

This is a preview - click here to buy the full publication



IEC TR 62543

Edition 2.0 2022-03
REDLINE VERSION

TECHNICAL REPORT



High-voltage direct current (HVDC) power transmission using voltage sourced converters (VSC)

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 29.200; 29.240.99

ISBN 978-2-8322-4546-0

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

CONTENTS

FOREWORD.....	6
1 Scope.....	8
2 Normative references	8
3 Terms and definitions	8
3.1 General.....	9
3.2 Letter symbols	11
3.3 VSC transmission	11
3.4 Power losses	12
4 VSC transmission overview	11
4.1 Basic operating principles of VSC transmission.....	13
4.1.1 Voltage sourced converter as a black box.....	13
4.1.2 Principles of active and reactive power control	14
4.1.3 Operating principles of a VSC transmission scheme	16
4.1.4 Applications of VSC transmission	17
4.2 Design life.....	17
4.3 VSC transmission configurations.....	17
4.3.1 General	17
4.3.2 DC circuit configurations.....	18
4.3.3 Monopole configuration	18
4.3.4 Bipolar configuration.....	19
4.3.5 Parallel connection of two converters	20
4.3.6 Series connection of two converters	21
4.3.7 Parallel and series connection of more than two converters	21
4.4 Semiconductors for VSC transmission	21
5 VSC transmission converter topologies.....	23
5.1 General.....	23
5.2 Converter topologies with VSC valves of switch type	23
5.2.1 General	23
5.2.2 Operating principle	24
5.2.3 Topologies.....	24
5.3 Converter topologies with VSC valves of the controllable voltage source type.....	28
5.3.1 General	28
5.3.2 MMC topology with VSC levels in half-bridge topology.....	30
5.3.3 MMC topology with VSC levels in full-bridge topology.....	32
5.3.4 CTL topology with VSC cells in half-bridge topology	33
5.3.5 CTL topology with VSC cells in full-bridge topology	33
5.4 VSC valve design considerations	33
5.4.1 Reliability and failure mode.....	33
5.4.2 Current rating	34
5.4.3 Transient current and voltage requirements	34
5.4.4 Diode requirements	34
5.4.5 Additional design details.....	35
5.5 Other converter topologies.....	35
5.6 Other equipment for VSC transmission schemes.....	36
5.6.1 General	36
5.6.2 Power components of a VSC transmission scheme.....	36

5.6.3	VSC substation circuit breaker.....	36
5.6.4	AC system side harmonic filters.....	36
5.6.5	Radio frequency interference filters.....	37
5.6.6	Interface transformers and phase reactors.....	37
5.6.7	Valve reactor.....	38
5.6.8	DC capacitors.....	38
5.6.9	DC reactor.....	40
5.6.10	Common mode blocking reactor.....	40
5.6.10	DC filter.....	40
5.6.11	Dynamic braking system.....	40
6	Overview of VSC controls.....	41
6.1	General.....	41
6.2	Operational modes and operational options.....	42
6.3	Power transfer.....	43
6.3.1	General.....	43
6.3.2	Telecommunication between converter stations.....	44
6.4	Reactive power and AC voltage control.....	44
6.4.1	AC voltage control.....	44
6.4.2	Reactive power control.....	44
6.5	Black start capability.....	45
6.6	Supply from a wind farm.....	45
7	Steady-state operation.....	45
7.1	Steady-state capability.....	45
7.2	Converter power losses.....	47
8	Dynamic performance.....	47
8.1	AC system disturbances.....	47
8.2	DC system disturbances.....	48
8.2.1	DC cable fault.....	48
8.2.2	DC overhead line fault.....	48
8.3	Internal faults.....	48
9	HVDC performance requirements.....	49
9.1	Harmonic performance.....	49
9.2	Wave distortion.....	50
9.3	Fundamental and harmonics.....	50
9.3.1	Three-phase 2-level VSC.....	50
9.3.2	Multi-pulse and multi-level converters.....	51
9.4	Harmonic voltages on power systems due to VSC operation.....	51
9.5	Design considerations for harmonic filters (AC side).....	52
9.6	DC side filtering.....	52
10	Environmental impact.....	52
10.1	General.....	52
10.2	Audible noise.....	52
10.3	Electric and magnetic fields (EMF).....	53
10.4	Electromagnetic compatibility (EMC).....	53
11	Testing and commissioning.....	54
11.1	General.....	54
11.2	Factory tests.....	54
11.2.1	Component tests.....	54

