment shall continue to operate as specified during and after the test and/or during and after an
 714 environmental disturbance.

715 No degradation of performance or loss of function is allowed.

716 Changes of actual operating state or stored data are not allowed.

717 Performance criterion A also satisfies performance criteria B and C.

718 **4.3.3 Performance criterion B**

719 The equipment shall continue to operate as specified after the test or after an environmental disturbance.

720 However, during the test or an environmental disturbance, degradation of performance is allowed.

721 Changes of actual operating state or stored data are not allowed.

722 Performance criterion B also satisfies performance criterion C.

723 **4.3.4 Performance criterion C**

724 During the test or during an environmental disturbance, temporary loss of function is allowed.

725 The equipment:

726 — shall automatically restart. The normal performance shall be obtained within a maximum defined time. After
 727 this time the equipment shall retain the previous operating state and shall work as intended. The loss of
 728 significant stored data are not allowed;

729 NOTE Significant stored data are application dependent and stated in the equipment documentation.

730 or:

731 — shall be manually restarted or process-controlled restarted. In this case the restart process shall be clearly
 732 defined in the user manual and agreed between user and supplier at tender stage.

733 **4.4 Environmental service conditions**

734 **4.4.1 Altitude**

735 The altitude at which the equipment is normally to function should not exceed the values called for in
 736 EN 50125-1:2014, Table 1 “Classes of altitude range”. If the required altitude exceeds the one specified in
 737 EN 50125-1:2014, Table 1 class A1, compliance with the requirements shall be agreed between the involved
 738 parties.

739 Unless otherwise specified, the requirements of EN 50125-1:2014, Table 1 class A1 apply.

740 **4.4.2 Operating temperature**

741 In order to fulfil the general environmental requirements stated in EN 50125-1:2014, Table 2 and considering
 742 that the on-board electronic equipment may be installed in significantly different locations, e.g. inside the vehicle
 743 or outside the vehicle on the roof and under car body, the electronic equipment itself shall be designed and
 744 manufactured to meet the specification for the selected operating temperature class (OTx) as stated in Table 1
 745 below:

Table 1 — Operating temperature classes

Class	Operating temperature range (°C)
OT1	–25 to +55
OT2	–40 to +55
OT3	–25 to +70
OT4	–40 to +70
OT5	–25 to +85
OT6	–40 to +85

Operating temperature classes OT1 and OT2 are mainly applicable for equipment in passenger compartments and the driver's cab with a reference permanent temperature of 25 °C. The temperature of 25 °C corresponds to the ambient temperature of the unit during its service life with its effects on material ageing.

Operating temperature classes OT3 and OT4 are mainly applicable for equipment in cabinets / cubicles with a reference permanent temperature of 45 °C. The temperature of 45 °C corresponds to the ambient temperature of the unit during its service life with its effects on material ageing.

It is not recommended to use classes OT5 and OT6 as a general requirement for operating temperature. Classes OT5 and OT6 can be applicable for PBA inside a subrack or inside an enclosure when it is necessary because of the internal enclosure temperature, for semiconductor drive units or for combustion engine control units (see also Figure C.1).

Unless otherwise specified, the requirements of class OT3 apply.

The design should take into account temperature rises within cubicles and enclosures to ensure that the components do not exceed their specified temperature ratings. It is expected that the air temperature surrounding the individual PBA can increase, for example between 10 °C ... 15 °C (this temperature rise depends significantly on the power dissipation of the PBA itself and on the power dissipation of other PBAs in the vicinity of it, on the natural or forced air flow, etc.). This should be taken into account for the design of the PBA, particularly when individual PBAs are intended to be horizontally or vertically juxtaposed or when sub-racks containing the PBAs are superposed.

The supplier should take into account the requirements resulting from the specific on-board installation constraints. Examples therefore are given in Annex C, Figure C.1.

The supplier of the electronic equipment shall specify its power dissipation and the thermal integration constraints (e.g. natural convection, forced air cooling, cooled plate, mounting position, free space inside integration volume, preheating, air outlet) to respect a correct integration of this electronic equipment into its operating environment.

The user of the electronic equipment shall respect the thermal integration constraints specified by the supplier and shall design the integration environment in order to ensure consistency between the operating temperature and the operating temperature class of the electronic equipment to be integrated.

