

INTERNATIONAL STANDARD

NORME INTERNATIONALE

High-voltage direct current (HVDC) transmission – Vocabulary

Transport d'énergie en courant continu à haute tension (CCHT) – Vocabulaire



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CONTENTS

FOREWORD	3
1 Scope	5
2 Normative references	5
3 Symbols and abbreviated terms	5
3.1 Letter symbols	5
3.2 Subscripts	6
3.3 Abbreviated terms	6
4 Graphical symbols	6
5 General terms related to converter circuits	6
6 Converter units and valves	9
7 Converter operating conditions	12
8 HVDC systems and substations	15
9 HVDC substation equipment	19
10 Modes of control	23
11 Control systems	23
12 Control functions	26
Bibliography	37
Figure 1 – Graphical symbols	27
Figure 2 – Bridge converter connection	27
Figure 3 – Example of a converter unit	28
Figure 4 – Commutation process at rectifier and inverter modes of operation	29
Figure 5 – Illustrations of commutation in inverter operation	30
Figure 6 – Typical valve voltage waveforms	31
Figure 7 – Example of an HVDC substation	32
Figure 8 – Example of bipolar two-terminal HVDC transmission system	33
Figure 9 – Example of a multiterminal bipolar HVDC transmission system with parallel connected HVDC substations	33
Figure 10 – Example of a multiterminal HVDC transmission system with series connected HVDC substations	34
Figure 11 – Simplified steady-state voltage-current characteristic of a two-terminal HVDC system	34
Figure 12 – Hierarchical structure of an HVDC control system	35
Figure 13 – Capacitor commutated converter configurations	36

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**HIGH-VOLTAGE DIRECT CURRENT
(HVDC) TRANSMISSION – VOCABULARY**

FOREWORD

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International Standard IEC 60633 has been prepared by subcommittee 22F: Power electronics for electrical transmission and distribution systems, of IEC technical committee 22: Power electronic systems and equipment.

This third edition cancels and replaces the second edition published in 1998, Amendment 1:2009 and Amendment 2:2015. This edition constitutes a technical revision.

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

- a) 40 terms and definitions have been amended and 31 new terms and definitions have been added mainly on converter units and valves, converter operating conditions, HVDC systems and substations and HVDC substation equipment;
- b) a new Figure 13 on capacitor commutated converter configurations has been added.

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

CDV	Report on voting
22F/480/CDV	22F/491A/RVC

Full information on the voting for the approval of this International Standard 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.

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.

The contents of the corrigendum of February 2020 have been included in this copy.

HIGH-VOLTAGE DIRECT CURRENT (HVDC) TRANSMISSION – VOCABULARY

1 Scope

This document defines terms for high-voltage direct current (HVDC) power transmission systems and for HVDC substations using electronic power converters for the conversion from AC to DC or vice versa.

This document is applicable to HVDC substations with line commutated converters, most commonly based on three-phase bridge (double way) connections (see Figure 2) in which unidirectional electronic valves, for example semiconductor valves, are used. For the thyristor valves, only the most important definitions are included in this document. A more comprehensive list of HVDC valve terminology is given in IEC 60700-2.

2 Normative references

There are no normative references in this document.

3 Symbols and abbreviated terms

The list covers only the most frequently used symbols. For a more complete list of the symbols which have been adopted for static converters, see IEC 60027 (all parts) and other standards listed in the Bibliography.

3.1 Letter symbols

U_d	direct voltage (any defined value)
U_{d0}	nominal no-load direct voltage
U_{di0}	ideal no-load direct voltage
U_{dN}	rated direct voltage
U_L	phase-to-phase voltage on line side of converter transformer, RMS value including harmonics
U_{LN}	rated value of U_L
U_{v0}	no-load phase-to-phase voltage on the valve side of transformer, RMS value excluding harmonics
I_d	direct current (any defined value)
I_{dN}	rated direct current
I_L	current on line side of converter transformer, RMS value including harmonics
I_{LN}	rated value of I_L
I_v	current on valve side of transformer, RMS value including harmonics
α	(trigger) delay angle
β	(trigger) advance angle
γ	extinction angle
μ	overlap angle
p	pulse number
q	commutation number

3.2 Subscripts

0 (zero)	at no load
N	rated value or at rated load
d	direct current or voltage
i	ideal
L	line side of converter transformer
v	valve side of converter transformer
max	maximum
min	minimum
n	pertaining to harmonic component of order n

3.3 Abbreviated terms

The following abbreviated terms are always in capital letters and without dots.

