

INTERNATIONAL STANDARD



Terminology for High-voltage direct current (HVDC) transmission – Vocabulary

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Terminology for High-voltage direct current (HVDC) transmission – Vocabulary

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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

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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- withdrawn,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.

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

~~TERMINOLOGY FOR~~ 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

~~The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All normative documents are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.~~

~~IEC 60027 (all parts), Letter symbols to be used in electrical technology~~

~~IEC 60050-551:1998, International Electrotechnical Vocabulary – Part 551: Power electronics~~

~~IEC 60146-1-1:1991, General requirements and line commutated converters – Part 1-1: Specifications of basic requirements~~

~~IEC 60617-5:1996, Graphical symbols for diagrams – Part 5: Semiconductors and electron tubes~~

~~IEC 60617-6:1996, Graphical symbols for diagrams – Part 6: Production and conversion of electrical energy~~

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 normative references and~~ the Bibliography.

3.1 Letter symbols

U_d	direct voltage (any defined value)
U_{d0}	conventional nominal no-load direct voltage
U_{di0}	ideal no-load direct voltage
U_{dN}	rated direct voltage

U_L	line-to-line 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 and IEC 60617-6.

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 which are connected as illustrated in Figure 2~~

~~NOTE—The term “bridge” may be used to describe either the circuit connection or the equipment implementing that circuit (see 6.2).~~

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 an operative circuit used for conversion which is connected between an a.c. terminal and a d.c. terminal, with the ability to conduct current in only one direction, defined as the forward direction (see 7.3)~~

~~NOTE—The main function of a converter arm is conversion; it may also perform additional functions such as voltage limiting, damping, etc.~~

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, ~~i.e.~~ 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 commutate

[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

~~NOTE— If a converter unit comprises two converter bridges with a phase displacement of 30°, then the converter unit forms a 12-pulse unit (see figure 7). The term “12-pulse group” is also used.~~

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

~~NOTE — An example of a non-controllable valve device assembly is a semiconductor diode valve. An example of a controllable valve device assembly is a thyristor valve.~~

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 ~~comprised of~~ comprising a mechanical assembly of thyristors with their immediate auxiliaries, ~~and but without valve reactors, if used~~

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

~~NOTE 2 — The deprecated term "valve module" has been used with an equivalent meaning.~~

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 ~~comprised of~~ 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 ~~the active part of the valve which houses the valve sections~~

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**

~~physical structure holding the thyristor levels of a valve which is insulated to the appropriate voltage above earth potential~~

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

6.12**valve interface (electronics) (unit)**

~~electronic unit which provides an interface between the control equipment, at earth potential, and the valve electronics or valve devices~~

~~NOTE 1 – Valve interface electronics units, if used, are typically located at earth potential close to the valve(s).~~

~~NOTE 2 – The term “valve base electronics” (VBE) has also been used for this unit.~~

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 ~~(anode) (cathode)~~ reactor**

~~reactor connected in series with the valve, commonly used with mercury arc technology~~

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

~~direction of current through a valve, when current flows from the anode terminal to the cathode terminal~~

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

7.4

reverse direction

non-conducting direction

~~direction of current through a valve, when current flows from the cathode terminal to the anode terminal~~

<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 ~~the valve exhibits a high resistance (see figure 6)~~ 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

~~NOTE—The control action to establish current in an individual thyristor is referred to as triggering or gating.~~

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 ~~by removing blocking action~~

7.17**valve blocking**

operation preventing further firing of a controllable valve ~~by inhibiting the valve control pulses~~

7.18**valve deblocking**

operation permitting firing of a controllable valve ~~by removing the valve blocking action~~

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 ~~incorrect~~ 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 ~~transmission~~ 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

~~reversible~~ bidirectional HVDC system

HVDC system for the transfer of energy in either direction

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

**8.8.1
monopolar earth return (HVDC) system**

~~monopolar system in which the return current path between neutrals of the HVDC substations is through the earth~~

**8.8.2
monopolar metallic return (HVDC) system**

~~monopolar system in which the return current path between neutrals of the HVDC substations is through a metallic circuit~~

**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**bipolar earth return (HVDC) system**

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

8.20**bipolar metallic return (HVDC) system**

bipolar system operation mode in which the return current path between neutrals of the HVDC system substations is through a metallic circuit 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**~~d.c.~~ smoothing reactor arrester**

arrester connected between the terminals of a ~~d.c.~~ 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

~~switching device~~ 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

~~switching device~~ 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

~~mechanical power switching device connected across the d.c. terminals of one or more converter bridges to shunt the bridge(s) during the turn-off procedure of the bridge(s) and to commutate current to the by-pass arm or a by-pass pair during the turn-on procedure of the bridge(s)~~

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 ~~a.c. or d.c. side voltages~~ DC voltage in an HVDC ~~system~~ 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 ~~in~~ exchanged between an HVDC ~~system~~ 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 ~~one or more~~ the connected AC networks by varying the ~~transmitted~~ active power exchanged between an HVDC substation and the connected AC network

10.7
damping control mode

supplementary control mode providing the damping of ~~electromechanical~~ power oscillations ~~such as network instability or sub-synchronous oscillations (SSO)~~ 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

Note 1 to entry: An example illustrating a typical HVDC control system hierarchy is shown in Figure 12.

11.2

HVDC system control

control system which governs the operation of an entire HVDC system consisting of more than one HVDC substation and performs those functions of controlling, monitoring and protection which require information from more than one substation

SEE: Figure 12.

11.2.1

multiterminal control

HVDC system control for more than two HVDC substations

11.3

(HVDC) master control

general concept for control coordination of an HVDC system

Note 1 to entry: The HVDC master control may be implemented at the bipole and/or pole level.

11.4

(HVDC system) bipole control

control system of a bipole

SEE: Figure 12.

11.5

(HVDC system) pole control

control system of a pole

Note 1 to entry: When the HVDC system has no bipole(s) but one or more poles, the pole control interfaces with the HVDC system control.

SEE: Figure 12.

11.6

(HVDC) substation control

control system used for the controlling, monitoring and protection within an HVDC substation

Note 1 to entry: HVDC substation control may be implemented at the bipole and/or pole level and may be referred to as local control.

11.6.1

(HVDC) substation bipole control
control system of a substation bipole

SEE: Figure 12.

11.6.2

(HVDC) substation pole control
control system of a substation pole

SEE: Figure 12.

11.7

converter unit control

control system used for the controlling, monitoring and protection of a single converter unit

SEE: Figure 12.

11.7.1

converter unit sequence control

part of the converter unit control which co-ordinates the operation of the converter unit firing control, transformer tap changer control, monitoring and protection, and which controls the sequence of action during any change in the operating conditions of the associated converter unit

11.7.2

converter unit firing control

part of the converter unit control for timing the intended firing of the valves

11.7.3

converter unit tap changer control

part of the converter unit control for controlling the converter transformer tap changers

11.7.4

converter unit monitoring

part of the converter unit control which monitors electrical, mechanical and thermal quantities

11.7.5

converter unit protection

part of the converter unit control which initiates action to protect components of the associated converter unit against damage due to abnormal electrical, mechanical or thermal conditions

11.8

valve control unit

VCU

~~control system for the firing, monitoring, and protection of a valve~~

electronic unit, at earth potential, providing the control and protection functions for individual valves

Note 1 to entry: VBE and VCU functions could be combined in one unit.

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

11.8.1

valve (control) firing

part of the valve control which initiates valve firing

11.8.2**valve (control) monitoring**

part of the valve control which monitors valve status

11.8.3**valve (control) protection**

part of the valve control which protects the valve by initiating, or disabling valve firing

11.9**integrated AC/DC system control**

control system which governs the integrated operation of AC and HVDC systems of a power system

Note 1 to entry: This control system is under the responsibility of the system operator.

12 Control functions**12.1****equal delay angle control
individual phase control**

method of controlling separately the valve control pulses for each valve by timing from the zero crossings of the commutation voltages

12.2**equidistant firing control**

method of controlling the valve control pulses whereby, in steady state, the delay between a control pulse and the previous control pulse is equal for all valves, irrespective of unbalance or distortion in the commutating voltages

12.3 **α control**

control of the delay angle between a minimum and maximum, determined by the design, to implement a control mode

12.4**minimum α control**

control of the delay angle to prevent it from decreasing below a set minimum value

12.5 **γ control**

control of the extinction angle between a minimum and maximum, determined by the design, to implement a control mode at an inverter

12.6**minimum γ control**

control of the extinction angle to prevent it from decreasing below a set minimum value

12.7**control order**

reference value of a desired controlled quantity, in a control mode

12.7.1**DC current (control) order**

reference value of the current to the DC current regulator

SEE: Figure 11.

12.7.2

DC voltage (control) order

reference value of the voltage to a voltage regulator

SEE: Figure 11.

12.8

current margin

in an HVDC pole with two ends, difference between the current order at the rectifier and the inverter

Note 1 to entry: The rectifier always has a higher current order than the inverter in a two-terminal HVDC transmission system.

SEE: Figure 11.

12.9

voltage dependent current order limit

VDCOL

limitation of the current order as a function of the DC voltage

12.10

pole (current) balancing

control action to balance the currents in the two poles of a bipole system, in order to limit the amplitude of the differential current that flows between the neutrals of the HVDC system

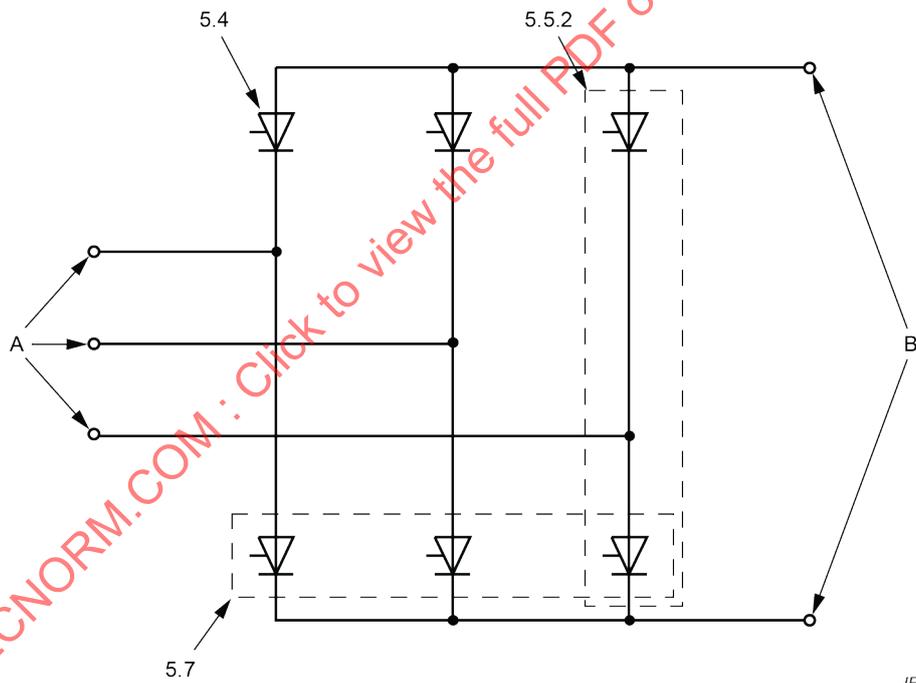
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No.	Symbol	Description
1		Non-controllable valve or arm
2		Controllable valve or arm
3		Non-controllable bridge
4		Controllable bridge

NOTE 1 Symbols 2 and 4 are used to represent the general meaning of valve, arm, or bridge, irrespective of controllability.

NOTE 2 The above symbols are irrespective of the type of device of which a valve, arm, or bridge is composed.

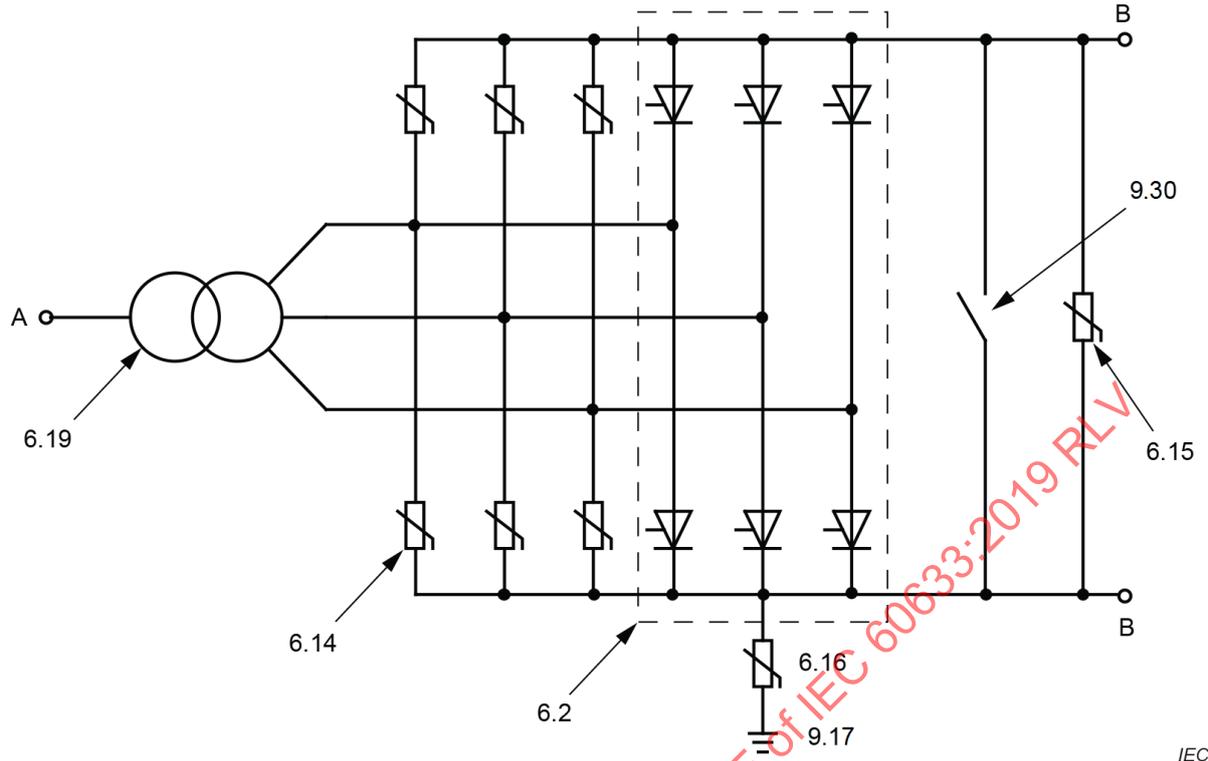
Figure 1 – Graphical symbols



Key

- A AC terminals
- B DC terminals
- 5.4 Converter arm or valve
- 5.5.2 By-pass pair
- 5.7 Commutating group

