
**Electrically propelled road vehicles —
Electrical specifications and tests
for voltage class B systems and
components —**

Part 1:
Voltage sub-classes and characteristics

*Véhicules à propulsion électrique — Spécifications et essais
électriques pour les systèmes et composants de classe B —*

Partie 1: Caractéristiques et sous classe de tension

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 37, *Electrically propelled vehicles*.

This first edition cancels and replaces ISO/PAS 19295:2016, which has been technically revised.

The main changes compared to the previous edition are as follows:

- a normative reference clause has been added,
- the terms and definitions clause has been revised,
- a requirement has been added to the component operating status (see [7.2](#)),
- a requirement has been added to load dump (see [7.6.3](#)),
- Figures 4-7 and Table 3 were removed.

A list of all parts in the ISO 21498 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

The requirements for voltage class B electric circuits that are used for electric power transfer for the propulsion of electric road vehicles and their characteristics are significantly different to those of voltage class A electric circuits. Moreover, the range of voltage class B is too wide to be used for a component design regarding to voltage.

The ISO 21498 series divides voltage class B in a set of voltage sub-classes to enable a component design for each voltage sub-class regarding to voltage. It provides appropriate descriptions and definitions for requirements and characteristics of voltage class B systems for electrically propelled vehicles.

The voltage sub-class itself and the component characteristics have a large cost impact on the component design and on the overall design of the electric system. Additionally, a high variety of different voltage sub-classes and operating conditions impedes the use of an existing component in different vehicle models. The standardisation of voltage sub-classes and characteristics and the reduction of varieties will enable the reduction of component and system costs. This allows the decoupling of the system or component designs of a voltage class B electric circuit from the design of the electric energy source. Finally, the exchange of components from different suppliers for different customers is facilitated.

This document provides definitions of and for voltage sub-classes and characteristics for rechargeable energy storage systems (RESS) and electric propulsion systems. It defines specific values for these sub-classes based on maximum working voltage. Voltage sub-classes listed in this document are used for voltage class B systems of all kinds of current or future electrically propelled road vehicles.

ISO 21498-2 provides electrical tests for electric and electronic components at voltage class B used for electrically propelled road vehicles. All relevant characteristics are covered considering usual driving scenarios as well as deviations from normal operation. The descriptions are generalized and include purpose, setup, procedure and requirements for the tests.

The specifications in this document are not intended to restrict the development of component performance or technology. The given definition of sub-classes does not exclude the use of other maximum operating voltages for an individual system design.

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Electrically propelled road vehicles — Electrical specifications and tests for voltage class B systems and components —

Part 1: Voltage sub-classes and characteristics

1 Scope

This document applies to voltage class B electric propulsion systems and connected auxiliary electric systems of electrically propelled road vehicles. Additionally, it applies to electric circuits and components in these systems.

This document provides specifications of voltage sub-classes related to DC electric circuits. It also provides specifications of characteristics which are relevant for design and operation of systems and components for the voltage sub-classes.

This document does not cover electrical safety (see ISO 17409 and the ISO 6469 series).

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 cited edition applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/TR 8713, *Electrically propelled road vehicles — Vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/TR 8713 and the following apply.

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

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <http://www.electropedia.org/>

3.1

component operating status

general functional behaviour of components which depend directly on the voltage in *voltage class B* (3.13) *electric circuits* (3.3)

3.2

customer

party that is interested in using *voltage class B* (3.13) components or systems

3.3

electric circuit

entire set of interconnected electric/electronic parts through which electrical current is designed to flow under normal operating conditions

3.4

lower voltage limit

minimum voltage of a *voltage class B* (3.13) sub-class disregarding *transients* (3.10) and *ripple* (3.8)

3.5

maximum working voltage

highest value of AC voltage (rms) or of DC voltage that can occur under any normal operating conditions according to the *customer's* (3.2) specifications, disregarding *transients* (3.10) and *ripple* (3.8)

3.6

power network

all components within *voltage class B* (3.13) DC network including their connections

3.7

rechargeable energy storage system

RESS

rechargeable system that stores energy for delivery of electric energy for the electric drive

EXAMPLE Batteries, capacitors, flywheel.