HVDC	high-voltage direct current
MVU	multiple valve (unit) (see 6.3.2)
SCR	short-circuit ratio (see 7.32)
ESCR	effective short-circuit ratio (see 7.33)
MTDC	multiterminal HVDC transmission system (see 8.2.2)
MRTB	metallic return transfer breaker (see 9.22)
ERTB	earth return transfer breaker (see 9.23)
VDCOL	voltage dependent current order limit (see 12.9)
SSTI	sub-synchronous torsional interaction (see 10.10)

4 Graphical symbols

Figure 1 shows the specific graphical symbols which are defined only for the purposes of this document. For a more complete list of the graphical symbols which have been adopted for static converters, see IEC 60617.

5 General terms related to converter circuits

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>

NOTE For a more complete list of the terms which have been adopted for static converters, see IEC 60050-551 and IEC 60146-1-1.

5.1

conversion

<HVDC> transfer of energy from AC to DC or vice versa, or a combination of these operations

5.2

converter connection

electrical arrangement of arms and other components necessary for the functioning of the main power circuit of a converter

5.3

bridge converter connection

double-way connection comprising six converter arms such that the centre terminals are the phase terminals of the AC circuit, and that the outer terminals of like polarity are connected together and are the DC terminals

Note 1 to entry: The double-way connection is illustrated in Figure 2.

5.3.1

uniform bridge

bridge where all converter arms are either controllable or non-controllable

5.3.2

non-uniform bridge

bridge with both controllable and non-controllable converter arms

5.4

converter arm

part of a bridge connecting two points of different potentials within a bridge, for example, between an AC terminal and a DC terminal

5.4.1

controllable converter arm

converter arm in which the start of forward conduction may be determined by an externally applied signal

5.4.2

non-controllable converter arm

converter arm in which the start of forward conduction is determined solely by the voltage applied to its terminals

5.5

by-pass path

low resistance path between the DC terminals of one or several bridges excluding the AC circuit

Note 1 to entry: The by-pass path may either constitute a unidirectional path, e.g. a by-pass arm (see 5.5.1), or a by-pass pair (see 5.5.2), or it may constitute a bidirectional path, e.g. a by-pass switch (see 9.30).

5.5.1

by-pass arm

unidirectionally conducting by-pass path connected only between DC terminals, commonly used with mercury arc valve technology

Note 1 to entry: By-pass arm is not shown in Figure 2.

5.5.2

by-pass pair

two converter arms of a bridge connected to a common AC terminal and forming a by-pass path

SEE: Figure 2.

5.6

commutation

transfer of current between any two paths with both paths carrying current simultaneously during this process

Note 1 to entry: Commutation may occur between any two converter arms, including the connected AC phases, between a converter arm and a by-pass arm, or between any two paths in the circuit.

5.6.1

line commutation

method of commutation whereby the commutating voltage is supplied by the AC system

5.7

commutating group

group of converter arms which commute cyclically and independently from other converter arms and where the commutations are normally not simultaneous

Note 1 to entry: In the case of a bridge, a commutating group is composed of the converter arms connected to a common DC terminal. In certain cases, e.g. when large currents and/or large commutation inductances are involved, the commutation in the two commutating groups belonging to the same bridge need not be independent.

SEE: Figure 2.

5.8

commutation inductance

total inductance included in the commutation circuit, in series with the commutating voltage

5.9

pulse number

p

characteristic of a converter connection expressed as the number of non-simultaneous symmetrical commutations occurring during one cycle of the AC line voltage

Note 1 to entry: The pulse number of a bridge converter connection defined in 5.3 is always $p = 6$.