Figure 2 – Bridge converter connection

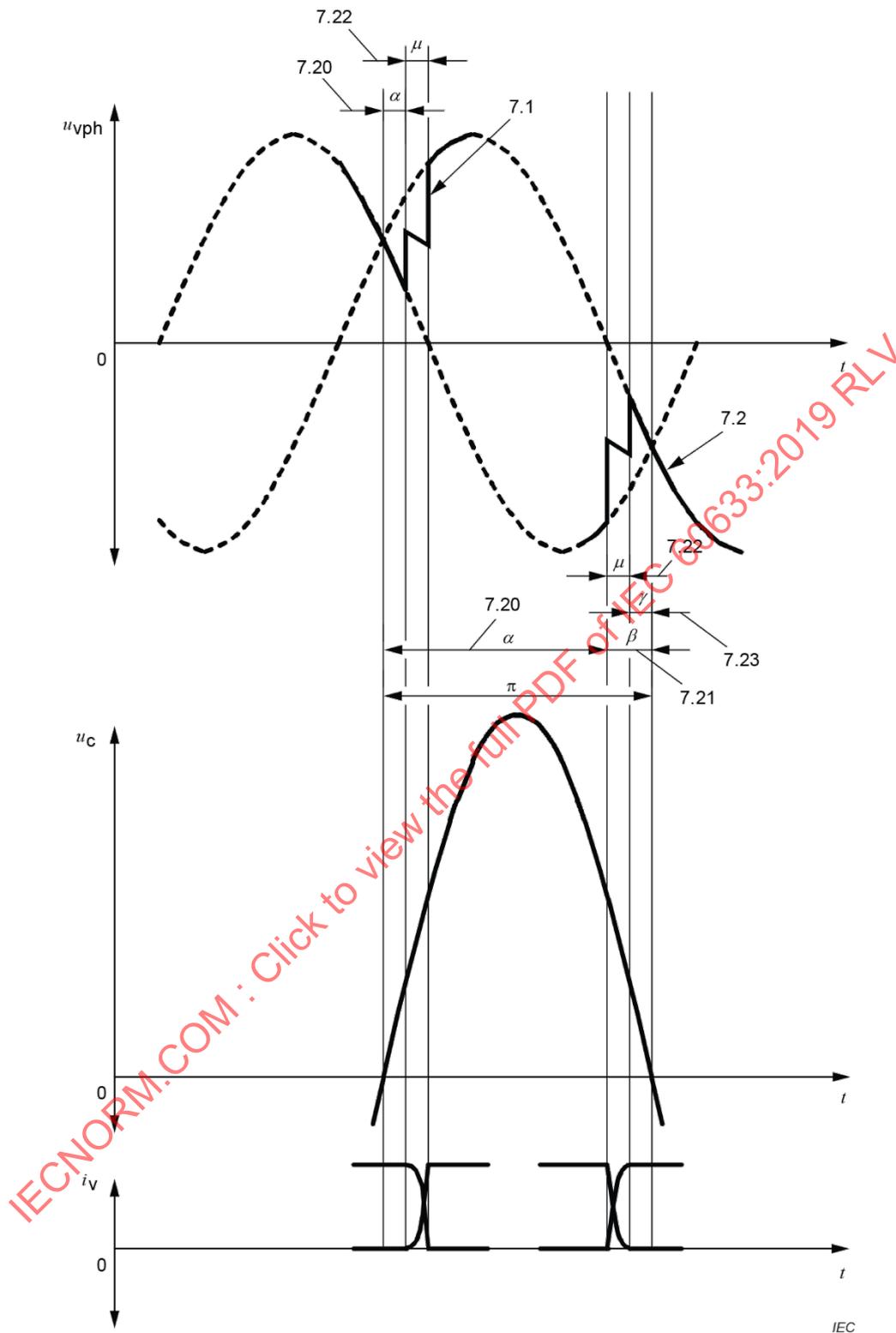


Key

- | | | | |
|------|-------------------------|------|--------------------------------|
| A | AC terminals | 6.16 | Converter unit DC bus arrester |
| B | DC terminals | 6.19 | Converter transformer |
| 6.2 | Bridge | 9.30 | By-pass switch |
| 6.14 | Valve arrester | 9.17 | Substation earth |
| 6.15 | Converter unit arrester | | |

Figure 3 – Example of a converter unit

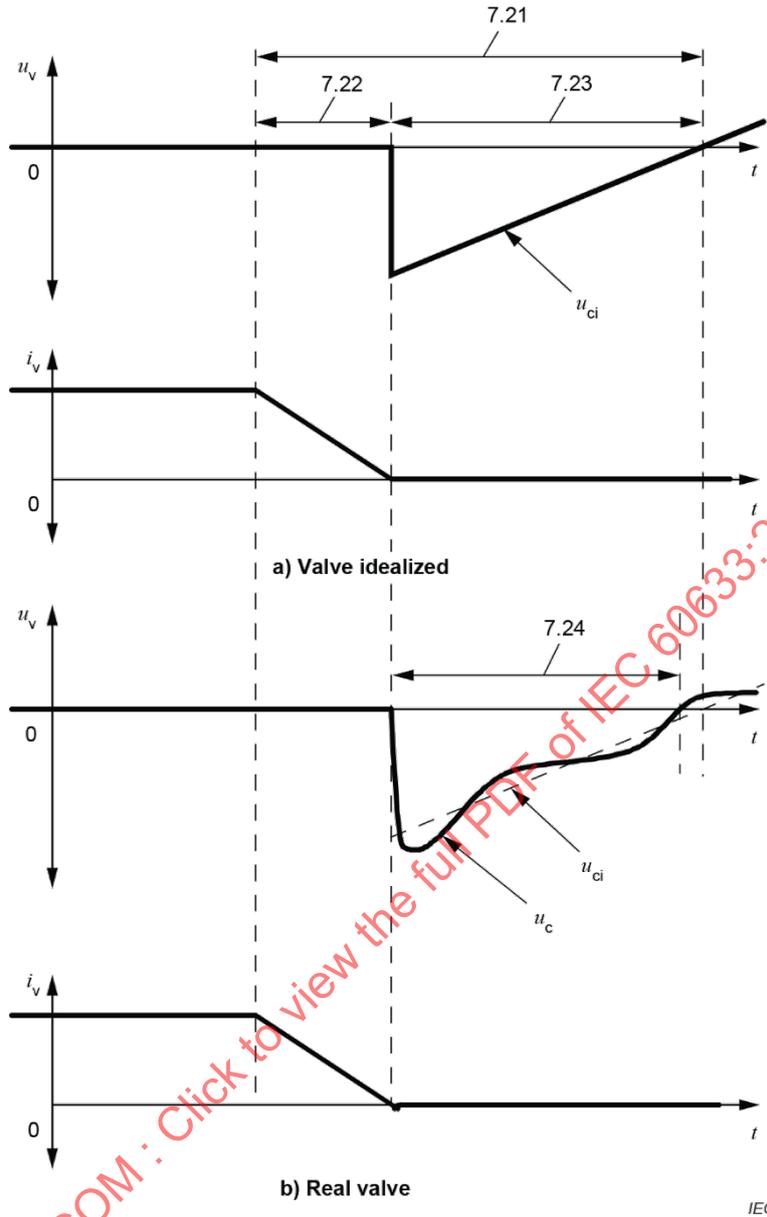
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Key

u_{vph}	Phase voltage	7.2	Inverter operation
u_c	Commutating voltage	7.20	Delay angle α
i_v	Valve currents	7.21	Advance angle β
t	Time	7.22	Overlap angle μ
7.1	Rectifier operation	7.23	Extinction angle γ

Figure 4 – Commutation process at rectifier and inverter modes of operation

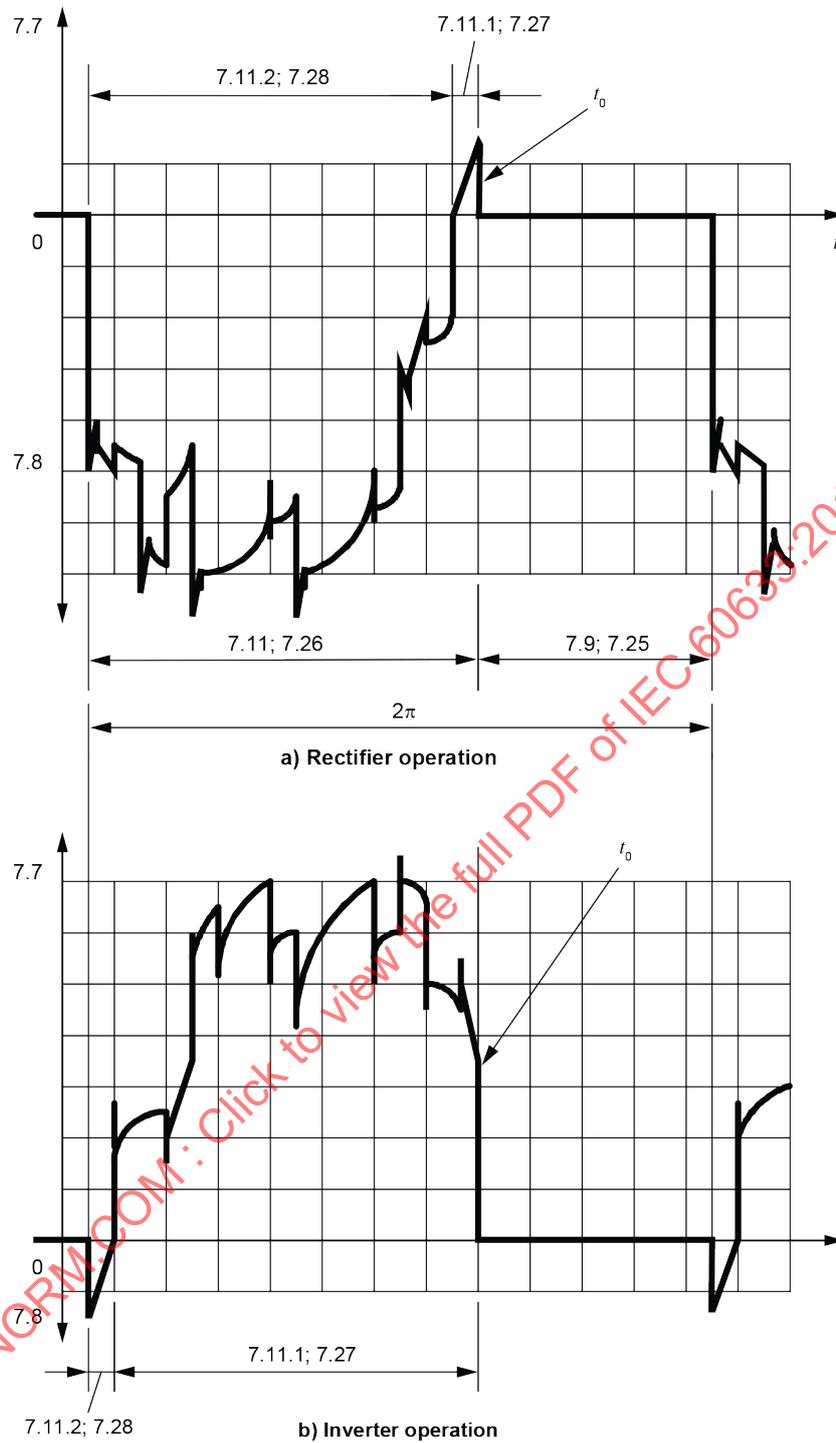


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Key

u_v	Voltage across outgoing valve	7.21	Advance angle β
i_v	Current in outgoing valve	7.22	Overlap angle μ
u_{ci}	Idealized commutating voltage	7.23	Extinction angle γ
u_c	Actual commutating voltage	7.24	Hold-off interval
t	Time		