3.8

ripple

set of unwanted periodic deviations with respect to the average value of the measured or supplied quantity, occurring at frequencies which can be related to that of components within a system

3.9

supplier

party that provides *voltage class B* (3.13) components or systems

3.10

transient

phenomenon or quantity which varies between two consecutive steady states during a short time interval compared to the timescale of interest

3.11

upper voltage limit

maximum voltage of a *voltage class B* (3.13) sub-class disregarding *transients* (3.10) and *ripple* (3.8)

Note 1 to entry: *Maximum working voltages* (3.5) within a *voltage sub-class* (3.15) are less than or equal to the upper voltage limit.

3.12

voltage class A

classification of an electric component or circuit with a *maximum working voltage* (3.5) of ≤ 30 V AC (rms) or ≤ 60 V DC respectively

3.13

voltage class B

classification of an electric component or circuit with a *maximum working voltage* (3.5) of (> 30 and $\leq 1\,000$) V AC (rms) or (> 60 and $\leq 1\,500$) V DC respectively

3.14

voltage range

general term covering *voltage sub-class* (3.15), *working voltages* (3.16) and deviations from working voltages

3.15

voltage sub-class

classification of an electric component or circuit with a DC voltage within the *voltage class B* (3.13)

3.16

working voltage

AC voltage (rms) or DC voltage that can occur in an electric system under normal operating conditions according to the *customer's* (3.2) specifications, disregarding *transients* (3.10) and *ripple* (3.8)

4 Abbreviated terms

IGBT insulated gate bipolar transistor

OS operating status

MOSFET metal-oxide-semiconductor field-effect transistor

5 General assumptions for the voltage class B system

The DC voltage class B system in electrically propelled road vehicles consists of electric components and the wiring harness that connects the components. Its main parts are the electric energy source and the electric drive. The primary function of the DC voltage class B system is the supply of electric energy to propel the EV. Other functions are charging of a RESS, supply of voltage class A electric circuits and auxiliary components.

The main energy flow in the DC voltage class B system is caused by the electric drive, the energy source and an external DC power supply if any. Besides that, the high current load, transients and ripple in the system mostly originate from these components and have major influence on the design of the DC voltage class B system. Within this document transients and ripple, which are generated by a single component, are referred to as “generated transients” and “generated ripple”.

An example of a voltage class B system is shown in [Figure 1](#). The actual configuration of the voltage class B electric circuit of the electric propulsion system and its connected auxiliary electric components is vehicle-specific and specified by the customer.