5.10

commutation number

q

number of commutations during one cycle of the AC line voltage occurring in each commutating group

Note 1 to entry: In a bridge converter connection, each commutating group has a commutation number $q = 3$.

5.11

capacitor commutated converter

converter in which series capacitors are included between the converter transformer and the valves

SEE: Figure 13 a).

5.12

controlled series capacitor converter

converter in which series capacitors are inserted between the AC filter bus and the AC network

SEE: Figure 13 b).

5.13

commutating voltage

voltage which causes the current to commute

[SOURCE: IEC 60050-551:1998, 551-16-02]

5.14

controlled capacitor commutated converter

converter in which controlled series capacitors are included between the converter transformer and the valves

5.15**series capacitor converter**

converter in which fixed series capacitors are inserted between the AC filter bus and the AC network

6 Converter units and valves**6.1****converter unit**

indivisible operative unit comprising all equipment between the point of common coupling on the AC side (see 8.24) and the point of common coupling-DC side (see 8.25), essentially one or more converter bridges, together with one or more converter transformers, converter unit control equipment, essential protective and switching devices and auxiliaries, if any, used for conversion

SEE: Figure 3.

6.2**converter bridge**

equipment used to implement the bridge converter connection and the by-pass arm, if used

Note 1 to entry: The term "bridge" may be used to describe either the circuit connection or the equipment implementing that circuit (see 5.3).

6.2.1**anode/cathode valve commutating group**

equipment used to implement the converter arms of one commutating group of a bridge with interconnected anode/cathode terminals

6.3**valve**

complete operative controllable or non-controllable valve device assembly, normally conducting in only one direction (the forward direction), which can function as a converter arm in a converter bridge

6.3.1**single valve unit**

single structure comprising only one valve

6.3.2**multiple valve unit****MVU**

single structure comprising more than one valve

Note 1 to entry: Examples of multiple valve units are double valves, quadrivalves and octovalves with two, four and eight series-connected valves respectively.

Note 2 to entry: This note applies to the French language only.

6.4**main valve**

valve in a converter arm

6.5**by-pass valve**

valve in a by-pass arm

6.6

thyristor module

part of a valve comprising a mechanical assembly of thyristors with their immediate auxiliaries but without valve reactors

Note 1 to entry: Thyristor modules may be elements in the construction of a valve, and/or be interchangeable for maintenance purposes.

6.7

reactor module

part of a valve, being a mechanical assembly of one or more reactors, used in some valve designs

Note 1 to entry: Reactor modules may be elements in the construction of a valve.

6.8

valve section

electrical assembly, comprising a number of thyristors and other components, which exhibits prorated electrical properties of a complete valve

Note 1 to entry: This term is mainly used to define a test object for valve testing purposes.

6.9

valve thyristor level

part of a valve comprising a thyristor, or thyristors connected in parallel, together with their immediate auxiliaries, and reactor, if any

6.10

valve support

part of the valve which mechanically supports and electrically insulates the active part of the valve from earth

Note 1 to entry: A part of a valve which is clearly identifiable in a discrete form to be a valve support may not exist in all designs of valves.

6.11

valve structure

structural components of a valve, required in order to physically support the valve modules

6.12

valve base electronics

VBE

electronic unit, at earth potential, providing the electrical to optical conversion between the converter control system and the valves

Note 1 to entry: This note applies to the French language only.

6.13

valve electronics

electronic circuits at valve potential(s) which perform control and protection functions for one or more thyristor levels

6.14

valve arrester

arrester connected across a valve

SEE: Figure 3.

6.15

converter unit arrester

arrester connected across the DC terminals of a converter unit

SEE: Figure 3.

6.16

converter unit DC bus arrester

arrester connected from the high-voltage DC bus of the converter unit to substation earth

SEE: Figure 3 and Figure 7.

