



SLOVENSKI STANDARD
SIST EN IEC 60143-4:2024

01-marec-2024

Zaporedni kondenzatorji za elektroenergetske sisteme - 4. del: Zaporedni kondenzatorji s tiristorskim upravljanjem (IEC 60143-4:2023)

Series capacitors for power systems - Part 4: Thyristor controlled series capacitors (IEC 60143-4:2023)

Reihen Kondensatoren für Starkstromanlagen - Teil 4: Thyristorgesteuerte Reihen Kondensatoren (IEC 60143-4:2023)

Condensateurs série destinés à être installés sur des réseaux - Partie 4: Condensateurs série commandés par thyristors (IEC 60143-4:2023)

Ta slovenski standard je istoveten z: EN IEC 60143-4:2024

[SIST EN IEC 60143-4:2024](https://standards.slovenski.si/standards/sist/29/290422-60143-4/2024-03-01/IEC-60143-4-2024)

<https://standards.slovenski.si/standards/sist/29/290422-60143-4/2024-03-01/IEC-60143-4-2024>

ICS:

29.240.99	Druga oprema v zvezi z omrežji za prenos in distribucijo električne energije	Other equipment related to power transmission and distribution networks
31.060.70	Močnostni kondenzatorji	Power capacitors

SIST EN IEC 60143-4:2024

en

EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

EN IEC 60143-4

January 2024

ICS 29.240.99; 31.060.70

Supersedes EN 60143-4:2010

English Version

**Series capacitors for power systems - Part 4: Thyristor controlled
series capacitors
(IEC 60143-4:2023)**

Condensateurs série destinés à être installés sur des
réseaux - Partie 4: Condensateurs série commandés par
thyristors
(IEC 60143-4:2023)

Reihencondensatoren für Starkstromanlagen - Teil 4:
Thyristorgesteuerte Reihencondensatoren
(IEC 60143-4:2023)

This European Standard was approved by CENELEC on 2024-01-18. 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.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CENELEC member.

This European Standard exists 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.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Bulgaria, Croatia, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Republic of North Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Türkiye and the United Kingdom.

<https://standards.iteh.ai>
SIST EN IEC 60143-4:2024

<https://standards.iteh.ai/catalog/standards/sist/a916ca22-08b5-448a-9795-b2d5b43f3ad1/sist-en-iec-60143-4-2024>



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

EN IEC 60143-4:2024 (E)**European foreword**

The text of document 33/696/FDIS, future edition 2 of IEC 60143-4, prepared by IEC/TC 33 "Power capacitors and their applications" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN IEC 60143-4:2024.

The following dates are fixed:

- latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2024-10-18
- latest date by which the national standards conflicting with the document have to be withdrawn (dow) 2027-01-18

This document supersedes EN 60143-4:2010 and all of its amendments and corrigenda (if any).

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

This document is read in conjunction with EN 60143-1:2015, EN 60143-2:2013 and EN 60143-3:2015.

Any feedback and questions on this document should be directed to the users' national committee. A complete listing of these bodies can be found on the CENELEC website.

iTeh Standards
Endorsement notice
 (<https://standards.iteh.ai>)

The text of the International Standard IEC 60143-4:2023 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standard indicated:

<https://standards.iteh.ai/catalog/standards/sist/a916ca22-08b5-448a-9795-b2d5b43f3ad1/sist-en-iec-60143-4-2024>

IEC 60060-2 NOTE Approved as EN 60060-2

IEC 60068-1 NOTE Approved as EN 60068-1

IEC 60068-3-3 NOTE Approved as EN IEC 60068-3-3

IEC 60721-1 NOTE Approved as EN 60721-1

IEC 61000-4-2 NOTE Approved as EN 61000-4-2

Annex ZA (normative)

Normative references to international publications with their corresponding European publications

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 1 Where an International Publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

NOTE 2 Up-to-date information on the latest versions of the European Standards listed in this annex is available here: www.cencenelec.eu.