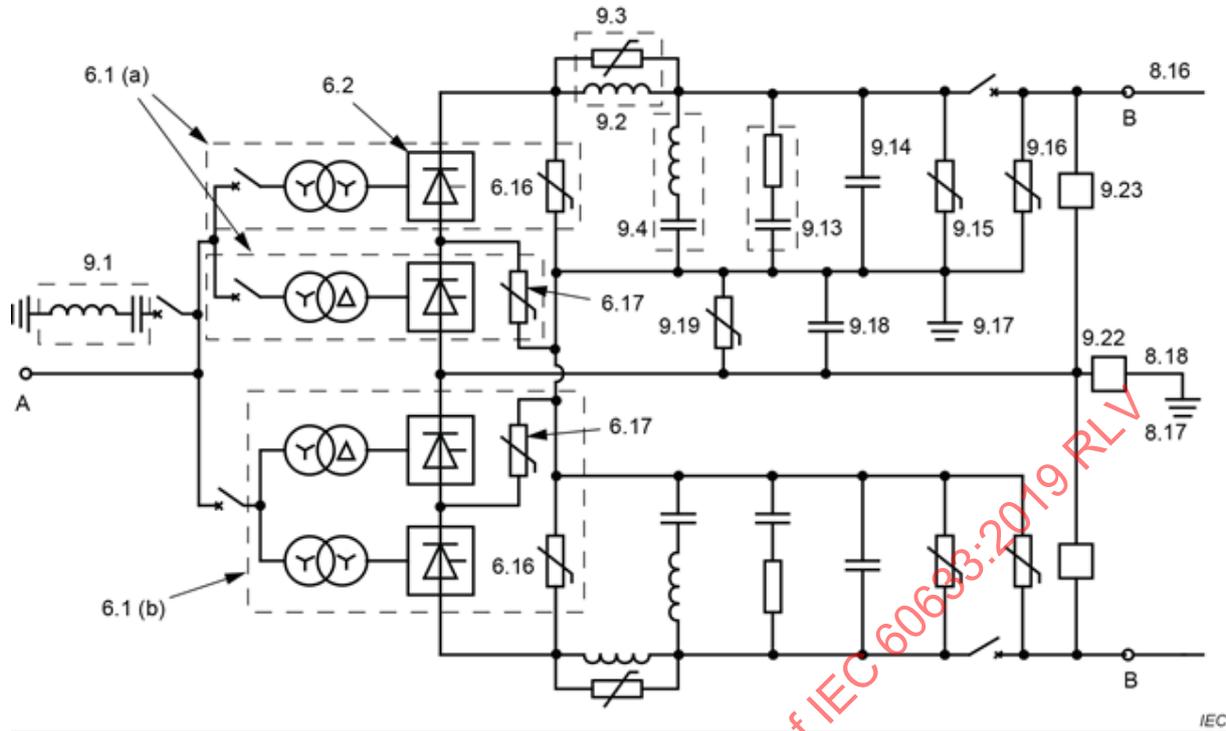
Figure 5 – Illustrations of commutation in inverter operation



Key

t	Time	7.11	Non-conducting state
t_0	Firing instant	7.11.1	Forward blocking state
7.7	Forward voltage	7.11.2	Reverse blocking state
7.8	Reverse voltage	7.25	Conduction interval
7.9	Conducting state	7.26	Blocking interval
		7.27	Forward blocking interval
		7.28	Reverse blocking interval

Figure 6 – Typical valve voltage waveforms

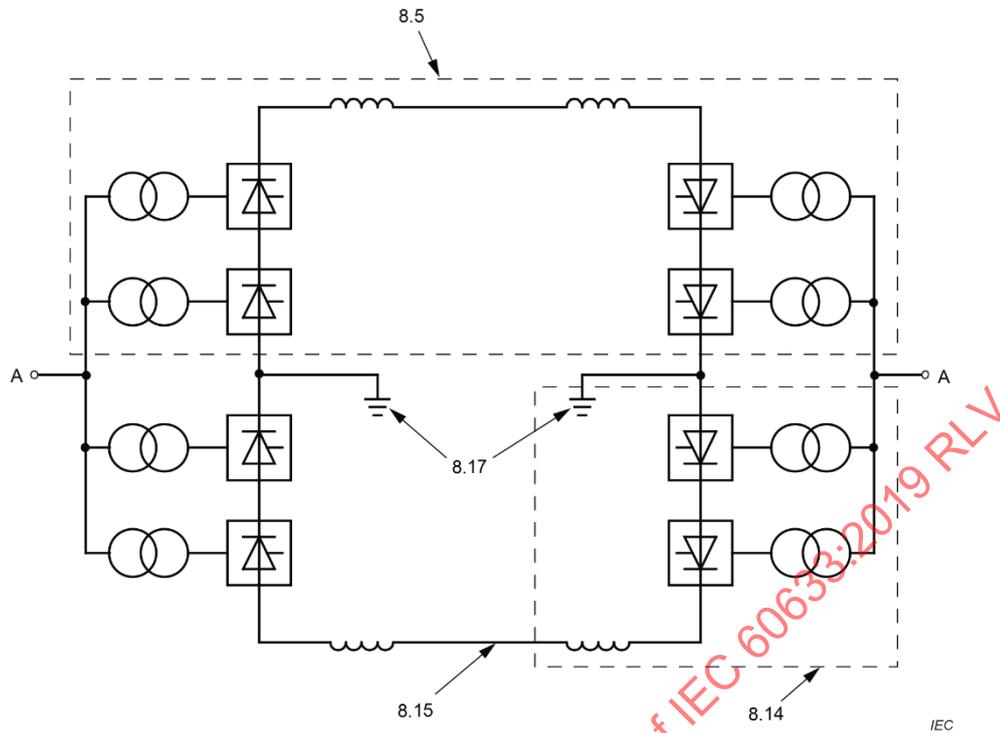


Key

A	AC system	9.3	DC Smoothing reactor arrester
B	DC terminal	9.4	DC filter
6.1 (a)	Converter unit ($p = 6$)	9.13	DC damping circuit
6.1 (b)	Converter unit ($p = 12$)	9.14	DC surge capacitor
6.2	Converter bridge	9.15	DC bus arrester
6.16	Converter unit DC bus arrester	9.16	DC line arrester
6.17	Midpoint DC bus arrester	9.17	Substation earth
8.16	HVDC transmission line pole	9.18	DC neutral bus surge capacitor
8.17	Earth electrode	9.19	DC neutral bus arrester
8.18	Earth electrode line	9.22	Metallic return transfer breaker (MRTB)
9.1	AC filter	9.23	Earth return transfer breaker (ERTB)
9.2	DC (smoothing) reactor		

Figure 7 – Example of an HVDC substation

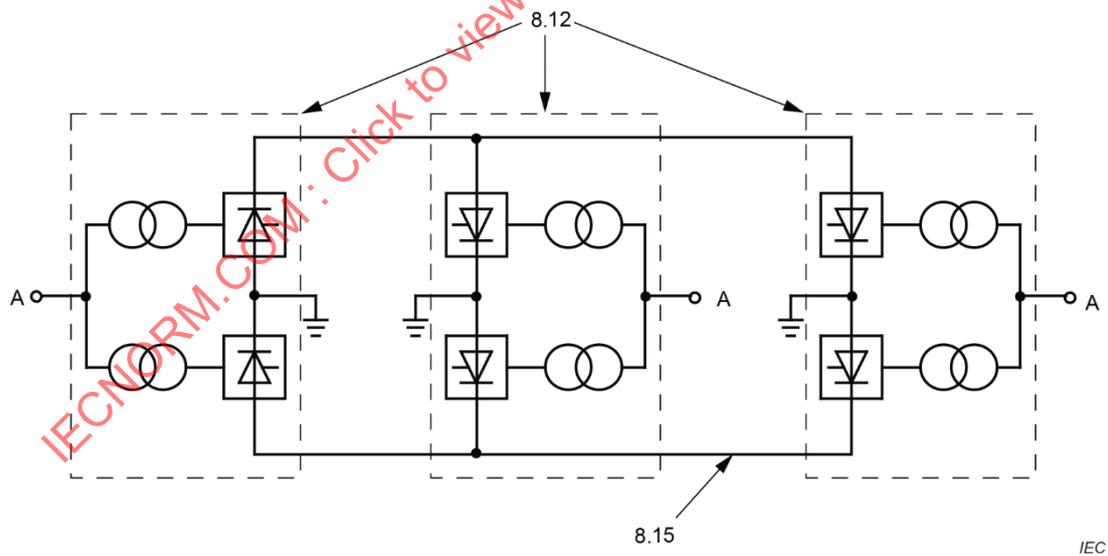
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Key

- | | | | |
|------|----------------------|------|------------------------|
| A | AC system | 8.15 | HVDC transmission line |
| 8.5 | HVDC system pole | 8.17 | Earth electrodes |
| 8.14 | HVDC substation pole | | |

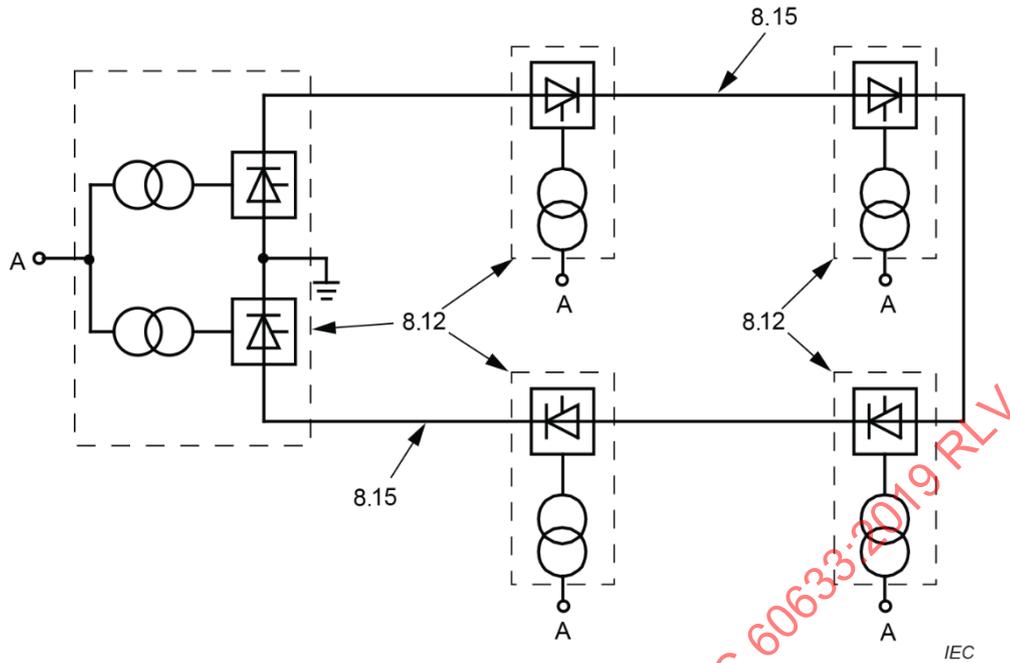
Figure 8 – Example of bipolar two-terminal HVDC transmission system



Key

- | | |
|------|------------------------|
| A | AC system |
| 8.12 | HVDC substations |
| 8.15 | HVDC transmission line |

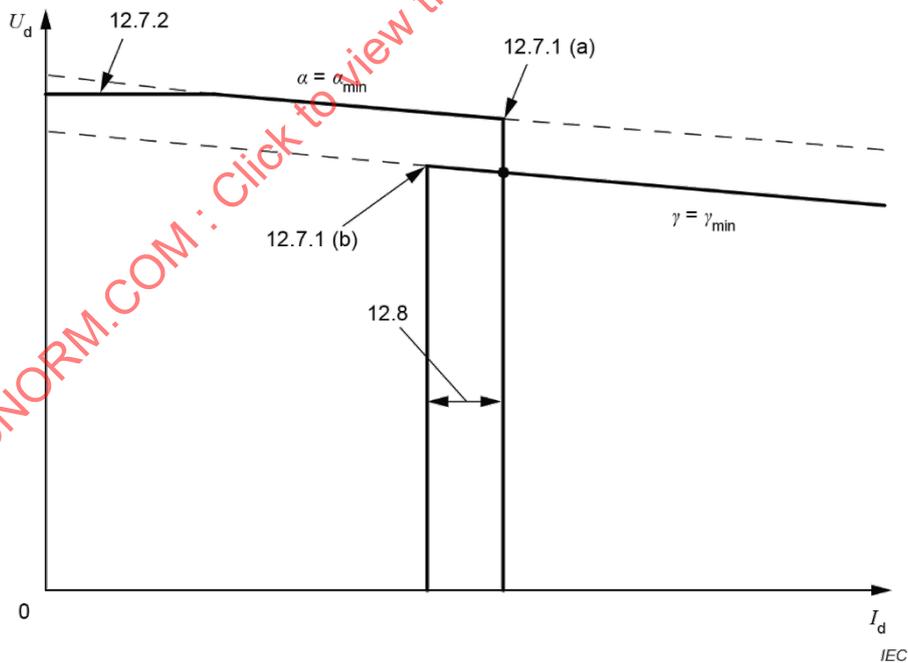
Figure 9 – Example of a multiterminal bipolar HVDC transmission system with parallel connected HVDC substations