6.17

midpoint DC bus arrester

arrester connected between the midpoint of the two 6-pulse bridges of a 12-pulse converter unit and substation earth

Note 1 to entry: In some HVDC substation designs, two twelve-pulse converter units are connected in series. In this case, the midpoint DC bus arrester at the upper twelve-pulse converter unit is not connected to the substation earth but to the high-voltage DC bus of the lower twelve-pulse converter unit.

SEE: Figure 7.

6.18

valve reactor

reactor(s) connected in series with the thyristors in a valve, for the purpose of limiting the rate of rise of current at turn-on and voltage during the off-state

Note 1 to entry: Valve reactors may be external to the entire valve or distributed within the valve.

6.19

converter transformer

transformer through which energy is transmitted from an AC system to one or more converter bridges or vice versa

SEE: Figure 3.

6.19.1

line side windings

converter transformer windings which are connected to the AC system

6.19.2

valve side windings

converter transformer windings which are connected to the AC terminals of one or more converter bridges

6.20

valve module

part of a valve comprising a mechanical assembly of thyristors with their immediate auxiliaries and valve reactor(s)

6.21

redundant levels

maximum number of series connected thyristor levels in a valve that may be short-circuited externally or internally during service without affecting the safe operation of the valve as demonstrated by type tests, and which if and when exceeded, would require shutdown of the valve to replace the failed levels or acceptance of increased risk of failures

6.22

valve anode terminal

valve terminal at which the forward current flows into the valve

6.23

valve cathode terminal

valve terminal at which the forward current flows out of the valve

7 Converter operating conditions

7.1

rectifier operation

rectification

mode of operation of a converter or an HVDC substation when energy is transferred from the AC side to the DC side

7.2

inverter operation

inversion

mode of operation of a converter or an HVDC substation when energy is transferred from the DC side to the AC side

7.3

forward direction

conducting direction

<of a valve> direction in which a valve is capable of conducting load current

7.4

reverse direction

non-conducting direction

<of a valve> reverse of the conducting direction

7.5

forward current

current which flows through a valve in the forward direction

7.6

reverse current

current which flows through a valve in the reverse direction

7.7

forward voltage

voltage applied between the anode and cathode terminals of a valve or an arm when the anode is positive with respect to the cathode

7.8

reverse voltage

voltage applied between the anode and cathode terminals of a valve or an arm when the anode is negative with respect to the cathode

7.9

conducting state

on-state

condition of a valve when the valve exhibits a low resistance

Note 1 to entry: The valve voltage for this condition is shown in Figure 6.

7.10

valve voltage drop

voltage which, during the conducting state, appears across the valve terminals

7.11

non-conducting state

blocking state

condition of a valve when all thyristors are turned off

7.11.1**forward blocking state****off-state**

non-conducting state of a controllable valve when forward voltage is applied between its main terminals

SEE: Figure 6.

7.11.2**reverse blocking state**

non-conducting state of a valve when reverse voltage is applied between its main terminals

SEE: Figure 6.

7.12**firing**

establishment of current in the forward direction in a valve

7.13**valve control pulse**

pulse which, during its entire duration, allows the firing of the valve

7.14**valve firing pulse**

pulse which initiates the firing of the valve, normally derived from the valve control pulse

7.15**converter blocking**

operation preventing further conversion by a converter by inhibiting valve control pulses

Note 1 to entry: This action may also include firing of a valve, or valves, selected to form a by-pass path.

7.16**converter deblocking**

operation permitting the start of conversion by a converter

7.17**valve blocking**

operation preventing further firing of a controllable valve

7.18**valve deblocking**

operation permitting firing of a controllable valve

7.19**phase control**

process of controlling the instant within the cycle at which forward current conduction in a controllable valve begins

7.20**trigger delay angle****firing delay angle**

α

time, expressed in electrical angular measure, from the zero crossing of the idealized sinusoidal commutating voltage to the starting instant of forward current conduction

SEE: Figure 4.

7.21

trigger advance angle
firing advance angle

β

time, expressed in electrical angular measure, from the starting instant of forward current conduction to the next zero crossing of the idealized sinusoidal commutating voltage

Note 1 to entry: The advance angle β is related to the delay angle α by $\beta = \pi - \alpha$ (see Figure 4).