11.2.2	Control system tests	54
11.3	Commissioning tests/system tests.....	55
11.3.1	General	55
11.3.2	Precommissioning tests	55
11.3.3	Subsystem tests	55
11.3.4	System tests.....	55
Annex A (informative) Functional specification requirements for VSC transmission systems		60
A.1	Introduction General	60
A.2	Purchaser and manufacturer information requirements	60
A.2.1	General	60
A.2.2	General requirements	61
A.2.3	Detailed descriptions	62
Annex B (informative) Modulation strategies for 2-level converters		66
B.1	Carrier wave PWM	66
B.2	Selective harmonic elimination modulation.....	67
Bibliography.....		69
Figure 1 – Major components that may can be found in a VSC substation.....		10
Figure 2 – Diagram of a generic voltage source converter.....		13
Figure 3 – Principle of active power control.....		15
Figure 4 – Principle of reactive power control		16
Figure 5 – A point-to-point VSC transmission scheme.....		16
Figure 6 – VSC transmission with a symmetrical monopole.....		18
Figure 7 – VSC transmission with an asymmetrical monopole with metallic return.....		18
Figure 8 – VSC transmission with an asymmetrical monopole with earth return.....		19
Figure 9 – VSC transmission in bipolar configuration with earth return.....		19
Figure 10 – VSC transmission in bipolar configuration with dedicated metallic return		20
Figure 11 – VSC transmission in rigid bipolar configuration.....		20
Figure 12 – Parallel connection of two converter units		21
Figure 13 – Symbol of a turn-off semiconductor device and associated free-wheeling diode		22
Figure 14 – Symbol of an IGBT and associated free-wheeling diode		22
Figure 15 – Diagram of a three-phase 2-level converter and associated AC waveform for one phase.....		25
Figure 16 – Single-phase AC output for 2-level converter with PWM switching at 21 times fundamental frequency		26
Figure 17 – Diagram of a three-phase 3-level NPC converter and associated AC waveform for one phase.....		27
Figure 18 – Single-phase AC output for 3-level NPC converter with PWM switching at 21 times fundamental frequency		28
Figure 19 – Electrical equivalent for a converter with VSC valves acting like a controllable voltage source		29
Figure 20 – VSC valve level arrangement and equivalent circuit in MMC topology in half-bridge topology		30
Figure 21 – Converter block arrangement with MMC topology in half-bridge topology		32

Figure 22 – VSC valve level arrangement and equivalent circuit in MMC topology with full-bridge topology	32
Figure 23 – Typical SSOA for the IGBT	34
Figure 24 – A 2-level VSC bridge with the IGBTs turned off	34
Figure 25 – Representing a VSC unit as an AC voltage of magnitude U and phase angle δ behind reactance	41
Figure 26 – Concept of vector control	43
Figure 27 – VSC power controller	43
Figure 28 – AC voltage controller	44
Figure 29 – A typical simplified PQ diagram	46
Figure 30 – Protection concept of a VSC substation	49
Figure 31 – Waveforms for three-phase 2-level VSC	51
Figure 32 – Equivalent circuit at the PCC of the VSC	51
Figure B.1 – Voltage harmonics spectra of a 2-level VSC with carrier frequency at 21st harmonic	67
Figure B.2 – Phase output voltage for selective harmonic elimination modulation (SHEM)	68

INTERNATIONAL ELECTROTECHNICAL COMMISSION

HIGH-VOLTAGE DIRECT CURRENT (HVDC) POWER TRANSMISSION USING VOLTAGE SOURCED CONVERTERS (VSC)

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.

This redline version of the official IEC Standard allows the user to identify the changes made to the previous edition IEC TR 62543:2011+AMD1:2013+AMD2:2017 CSV. A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text.

IEC TR 62543 has been prepared by subcommittee 22F: Power electronics for electrical transmission and distribution systems, of IEC technical committee 22: Power electronic systems and equipment. It is a Technical Report.