Key

- A AC system
- 8.12 HVDC substations
- 8.15 HVDC transmission line

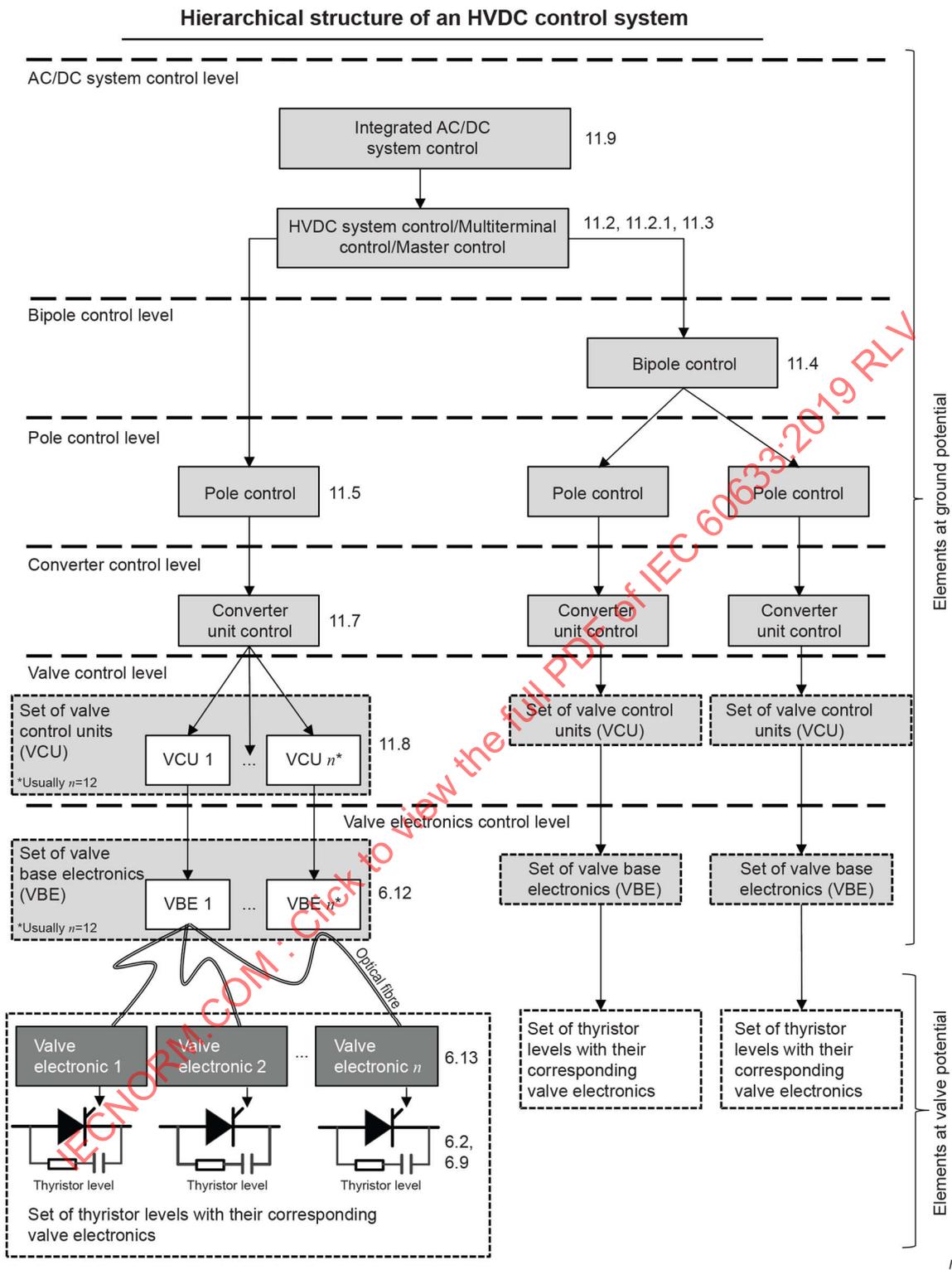
Figure 10 – Example of a multiterminal HVDC transmission system with series connected HVDC substations



Key

- U_d Direct voltage
- I_d Direct current
- 12.7.1 (a) Current order (rectifier)
- 12.7.1 (b) Current order (inverter)
- 12.7.2 Voltage order (rectifier)
- 12.8 Current margin

Figure 11 – Simplified steady-state voltage-current characteristic of a two-terminal HVDC system

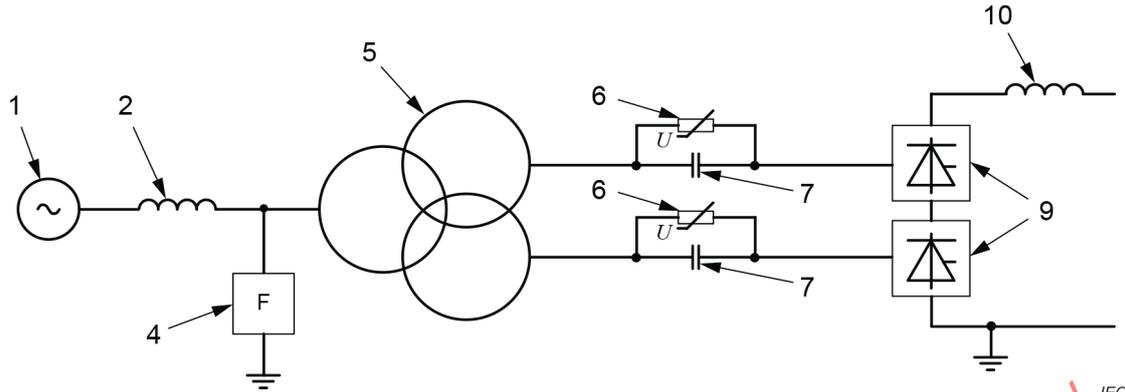


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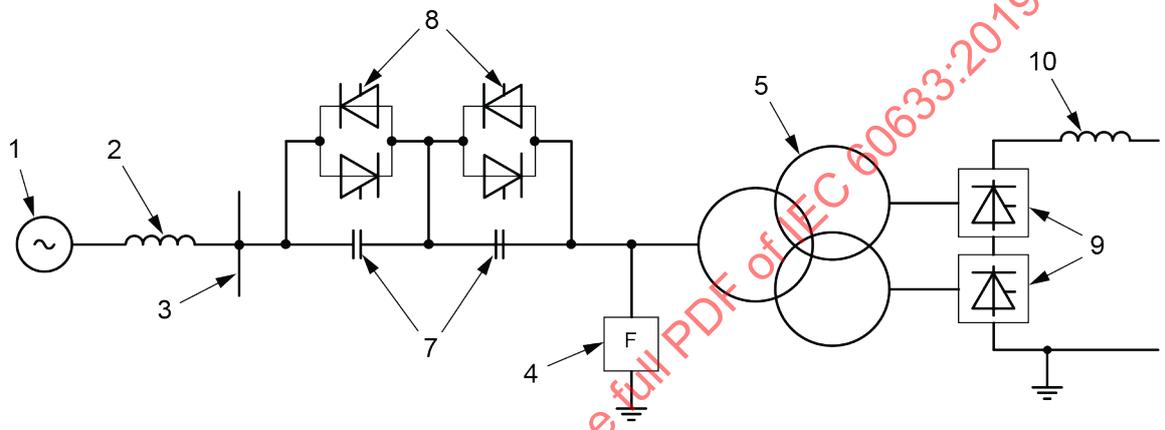
Key

- | | | | |
|--------|------------------------|------|---------------------------------|
| 6.2 | Converter bridge | 11.3 | HVDC master control |
| 6.9 | Valve thyristor levels | 11.4 | HVDC system bipole control |
| 6.12 | Valve base electronics | 11.5 | HVDC system pole control |
| 6.13 | Valve electronics | 11.7 | Converter unit control |
| 11.2 | HVDC system control | 11.8 | Valve control unit |
| 11.2.1 | Multiterminal control | 11.9 | Integrated AC/DC system control |

Figure 12 – Hierarchical structure of an HVDC control system



a) Capacitor commutated converter (CCC)



b) Controlled series capacitor converter (CSCC)

Key

- | | | | |
|---|--|----|---------------------|
| 1 | AC system electromotive force (e.m.f.) | 6 | Overvoltage limiter |
| 2 | AC system impedance | 7 | Capacitor |
| 3 | AC system bus | 8 | Thyristors |
| 4 | AC filters | 9 | Converter bridges |
| 5 | Converter transformer | 10 | DC reactor |

Figure 13 – Capacitor commutated converter configurations

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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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INTERNATIONAL ELECTROTECHNICAL COMMISSION

**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.

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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 commutate 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

Note 1 to entry: An example illustrating a typical HVDC control system hierarchy is shown in Figure 12.

11.2 HVDC system control

control system which governs the operation of an entire HVDC system consisting of more than one HVDC substation and performs those functions of controlling, monitoring and protection which require information from more than one substation

SEE: Figure 12.

11.2.1 multiterminal control

HVDC system control for more than two HVDC substations

11.3 HVDC master control

general concept for control coordination of an HVDC system

Note 1 to entry: The HVDC master control may be implemented at the bipole and/or pole level.

11.4 HVDC system bipole control

control system of a bipole

SEE: Figure 12.

11.5 HVDC system pole control

control system of a pole

Note 1 to entry: When the HVDC system has no bipole(s) but one or more poles, the pole control interfaces with the HVDC system control.

SEE: Figure 12.

11.6 HVDC substation control

control system used for the controlling, monitoring and protection within an HVDC substation

Note 1 to entry: HVDC substation control may be implemented at the bipole and/or pole level and may be referred to as local control.

11.6.1 HVDC substation bipole control

control system of a substation bipole

SEE: Figure 12.

11.6.2 HVDC substation pole control

control system of a substation pole

SEE: Figure 12.

11.7 converter unit control

control system used for the controlling, monitoring and protection of a single converter unit

SEE: Figure 12.

11.7.1**converter unit sequence control**

part of the converter unit control which co-ordinates the operation of the converter unit firing control, transformer tap changer control, monitoring and protection, and which controls the sequence of action during any change in the operating conditions of the associated converter unit

11.7.2**converter unit firing control**

part of the converter unit control for timing the intended firing of the valves

11.7.3**converter unit tap changer control**

part of the converter unit control for controlling the converter transformer tap changers

11.7.4**converter unit monitoring**

part of the converter unit control which monitors electrical, mechanical and thermal quantities

11.7.5**converter unit protection**

part of the converter unit control which initiates action to protect components of the associated converter unit against damage due to abnormal electrical, mechanical or thermal conditions

11.8**valve control unit****VCU**

electronic unit, at earth potential, providing the control and protection functions for individual valves

Note 1 to entry: VBE and VCU functions could be combined in one unit.

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

11.8.1**valve control firing**

part of the valve control which initiates valve firing

11.8.2**valve control monitoring**

part of the valve control which monitors valve status

11.8.3**valve control protection**

part of the valve control which protects the valve by initiating, or disabling valve firing

11.9**integrated AC/DC system control**

control system which governs the integrated operation of AC and HVDC systems of a power system

Note 1 to entry: This control system is under the responsibility of the system operator.

12 Control functions

12.1

equal delay angle control individual phase control

method of controlling separately the valve control pulses for each valve by timing from the zero crossings of the commutation voltages

12.2

equidistant firing control

method of controlling the valve control pulses whereby, in steady state, the delay between a control pulse and the previous control pulse is equal for all valves, irrespective of unbalance or distortion in the commutating voltages

12.3

α control

control of the delay angle between a minimum and maximum, determined by the design, to implement a control mode

12.4

minimum α control

control of the delay angle to prevent it from decreasing below a set minimum value

12.5

γ control

control of the extinction angle between a minimum and maximum, determined by the design, to implement a control mode at an inverter

12.6

minimum γ control

control of the extinction angle to prevent it from decreasing below a set minimum value

12.7

control order

reference value of a desired controlled quantity, in a control mode

12.7.1

DC current control order

reference value of the current to the DC current regulator

SEE: Figure 11.

12.7.2

DC voltage control order

reference value of the voltage to a voltage regulator

SEE: Figure 11.

12.8

current margin

in an HVDC pole with two ends, difference between the current order at the rectifier and the inverter

Note 1 to entry: The rectifier always has a higher current order than the inverter in a two-terminal HVDC transmission system.

SEE: Figure 11.

12.9 voltage dependent current order limit VDCOL

limitation of the current order as a function of the DC voltage

12.10 pole current balancing

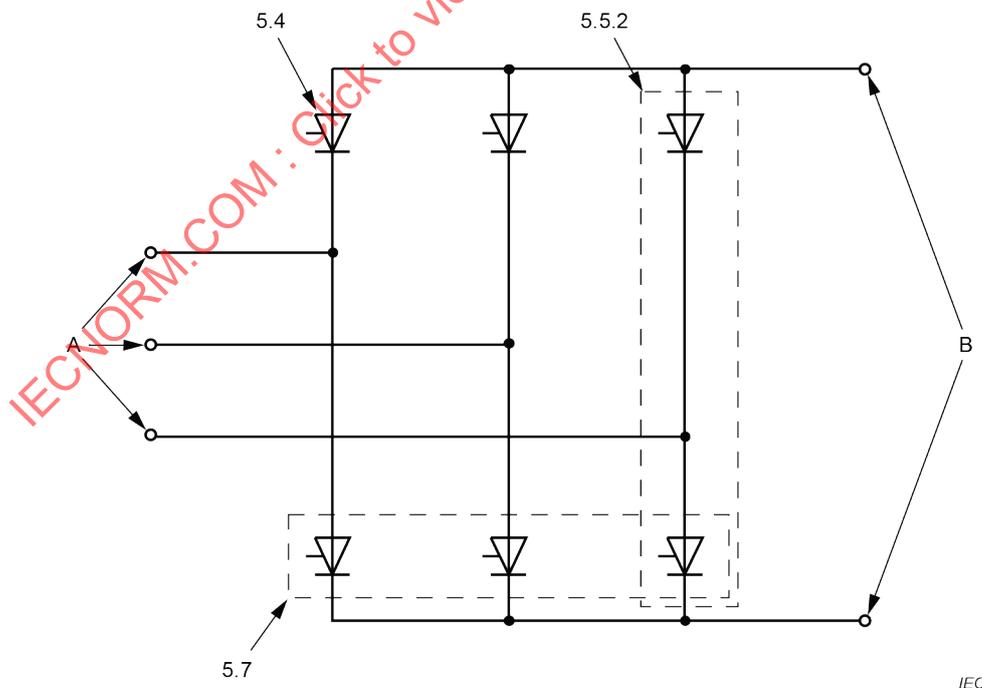
control action to balance the currents in the two poles of a bipole system, in order to limit the amplitude of the differential current that flows between the neutrals of the HVDC system

No.	Symbol	Description
1		Non-controllable valve or arm
2		Controllable valve or arm
3		Non-controllable bridge
4		Controllable bridge

NOTE 1 Symbols 2 and 4 are used to represent the general meaning of valve, arm, or bridge, irrespective of controllability.

NOTE 2 The above symbols are irrespective of the type of device of which a valve, arm, or bridge is composed.