7.22

overlap angle

μ

duration of commutation between two converter arms, expressed in electrical angular measure

SEE: Figure 4 and Figure 5.

7.23

extinction angle

γ

time, expressed in electrical angular measure, from the end of current conduction to the next zero crossing of the idealized sinusoidal commutating voltage

Note 1 to entry: γ depends on the advance angle β and the overlap angle μ and is determined by the relation $\gamma = \beta - \mu$ (see Figure 4 and Figure 5).

7.24

hold-off interval

time from the instant when the forward current of a controllable valve has decreased to zero to the instant when the same valve is subjected to forward voltage

Note 1 to entry: Hold-off interval, when expressed in electrical angular measure, is commonly referred to as the extinction angle. However, the difference between the concepts of extinction angle and hold-off interval should be noted, as shown in Figure 5.

7.24.1

critical hold-off interval

minimum hold-off interval for which the inverter operation can be maintained

7.25

conduction interval

part of a cycle during which a valve is in the conducting state

SEE: Figure 6.

7.26

blocking interval
idle interval

part of a cycle during which a valve is in the non-conducting state

SEE: Figure 6.

7.27

forward blocking interval

part of the blocking interval during which a controllable valve is in the forward blocking state

SEE: Figure 6.

7.28

reverse blocking interval

part of the blocking interval during which a valve is in the reverse blocking state

SEE: Figure 6.

7.29**false firing****misfiring**

firing of a valve at an unintended instant

7.30**firing failure**

failure to achieve firing of a valve during the entire forward voltage interval

7.31**commutation failure**

failure to commute the forward current from the conducting converter arm to the succeeding converter arm

7.32**short-circuit ratio****SCR**

ratio of the AC network short-circuit level (in MVA) at 1 p.u. voltage at the point of connection to the HVDC substation AC bus, to the rated DC power of the HVDC substation (in MW)

Note 1 to entry: The present definition of SCR differs from the definition given in IEC 60146-1-1.

7.33**effective short-circuit ratio****ESCR**

ratio of the AC network short-circuit level (in MVA) at 1 p.u. voltage at the point of connection to the HVDC substation AC bus, reduced by the reactive power of the shunt capacitor banks and AC filters connected to this point (in Mvar), to the rated DC power of the HVDC substation (in MW)

7.34**triggering****gating**

control action to achieve firing of a valve or an individual thyristor

7.35**operating state**

condition in which the HVDC substation is energized and the converters are operating at non-zero active or reactive power output at the point of common coupling (PCC) to the AC network

7.36**blocked state**

condition in which all valves of the converter unit are blocked

7.37**valve voltage**

difference in voltage between the valve anode terminal and valve cathode terminal

8 HVDC systems and substations

8.1**HVDC system**

electrical power system which transfers energy in the form of high-voltage direct current between two or more AC buses

8.2

HVDC transmission system

HVDC system which transfers energy between two or more geographic locations

8.2.1

two-terminal HVDC transmission system

HVDC transmission system consisting of two HVDC substations and the connecting HVDC transmission line(s)

SEE: Figure 8.

8.2.2

multiterminal HVDC transmission system

MTDC

HVDC transmission system consisting of more than two separated HVDC substations and the interconnecting HVDC transmission lines

SEE: Figure 9 and Figure 10.

8.2.3

HVDC back-to-back system

HVDC system which transfers energy between AC buses at the same location

8.3

unidirectional HVDC system

HVDC system for the transfer of energy in only one direction

Note 1 to entry: Most HVDC systems are inherently bidirectional. However, some systems may be optimized to transmit power in only one preferred direction. Such systems may still be considered as "bidirectional".

8.4

bidirectional HVDC system

HVDC system for the transfer of energy in either direction

Note 1 to entry: A multiterminal HVDC system is bidirectional if one or more substations are bidirectional.

8.5

HVDC system pole

part of an HVDC system consisting of all the equipment in the HVDC substations and the interconnecting transmission lines, if any, which during normal operation exhibit a common direct voltage polarity with respect to earth

SEE: Figure 8.