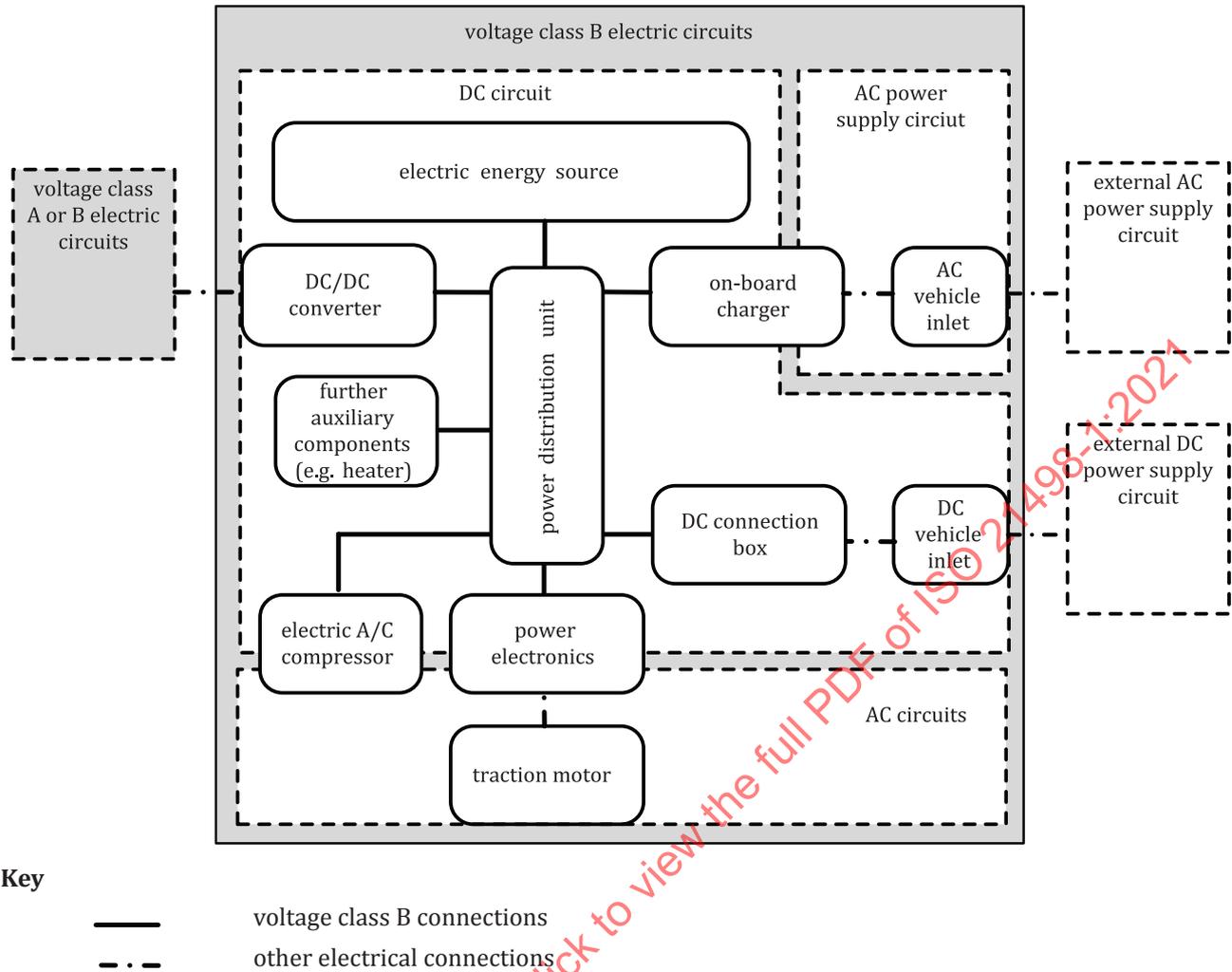


Figure 1 — Example of an electric system for an EV

6 Voltage sub-classes

The specifications and requirements on voltage sub-classes shall apply to electric circuits, systems and components of voltage class B.

The specifications and descriptions of voltages for a component shall apply to the voltage at its terminals to the voltage class B electric circuit, if not otherwise stated in this document.

The voltage sub-classes shown in [Table 1](#) are based on the specification of an upper voltage limit for each voltage sub-class. Technical background for selection of voltage sub-classes is given in [Table A.1](#).

Table 1 — Voltage sub-classes

Voltage sub-class	Upper voltage limit
B_220	$U \leq 220 \text{ V DC}$
B_420	$U \leq 420 \text{ V DC}$
B_470	$U \leq 470 \text{ V DC}^a$
B_750	$U \leq 750 \text{ V DC}^b$
B_850	$U \leq 850 \text{ V DC}$
B_1250	$U \leq 1\,250 \text{ V DC}^c$

^a B_470 is considering 700 V breakdown voltage for IGBT and dedicated module technology ([Table A1](#)).

^b B_750 is related to a voltage classification of 750 V DC given by regulation in Japan.

^c B_1250 is considering the limit of 1 000 V AC for voltage class B.