The requirements for active or assisted cooling system shall be described in accordance with 12.5.

“Electronic equipment” and “Integration environment” are generic designations applicable to several levels; some examples are listed below:

- an “Enclosed” or “Open frame” piggyback module integrated on a PCB;
- a “PBA” or a “Plug-In unit” integrated into a “Sub-rack”;
- a “PBA” integrated into an “Enclosure”;

781 — a “Sub-rack” integrated into a “Container”; “Cubicle” or “Cabinet”;

782 — a “Rack” or a “Box” integrated into a “Vehicle”.

783 The ambient temperatures outside vehicle are defined in EN 50125-1:2014, Table 2, column 1.

784 4.4.3 Increased operating temperature at switch-on

785 In some situations (e.g. dissipation of part with important thermal inertia that continues to dissipate energy inside
786 the cubicle when forced ventilation is switched off, effect of solar radiation on equipment, assisting cooling
787 system shutdown), it is possible that the temperature of the equipment at switch-on is above the maximum
788 temperature defined by the operating temperature class.

789 Depending on the severity of these effects, there are three classes of switch-on at increased operating
790 temperatures which are described by the corresponding type test cycles.

791 **Table 2 — Classes for increased operating temperature at switch-on**

Class	Increased operating temperature at switch-on	Thermal test cycle See 13.4.5
ST0	OTx (no increased temperature)	Test cycle A
ST1	OTx +15 °C	Test cycle B
ST2	OTx +15 °C	Test cycle C
NOTE “OTx +15 °C” = maximum temperature of OTx operating temperature range +15 °C (with “OTx” classes = OT1, OT2, OT3, OT4).		

792 Class ST1 and ST2 do not apply to classes OT5 and OT6.

793 Unless otherwise specified, the requirements of class ST1 apply.

794 The equipment shall pass the continuous operational checks applied during the increased operating
795 temperature for classes ST1 and ST2.

796 4.4.4 Rapid temperature variations

797 Rapid external ambient temperature variations resulting from running through tunnels shall be taken into
798 account depending on the installation location.

799 The temperature variation seen by the equipment depends on the installation location (see Figure C.1 and
800 Table C.1; locations 4, 5, 6, 7 are particularly exposed).

801 The following classes define the requirements that the equipment shall fulfil:

802

Table 3 — Temperature variation classes

Class	Column 1	Column 2	Column 3
	Cold air temperature surrounding the equipment (RH not relevant)	Hot air temperature surrounding the equipment	External temperature gradient
H1	No requirements	No requirements	No requirements
H2	−25 °C	+15 °C / 95 %RH	±3 K/s ^a
	+10 °C	+40 °C / 60 %RH	±3 K/s ^a
^a The temperature gradient might be higher than ± 3 K/s dependent on the special installation condition of the equipment and the speed of the vehicle. If it is different from ± 3 K/s, it should be specified. NOTE 1 The H2 class takes into account the situation of a vehicle entering into a tunnel from low temperature environment (rapid change from −25°C to +15°C) or exiting from a tunnel into a hot and wet environment (rapid change from +10°C to +40°C). Condensation phenomena occur in both cases. NOTE 2 The unit Kelvin [K] is used in case of a temperature variation or temperature difference or temperature gradient.			

803 The values given in Table 3, Class H2 are worst case values which will typically not occur regularly throughout
804 the year. Both directions of the rapid temperature change shall be taken into account.

805 Class H2 cannot be used as a general requirement for temperature and humidity change in vehicle (e.g. can be
806 used for equipment mounted outside vehicle body).

807 If class H2 is required, the duration of the exposure to temperature from column 1 and column 2 shall be
808 specified (typical and worst case).

809 Furthermore, the frequency of occurrence of the rapid temperature change shall be specified.

810 Unless otherwise specified, the requirements of class H1 apply.

811 **4.4.5 Shock and vibration**

812 The equipment shall be able to withstand, without deterioration or malfunction, vibrations and shocks that occur
813 in service.

814 The level of shock and vibration that the equipment can withstand in normal operation shall be specified. This
815 shall be done using the Categories and Classes as specified by EN 61373:2010. The supplier shall specify the
816 permitted orientation for mounting the equipment on the vehicle according to the definitions of EN 61373:2010.