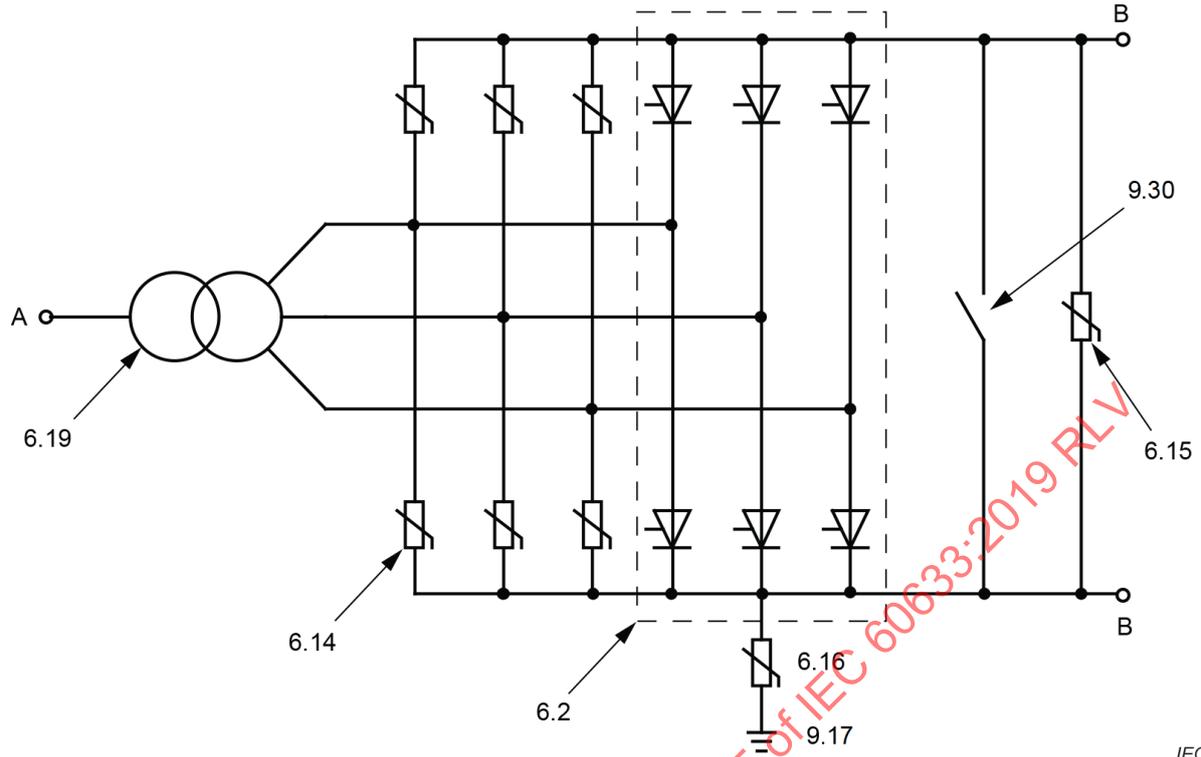
Figure 1 – Graphical symbols



Key

A	AC terminals	5.5.2	By-pass pair
B	DC terminals	5.7	Commutating group
5.4	Converter arm or valve		

Figure 2 – Bridge converter connection



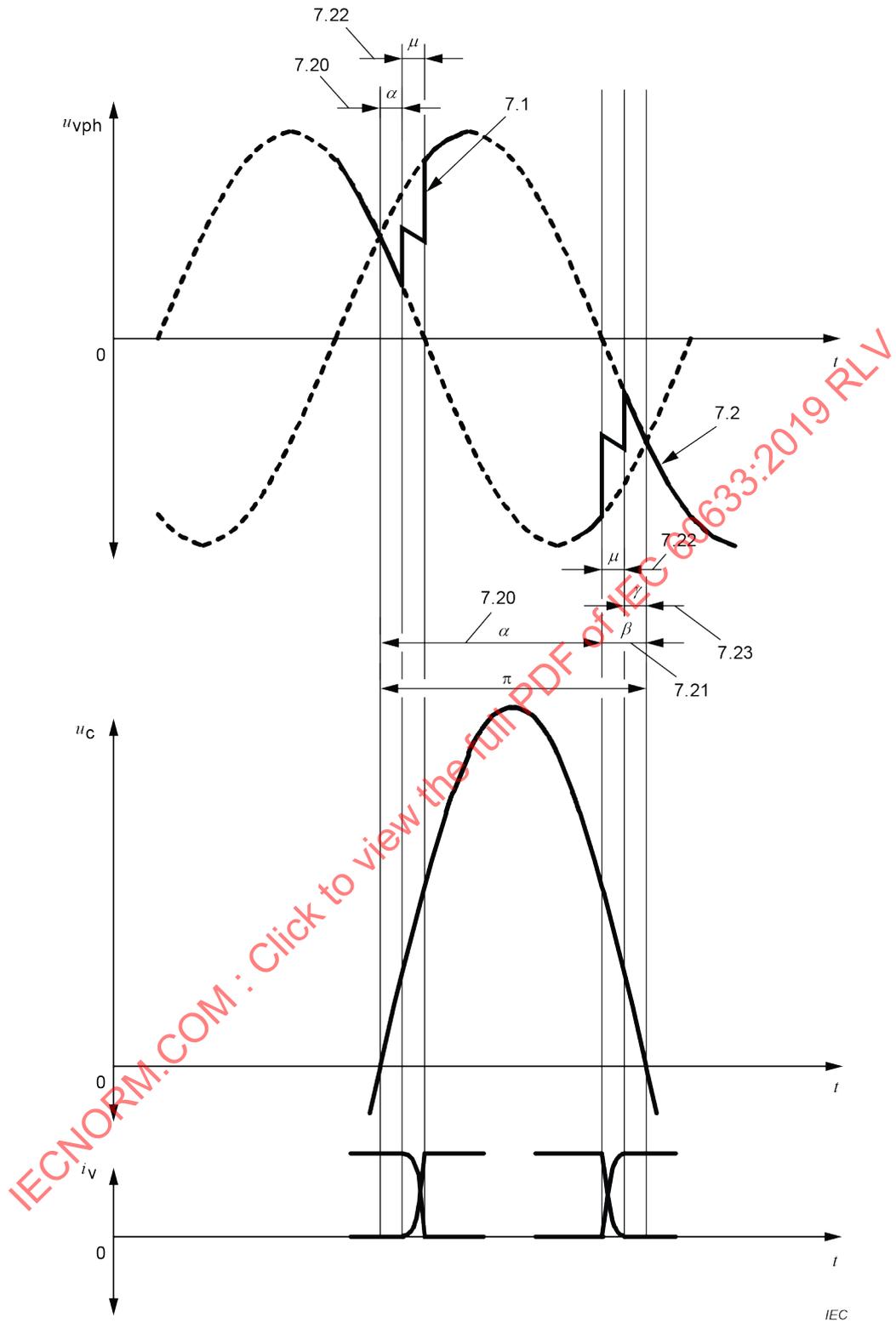
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Key

- | | | | |
|------|-------------------------|------|--------------------------------|
| A | AC terminals | 6.16 | Converter unit DC bus arrester |
| B | DC terminals | 6.19 | Converter transformer |
| 6.2 | Bridge | 9.30 | By-pass switch |
| 6.14 | Valve arrester | 9.17 | Substation earth |
| 6.15 | Converter unit arrester | | |

Figure 3 – Example of a converter unit

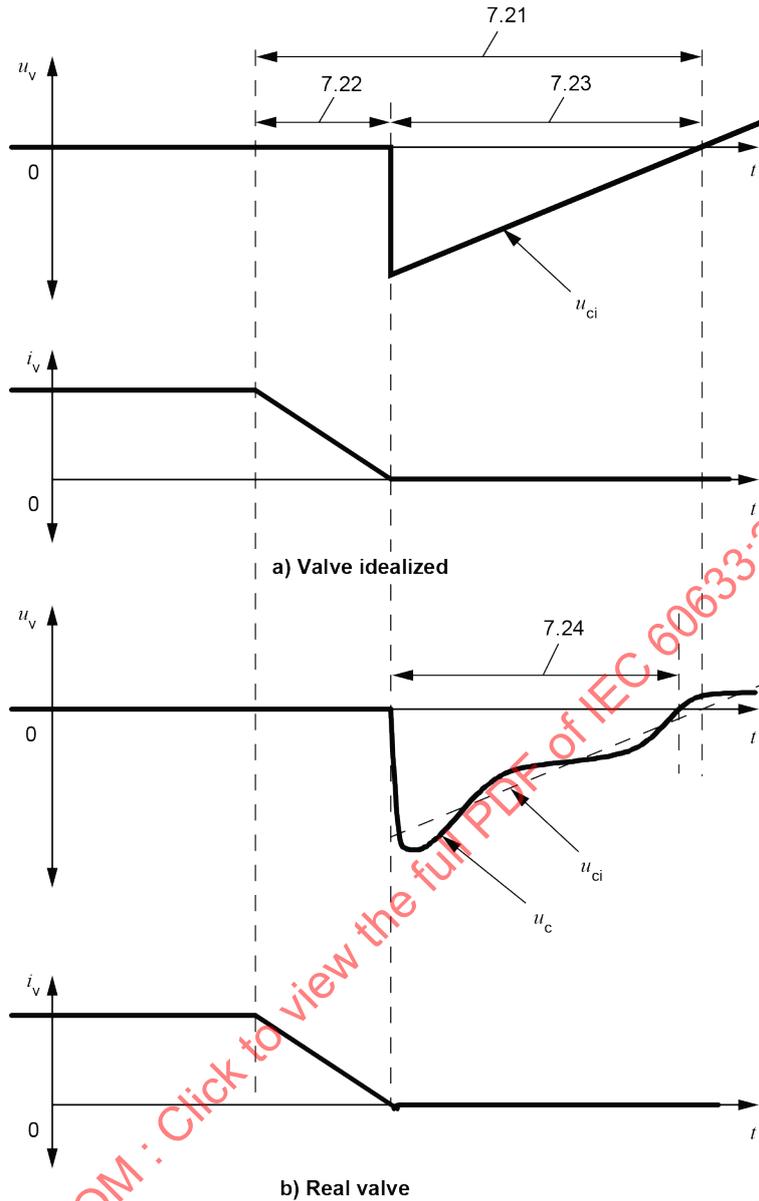
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Key

u_{vph}	Phase voltage	7.2	Inverter operation
u_c	Commutating voltage	7.20	Delay angle α
i_v	Valve currents	7.21	Advance angle β
t	Time	7.22	Overlap angle μ
7.1	Rectifier operation	7.23	Extinction angle γ

Figure 4 – Commutation process at rectifier and inverter modes of operation

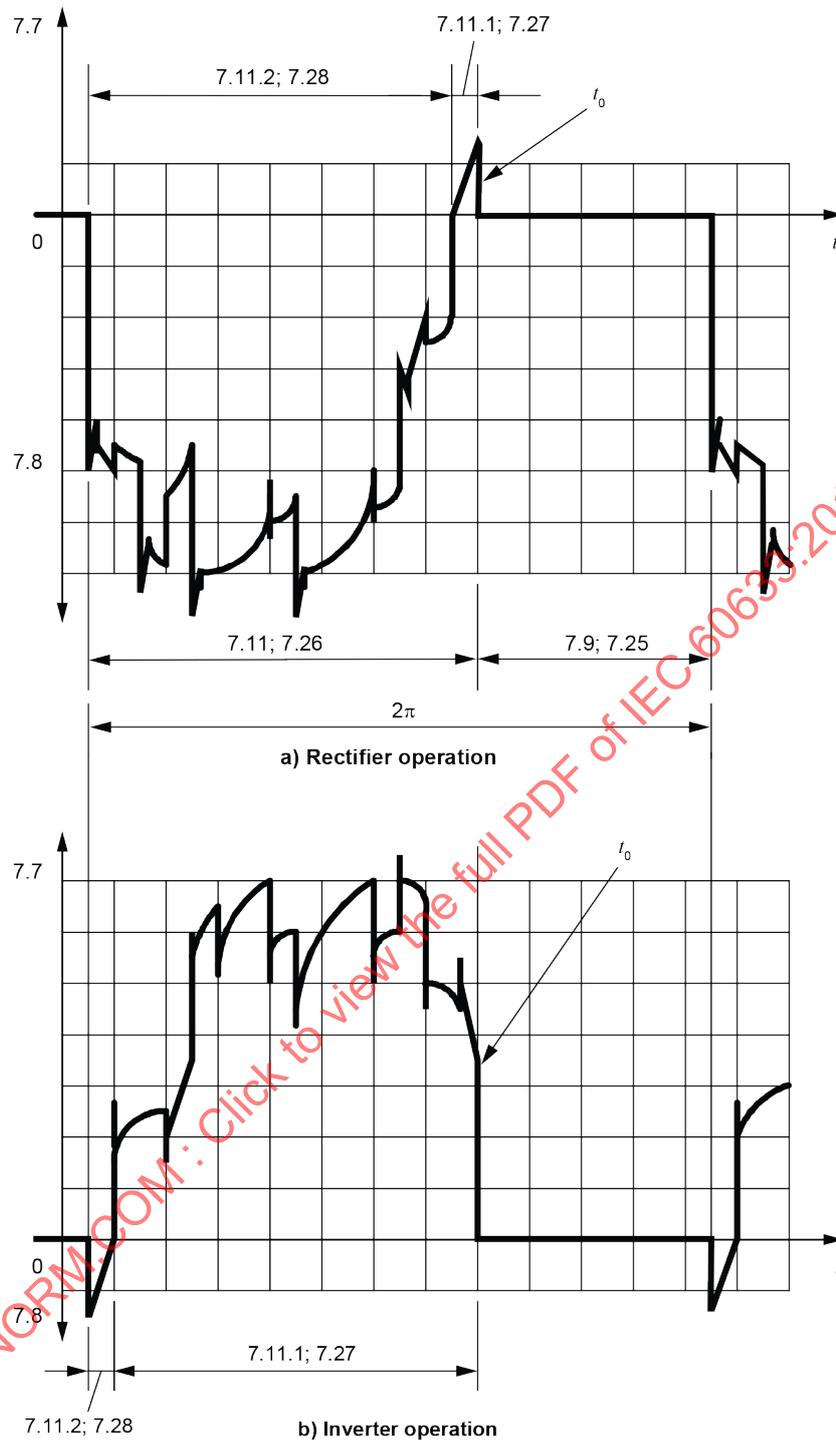


IEC

Key

u_v	Voltage across outgoing valve	7.21	Advance angle β
i_v	Current in outgoing valve	7.22	Overlap angle μ
u_{ci}	Idealized commutating voltage	7.23	Extinction angle γ
u_c	Actual commutating voltage	7.24	Hold-off interval
t	Time		

