# SLOVENSKI STANDARD
# kSIST-TP FprCEN/CLC/TR 17603-20-05:2021

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**Vesoljska tehnika - Priročnik za visokonapetostno tehniko in načrtovanje**

Space engineering - High voltage engineering and design handbook

Raumfahrttechnik - Handbuch für Hochspannungstechnik und Design

Ingénierie spatiale - Manuel d'ingénierie et de conception haute tension



**Ta slovenski standard je istoveten z:** **FprCEN/CLC/TR 17603-20-05**

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TECHNICAL REPORT

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# Space engineering - High voltage engineering and design handbook

Ingénierie spatiale - Manuel d'ingénierie et de conception haute tension

Raumfahrttechnik - Handbuch für Hochspannungstechnik und Design

This draft Technical Report is submitted to CEN members for Vote. It has been drawn up by the Technical Committee CEN/CLC/JTC 5.

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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.



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# European Foreword

This document (FprCEN/CLC/TR 17603-20-05:2021) has been prepared by Technical Committee CEN/CLC/JTC 5 “Space”, the secretariat of which is held by DIN.

This document is currently submitted to the Vote on TR.

It is highlighted that this technical report does not contain any requirement but only collection of data or descriptions and guidelines about how to organize and perform the work in support of EN 16603-20-05.

This Technical report (FprCEN/CLC/TR 17603-20-05:2021) originates from ECSS-E-HB-20-05A.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association.

This document has been developed to cover specifically space systems and has therefore precedence over any TR covering the same scope but with a wider domain of applicability (e.g.: aerospace).

**This document is currently submitted to the CEN CONSULTATION.**

# Introduction

The subject of high voltage engineering and design has been part of the spacecraft design process since the early times of spaceflight.

This was due to need for high voltage power conditioners being a key element of communication links. The relate expertise was built up in Europe in the decade of the 1980 with the support of the development of modern Electronic Power Conditioners (EPC's), to operate Travelling Wave Tube Amplifiers for telecommunication satellites and for high power radar applications.

In 1989 ESA launched its first high power radar for earth observation onboard the ERS-1 (European Remote Sensing Satellite), achieving a technology for 15 kV – 17 kV in space.

Today typically between some ten and over hundred EPC's with operating voltages of 5 kV - 8 kV are placed on many of the telecommunications satellites.

Several space borne radars with travelling wave tubes and klystrons are in orbit using voltage up to 20 kV. Various detectors for various kind of space environment with voltage between a few hundred volts and up to 30 kV are used in many missions, high power lasers up to 150 kV were studied, and even some experiments onboard the International Space Station using fancy high voltage sources.

The latest trend is the increasing use of electric propulsion for satellites dealing with supply voltage in the range between a few hundred volts and above 10 kV. High voltage related anomalies have been observed only a few times, some in the early years of building up experience, some also later, especially when new developments were done with new teams inexperienced in the field.



A need was identified for a standard already in the early years of the space flight, the US air force and NASA presented a series design and test handbook in the 1970's and 1980's. In Europe, ESA started discussing a draft standard with industry: the PSS-02-303 draft 2 from 1992 "Requirements for High Voltage Transformer and Components used in Electronic Power Conditioners for ESA Space Systems" this became a quasi standard reference in many space projects, even if it was never formally released. The growing diversity of high voltage application gave finally the urgency to make a new approach for standardization. The discussion started in 2007 with ECSS who led to the conclusion, that a standard would not satisfy the immediate needs for projects, as it would be too wide to cover the diverse applications and also would not be suitable to transfer the "know-how" of high voltage engineering and design. Therefore it was decided to produce a handbook to give a broad scope of knowledge and recommendations for design and test of high voltage equipment and components.



This document aims to satisfy these needs and provides a detailed view of high voltage knowledge aspects as well as giving a guideline to identify suitable design rules.

Proper design of high voltage effects of these processes is part of the system engineering process as defined in ECSS-E-ST-20, where only a small subset of high voltage requirements is given.

For new projects involving high voltage equipment and design it is useful to provide this handbook as a reference to generate suitable requirements specific to the targeted high voltage application.

Chapter 7 of this document gives some "best practice" statements.

Only a smart answer can be given to the definition of the range of voltages which should be considered as high voltages: The ECSS-E-ST-20C states for the definition of a high voltage "AC or DC voltage at which partial discharges, corona, arcing or high electrical fields can occur". For space environment this can occur ". This in fact can already appear at 60 V – 80 V if a low pressure environment in an inert gas provides a critical pressure for "Paschen Breakdown". Under air ($N_2/O_2$ mixtures) this can occur for voltage of above 300 V.

# 1 Scope

This Handbook establishes guidelines to ensure a reliable design, manufacturing and testing of high voltage electronic equipment and covers:

- Design
- Manufacturing
- Verification/Testing

of equipment generating, carrying or consuming high voltage, like: high voltage power conditioner, high voltage distribution (cables and connectors).

This Handbook is dedicated to all parties involved at all levels in the realization of space segment hardware and its interface with high voltage for which ECSS-E-ST-20C is applicable.

This handbook sets out to:

- summarize most relevant aspects and data of high voltage insulation
- provide design guidelines for high voltage insulation
- provide design guidelines for high voltage electronic equipment
- give an overview of appropriate high voltage test methods
- establish a set of recommendations for generation design and verification rules and methods
- provide best practices



Applicability is mainly focused on power conditioning equipment but may be also applicable for all other high voltage electric and electronic power equipment used on space missions, except items of experimental nature.

# 2 References

| EN Reference | Reference in text | Title |
|---|---|---|
| EN 16601-00-01 | ECSS-S-ST-00-01 | ECSS System – Glossary of terms |
| EN 16603-10-02 | ECSS-E-ST-10-02 | Space engineering - Verification |
| EN 16603-10-03 | ECSS-E-ST-10-03 | Space engineering - Testing |
| EN 16603-10-04 | ECSS-E-ST-10-04 | Space engineering - Space environment |
| EN 16603-20 | ECSS-E-ST-20 | Space engineering - Electrical and electronic |
| EN 16603-20-01 | ECSS-E-ST-20-01 | Space engineering - Multipactor design and test |
| EN 16603-20-06 | ECSS-E-ST-20-06 | Space engineering - Spacecraft charging |
| EN 16603-32 | ECSS-E-ST-32 | Space engineering - Structural general requirements |
| EN 16602-30-11 | ECSS-Q-ST-30-11 | Space product assurance - Derating – EEE components |
| EN 16602-70-10 | ECSS-Q-ST-70-10 | Space product assurance - Qualification of printed circuit boards |
| EN 16602-70-11 | ECSS-Q-ST-70-11 | Space product assurance - Procurement of printed circuit boards |
| EN 16602-70-71 | ECSS-Q-ST-70-71 | Space product assurance - Data for selection of space materials and processes |
| - | ESA SP-398 (May 1997) | Power supply and control unit (PCSU) for radio frequency ion thrusters (RIT)" ESA, Proc. 2nd European Spacecraft Propulsion, Noordwijk, The Netherlands, 27-29 May 1997 (ESA SP-398), pp 643-648. |
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