7 Characteristics of voltage sub-classes

7.1 General

The specifications and characteristics for voltage sub-classes include the following subjects:

- component operating status;
- voltage operating ranges;
- undervoltages and overvoltages;
- voltage transients and ripple for components.

The voltage ranges and operating status shall apply to all components for the selected voltage sub-class. The voltage sub-class depends on the vehicle project and shall be selected by an agreement between customer and supplier.

The requirements in accordance with [Table 1](#) shall apply to a RESS when it is disconnected from the voltage class B electric circuit.

Different requirements may be specified by the customer for a RESS when it is connected to the voltage class B electric circuit because the voltage of a RESS is limited to the maximum working voltage of the vehicle project and given by the number of battery cells.

For each voltage sub-class, the corresponding working voltages, component operating status, overvoltage and undervoltage are described as follows.

7.2 Component operating status

The operating status describes the general operating behaviour of components. It depends directly on the voltage at the terminals of a component of the voltage class B electric circuit and is focused on performance and electrical power.

In every operating status, the components shall fulfil the following requirements:

- it shall be ready to operate;
- it shall not enter any undefined states;

The different operating statuses are described in [Table 2](#).

Table 2 — Component operating status

Operating status	Description
OS1	The component shall provide the specified performance (reduction of performance not allowed). The component shall automatically change its operating status depending on the voltage relevant for the operating status.
OS2	The component shall provide the specified reduced performance within its permissible deviations (reduction of performance allowed). The component shall automatically change its operating status depending on the voltage relevant for the operating status.
OS3	The component may derate or cut-off its performance for self-protection purpose. The component shall automatically change its operating status depending on the voltage relevant for the operating status.
OS4	The component may cut-off its performance. Triggered by a reset or an external event (e.g. change of ignition status, restart vehicle), the component shall change its operating status depending on the voltage relevant for the operating status.

The specified operating statuses in [Table 2](#) are valid exclusively for functions that depend directly on the voltage in voltage class B electric circuits.

Detailed requirements for an operating status for individual voltage class B components shall be based on an agreement between customer and supplier.

7.3 Voltage operating ranges

For further description of characteristics of a voltage sub-class, different voltage operating ranges are introduced as follows:

- upper limited operating capability;
- unlimited operating capability;
- lower limited operating capability.

[Figure 2](#) shows an overview on the voltage operating ranges of a voltage sub-class.

The specific values for voltage operating ranges (upper limited, unlimited and lower limited operating capability) are specified by the customer for a vehicle project.

The characteristics of a component in the different voltage operating ranges are specified by the allocation of operating statuses to the voltage operating ranges as described in [7.5](#).

7.4 Undervoltage and overvoltage

7.4.1 General

Voltage deviations are caused by deviations from normal system operation. These deviations can occur intentionally (e.g. as a consequence of a system or component reaction) or may be caused by a fault.

Voltage deviations as follows are considered:

- overvoltage;
- undervoltage.

7.4.2 Overvoltage

An overvoltage event may be caused by a component in generator mode while another component is turned-off (e.g. power network without battery stabilization).

The overvoltage range is defined between:

- upper voltage limit, and
- overvoltage limit (see [Figure 2](#)).

The overvoltage limit is the maximum voltage that can occur under abnormal operating conditions. Therefore, the overvoltage limit is the maximum voltage a component shall withstand without impact on its specified service life. Within the overvoltage range, the operating status OS3 or OS4 according to [Table 2](#) shall be fulfilled and the component is allowed to take action to protect itself.

When the voltage exceeds the overvoltage limit temporarily or continuously, a severe fault, e.g. breakdown of a component, may occur.

7.4.3 Undervoltage

Below the lower voltage limit an undervoltage range is defined. This range indicates a voltage that is below the lowest voltage in normal operation. At normal operation an undervoltage event may occur as a short-time event.

Several causes may lead to reaching undervoltage during vehicle operation (e.g. resonant effect caused by switching).

