IEC TR 63363-1

Edition 1.0 2022-05

TECHNICAL REPORT

colour inside

Performance of voltage sourced converter (VSC) based high-voltage direct current (HVDC) transmission – Part 1: Steady-state conditions

IEC TR 63363-1:2022-05(en)

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

ICS 29.200; 29.240.01

ISBN 978-2-8322-2198-3

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CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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Part 1: Steady-state conditions

FOREWORD

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IEC TR 63363-1 has been prepared by IEC technical committee 115: High Voltage Direct Current (HVDC) transmission for DC voltages above 100 kV and IEC subcommittee 22F: Power electronics for electrical transmission and distribution systems. It is a Technical Report.

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

Draft	Report on voting
115/281/DTR	115/298/RVDTR

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 Technical Report is English.

A list of all parts in the IEC 63363 series, published under the general title *Performance of voltage sourced converter (VSC) based high-voltage direct current (HVDC) transmission*, can be found on the IEC website.

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/standardsdev/publications.

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,
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INTRODUCTION

High-voltage direct current (HVDC) is an established technology that has been in commercial use for more than 60 years. With the changes in demands due to evolving environmental needs, installation of HVDC systems has increased dramatically in the last 30 years and almost half of the world's HVDC projects were commissioned after the year 2000. HVDC has become a common tool in the design of future global transmission systems.

An HVDC system transmits more electrical power over longer distances than a similar alternating current (AC) transmission system, which means fewer transmission lines are needed, saving both money and land and simplifying approvals. In addition to significantly lowering electrical losses over long distances, HVDC transmission is also very stable and easily controlled, and can stabilize and interconnect AC power networks that are otherwise incompatible. Typically, an HVDC system provides unique or superior capabilities in the following aspects:

– long distance bulk power transmission;
– asynchronous interconnections;
– long distance cable;
– controllability;
– lower losses;
– environmental concerns;
– limitation of short-circuit currents.

The voltage sourced converter (VSC) HVDC transmission system is a new generation of HVDC transmission technology, which can increase the reliability of power grids and provide an alternative to connecting wind farms or solar farms to power grids, providing power to islands, connecting asynchronous grids and building direct current (DC) grids. VSC HVDC can provide:

– independent decoupled control of active and reactive power;
– power supply for weak or even passive networks without a need for AC network to provide commutating voltage;
– simultaneous support of both active and reactive power to the AC power systems, which is beneficial for enhancing system reliability and improving power quality.

Simply due to these technical merits, the market demand for VSC HVDC transmission technology is spreading widely over the world. VSC HVDC has been selected for a number of transmission projects aimed at exchanging energy between areas and connection of remote renewable energy sources such as offshore wind farms to onshore.

With the fast development of the VSC HVDC power transmission industry, IEC standardization work has been carried out accordingly. Up to the time of writing, more than four IEC documents, related to VSC DC equipment and systems have been published. Among these, IEC 62747, IEC TR 62543, IEC 62501, and the IEC TS 62751 series provide essential information for the design and operation of VSC HVDC transmission systems.

This document provides, as a supplement to above publications, a basic guide in VSC HVDC transmission system design and operation.

This document is part one of a series of three intended technical reports, covering steady-state performance, while parts two and three (yet to be published) are intended to cover transient performance and dynamic performance, respectively.

PERFORMANCE OF VOLTAGE SOURCED CONVERTER (VSC) BASED HIGH-VOLTAGE DIRECT CURRENT (HVDC) TRANSMISSION –

Part 1: Steady-state conditions

1 Scope

The objective of this Technical Report is to present the "state of the art" with respect to general guidance on the steady-state performance demands of VSC HVDC transmission systems. It concerns the steady-state performance of two-terminal VSC HVDC transmission systems utilizing converters with power flow capability in both directions.

Different configurations of a VSC HVDC transmission system are covered in this document, including the symmetrical monopolar, asymmetrical monopolar, bipolar with earth return, bipolar with dedicated metallic return and rigid bipolar configurations.

There are many variations between different VSC HVDC transmission systems. This document does not consider these in detail; consequently, it cannot be used directly as a specification for a particular project, but rather to provide the general basis for the system steady-state performance demands.

Normally, the performance specifications are based on a complete system including two VSC HVDC converter stations. However, sometimes a VSC HVDC transmission system can also be separately specified and purchased from multiple vendors instead of single turnkey vendor. In such cases, due consideration can be given to the coordination of each part with the overall VSC HVDC system performance objectives and the interface of each with the system can be clearly defined. The major components of the VSC HVDC transmission system are presented in IEC 62747.

Referring to IEC 62747, an HVDC substation/converter station is defined as that part of the VSC HVDC transmission system which consists of one or more VSC converter units installed in a single location together with buildings, reactors, filters, reactive power supply, control, monitoring, protective, measuring and auxiliary equipment. The AC substations are not covered in this document.

This document provides guidance and supporting information on the procedure for system design and the technical issues involved in the system design of VSC HVDC transmission projects for both owners and contractors. This document can be used as the basis for drafting a procurement specification and as a guide during project implementation.

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 62747:2014, *Terminology for voltage-sourced converters (VSC) for high-voltage direct current (HVDC) systems*
IEC 62747:2014/AMD1:2019