817 Unless otherwise specified, the requirements of EN 61373:2010 category 1 class B apply.

818 **4.4.6 Electromagnetic compatibility**

819 All electronic equipment shall fulfil the requirements of EN 50121-3-2:2016.

820 **4.4.7 Relative humidity**

821 External relative humidity values and duration exposure to consider are specified in EN 50125-1:2014.

822 The following shall be taken into account in order to avoid malfunction or failure due to relative humidity (see also
823 Annex C):

824 — air temperature surrounding the electronic equipment;

825 — service conditions (e.g. pollution degree of EN 50124-1);

- 826 — rolling stock installation location;
- 827 — type of enclosure (IP Code of EN 60529:1991).

828 **4.5 Special service conditions**

829 **4.5.1 General**

830 Special arrangements shall be agreed between the involved parties when service conditions can be proved
 831 different from those mentioned in 4.4 (e.g. bogie mounted equipment or equipment integrated into a power
 832 converter). For checking the functionality and the expected performance of such arrangements, optional type
 833 tests can be carried out on the vehicle itself in accordance with methods to be agreed between the involved
 834 parties.

835 **4.5.2 Atmospheric pollutants**

836 It is to be expected that the equipment is exposed throughout its life to various pollutants (e.g. oil mist, salt
 837 spray, conductive dust, sulphur dioxide, microorganism like fungi and mould). The types of pollutants, their
 838 concentration, test procedures and test specifications should be defined in the tender documents.

839 **4.6 Installation requirements**

840 **4.6.1 General**

841 The manufacturer shall provide the installation manual of the equipment.
 842 The integrator shall ensure that the installation requirements are taken into account.
 843 The requirements in the following 4.6.2 to 4.6.8 are necessary for the installation to maintain the full functionality
 844 of the equipment.

845 **4.6.2 Installation instructions**

846 The installation manual of the equipment shall contain the specific installation instructions, see 12.5 for details.

847 **4.6.3 Battery voltage supply system**

848 The battery voltage supply system for the electronic equipment should be provided by a separate conductor
 849 connected as directly as possible to the source or the main battery line. The separated conductor should only
 850 be used for the supply to electronic circuits.

851 EN 50343:2014 provides additional recommendations.

852 Calculations for the cabling of the battery voltage supply system and the protection against overcurrent shall
 853 take into account the power demand and the inrush current specified in the datasheet or in the installation
 854 manual of the equipment.

855 **4.6.4 Thermal compatibility**

856 When integrating the electronic equipment into its operating environment, the thermal integration constraints
 857 specified in the equipment datasheet or in the installation manual shall be taken into account. In addition, the
 858 integration environment shall be designed to ensure that the operating temperature matches the operating
 859 temperature class of the integrated electronic equipment.

860 **4.6.5 Electromagnetic compatibility**

861 The installation of the electronic equipment shall be arranged to reduce, as far as possible, the effects of
 862 electrical/electromagnetic disturbances to the electronic equipment and as far as possible the effect of
 863 emissions by the equipment to the electrical/electronic system of the rolling stock in accordance with
 864 EN 50121-3-2:2016.

4.6.6 Cabling inside vehicle

The vehicle cabling shall be done in accordance with EN 50343:2014.

Requirements for special cabling (e.g. for sensors, transducers and communication lines) should be taken into account.

4.6.7 Wiring inside equipment

As far as possible, wiring inside equipment should be done in accordance with the rules of EN 50343:2014. Useful hints are available in Annex F.

Requirements for special wiring (e.g. for sensors, transducers and communication lines) should be taken into account.

The installation requirements of devices/equipment intended to be integrated into another equipment shall be respected.

4.6.8 Insulation of the installation

The insulation coordination requirements are defined in EN 50124-1:2017. Test voltages are specified in EN 50343:2014.

5 Electrical service conditions

5.1 Typical supply systems

5.1.1 General

Typical architectures for supply systems are illustrated in Figure 2 of CLC/TS 50534:2010.