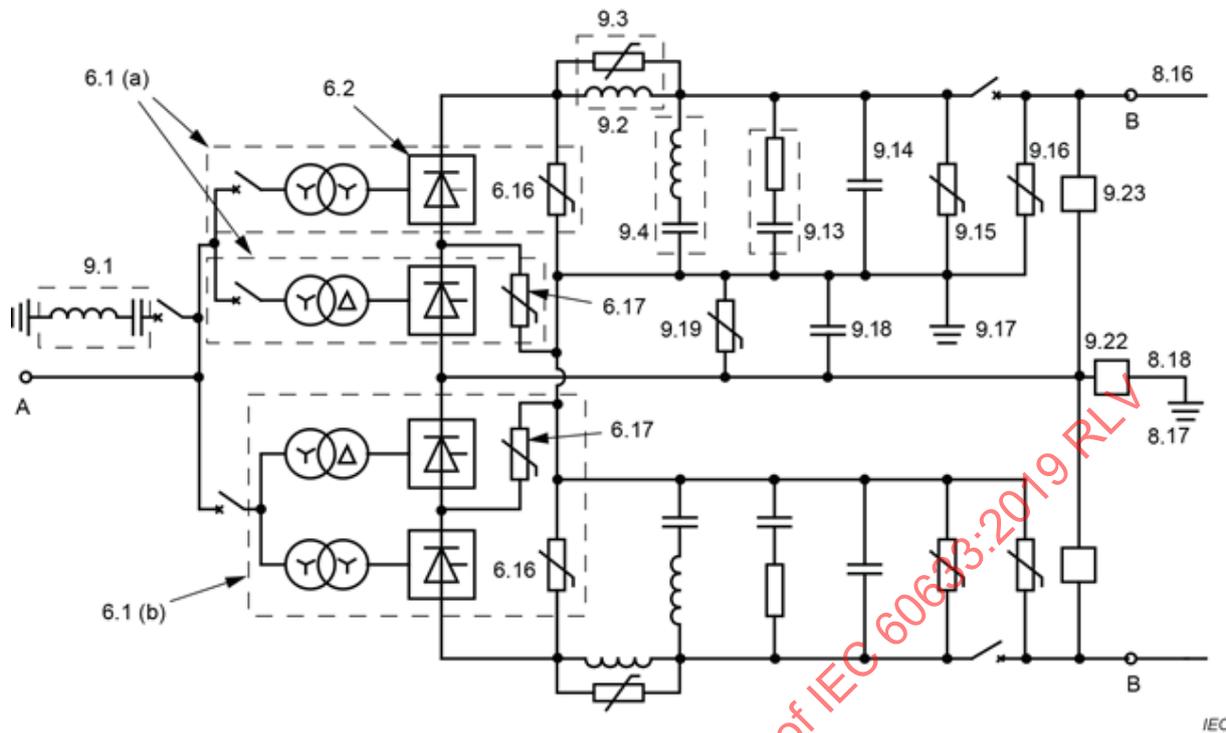
Figure 5 – Illustrations of commutation in inverter operation



Key

t	Time	7.11	Non-conducting state
t_0	Firing instant	7.11.1	Forward blocking state
7.7	Forward voltage	7.11.2	Reverse blocking state
7.8	Reverse voltage	7.25	Conduction interval
7.9	Conducting state	7.26	Blocking interval
		7.27	Forward blocking interval
		7.28	Reverse blocking interval

Figure 6 – Typical valve voltage waveforms

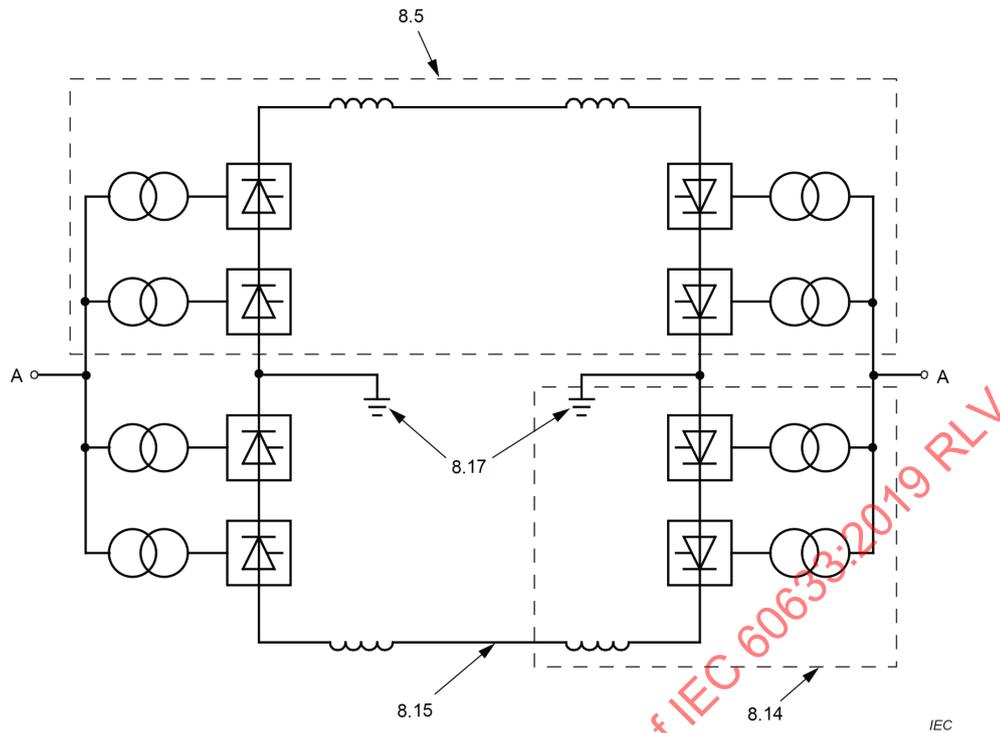


Key

A	AC system	9.3	Smoothing reactor arrester
B	DC terminal	9.4	DC filter
6.1 (a)	Converter unit ($p = 6$)	9.13	DC damping circuit
6.1 (b)	Converter unit ($p = 12$)	9.14	DC surge capacitor
6.2	Converter bridge	9.15	DC bus arrester
6.16	Converter unit DC bus arrester	9.16	DC line arrester
6.17	Midpoint DC bus arrester	9.17	Substation earth
8.16	HVDC transmission line pole	9.18	DC neutral bus surge capacitor
8.17	Earth electrode	9.19	DC neutral bus arrester
8.18	Earth electrode line	9.22	Metallic return transfer breaker (MRTB)
9.1	AC filter	9.23	Earth return transfer breaker (ERTB)
9.2	DC smoothing reactor		

Figure 7 – Example of an HVDC substation

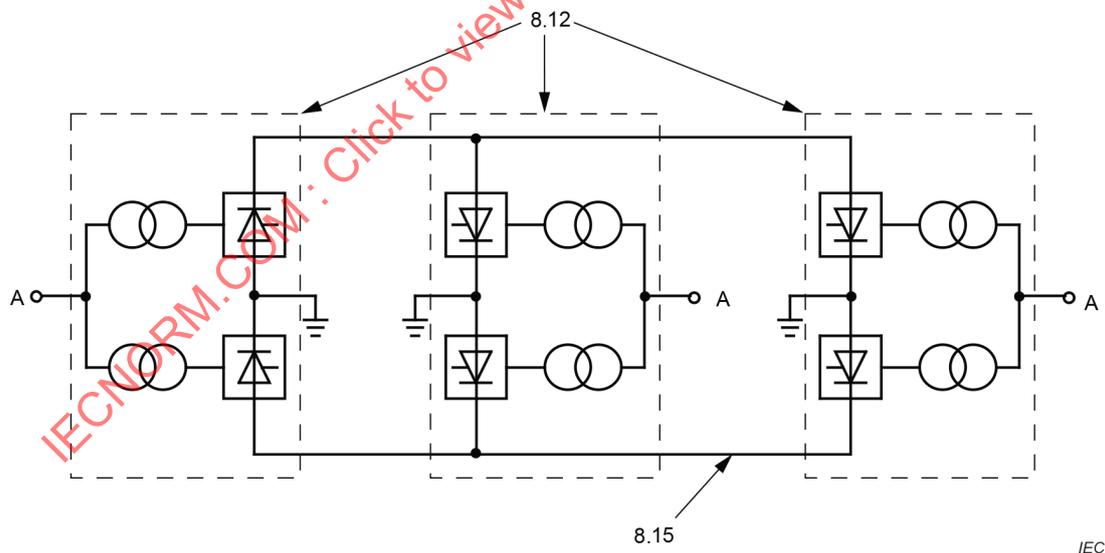
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Key

- | | | | |
|------|----------------------|------|------------------------|
| A | AC system | 8.15 | HVDC transmission line |
| 8.5 | HVDC system pole | 8.17 | Earth electrodes |
| 8.14 | HVDC substation pole | | |

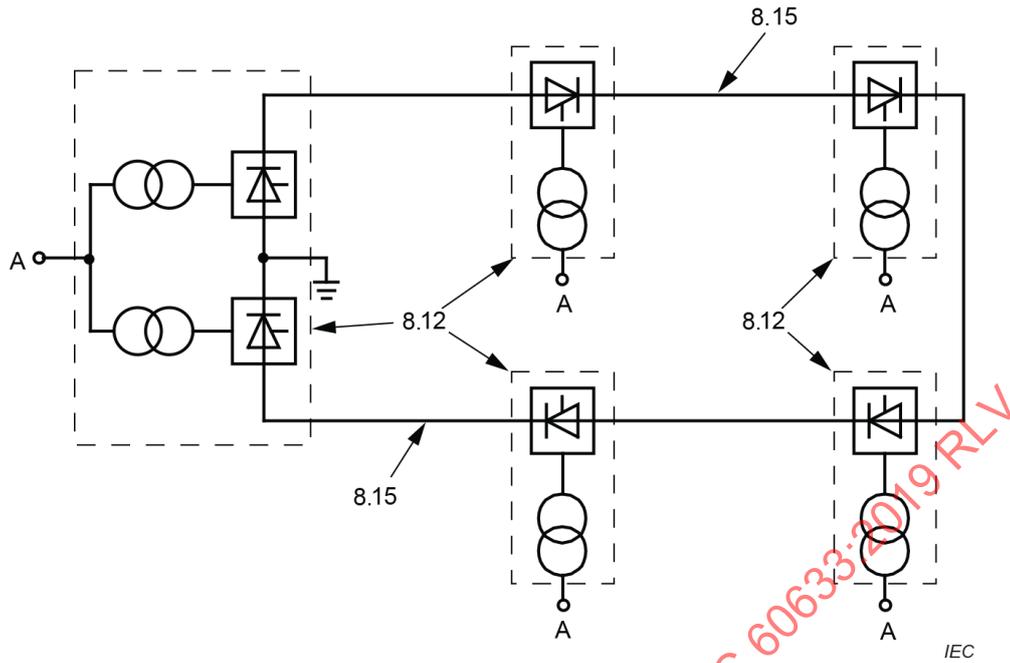
Figure 8 – Example of bipolar two-terminal HVDC transmission system



Key

- | | |
|------|------------------------|
| A | AC system |
| 8.12 | HVDC substations |
| 8.15 | HVDC transmission line |

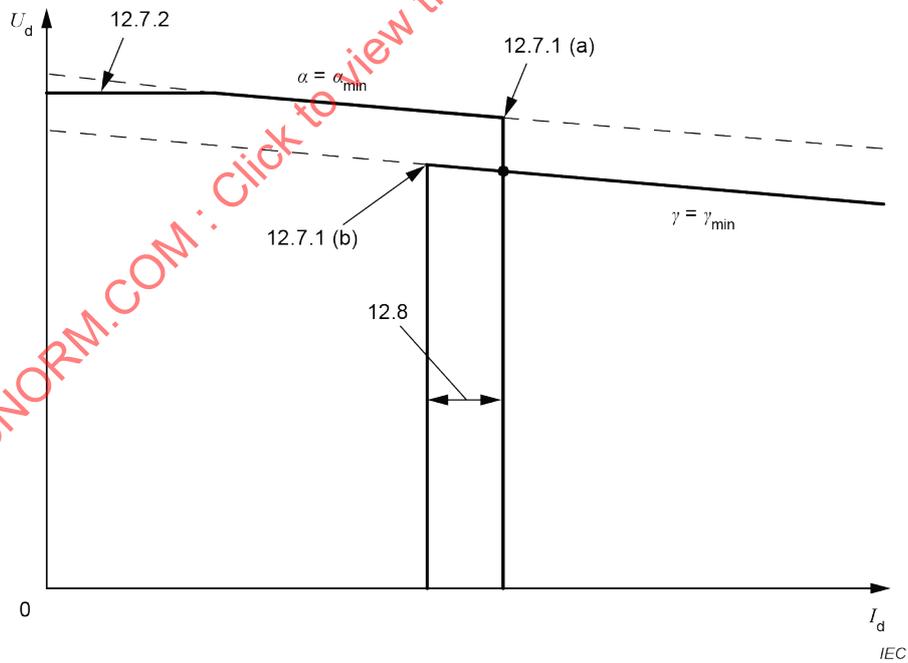
Figure 9 – Example of a multiterminal bipolar HVDC transmission system with parallel connected HVDC substations



Key

- A AC system
- 8.12 HVDC substations
- 8.15 HVDC transmission line

Figure 10 – Example of a multiterminal HVDC transmission system with series connected HVDC substations