An undervoltage event may occur, if the component has a power request or not.

The undervoltage range is the range between:

- 0 V DC, and
- lower voltage limit (see [Figure 2](#)).

The lower voltage limit is the lowest voltage for which a component shall fulfil OS2 or OS1.

Within the undervoltage range, the operating status OS3 or OS4 according to [Table 2](#) shall be fulfilled.

7.5 Allocation of voltage ranges and operating status – Overview

[Figure 2](#) shows the allocation of a component operating status to the voltage operating ranges of a voltage sub-class.

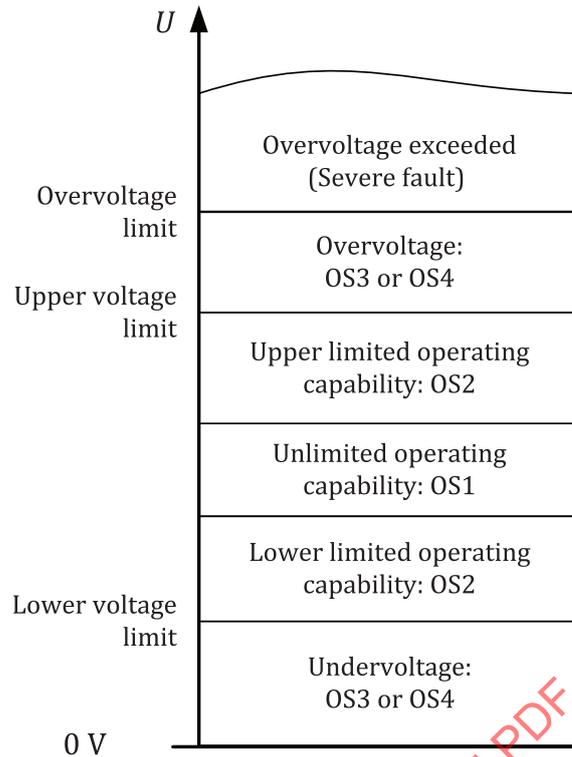


Figure 2 — Component operating status at a voltage sub-class

NOTE An example for voltage operating ranges of voltage sub-class B_220 is given in [Table A.2](#).

A dedicated voltage sub-class can be used for different vehicle projects. Within this sub-class, different values for operating ranges and minimum and maximum working voltages can be used.

The maximum working voltage for the vehicle project shall be less than or equal to the upper voltage limit of this voltage sub-class.

The minimum working voltage is the lowest voltage that can occur under normal operating conditions for a vehicle project. The minimum working voltage for a project shall be higher than or equal to the lower voltage limit of the components.

A component developed for a dedicated voltage sub-class can be used for different vehicle projects which are using different voltage ranges within this voltage sub-class.

[Figure 3](#) shows how a voltage sub-class B_x component can be used for different vehicle projects with different working voltages.