5.1.2 DC supply system

A typical topology of on-board DC supply system of rolling stock is given in Figure 3:

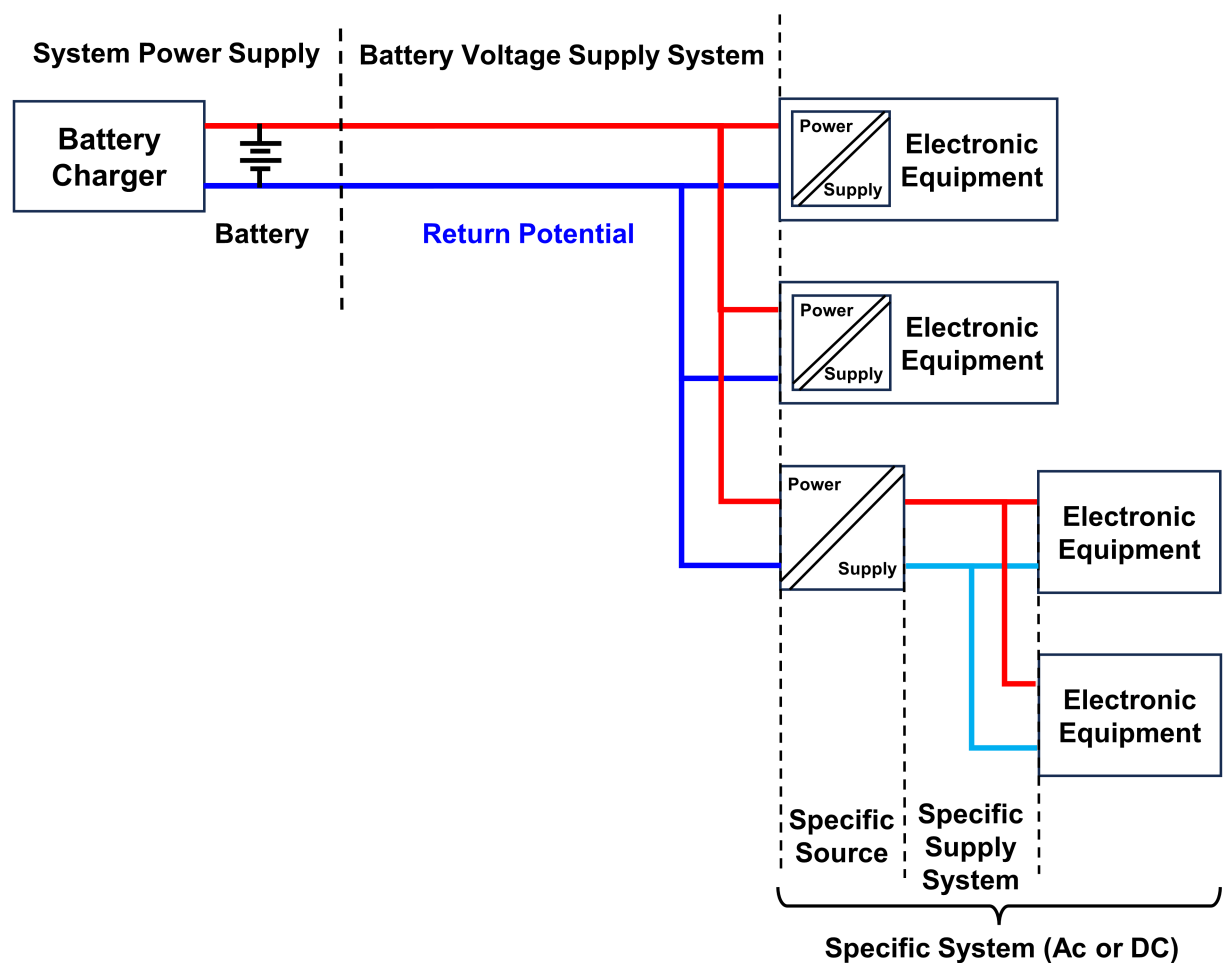


Figure 3 — Topology of on-board DC supply system

The system power supply is composed by the vehicle battery and the battery charger. Normally the battery is charged from battery chargers, auxiliary inverters or motor-generators with associated electronic regulations.