8.6

HVDC system bipole

part of an HVDC system consisting of two independently operable HVDC system poles, which during normal operation, exhibit opposite direct voltage polarities with respect to earth

8.7

symmetrical monopole

part of an HVDC system consisting of all the equipment in the HVDC substations and the interconnecting transmission lines, if any, which during normal operation exhibits equal and opposite direct voltage polarities with respect to earth but without series connection of converters in each converter station

Note 1 to entry: The term "symmetrical monopole" is used even though there are two polarities with DC voltages, because with only one converter it is not possible to provide the redundancy which is normally associated with the term "bipole".

8.8**bipolar HVDC system**

HVDC system with two poles of opposite polarity with respect to earth

Note 1 to entry: The overhead lines, if any, of the two poles may be carried on common or separate towers.

SEE: Figure 8.

8.9**rigid DC current bipolar system**

bipolar HVDC system without neutral connection between both converter stations

Note 1 to entry: Since only two (pole) conductors exist, no unbalance current between both poles is possible. In case of interruption of power transfer of one converter pole, the current of the other pole has to be interrupted as well (at least for a limited time to allow reconfiguration of the DC circuit).

8.10**monopolar HVDC system****asymmetric HVDC system**

HVDC system with only one pole

8.11**symmetrical monopolar HVDC system**

HVDC system with only one symmetrical monopole

8.12**HVDC substation****HVDC converter station**

part of an HVDC system which consists of one or more converter units installed in a single location together with buildings, reactors, filters, reactive power supply, control, monitoring, protective, measuring and auxiliary equipment

Note 1 to entry: An HVDC substation forming part of an HVDC transmission system may be referred to as an HVDC transmission substation.

SEE: Figure 7.

8.12.1**HVDC tapping substation**

HVDC substation, mainly used for inversion, with a rating which is a small fraction of that of the rectifier(s) in the system

8.13**HVDC substation bipole**

part of a bipolar HVDC system contained within a substation

8.14**HVDC substation pole**

part of an HVDC system pole which is contained within a substation

SEE: Figure 8.

8.15**HVDC transmission line**

part of an HVDC transmission system consisting of a system of overhead lines and/or cables

Note 1 to entry: The HVDC transmission lines are terminated in HVDC substations (see Figure 8).

8.16**HVDC transmission line pole**

part of an HVDC transmission line which belongs to the same HVDC system pole

8.17

earth electrode

array of conducting elements placed in the earth, or the sea, which provides a low resistance path between a point in the DC circuit and the earth and is capable of carrying continuous current for some extended period

Note 1 to entry: An earth electrode may be located at a point some distance from the HVDC substation.

Note 2 to entry: Where the electrode is placed in the sea it may be termed a sea electrode.

SEE: Figure 7.

8.18

earth electrode line

insulated line between the HVDC substation DC neutral bus and the earth electrode

SEE: Figure 7.

8.19

earth return

operation mode in which the return current path between neutrals of the HVDC substations is through the earth

8.20

metallic return

operation mode in which the return current path between neutrals of the HVDC substations is through a dedicated conductor

Note 1 to entry: The metallic return conductor may be either a dedicated neutral conductor or another high voltage conductor.

8.21

series converter configuration

converter configuration which consists of two or more converters connected in series on the DC side and located in the same substation and connected to the same AC and DC transmission system

8.22

unitary connection

HVDC system where only one generator is directly connected to an HVDC system through a specific converter and without any other AC component except for an assigned step-up transformer

8.23

isolated generating system

HVDC system in which several generators are directly connected to one HVDC converter through one or more specifically assigned step-up transformers but without any other AC network connection

8.24

point of common coupling

PCC

point of interconnection of the HVDC converter station to the adjacent AC system

Note 1 to entry: This note applies to the French language only.

8.25

point of common coupling-DC side

PCC-DC

point of interconnection of the HVDC converter station to the DC transmission line

Note 1 to entry: This note applies to the French language only.