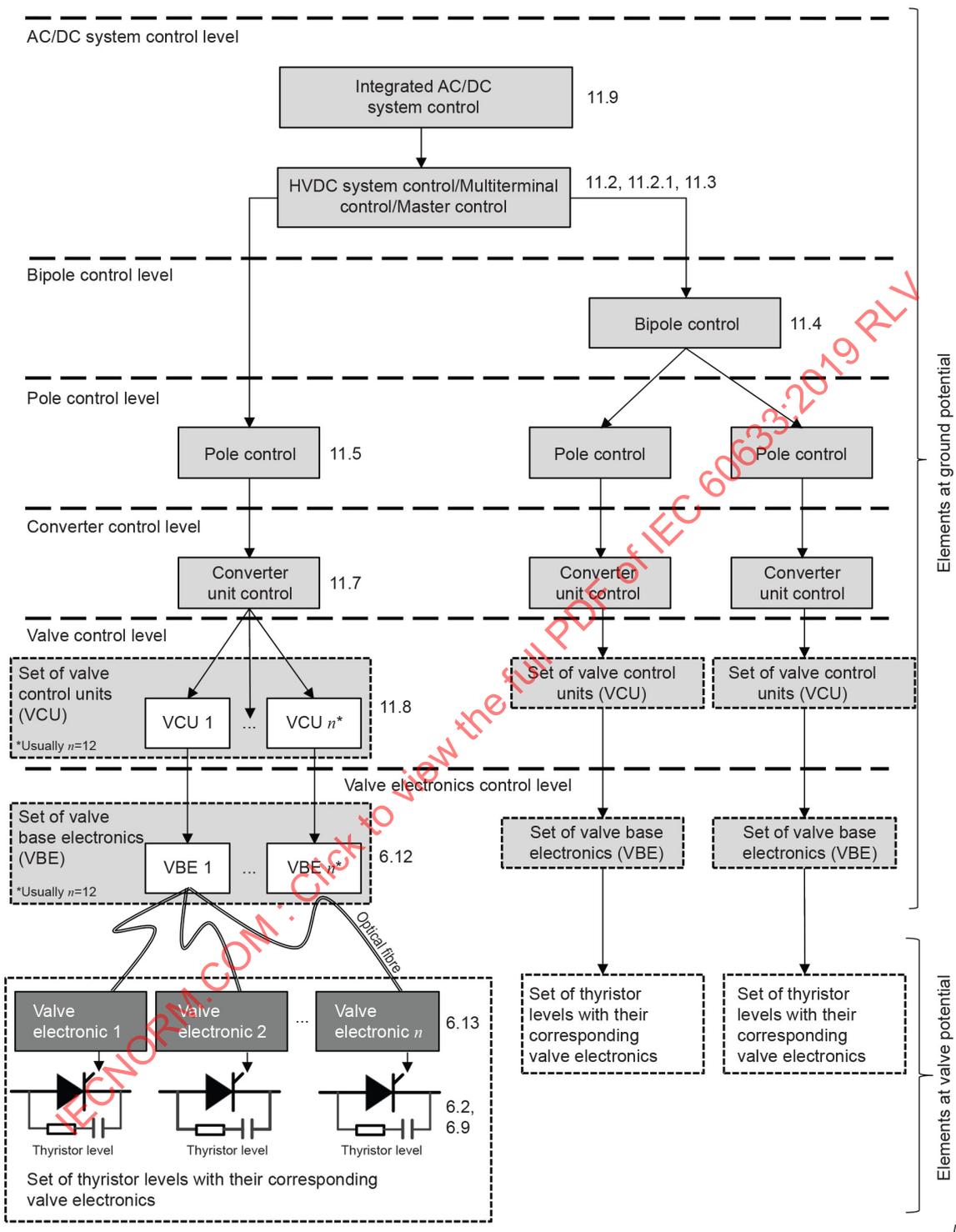


Key

- U_d Direct voltage
- I_d Direct current
- 12.7.1 (a) Current order (rectifier)
- 12.7.1 (b) Current order (inverter)
- 12.7.2 Voltage order (rectifier)
- 12.8 Current margin

Figure 11 – Simplified steady-state voltage-current characteristic of a two-terminal HVDC system

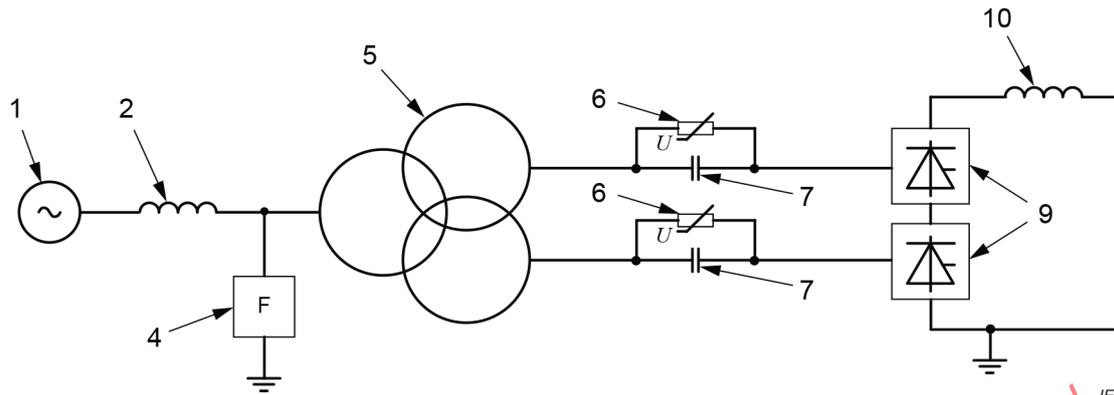
Hierarchical structure of an HVDC control system



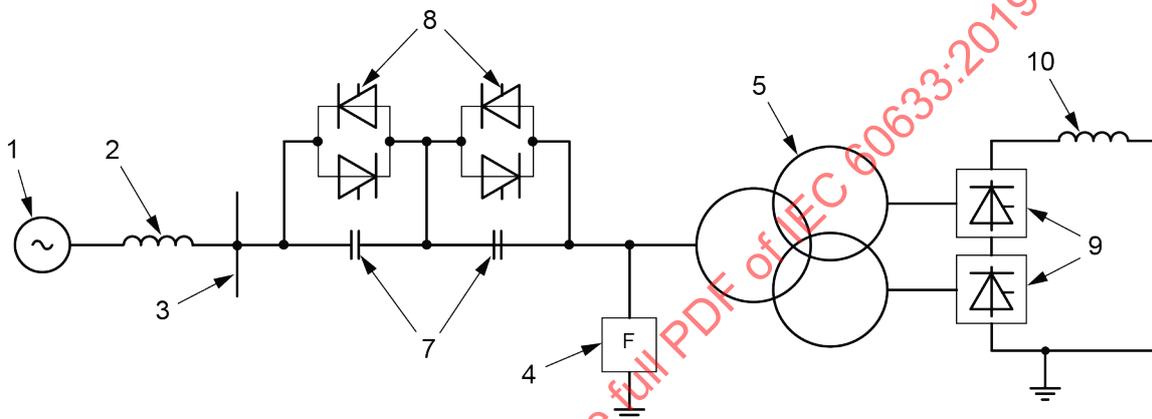
Key

- | | | | |
|--------|------------------------|------|---------------------------------|
| 6.2 | Converter bridge | 11.3 | HVDC master control |
| 6.9 | Valve thyristor levels | 11.4 | HVDC system bipole control |
| 6.12 | Valve base electronics | 11.5 | HVDC system pole control |
| 6.13 | Valve electronics | 11.7 | Converter unit control |
| 11.2 | HVDC system control | 11.8 | Valve control unit |
| 11.2.1 | Multiterminal control | 11.9 | Integrated AC/DC system control |

Figure 12 – Hierarchical structure of an HVDC control system



a) Capacitor commutated converter (CCC)



b) Controlled series capacitor converter (CSCC)

Key

- | | | | |
|---|--|----|---------------------|
| 1 | AC system electromotive force (e.m.f.) | 6 | Overvoltage limiter |
| 2 | AC system impedance | 7 | Capacitor |
| 3 | AC system bus | 8 | Thyristors |
| 4 | AC filters | 9 | Converter bridges |
| 5 | Converter transformer | 10 | DC reactor |

Figure 13 – Capacitor commutated converter configurations

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COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

**TRANSPORT D'ÉNERGIE EN COURANT CONTINU À HAUTE TENSION
(CCHT) – VOCABULAIRE**

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Cette troisième édition annule et remplace la deuxième édition parue en 1998, l'Amendement 1:2009 et l'Amendement 2:2015. Cette édition constitue une révision technique.

Cette édition inclut les modifications techniques majeures suivantes par rapport à l'édition précédente:

- a) 40 termes et définitions ont été modifiés et 31 nouveaux termes et définitions ont été ajoutés principalement pour les unités de conversion et les valves, les conditions de fonctionnement du convertisseur, les systèmes et postes CCHT et les équipements des postes CCHT;

- b) une nouvelle Figure 13 portant sur les configurations à convertisseurs commutés a été ajoutée.

Le texte de cette Norme internationale est issu des documents suivants:

CDV	Rapport de vote
22F/480/CDV	22F/491A/RVC

Le rapport de vote indiqué dans le tableau ci-dessus donne toute information sur le vote ayant abouti à l'approbation de cette Norme internationale.

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TRANSPORT D'ÉNERGIE EN COURANT CONTINU À HAUTE TENSION (CCHT) – VOCABULAIRE

1 Domaine d'application

Le présent document définit les termes relatifs aux systèmes de transport de puissance en courant continu à haute tension (CCHT), et aux postes CCHT utilisant des convertisseurs électroniques de puissance pour la conversion du courant alternatif en courant continu ou inversement.

Le présent document est applicable aux postes CCHT avec des convertisseurs commutés par le réseau, fondés le plus souvent sur le schéma en pont triphasé (deux voies) (voir Figure 2) dans lequel des valves électroniques unidirectionnelles, comme les valves à semiconducteurs, sont utilisées. Pour les valves à thyristors, seules les définitions les plus importantes sont incluses dans le présent document. Une liste plus complète de la terminologie des valves CCHT est donnée dans l'IEC 60700-2.

2 Références normatives

Le présent document ne contient aucune référence normative.

3 Symboles et abréviations

Cette liste ne comporte que les symboles les plus fréquemment utilisés. Des listes plus complètes des symboles adoptés pour les convertisseurs statiques se trouvent dans l'IEC 60027 (toutes les parties) et les autres normes indiquées dans la Bibliographie.

3.1 Symboles littéraux

U_d	tension continue (toute valeur définie)
U_{d0}	tension continue nominale à vide
U_{di0}	tension continue fictive à vide (ou idéale)
U_{dN}	tension continue assignée
U_L	tension entre phases côté réseau du transformateur du convertisseur, valeur efficace tenant compte des harmoniques
U_{LN}	valeur assignée de U_L
U_{v0}	tension à vide entre phases, côté valve du transformateur, valeur efficace à l'exclusion des harmoniques
I_d	courant continu (toute valeur définie)
I_{dN}	courant continu assigné
I_L	courant côté réseau du transformateur du convertisseur, valeur efficace tenant compte des harmoniques
I_{LN}	valeur assignée de I_L
I_v	courant côté valve du transformateur, valeur efficace tenant compte des harmoniques
α	angle de retard de l'ordre d'amorçage
β	angle d'avance de l'ordre d'amorçage
γ	angle d'extinction

μ	angle d'empiétement
p	indice de pulsation
q	indice de commutation

3.2 Indices

0 (zéro)	à vide
N	valeur assignée ou à la charge assignée
d	courant ou tension continu(e)
i	idéal
L	côté réseau du transformateur du convertisseur
v	côté valve du transformateur du convertisseur
max	maximal
min	minimal
n	relatif à la composante harmonique de rang n

3.3 Abréviations

Les abréviations suivantes s'écrivent toujours en majuscules et sans points.

CCHT	courant continu à haute tension
MVU	multiple valve (unit) (ensemble à valves multiples) (voir 6.3.2)
RCC	rapport de court-circuit (voir 7.32)
RCCE	rapport de court-circuit efficace (voir 7.33)
CCMT	système de transport CCHT multiterminal (voir 8.2.2)
DTRM	disjoncteur de transfert du retour métallique (voir 9.22)
DTRT	disjoncteur de transfert du retour par la terre (voir 9.23)
LCCDT	limitation de la consigne de courant dépendant de la tension (voir 12.9)
ITHS	interaction torsionnelle hyposynchrone (voir 10.10)

4 Symboles graphiques

La Figure 1 représente les symboles graphiques spéciaux qui sont donnés uniquement pour les besoins du présent document. Des listes plus complètes des symboles graphiques adoptés pour les convertisseurs statiques se trouvent dans l'IEC 60617.

5 Termes généraux relatifs aux circuits de conversion

Pour les besoins du présent document, les termes et définitions suivants s'appliquent.

L'ISO et l'IEC tiennent à jour des bases de données terminologiques destinées à être utilisées en normalisation, consultables aux adresses suivantes:

- IEC Electropedia: disponible à l'adresse <http://www.electropedia.org/>
- ISO Online browsing platform: disponible à l'adresse <http://www.iso.org/obp>

NOTE Des listes plus complètes des termes adoptés pour les convertisseurs statiques se trouvent dans l'IEC 60050-551 et l'IEC 60146-1-1.

5.1 conversion

<CCHT> transfert de la puissance de courant alternatif en courant continu ou inversement, ou une combinaison de ces opérations

5.2

schéma convertisseur

montage électrique de demi-bras et d'autres composants nécessaires pour assurer la fonction du circuit principal de puissance d'un convertisseur

5.3

schéma convertisseur en pont

schéma double alternance comprenant six demi-bras de convertisseur de telle sorte que les bornes centrales soient les bornes de phase du circuit en courant alternatif et que les bornes extérieures de polarité similaire soient connectées ensemble et soient les bornes à courant continu

Note 1 à l'article: Le schéma double alternance est représenté à la Figure 2.