This second edition cancels and replaces the first edition published in 2011, Amendment 1:2013 and Amendment 2:2017. This edition constitutes a technical revision.

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

- a) in Clause 3, some redundant definitions which were identical to those listed in IEC 62747 have been deleted;
- b) in 4.3.4, description and diagrams have been added for the cases of a bipole with dedicated metallic return and a rigid bipole;
- c) in 4.4, mention is made of the bi-mode insulated gate transistor (BiGT) and injection enhanced gate transistor (IEGT) as possible alternatives to the IGBT;
- d) in 5.6, the reference to common-mode blocking reactors has been deleted since these are very rarely used nowadays.

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

Draft	Report on voting
22F/649/DTR	22F/669/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.

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.

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

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.

HIGH-VOLTAGE DIRECT CURRENT (HVDC) POWER TRANSMISSION USING VOLTAGE SOURCED CONVERTERS (VSC)

1 Scope

This document gives general guidance on the subject of voltage sourced converters (VSC) used for transmission of power by high voltage direct current (HVDC). It describes converters that are not only voltage sourced (containing a capacitive energy storage medium and where the polarity of DC voltage remains fixed) but also self-commutated, using semiconductor devices which can both be turned on and turned off by control action. The scope includes 2-level and 3-level converters with pulse-width modulation (PWM), along with multi-level converters, modular multi-level converters and cascaded two-level converters, but excludes 2-level and 3-level converters operated without PWM, in square-wave output mode.

HVDC power transmission using voltage sourced converters is known as "VSC transmission".

The various types of circuit that can be used for VSC transmission are described in this document, along with their principal operational characteristics and typical applications. The overall aim is to provide a guide for purchasers to assist with the task of specifying a VSC transmission scheme.

Line-commutated and current-sourced converters are specifically excluded from this document.

2 Normative references

The following referenced documents are indispensable for the application 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 61975, High-voltage direct current (HVDC) installations – System tests~~

IEC 62501, *Voltage sourced converter (VSC) valves for high-voltage direct current (HVDC) power transmission – Electrical testing*

IEC 62747, *Terminology for voltage-sourced converters (VSC) for high-voltage direct current (HVDC) systems*

~~IEC 62751 (all parts), Power losses in voltage sourced converter (VSC) valves for high voltage direct current (HVDC) systems~~

TECHNICAL REPORT



High-voltage direct current (HVDC) power transmission using voltage sourced converters (VSC)



CONTENTS

FOREWORD	6
1 Scope	8
2 Normative references	8
3 Terms and definitions	8
3.1 General.....	8
3.2 Letter symbols	10
3.3 VSC transmission	10
3.4 Power losses	11
4 VSC transmission overview	11
4.1 Basic operating principles of VSC transmission.....	11
4.1.1 Voltage sourced converter as a black box.....	11
4.1.2 Principles of active and reactive power control	12
4.1.3 Operating principles of a VSC transmission scheme	14
4.1.4 Applications of VSC transmission	15
4.2 Design life.....	15
4.3 VSC transmission configurations.....	15
4.3.1 General	15
4.3.2 DC circuit configurations.....	16
4.3.3 Monopole configuration	16
4.3.4 Bipolar configuration.....	17
4.3.5 Parallel connection of two converters	18
4.3.6 Series connection of two converters	19
4.3.7 Parallel and series connection of more than two converters	19
4.4 Semiconductors for VSC transmission	19
5 VSC transmission converter topologies.....	21
5.1 General.....	21
5.2 Converter topologies with VSC valves of switch type	21
5.2.1 General	21
5.2.2 Operating principle	22
5.2.3 Topologies.....	22
5.3 Converter topologies with VSC valves of the controllable voltage source type.....	25
5.3.1 General	25
5.3.2 MMC topology with VSC levels in half-bridge topology.....	26
5.3.3 MMC topology with VSC levels in full-bridge topology.....	28
5.3.4 CTL topology with VSC cells in half-bridge topology	28
5.3.5 CTL topology with VSC cells in full-bridge topology	28
5.4 VSC valve design considerations	29
5.4.1 Reliability and failure mode.....	29
5.4.2 Current rating	29
5.4.3 Transient current and voltage requirements	29
5.4.4 Diode requirements	30
5.4.5 Additional design details.....	30
5.5 Other converter topologies.....	31
5.6 Other equipment for VSC transmission schemes.....	31
5.6.1 General	31
5.6.2 Power components of a VSC transmission scheme.....	31