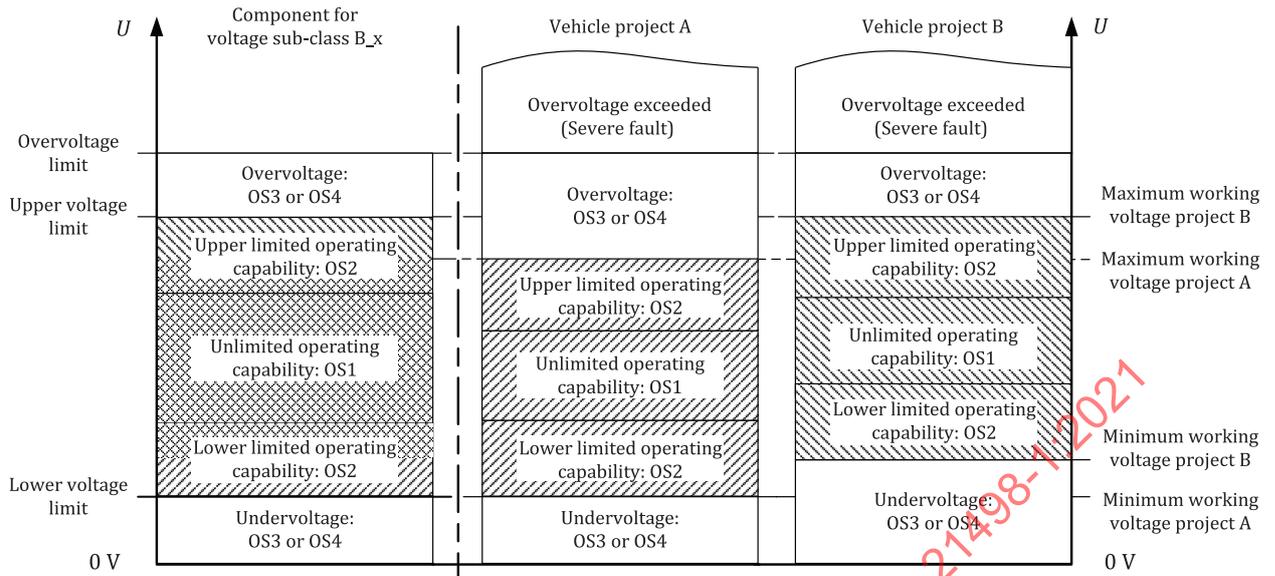


Figure 3 — Use of a component for voltage sub-class B_x for different vehicle projects — Example

7.6 Voltage transients and ripple

7.6.1 General

A voltage transient is a singular dynamic change that can occur due to on- or off-switching of electrical loads, rapid load changes and electric load imbalance. This document only considers transients which have an effect on the voltage at the terminals of a component connected to the voltage class B electric circuit. Voltage transients considered in this document are voltage slope and load dump.

A ripple is a quasi-periodical or continuous change that can be caused by periodic switching of semiconductors.

7.6.2 Voltage slope

A voltage slope is a singular dynamic change of the working voltage expressed in voltage difference over time. It does not occur periodically or continuously. It is typically due to a change of power demand and is mostly associated to a component action (e.g. accelerating, regenerative braking or control loop regulation by software).

A limitation of the voltage dynamics is necessary for a stable operation of the vehicle. A maximum value for voltage slope shall be agreed between customer and supplier.

Every component that is controlled by power electronics shall limit the change of the DC circuit voltage over time according to the specified maximum generated voltage slope.

All components shall be robust against voltage slope in the voltage class B system. In the event of a change of the DC circuit voltage according to the specified maximum slope, the component shall fulfil the conditions according to the corresponding operating status.

7.6.3 Load dump

A load dump is an abrupt disconnection of a high load. If a component feeds electrical energy into the voltage class B electric circuit during the load dump this can result in a fast transient increase of voltage. The voltage might exceed the overvoltage limit, if no means of limitation are provided.

Every component, which is able to feed electrical energy into the voltage class B electric circuit shall limit the rise time and the peak value of the voltage according to the specifications agreed between customer and supplier.

Every component shall be able to withstand a rapid voltage rise up to the overvoltage limit during a load dump.

7.6.4 Voltage ripple

Voltage ripple is an overlay of an AC voltage on the DC voltage. The switching of semiconductors inside components causes this overlay. In the power network of the vehicle several ripple sources create a ripple consisting of several frequencies. This frequency composition depends on the specific vehicle project.

In this document voltage ripple within a frequency range between 10 Hz and 150 kHz is considered. In the time domain, the ripple is specified by its peak to peak voltage and in the frequency domain by its dominating frequency components within a set frequency range.

Every component controlled by power electronics shall limit its generated voltage ripple (amplitude and frequency range) to the values agreed between customer and supplier.

For every component, robustness and stable operation shall be fulfilled when there is a voltage ripple present during the operation of the system.

In general, the voltage ripple in the DC circuit should be optimized regarding, e.g. robustness of the components.

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