5.1.3 AC supply system

A typical topology of on-board AC supply system of rolling stock with an AC auxiliary power converter as intended in EN 50533:2011 is given in Figure 4:

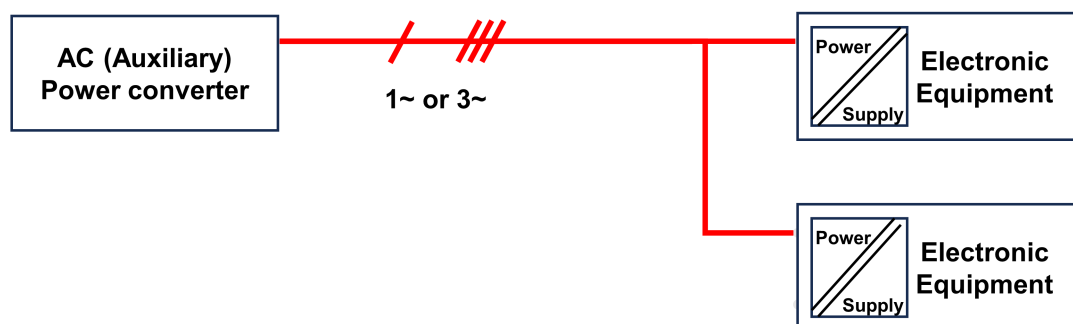


Figure 4 — Topology of on-board AC supply system (1~ or 3~)

5.2 Battery voltage supply system

5.2.1 General

The battery voltage supply system can be of the following types:

- Battery voltage supply system referred to vehicle body: One of the poles of the battery voltage supply system is connected (directly or by an impedance) to the vehicle body;
- Floating battery voltage supply system: No galvanic connection between the battery voltage supply system and the vehicle body.

In general, the electronic equipment shall work with both types of battery voltage supply systems unless the system integrator specifies the type of battery voltage supply system.

The battery referenced ports of the equipment shall be insulated from earth and from other internal circuits of the equipment which are not referenced to the battery voltage supply system (see Annex K).

5.2.2 Supply voltage range

The nominal voltage (U_n) of the electronic equipment should be selected from amongst the following values:

24 V, 28 V, 36 V, 48 V, 72 V, 96 V, 110 V.

The recommended values are the following:

24 V, 72 V, 110 V.

These **nominal voltage** values are given as standardized values for the design of equipment.

The nominal voltage should not be considered as the off-load battery voltage as it is determined by the type of battery, the number of cells and the operating conditions. The nominal voltage represents approximately the output voltage of a charged battery with low load.

The **rated voltage** value represents the charging voltage of a battery powered supply system under normal conditions.

All requirements related to power supply (with possible exception for interruptions of supply voltage in 5.2.4 and supply change-over in 5.2.5) shall be applied to all I/O ports referenced to the battery voltage supply system.

Equipment shall operate satisfactorily within the voltage range and duration defined in Table 4, measured at its power input terminals.

Table 4 — Supply voltage limits and performance criteria

Designation	Limit	Duration	Performance criterion
Minimum temporary supply undervoltage	$0,6 U_n$	$\leq 0,1 \text{ s}$	A
Minimum continuous voltage	$0,7 U_n$	Permanent	A
Nominal voltage	U_n		
Rated voltage	$1,15 U_n$		
Maximum continuous voltage	$1,25 U_n$		
Maximum temporary supply overvoltage	$1,4 U_n$	$\leq 0,1 \text{ s}$	A
Maximum temporary supply overvoltage	$1,4 U_n$	$\leq 1,0 \text{ s}$	B

If the supply voltage is permanently below $0,7 U_n$, see 7.2.6.

922 If the supply voltage is permanently over $1,25 U_n$, equipment can be damaged.

923 For thermal design the most stringent values in the voltage range shall be considered.

924 5.2.3 Temporary supply voltage variation

925 Electronic equipment shall also operate at the values of the DC supply voltage, which are measured at the
926 terminals of the equipment, within the entire range of temporary supply voltage variation defined in Table 4.

927 Voltage variations can be either positive (overvoltage) or negative (undervoltage).

928 Temporary supply overvoltage up to $1,4 U_n$ and not exceeding 0,1 s shall not cause deviation of function
929 (performance criterion A).

930 Temporary supply overvoltage up to $1,4 U_n$ and not exceeding 1 s shall fulfil performance criterion B.

931 Temporary supply undervoltage down to $0,6 U_n$ and not exceeding 0,1 s shall not cause deviation of function
932 (performance criterion A).

933 Temporary supply overvoltages shall be assumed to be generated with respect to the system power supply
934 return potential and to be present only as an increase to the level of the supply voltage, which shall be assumed
935 to be present before and after the application of the overvoltage.