5.6.3	VSC substation circuit breaker.....	32
5.6.4	AC system side harmonic filters.....	32
5.6.5	Radio frequency interference filters.....	32
5.6.6	Interface transformers and phase reactors.....	32
5.6.7	Valve reactor.....	33
5.6.8	DC capacitors.....	33
5.6.9	DC reactor.....	35
5.6.10	DC filter.....	36
5.6.11	Dynamic braking system.....	36
6	Overview of VSC controls.....	36
6.1	General.....	36
6.2	Operational modes and operational options.....	37
6.3	Power transfer.....	38
6.3.1	General.....	38
6.3.2	Telecommunication between converter stations.....	38
6.4	Reactive power and AC voltage control.....	38
6.4.1	AC voltage control.....	38
6.4.2	Reactive power control.....	39
6.5	Black start capability.....	39
6.6	Supply from a wind farm.....	39
7	Steady-state operation.....	40
7.1	Steady-state capability.....	40
7.2	Converter power losses.....	41
8	Dynamic performance.....	42
8.1	AC system disturbances.....	42
8.2	DC system disturbances.....	42
8.2.1	DC cable fault.....	42
8.2.2	DC overhead line fault.....	43
8.3	Internal faults.....	43
9	HVDC performance requirements.....	44
9.1	Harmonic performance.....	44
9.2	Wave distortion.....	45
9.3	Fundamental and harmonics.....	45
9.3.1	Three-phase 2-level VSC.....	45
9.3.2	Multi-pulse and multi-level converters.....	45
9.4	Harmonic voltages on power systems due to VSC operation.....	46
9.5	Design considerations for harmonic filters (AC side).....	46
9.6	DC side filtering.....	46
10	Environmental impact.....	47
10.1	General.....	47
10.2	Audible noise.....	47
10.3	Electric and magnetic fields (EMF).....	47
10.4	Electromagnetic compatibility (EMC).....	47
11	Testing and commissioning.....	48
11.1	General.....	48
11.2	Factory tests.....	49
11.2.1	Component tests.....	49
11.2.2	Control system tests.....	49

11.3	Commissioning tests/system tests.....	49
11.3.1	General	49
11.3.2	Precommissioning tests	50
11.3.3	Subsystem tests	50
11.3.4	System tests.....	50
Annex A (informative) Functional specification requirements for VSC transmission systems		55
A.1	General.....	55
A.2	Purchaser and manufacturer information requirements	55
A.2.1	General	55
A.2.2	General requirements	56
A.2.3	Detailed descriptions	57
Annex B (informative) Modulation strategies for 2-level converters		61
B.1	Carrier wave PWM.....	61
B.2	Selective harmonic elimination modulation.....	62
Bibliography.....		64
Figure 1 – Major components that can be found in a VSC substation		9
Figure 2 – Diagram of a generic voltage source converter.....		12
Figure 3 – Principle of active power control.....		13
Figure 4 – Principle of reactive power control		14
Figure 5 – A point-to-point VSC transmission scheme.....		14
Figure 6 – VSC transmission with a symmetrical monopole.....		16
Figure 7 – VSC transmission with an asymmetrical monopole with metallic return.....		17
Figure 8 – VSC transmission with an asymmetrical monopole with earth return.....		17
Figure 9 – VSC transmission in bipolar configuration with earth return.....		17
Figure 10 – VSC transmission in bipolar configuration with dedicated metallic return		18
Figure 11 – VSC transmission in rigid bipolar configuration.....		18
Figure 12 – Parallel connection of two converter units		19
Figure 13 – Symbol of a turn-off semiconductor device and associated free-wheeling diode		20
Figure 14 – Symbol of an IGBT and associated free-wheeling diode		20
Figure 15 – Diagram of a three-phase 2-level converter and associated AC waveform for one phase.....		23
Figure 16 – Single-phase AC output for 2-level converter with PWM switching at 21 times fundamental frequency		23
Figure 17 – Diagram of a three-phase 3-level NPC converter and associated AC waveform for one phase.....		24
Figure 18 – Single-phase AC output for 3-level NPC converter with PWM switching at 21 times fundamental frequency		25
Figure 19 – Electrical equivalent for a converter with VSC valves acting like a controllable voltage source		26
Figure 20 – VSC valve level arrangement and equivalent circuit in MMC topology in half-bridge topology		27
Figure 21 – Converter block arrangement with MMC topology in half-bridge topology		27
Figure 22 – VSC valve level arrangement and equivalent circuit in MMC topology with full-bridge topology		28