9 HVDC substation equipment

9.1

AC harmonic filter

filter designed to reduce the harmonic voltage at the AC bus and the flow of harmonic current into the associated AC system and to prevent amplification of background harmonics on the AC system

SEE: Figure 7.

9.2

DC smoothing reactor

reactor connected in series with a converter unit or converter units on the DC side for the primary purpose of smoothing the direct current and reducing current transients

SEE: Figure 7.

9.3

smoothing reactor arrester

arrester connected between the terminals of a smoothing reactor

SEE: Figure 7.

9.4

DC harmonic filter

filter which, in conjunction with the DC reactor(s) and with the DC surge capacitor(s), if any, serves the primary function of reducing (current or voltage) ripple on the HVDC transmission line and/or earth electrode line

SEE: Figure 7.

9.5

main DC filter capacitor

high voltage DC filter capacitor which is exposed to a substantial DC voltage

9.6

main AC filter capacitor

high voltage AC filter capacitor which is exposed to most of the system fundamental frequency voltage

9.7

auxiliary filter capacitor

LV filter capacitor

capacitor in an AC or DC filter, not generally stressed by high DC or fundamental frequency voltage, which acts with other components to provide an impedance tuned to a particular harmonic or multiple harmonics.

9.8

filter resistor

power resistor forming part of some types of harmonic filter bank and connected in parallel and/or series with the LV filter capacitors and/or filter reactors, usually at the neutral side of the filter

9.9

resistor element

single part of resistor, which cannot be divided into smaller parts (such as a grid, a mat, a spring coil, etc. depending on the technology)

9.10

bank of resistor elements

mechanical assembly of several single elements electrically connected together, plus a mechanical structure, insulating parts, terminals, etc.

9.11

resistor module

part of the resistor in one an enclosure (if applicable)

9.12

filter reactor

power reactor forming part of a harmonic filter bank, responsible (together with the LV filter capacitors, where used) for defining the tuned frequency(ies) of the filter bank

9.13

DC damping circuit

combination of circuit elements which serve to reduce voltage transients and/or change resonance conditions on the DC line

Note 1 to entry: DC damping circuits are no longer commonly used on HVDC schemes.

SEE: Figure 7.

9.14

DC surge capacitor

capacitor array connected between the DC line and the substation earth (directly or indirectly) to serve the primary function of reducing the amplitude and steepness of lightning surges applied to the substation equipment

Note 1 to entry: DC surge capacitors are no longer commonly used on HVDC schemes.

SEE: Figure 7.

9.15

DC bus arrester

arrester connected between the DC bus (at a point between the DC reactor and the DC line disconnector) and the substation earth

SEE: Figure 7.

9.16

DC line arrester

arrester connected between an HVDC line (at an HVDC substation) and substation earth

SEE: Figure 7.

9.17

HVDC substation earth

array of conducting elements which provides a low impedance path from the earthed parts of the equipment in the HVDC substation to earth and which is capable of carrying high surge currents of momentary duration

SEE: Figure 7.

9.18

DC neutral bus capacitor

capacitor array connected between the DC neutral bus and the substation earth

SEE: Figure 7.

9.19**DC neutral bus arrester**

arrester connected between the DC neutral bus and the substation earth

SEE: Figure 7.

9.20**high-speed DC switch**

type of switchgear used on an HVDC scheme, required to open or close rapidly (< 1 s), including in some cases the need to commutate load current into a parallel conducting path, but with no requirement to interrupt fault or load current

Note 1 to entry: DC switchgear is usually based on a single-phase unit of an AC circuit-breaker, appropriately modified for their DC applications. Their capabilities to perform faster opening and closing than disconnect switches are used but the function of breaking short-circuit currents is not required.

9.21**DC commutation switch**

type of high-speed DC switch specifically designed to commutate load current into an alternative parallel current path

9.22**metallic return transfer breaker****MRTB****metallic return transfer switch****MRTS**

DC commutation switch used to transfer DC current from an earth return path to a metallic return path

Note 1 to entry: Although the term "metallic return transfer breaker" has been widely used in the industry for many years, it is misleading since such switches have no ability to interrupt fault current.

