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TECHNICAL REPORT

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

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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CONTENTS

FOREWORD 6
INTRODUCTION 8
1 Scope 9
2 Normative references 9
3 Terms, definitions and abbreviated terms 10
3.1 Terms and definitions 10
3.2 Abbreviated terms 11
4 Classifications of VSC HVDC systems 12
4.1 General 12
4.2 Symmetrical monopolar HVDC system 12
4.3 Asymmetrical monopolar HVDC system 13
4.3.1 General 13
4.3.2 ASMP with earth return 13
4.3.3 ASMP with metallic return 13
4.4 Bipolar HVDC system 14
4.4.1 General 14
4.4.2 Bipolar HVDC with earth return 14
4.4.3 Rigid bipolar configuration 14
4.4.4 Bipolar HVDC with dedicated metallic return 15
4.5 Back-to-back HVDC system 15
4.6 Interface transformer arrangements 15
4.7 Switching and reconfiguration 16
4.7.1 Converter station and DC yard switching 16
4.7.2 Transition station switching 17
4.7.3 Connecting multiple converters 18
4.7.4 DC gas-insulated metal enclosed switchgear (DC GIS) 22
5 Environmental information 22
6 Rated power, current and voltage 24
6.1 Rated power 24
6.2 Rated DC current 24
6.3 Rated DC voltage 25
7 Steady-state operation 25
7.1 General 25
7.2 PQ diagram 25
7.3 UQ diagram 26
7.4 Reactive power exchange 27
8 Overload and equipment capability 28
8.1 Overload 28
8.2 Equipment capability 28
8.2.1 General 28
8.2.2 Converter valve capability 29
8.2.3 Capability of oil-cooled transformers and dry type reactors 29
8.2.4 Capability of other converter station equipment 29
9 Converter station types and operation modes 29
9.1 Converter station types 29
9.2 Operation modes 31

9.2.1 Reduced direct voltage operation 31
9.2.2 Full direct voltage operation 31
9.2.3 Operating sequences 31
10 AC system 33
10.1 General 33
10.2 AC voltage 34
10.2.1 Steady-state voltage range 34
10.2.2 Negative sequence voltage 34
10.3 Frequency 34
10.3.1 Rated frequency 34
10.3.2 Steady-state frequency range 34
10.3.3 Short-term frequency variation 34
10.3.4 Frequency variation during emergency 35
10.4 AC voltage and frequency operation ranges 35
10.5 System impedance 35
10.6 Positive and zero-sequence surge impedance 36
10.7 Other sources of harmonics 36
11 Reactive power 36
11.1 General 36
11.2 VSC HVDC systems 36
12 HVDC transmission line, earth electrode line and earth electrode 37
12.1 General 37
12.2 Overhead line(s) 37
12.2.1 General 37
12.2.2 Electrical parameters 37
12.3 Cable(s) 38
12.3.1 General 38
12.3.2 Electrical parameters 38
12.4 Transmission line combined with overhead line and cable section 39
12.5 Electrode line 39
12.6 Earth electrode 39
12.7 Gas insulated line 39
13 Reliability 39
14 HVDC control 39
14.1 General 39
14.2 Control objectives 40
14.3 Control structure 40
14.3.1 General 40
14.3.2 HVDC bipole/station control 41
14.3.3 HVDC pole control 42
14.3.4 Converter and valve control 43
14.4 Measurement 43
15 Telecommunication 44
15.1 Types of telecommunication links 44
15.2 Classification of data to be shared 44
15.3 Fast response telecommunication 44
16 Auxiliary systems 45
16.1 General 45

16.2 Electrical auxiliary system 45
16.2.1 General 45
16.2.2 Auxiliary power supplies 45
16.2.3 Batteries and uninterruptible power supplies (UPS) 46
16.2.4 Emergency supply 46
16.3 Mechanical auxiliary system 47
17 Audible noise 48
17.1 General 48
17.2 Public nuisance 48
17.2.1 Valves and valve coolers 48
17.2.2 Interface transformers 48
17.2.3 Reactors 48
17.3 Noise in working areas 49
18 AC side harmonics 49
18.1 General 49
18.2 Harmonic sources 50
18.2.1 General 50
18.2.2 Converter generated harmonics 50
18.2.3 Pre-existing network harmonics 50
18.3 Total harmonic distortion 51
19 DC side harmonics 51
19.1 General 51
19.2 Coupling between parallel AC and DC circuits 52
20 Power line carrier (PLC) interference 53
20.1 General 53
20.2 Performance specification 54
21 Radio frequency interference 54
21.1 General 54
21.2 RFI from HVDC systems 54
21.2.1 RFI sources 54
21.2.2 RFI propagation 55
22 Power losses 55
Annex A (informative) Fundamental PQ equations of the VSC converter station 56
Annex B (informative) Reactive power exchange of the VSC converter station 58
Bibliography 59

Figure 1 – Symmetrical monopolar VSC HVDC system 13
Figure 2 – Asymmetrical monopolar VSC HVDC system with earth return 13
Figure 3 – Asymmetrical monopolar VSC HVDC system with metallic return 13
Figure 4 – Bipolar VSC HVDC system with earth return 14
Figure 5 – Rigid bipolar VSC HVDC system 15
Figure 6 – Bipolar HVDC system with dedicated metallic return 15
Figure 7 – DC switching of line conductors 17
Figure 8 – DC switching – Overhead line to cable 18
Figure 9 – Examples of VSC HVDC system with two converter units per pole 19
Figure 10 – Example of PQ diagram of the VSC converter 26

Figure 11 – Example of UQ diagram of the VSC converter 27
Figure 12 – Reactive power exchanges of the VSC converter station at PCC 28
Figure 13 – AC/DC converter station types in the U/I diagram 30
Figure 14 – Operating sequence transitions of the VSC HVDC system 32
Figure 15 – Example of the AC grid voltage and frequency operation ranges 35
Figure 16 – Hierarchical structure of an HVDC control system 41
Figure 17 – HVDC pole control 43
Figure 18 – Harmonic contribution by the VSC converter 50
Figure 19 – Amplification of the pre-existing network harmonics 51
Figure 20 – Example of separate AC and DC tower configurations 52
Figure 21 – Example of hybrid AC and DC tower configuration 53
Figure A.1 – Simple configuration of the VSC converter station to AC grid 56
Figure A.2 – Example of power-circle diagrams of the VSC converter 57
Figure B.1 – Simplified equivalent AC grid at PCC of the VSC converter station 58

Table 1 – Information supplied for HVDC substation 22

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

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

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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