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC 60050-436	-	International Electrotechnical Vocabulary. Chapter 436: Power capacitors	-	-
IEC 60068-2-2	-	Environmental testing - Part 2-2: Tests - Test B: Dry heat	EN 60068-2-2	-
IEC 60068-2-78	-	Environmental testing - Part 2-78: Tests - Test Cab: Damp heat, steady state	EN 60068-2-78	-
IEC 60076-1	-	Power transformers - Part 1: General	EN 60076-1	-
IEC 60076-6	2007	Power transformers - Part 6: Reactors	EN 60076-6	2008
IEC 60143-1	2015	Series capacitors for power systems - Part 1: General	EN 60143-1	2015
IEC 60143-2	2012	Series capacitors for power systems - Part 2: Protective equipment for series capacitor banks	EN 60143-2	2013
IEC 60143-3	2015	Series capacitors for power systems - Part 3: Internal fuses	EN 60143-3	2015
IEC 60255-21	series	Electrical relays - Part 21: Vibration, shock, bump and seismic tests on measuring relays and protection equipment	EN 60255-21	series
IEC 60255-27	-	Measuring relays and protection equipment - Part 27: Product safety requirements	EN 60255-27	-
IEC 61000-4	series	Electromagnetic compatibility (EMC) - Part 4: Testing and measurement techniques	EN 61000-4	series
IEC 61000-4-11	-	Electromagnetic compatibility (EMC) - Part 4-11: Testing and measurement techniques - Voltage dips, short interruptions and voltage variations immunity tests for equipment with input current up to 16 A per phase	EN IEC 61000-4-11	-

EN IEC 60143-4:2024 (E)

IEC 61000-4-29	-	Electromagnetic compatibility (EMC) - Part 4-29: Testing and measurement techniques - Voltage dips, short interruptions and voltage variations on d.c. input power port immunity tests	EN 61000-4-29	-
IEC 62823	2015	Thyristor valves for thyristor controlled series capacitors (TCSC) - Electrical testing	EN 62823	2015
+ A1	2019		+ A1	2020

iTeh Standards
 (<https://standards.iteh.ai>)
 Document Preview

[SIST EN IEC 60143-4:2024](https://standards.iteh.ai/catalog/standards/sist/a916ca22-08b5-448a-9795-b2d5b43f3ad1/sist-en-iec-60143-4-2024)

<https://standards.iteh.ai/catalog/standards/sist/a916ca22-08b5-448a-9795-b2d5b43f3ad1/sist-en-iec-60143-4-2024>



IEC 60143-4

Edition 2.0 2023-12

INTERNATIONAL STANDARD

NORME INTERNATIONALE



**Series capacitors for power systems –
Part 4: Thyristor controlled series capacitors**

**Condensateurs série destinés à être installés sur des réseaux –
Partie 4: Condensateurs série commandés par thyristors**

[SIST EN IEC 60143-4:2024](https://standards.iteh.ai/catalog/standards/sist/a916ca22-08b5-448a-9795-b2d5b43f3ad1/sist-en-iec-60143-4-2024)

<https://standards.iteh.ai/catalog/standards/sist/a916ca22-08b5-448a-9795-b2d5b43f3ad1/sist-en-iec-60143-4-2024>

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

ICS 29.240.99, 31.060.70

ISBN 978-2-8322-8029-4

**Warning! Make sure that you obtained this publication from an authorized distributor.
Attention! Veuillez vous assurer que vous avez obtenu cette publication via un distributeur agréé.**

CONTENTS

FOREWORD.....	5
1 Scope.....	7
2 Normative references	7
3 Terms, definitions and abbreviated terms	8
3.1 Terms and definitions.....	8
3.2 Abbreviated terms.....	11
4 Operating and rating considerations	11
4.1 General.....	11
4.2 TCSC characteristics	14
4.3 Operating range.....	15
4.4 Reactive power rating	16
4.5 Power oscillation damping (POD).....	16
4.6 SSR mitigation	16
4.7 Harmonics	17
4.8 Control interactions between TCSCs in parallel lines	17
4.9 Operating range, overvoltages and duty cycles	17
4.9.1 Operating range.....	17
4.9.2 Transient overvoltages	18
4.9.3 Duty cycles.....	18
5 Valve control	18
5.1 Triggering system	18
5.2 System aspects	19
5.3 Normal operating conditions.....	19
5.4 Valve firing during system faults	20
5.5 Actions at low line current.....	20
5.6 Monitoring.....	20
6 Ratings.....	20
6.1 General.....	20
6.2 Capacitor rating	21
6.3 Reactor rating	21
6.4 Thyristor valve rating	21
6.4.1 General	21
6.4.2 Current capability	21
6.4.3 Voltage capability	22
6.5 Varistor rating	24
6.6 Insulation level and creepage distance.....	25
7 Tests	25
7.1 General.....	25
7.2 Test of the capacitor	25
7.2.1 General	25
7.2.2 Routine tests	25
7.2.3 Type tests.....	26
7.2.4 Special test (ageing test)	26
7.3 Tests of the TCSC reactor	26
7.3.1 General	26
7.3.2 Routine tests	26

7.3.3	Type tests.....	27
7.3.4	Special tests.....	27
7.4	Tests of thyristor valves.....	27
7.4.1	General.....	27
7.4.2	Routine tests.....	27
7.4.3	Type tests.....	28
7.5	Tests of protection and control system.....	28
7.5.1	General.....	28
7.5.2	Routine tests.....	28
7.5.3	Type tests.....	29
7.5.4	Special tests – Hardware-in-the-loop (HIL) tests.....	29
8	Guidance for selection of rating and operation.....	30
8.1	General.....	30
8.2	Thyristor controlled series capacitor.....	31
8.2.1	AC transmission system.....	31
8.2.2	TCSC operational objectives.....	32
8.2.3	TCSC ratings.....	32
8.3	Thyristor valves.....	34
8.4	Capacitors and reactors.....	34
8.4.1	General.....	34
8.4.2	Capacitor considerations.....	34
8.4.3	Reactor considerations.....	34
8.5	Fault duty cycles for varistor rating.....	35
8.6	Valve cooling system.....	36
8.7	TCSC control and protection.....	36
8.7.1	General.....	36
8.7.2	Control.....	37
8.7.3	Protection.....	39
8.7.4	Monitoring and recording.....	39
8.8	Precommissioning and commissioning tests.....	40
8.8.1	General.....	40
8.8.2	Pre-commissioning tests.....	40
8.8.3	Station tests.....	41
	Bibliography.....	43
	Figure 1 – Typical nomenclature of a TCSC installation.....	12
	Figure 2 – TCSC subsegment.....	13
	Figure 3 – TCSC steady state waveforms for control angle α and conduction interval σ	14
	Figure 4 – TCSC apparent reactance characteristics according to Formula (1), with $\lambda = 2,5$	15
	Figure 5 – Example of TCSC operating range for POD (left) and SSR mitigation (right).....	15
	Figure 6 – Valve base electronics (VBE).....	18
	Figure 7 – Valve electronics (VE).....	19
	Figure 8 – Thyristor valve voltage in a TCSC.....	23
	Figure 9 – Typical block diagram of a real time TCSC protection and control system simulation environment.....	30
	Figure 10 – Example of operating range diagram for TCSC.....	33

Table 1 – Peak and RMS voltage relationships	13
Table 2 – Typical external fault duty cycle with unsuccessful high speed auto-reclosing	35
Table 3 – Typical duty cycle for internal fault with successful high speed auto-reclosing	35
Table 4 – Typical duty cycle for internal fault with unsuccessful high speed auto-reclosing	36

iTeh Standards
(<https://standards.iteh.ai>)
Document Preview

[SIST EN IEC 60143-4:2024](https://standards.iteh.ai/catalog/standards/sist/a916ca22-08b5-448a-9795-b2d5b43f3ad1/sist-en-iec-60143-4-2024)

<https://standards.iteh.ai/catalog/standards/sist/a916ca22-08b5-448a-9795-b2d5b43f3ad1/sist-en-iec-60143-4-2024>

INTERNATIONAL ELECTROTECHNICAL COMMISSION

SERIES CAPACITORS FOR POWER SYSTEMS –**Part 4: Thyristor controlled series capacitors**

FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as “IEC Publication(s)”). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) IEC draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). IEC takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, IEC had not received notice of (a) patent(s), which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at <https://patents.iec.ch>. IEC shall not be held responsible for identifying any or all such patent rights.

IEC 60143-4 has been prepared by IEC technical committee 33: Power capacitors and their applications. It is an International Standard.

This second edition cancels and replaces the first edition published in 2010. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- a) thyristor valve testing requirements refer to IEC 62823;
- b) Formula (1) in Subclause 4.2 has been corrected;
- c) Hardware-in-the-loop (HIL) tests, Subclause 7.5.4, replaces previously specified real time protection and control system test with network simulator.

The text of this International Standard is based on the following documents:

Draft	Report on voting
33/696/FDIS	33/702/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This part of IEC 60143 is to be used in conjunction with the following standards:

- IEC 60143-1:2015,
- IEC 60143-2:2012,
- IEC 60143-3:2015.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

A list of all parts of IEC 60143 series, under the general title *Series capacitors for power systems*, can be found on the iec website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn, or
- revised.

[SIST EN IEC 60143-4:2024](https://standards.iteh.ai/catalog/standards/sist/a916ca22-08b5-448a-9795-b2d5b43f3ad1/sist-en-iec-60143-4-2024)

<https://standards.iteh.ai/catalog/standards/sist/a916ca22-08b5-448a-9795-b2d5b43f3ad1/sist-en-iec-60143-4-2024>

IMPORTANT – The "colour inside" logo on the cover page of this document indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.