SEE: Figure 7.

9.23**earth return transfer breaker****ERTB****earth return transfer switch****ERTS**

DC commutation switch used to transfer DC current from a metallic return path to an earth return path

Note 1 to entry: In some applications, this function is performed by a by-pass switch (see Figure 3).

Note 2 to entry: Although the term "earth return transfer breaker" has been widely used in the industry for many years, it is misleading since such switches have no ability to interrupt fault current.

SEE: Figure 7.

9.24**AC high frequency filter****AC HF filter**

filter on the AC side of a converter, designed to prevent converter-generated high frequency (HF) harmonics from penetrating into the AC system

9.25**DC high frequency filter****DC HF filter**

filter on the DC side of a converter, designed to prevent converter-generated high frequency (HF) harmonics from penetrating into the DC system

Note 1 to entry: DC high frequency filters may be located at the high-voltage or low-voltage (neutral) terminals of the converter.

9.26

neutral bus switch

NBS

DC commutation switch connected in series with the neutral bus on a bipolar HVDC scheme, designed to commutate current out of the pole conductor or neutral bus and into the electrode line or dedicated metallic return conductor or earth in response to a fault in a converter or neutral bus

Note 1 to entry: This note applies to the French language only.

9.27

neutral bus grounding switch

NBGS

neutral bus earthing switch

NBES

DC commutation switch connected from the neutral bus to the station earth mat on a bipolar HVDC scheme, designed to provide a temporary earth connection in the event of an open-circuit fault on the electrode line until the imbalance of current between the two poles can be reduced to a safe minimum level or the electrode line connection can be restored

Note 1 to entry: This note applies to the French language only.

Note 2 to entry: This note applies to the French language only.

9.28

converter paralleling switch

CPS

high-speed DC switch connected in series with each converter at the high-voltage DC terminal in HVDC schemes where two or more converters are connected in parallel onto a common pole conductor, designed to allow additional converter(s) to be connected in parallel or disconnected without affecting the load current in the other converter

Note 1 to entry: This note applies to the French language only.

9.29

line paralleling switch

LPS

DC commutation switch placed in series with one or more high-voltage pole conductors, allowing two or more lines to be connected in parallel or to revert to single-line operation while conducting load current

Note 1 to entry: This note applies to the French language only.

9.30

by-pass switch

BPS

high-speed DC switch connected across each converter valve group in HVDC schemes using more than one independent converter per pole, designed to close rapidly to bypass a converter group that is being taken out of service and commutate the current back into a valve group that is being taken back in service.

Note 1 to entry: A by-pass switch may also be used for prolonged shunting of the bridge(s).

Note 2 to entry: This note applies to the French language only.

SEE: Figure 3.

10 Modes of control

10.1

control mode

manner in which a converter unit, pole, or HVDC substation is controlled in order to maintain one or more electrical quantities at desired values

Note 1 to entry: The desired values may change with time or as a function of measured quantities and defined priorities.

10.2

DC voltage control mode

control of the DC voltage in an HVDC substation

10.3

current control mode

control of the DC current in an HVDC system

10.4

active power control mode

control of the active power flow exchanged between an HVDC substation and the connected AC network

10.5

reactive power control mode

control of the reactive power exchanged between a converter unit, or HVDC substation and the connected AC network

10.6

frequency control mode

control of the frequency of the connected AC network by varying the active power exchanged between an HVDC substation and the connected AC network

10.7

damping control mode

supplementary control mode providing the damping of power oscillations in one or more connected AC networks

10.8

AC voltage control mode

control of the AC voltage of the AC network connected to an HVDC substation

10.9

islanded network operation mode

control mode in which the HVDC substation is connected to an islanded AC network

10.10

SSTI damping control mode

supplementary control mode providing the damping of critical frequencies of an (electrical) nearby generator

11 Control systems

11.1

HVDC control system

function of, or the equipment used for, controlling, monitoring or protection of main plant equipment, such as circuit breakers, valves, converter transformers and their tap changers, forming part of an HVDC system