936 Overvoltage of reverse polarity to the system power supply need not be considered, see also design
937 requirements in 7.2.7.

938 Temporary undervoltages are mainly caused by faults in the battery voltage supply system, or by sudden large
939 changes of load.

940 In the case of combustion engines, see also 5.2.8.

941 5.2.4 Interruption of supply voltage

942 For the interruption of supply voltage, the equipment shall be validated for the nominal voltage for which it is
943 designed for operation.

944 Due to a short circuit on the battery voltage supply system and subsequent operation of fuse/circuit breakers,
945 input voltage can go down to 0 V for a short period.

946 During a short interruption, the battery voltage supply system presents a “**low impedance**” (short circuit)
947 condition due to the clearing of an overload or fault condition on the battery voltage supply system. This condition
948 can cause reverse current (negative peak inrush current) from the load.

949 Regarding interruption of supply voltage, there are three classes listed in Table 5:

950 **Table 5 — Supply voltage interruption classes**

Class	Interruption time	Performance criterion
S1	> 0 ms	C
S2	≤ 10 ms	A
	> 10 ms	C
S3	≤ 20 ms	A
	> 20 ms	C

951 The requirements of this table shall be fulfilled for nominal voltage.

952 The system integrator should define the supply voltage interruption class. Unless otherwise specified, the
953 requirements of class S2 apply.

954 Unless otherwise specified, the requirements for interruption of supply voltage apply to the power supply input
955 ports only.

The requirements for interruption of supply voltage on I/O ports, connected to the same battery voltage supply system, shall be handled as described in the specification of the equipment.

5.2.5 Supply change-over

In the case of equipment supplied with power alternatively from a battery and a DC stabilized source switched with dead time (e.g. mechanical switch), the voltage supply system presents a “high impedance” condition due to switching from one source to another.

During supply change-over, the equipment shall operate satisfactorily under the conditions stated in 5.2.1, 5.2.2 and 5.2.6.

The supply change-over classes are listed in Table 6:

Table 6 — Supply change-over classes

Class	Starting Condition	Condition during change-over	Change-over time	Performance criterion
C1	U_n	$0,6 U_n$	$\leq 100 \text{ ms}$	A
C2	U_n	Supply break (open circuit)	$\leq 30 \text{ ms}$	B

Unless otherwise specified, the requirements of class C1 apply.

Unless otherwise specified, the requirements for supply changeover only apply to the power supply input ports of the electronic equipment.

The requirements for supply changeover on I/O ports, connected to the same battery voltage supply system, shall be handled as described in the specification of the equipment.

5.2.6 Grouping of supply voltages

It is permitted to group different nominal voltages for equipment designed for a wide input voltage range. In case of grouping, the principle (for compliance with performance and power supply type test) is to consider the most stringent values in the voltage range:

— In case of supply voltage variation within the continuous voltage range (see Table 4) the following applies:

The minimum continuous voltage shall be $0,7 U_n$ of the lowest nominal voltage and the maximum continuous voltage shall be $1,25 U_n$ of the highest nominal voltage;

EXAMPLE 1 Considering the voltage variation for equipment designed to operate at nominal voltages from 24 V up to 110 V, the minimum continuous voltage is $0,7 \times 24 \text{ V}$ and the maximum continuous voltage is $1,25 \times 110 \text{ V}$.

— In case of temporary supply overvoltage and undervoltage, interruption, change-over the following applies:

The most stringent nominal voltage shall be considered.

EXAMPLE 2 For the interruption of the supply voltage, the supply voltage for equipment designed for operation with nominal voltages from 24 V up to 110 V is 24 V.

EXAMPLE 3 Considering the maximum and minimum temporary supply voltage for equipment designed to operate at nominal voltages from 24 V up to 110 V, the minimum temporary voltage is $0,6 \times 24 \text{ V}$ and the maximum temporary voltage is $1,4 \times 110 \text{ V}$.

5.2.7 DC ripple factor

The DC ripple voltage, and frequency, on a supply voltage is dependent on the type of power generator or converter that produces the stabilized supply voltage. The DC ripple normally consists of a small AC waveform superimposed on the supply voltage once the generator or converter output voltage has been rectified and filtered. In practice, there are three common ways to produce a stabilized supply voltage, as follows: