



BSI Standards Publication

UHV AC transmission systems

Part 101: Voltage regulation and insulation design

National foreword

This Published Document is the UK implementation of IEC TS 63042-101:2019.

The UK participation in its preparation was entrusted to Technical Committee GEL/8, Systems Aspects for Electrical Energy Supply.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

© The British Standards Institution 2019
Published by BSI Standards Limited 2019

ISBN 978 0 580 97316 1

ICS 29.240.01

Compliance with a British Standard cannot confer immunity from legal obligations.

This Published Document was published under the authority of the Standards Policy and Strategy Committee on 31 January 2019.

Amendments/corrigenda issued since publication

Date	Text affected
------	---------------



IEC TS 63042-101

Edition 1.0 2019-01

TECHNICAL SPECIFICATION



**UHV AC transmission systems –
Part 101: Voltage regulation and insulation design**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 29.240.01

ISBN 978-2-8322-6456-0

Warning! Make sure that you obtained this publication from an authorized distributor.

CONTENTS

FOREWORD.....	4
INTRODUCTION.....	6
1 Scope.....	7
2 Normative references	7
3 Terms and definitions	7
4 Reactive power compensation for UHV AC transmission systems.....	8
4.1 General principles.....	8
4.2 Configuration of reactive power compensation – consider placing after general functions	9
4.3 Determining reactive power compensation	9
4.3.1 Reactive compensation at UHV side	9
4.3.2 Compensation at tertiary side of UHV transformers.....	9
4.3.3 Reactive power compensation at UHV side.....	10
4.3.4 Shunt capacitor configuration at tertiary side of UHV transformers	11
4.3.5 Shunt reactor configuration at tertiary side of UHV transformers.....	12
4.4 Controllable shunt reactor at UHV side	13
4.4.1 General	13
4.4.2 Capacity selection	13
4.4.3 Tap-changer	13
4.4.4 Response speed of CSR.....	13
4.4.5 Control mode.....	14
4.5 Other requirements for compensation at tertiary side of UHV transformers	14
4.5.1 Configuration of shunt compensator banks	14
4.5.2 Connection	14
4.5.3 Dynamic reactive compensation	14
5 Voltage regulation	15
5.1 General.....	15
5.2 Voltage regulation for UHV transformers.....	15
5.2.1 Voltage regulation via transformer tap changes	15
5.2.2 Selection of transformer taps	15
5.2.3 Voltage selection for transformers	15
5.2.4 Types of tap-changers	15
5.2.5 UHV transformer tap range.....	15
5.2.6 Selection of transformer tap position during operation	15
6 Generator reactive power control.....	16
6.1 General.....	16
6.2 Coordination among reactive devices.....	17
7 Insulation design and coordination procedure for transmission line and substation design	17
7.1 General.....	17
7.2 Insulation design procedure	18
7.3 UHV AC system overvoltage	18
7.3.1 General	18
7.3.2 Temporary overvoltage (TOV).....	19
7.3.3 Switching overvoltage (slow-front overvoltage)	19
7.3.4 Lightning overvoltage (fast-front overvoltage)	20
7.3.5 Very fast front overvoltage (VFFO)	21

7.4	Reduction of insulation levels using overvoltage suppression measures	21
7.4.1	General	21
7.4.2	Overvoltage suppression using surge arrester with low protective level	21
7.4.3	Resistor-fitted circuit-breakers with closing/opening resistor	21
7.4.4	Damping effect of resistor-fitted disconnectors employed in GIS to suppress VFFO.....	22
7.4.5	Damping effect of AIS for suppressing VFFO	22
7.4.6	Fast insertion of switchable or controllable shunt reactors	22
7.4.7	Controlled switching	22
7.5	Coordination of design requirements.....	22
7.5.1	General	22
7.5.2	Transmission line.....	22
7.5.3	Substation	23
Annex A (informative)	UHV multi-stage controllable shunt reactor.....	24
Annex B (informative)	General procedure for the selection of transformer tap positions	26
Bibliography.....		29
Figure 1	– Flowchart for reactive power compensation configuration.....	9
Figure 2	– Flow chart for rational insulation specification for UHV.....	18
Figure 3	– Overvoltage categorized by time domain.....	18
Figure 4	– Overvoltage mechanism caused by back-flashover and direct lightning	20
Figure A.1	– Illustrative example of a UHV project with an MCSR	24
Figure B.1	– Schematic diagram of UHV transmission line	26
Figure B.2	– Voltage profile of UHV line A-B while energized at substation	27
Table A.1	– Impact of MCSR switching on voltage at station B.....	25
Table B.1	– Lower limits of operating voltage for UHV substations	28

INTERNATIONAL ELECTROTECHNICAL COMMISSION

UHV AC TRANSMISSION SYSTEMS –

Part 101: Voltage regulation and insulation design

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

The main task of IEC technical committees is to prepare International Standards. In exceptional circumstances, a technical committee may propose the publication of a Technical Specification, when

- the required support cannot be obtained for the publication of an International Standard, despite repeated efforts, or
- the subject is still under technical development or where, for any other reason, there is the future but no immediate possibility of an agreement on an International Standard.

Technical Specifications are subject to review within three years of publication to decide whether they can be transformed into International Standards.

IEC TS 63042-101, which is a Technical Specification, has been prepared by IEC technical committee 122: UHV AC transmission systems.

The text of this Technical Specification is based on the following documents:

Enquiry draft	Report on voting
122/60/DTS	122/70A/RVDTS

Full information on the voting for the approval of this Technical Specification can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 63042 series, published under the general title *UHV AC transmission 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 "<http://webstore.iec.ch>" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

IMPORTANT – The 'colour inside' logo on the cover page of this publication 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.

INTRODUCTION

Large-scale power sources including renewable energy have recently been developed. To meet the requirements for large power transmission capacity, some countries have introduced, or are considering introducing, ultra high voltage (UHV) transmission systems, overlaying these on the existing transmission systems at lower voltages such as 420 kV and 550 kV.

However, the introduction of UHV AC also presents many challenges to planners and operators. One of the major challenges is the management and control of system voltage and reactive power control. Reactive power control is normally used to address power frequency voltage requirements and maintain the voltage under transient conditions. Suitable insulation designs and coordination procedures are adopted in order to control transient overvoltages and prevent damage to equipment.

The objective of UHV AC power system design is to achieve both economic efficiency and high reliability, considering its impact on systems at lower voltages such as 420 kV and 550 kV. Long-distance transmission lines in particular generate a large amount of charging reactive power (Mvar) that could cause the system voltage to rise significantly. For example, when energizing a transmission line, the terminal voltage at the remote end could reach an unacceptable level. Reactive power compensation is implemented to ensure that the UHV AC system operates within an adequate voltage range under normal conditions and any contingency conditions that the system is designed to withstand.

Moreover, effective insulation design that limits internal electric field stress is important for minimizing and optimizing the size and structure of UHV AC transmission lines and substation apparatus. This document provides technical specifications on insulation design and coordination, reactive power compensation design and voltage regulation that are essential for maintaining UHV AC transmission systems so that they operate safely and efficiently.

UHV AC TRANSMISSION SYSTEMS –

Part 101: Voltage regulation and insulation design

1 Scope

This part of IEC 63042 specifies reactive power compensation design, voltage regulation and control, and insulation design for the coordination of UHV AC transmission systems.

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.

IEC 60071-1, *Insulation co-ordination – Part 1: Definitions, principles and rules*

3 Terms and definitions

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

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

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

3.1

voltage deviation

difference between the actual voltage and nominal system voltage under continuous operating conditions

3.2

network node

<in power networks> any point where two or more transmission lines meet

3.3

controllable shunt reactor

CSR

high voltage shunt reactor whose capacity can be adjusted

3.4

continuous controllable shunt reactor

CCSR

high voltage shunt reactor whose capacity can be adjusted continuously

3.5

multi-stage controllable shunt reactor

MCSR

type of controllable shunt reactor, based on the principle of high impedance transformers whose reactive power output usually varies in discrete stages and is achieved by controlling transistors, circuit-breakers and other devices