Figure 23 – Typical SSOA for the IGBT	29
Figure 24 – A 2-level VSC bridge with the IGBTs turned off	30
Figure 25 – Representing a VSC unit as an AC voltage of magnitude U and phase angle δ behind reactance	36
Figure 26 – Concept of vector control	37
Figure 27 – VSC power controller	38
Figure 28 – AC voltage controller	39
Figure 29 – A typical simplified PQ diagram	41
Figure 30 – Protection concept of a VSC substation.....	43
Figure 31 – Waveforms for three-phase 2-level VSC	45
Figure 32 – Equivalent circuit at the PCC of the VSC	46
Figure B.1 – Voltage harmonics spectra of a 2-level VSC with carrier frequency at 21st harmonic.....	62
Figure B.2 – Phase output voltage for selective harmonic elimination modulation (SHEM).....	63

INTERNATIONAL ELECTROTECHNICAL COMMISSION

HIGH-VOLTAGE DIRECT CURRENT (HVDC) POWER TRANSMISSION USING VOLTAGE SOURCED CONVERTERS (VSC)

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.

IEC TR 62543 has been prepared by subcommittee 22F: Power electronics for electrical transmission and distribution systems, of IEC technical committee 22: Power electronic systems and equipment. It is a Technical Report.

This second edition cancels and replaces the first edition published in 2011, Amendment 1:2013 and Amendment 2:2017. This edition constitutes a technical revision.

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

- a) in Clause 3, some redundant definitions which were identical to those listed in IEC 62747 have been deleted;
- b) in 4.3.4, description and diagrams have been added for the cases of a bipole with dedicated metallic return and a rigid bipole;
- c) in 4.4, mention is made of the bi-mode insulated gate transistor (BiGT) and injection enhanced gate transistor (IEGT) as possible alternatives to the IGBT;

d) in 5.6, the reference to common-mode blocking reactors has been deleted since these are very rarely used nowadays.

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

Draft	Report on voting
22F/649/DTR	22F/669/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.

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.

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

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.

HIGH-VOLTAGE DIRECT CURRENT (HVDC) POWER TRANSMISSION USING VOLTAGE SOURCED CONVERTERS (VSC)

1 Scope

This document gives general guidance on the subject of voltage sourced converters (VSC) used for transmission of power by high voltage direct current (HVDC). It describes converters that are not only voltage sourced (containing a capacitive energy storage medium and where the polarity of DC voltage remains fixed) but also self-commutated, using semiconductor devices which can both be turned on and turned off by control action. The scope includes 2-level and 3-level converters with pulse-width modulation (PWM), along with multi-level converters, modular multi-level converters and cascaded two-level converters, but excludes 2-level and 3-level converters operated without PWM, in square-wave output mode.

HVDC power transmission using voltage sourced converters is known as "VSC transmission".

The various types of circuit that can be used for VSC transmission are described in this document, along with their principal operational characteristics and typical applications. The overall aim is to provide a guide for purchasers to assist with the task of specifying a VSC transmission scheme.

Line-commutated and current-sourced converters are specifically excluded from this document.

2 Normative references

The following referenced documents are indispensable for the application 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 62501, *Voltage sourced converter (VSC) valves for high-voltage direct current (HVDC) power transmission – Electrical testing*

IEC 62747, *Terminology for voltage-sourced converters (VSC) for high-voltage direct current (HVDC) systems*