5.3.1

pont homogène

pont dont tous les demi-bras de convertisseur sont commandables ou non commandables

5.3.2

pont mixte

pont comprenant des demi-bras de convertisseur commandables et non commandables

5.4

demi-bras de convertisseur

partie d'un pont raccordant deux points de potentiels différents dans un pont, par exemple, entre une borne à courant alternatif et une borne à courant continu

5.4.1

demi-bras de convertisseur commandable

demi-bras de convertisseur dans lequel le début de la conduction dans le sens direct peut être déterminé par un signal appliqué extérieurement

5.4.2

demi-bras de convertisseur non commandable

demi-bras de convertisseur dans lequel le début de la conduction dans le sens direct est déterminé uniquement par la tension appliquée à ses bornes

5.5

chemin de shuntage

chemin de faible résistance entre les bornes à courant continu d'un ou de plusieurs ponts, excluant le circuit à courant alternatif

Note 1 à l'article: Le chemin de shuntage peut constituer soit un chemin unidirectionnel, par exemple un demi-bras de shuntage (voir 5.5.1) ou une paire de shuntage (voir 5.5.2), soit un chemin bidirectionnel, par exemple un interrupteur de shuntage (voir 9.30).

5.5.1

demi-bras de shuntage

chemin de shuntage unidirectionnel raccordé seulement entre les bornes à courant continu, habituellement utilisé en technologie des valves à arc au mercure

Note 1 à l'article: Le demi-bras de shuntage n'est pas représenté à la Figure 2.

5.5.2

paire de shuntage

paire de shuntage bivalente

deux demi-bras du convertisseur d'un pont connectés à une borne commune à courant alternatif et formant un chemin de shuntage

VOIR: Figure 2.

5.6 commutation

transfert de courant entre deux chemins quelconques, ces deux chemins transportant simultanément du courant pendant ce transfert

Note 1 à l'article: La commutation peut se produire entre deux demi-bras quelconques du convertisseur, incluant les phases du réseau à courant alternatif, entre un demi-bras du convertisseur et un demi-bras de shuntage ou entre deux chemins quelconques du circuit.

5.6.1 commutation par le réseau

méthode de commutation dans laquelle la tension de commutation est fournie par le réseau à courant alternatif

5.7 groupe commutant

groupe de demi-bras qui commutent cycliquement et indépendamment des autres demi-bras de convertisseur et où les commutations ne sont normalement pas simultanées

Note 1 à l'article: Dans le cas d'un pont, un groupe commutant se compose des demi-bras raccordés à une borne commune à courant continu. Dans certains cas, par exemple impliquant des courants élevés et/ou des inductances de commutation de forte valeur, les commutations à l'intérieur de deux groupes commutants appartenant à un même pont ne sont pas nécessairement indépendantes.

VOIR: Figure 2.

5.8 inductance de commutation

inductance totale incluse dans le circuit de commutation, en série avec la tension de commutation

5.9 indice de pulsation

p
caractéristique d'un schéma de convertisseur, exprimée par le nombre de commutations symétriques non simultanées qui se produisent au cours d'une période de la tension alternative du réseau

Note 1 à l'article: L'indice de pulsation du schéma convertisseur en pont de 5.3 est toujours $p = 6$.

5.10 indice de commutation

q
nombre de commutations au cours d'une période de la tension alternative du réseau dans chaque groupe commutant

Note 1 à l'article: Dans le schéma convertisseur en pont, chaque groupe commutant a un indice de commutation $q = 3$.

5.11 convertisseur à condensateurs commutés

convertisseur dans lequel les condensateurs en série sont insérés entre le transformateur du convertisseur et les valves

VOIR: Figure 13 a).

5.12 convertisseur à condensateurs en série contrôlés

convertisseur dans lequel les condensateurs en série sont insérés entre le jeu de barres des filtres (côté courant alternatif) et le réseau en courant alternatif

VOIR: Figure 13 b).

5.13**tension de commutation**

tension qui provoque la commutation de courant

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

5.14**convertisseur à condensateurs commutés contrôlés**

convertisseur dans lequel les condensateurs en série contrôlés sont insérés entre le transformateur du convertisseur et les valves

5.15**convertisseur à condensateurs en série**

convertisseur dans lequel les condensateurs fixes en série sont insérés entre le jeu de barres des filtres (côté courant alternatif) et le réseau en courant alternatif

6 Unités de conversion et valves**6.1****unité de conversion**

ensemble opérationnel indivisible comprenant tout l'équipement situé entre le point de couplage commun côté courant alternatif (voir 8.24) et le point de couplage commun côté courant continu (voir 8.25), essentiellement un ou plusieurs ponts de conversion, avec un ou plusieurs transformateurs de convertisseur, l'équipement de commande de l'unité de conversion, les dispositifs essentiels de protection et de commutation et les équipements auxiliaires, s'ils existent, pour la conversion

VOIR: Figure 3.

6.2**pont de conversion**

équipement utilisé pour réaliser le schéma convertisseur en pont et le demi-bras de shuntage s'il existe

Note 1 à l'article: Le terme "pont" peut être utilisé pour décrire aussi bien le schéma du circuit que l'équipement réalisant ce circuit (voir 5.3).

6.2.1**groupe commutant de valves d'anode/de cathode**

équipement utilisé pour réaliser les demi-bras de convertisseur d'un groupe commutant d'un pont, interconnectés par leurs bornes d'anode/de cathode

6.3**valve**

ensemble d'éléments de valve opérationnel, commandable ou non commandable, conduisant normalement dans un seul sens (le sens direct), qui peut fonctionner comme demi-bras de convertisseur dans un pont de conversion

6.3.1**ensemble à valve unique**

structure comportant une seule valve

6.3.2**ensemble à valves multiples****MVU**

structure unique comportant plus d'une valve

Note 1 à l'article: Des exemples de valves multiples sont les bivalves, les quadrivalves et les octovalves comportant respectivement deux, quatre et huit valves connectées en série.

Note 2 à l'article: L'abréviation "MVU" est dérivée du terme anglais développé correspondant "multiple valve unit".

6.4

valve principale

valve d'un demi-bras de convertisseur

6.5

bivalve

valve d'un demi-bras de shuntage

6.6

module de thyristors

partie d'une valve comprenant un assemblage mécanique de thyristors, avec leurs auxiliaires proches, mais sans inductance de valve

Note 1 à l'article: Les modules de thyristors peuvent être des éléments dans la construction d'une valve, et/ou être interchangeables pour des besoins de maintenance.

6.7

module d'inductance

partie d'une valve constituée d'un assemblage mécanique d'une ou de plusieurs inductances, utilisée dans la conception de certaines valves

Note 1 à l'article: Les modules d'inductance peuvent être des éléments dans la construction d'une valve.

6.8

section de valve

assemblage électrique, comprenant un certain nombre de thyristors et d'autres composants, qui présente les mêmes propriétés électriques qu'une valve complète à échelle réduite

Note 1 à l'article: Le terme est principalement utilisé pour désigner un objet d'essai pour les besoins d'essai de valve.

6.9

niveau de thyristor de valve

partie d'une valve, pouvant être un thyristor ou des thyristors branchés en parallèle, avec leurs circuits auxiliaires proches, et le cas échéant une inductance

6.10

support de valve

partie de la valve fournissant un support mécanique et l'isolation électrique de la terre à la partie sous tension de la valve

Note 1 à l'article: Toutes les conceptions de valve peuvent ne pas contenir la partie d'une valve clairement identifiable sous une forme discrète comme étant un support de valve.

6.11

structure de valve

composants de structure d'une valve, exigés afin de soutenir physiquement les modules de valve

6.12

électronique de contrôle de gâchette de la valve

VBE

unité électronique, au potentiel de terre, qui assure la conversion électrique-optique entre le système de commande du convertisseur et les valves

Note 1 à l'article: L'abréviation "VBE" est dérivée du terme anglais développé correspondant "valve base electronics".

6.13**électronique de valve**

circuits électroniques au(x) potentiel(s) de la ou des valves qui remplissent des fonctions de commande et de protection d'un ou de plusieurs niveaux de thyristors

6.14**parafoudre de valve**

parafoudre raccordé aux bornes de la valve

VOIR: Figure 3.

6.15**parafoudre d'une unité de conversion**

parafoudre raccordé aux bornes à courant continu d'une unité de conversion

VOIR: Figure 3.

6.16**parafoudre de barre à courant continu d'une unité de conversion**

parafoudre raccordé entre la borne à haute tension à courant continu d'une unité de conversion et la terre du poste

VOIR: Figure 3 et Figure 7.

6.17**parafoudre de barre à courant continu du milieu**

parafoudre raccordé entre le milieu des deux ponts hexaphasés d'une unité de conversion dodécaphasée et la terre du poste

Note 1 à l'article: Dans certaines conceptions de postes CCHT, deux unités de conversion dodécaphasées sont raccordées en séries. Dans un tel cas, le parafoudre de barre à courant continu du milieu à l'unité de conversion dodécaphasée supérieure n'est pas raccordé à la terre du poste, mais à la borne à haute tension à courant continu de l'unité de conversion dodécaphasée inférieure.

VOIR: Figure 7.

6.18**inductance de valve**

inductance(s) connectée(s) en série avec les thyristors dans une valve ayant pour objet de limiter la vitesse d'augmentation du courant à la mise sous tension et la tension dans l'état bloqué

Note 1 à l'article: Les inductances de valve peuvent être extérieures à l'ensemble de la valve ou distribuées à l'intérieur de la valve.

6.19**transformateur du convertisseur**

transformateur à travers lequel la puissance est transmise d'un réseau à courant alternatif à un ou à plusieurs ponts de conversion ou inversement

VOIR: Figure 3.

6.19.1**enroulements côté réseau**

enroulements du transformateur du convertisseur connectés au réseau à courant alternatif

6.19.2**enroulements côté valve**

enroulements du transformateur du convertisseur connectés aux bornes à courant alternatif d'un ou de plusieurs ponts de conversion

6.20

module de valve

partie d'une valve comprenant un assemblage mécanique de thyristors, avec leurs auxiliaires proches et inductance(s) de valve

6.21

niveaux redondants

nombre maximal de niveaux de thyristors connectés en série dans une valve, qui peut supporter un court-circuit externe ou interne en service sans que le fonctionnement sécurisé de la valve n'en soit altéré, comme cela est démontré par les essais de type, et qui, en cas de dépassement, entraîne l'arrêt de la valve pour permettre le remplacement des niveaux défectueux ou l'acceptation d'un risque accru de dysfonctionnements

6.22

borne d'anode de valve

borne de valve sur laquelle le courant direct entre dans la valve

6.23

borne de cathode de valve

borne de valve sur laquelle le courant direct sort de la valve

7 Conditions de fonctionnement du convertisseur

7.1

fonctionnement en redresseur

redressement

mode de fonctionnement d'un convertisseur ou d'un poste CCHT quand la puissance est transmise du côté courant alternatif vers le côté courant continu

7.2

fonctionnement en onduleur

renvoi au réseau

mode de fonctionnement d'un convertisseur ou d'un poste CCHT quand la puissance est transmise du côté courant continu vers le côté courant alternatif

7.3

sens direct

sens de conduction

<d'une valve> sens dans lequel une valve est capable de conduire le courant de charge

7.4

sens inverse

sens de non-conduction

<d'une valve> inverse du sens de conduction

7.5

courant direct

courant qui circule dans une valve dans le sens direct

7.6

courant inverse

courant qui circule dans une valve dans le sens inverse

7.7

tension directe

tension appliquée entre la borne d'anode et la borne de cathode d'une valve ou d'un demi-bras quand la borne d'anode est positive par rapport à la borne de cathode

7.8**tension inverse**

tension appliquée entre la borne d'anode et la borne de cathode d'une valve ou d'un demi-bras quand la borne d'anode est négative par rapport à la borne de cathode

7.9**état conducteur****état passant**

situation d'une valve quand la valve présente une résistance faible

Note 1 à l'article: La tension de la valve dans cette condition est indiquée à la Figure 6.

7.10**chute de tension de valve**

tension à travers les bornes d'une valve pendant l'état conducteur

7.11**état non conducteur****état bloqué**

situation d'une valve quand tous les thyristors sont hors tension

7.11.1**état bloqué direct**

état non conducteur d'une valve commandable quand la tension directe est appliquée à ses bornes principales

VOIR: Figure 6.

7.11.2**état bloqué inverse**

état non conducteur d'une valve quand la tension inverse est appliquée à ses bornes principales

VOIR: Figure 6.

7.12**allumage**

établissement du courant dans le sens direct dans une valve

7.13**impulsion de commande de valve**

impulsion qui, pendant toute sa durée, autorise l'allumage de la valve

7.14**impulsion d'allumage de valve**

impulsion qui déclenche l'allumage de la valve, normalement dérivée de l'impulsion de commande de valve

7.15**blocage d'un convertisseur**

opération évitant la poursuite de la conversion par un convertisseur en inhibant les impulsions de commande des valves

Note 1 à l'article: Cette opération peut aussi comprendre l'allumage de la ou des valves choisies pour former un chemin de shuntage.

7.16**déblocage d'un convertisseur**

opération permettant le commencement de la conversion dans un convertisseur

7.17**blocage d'une valve**

opération évitant un allumage ultérieur d'une valve commandable

7.18**déblocage d'une valve**

opération permettant l'allumage d'une valve commandable

7.19**réglage de phase**

action consistant à faire varier l'instant du cycle auquel commence la conduction du courant direct dans une valve commandable

7.20**angle de retard de l'ordre d'amorçage****angle de retard de l'ordre d'allumage**

α

temps, exprimé en unités d'angle électrique, entre le passage à zéro de la tension de commutation sinusoïdale idéalisée et l'instant du début de conduction du courant direct

VOIR: Figure 4.

7.21**angle d'avance de l'ordre d'amorçage****angle d'avance de l'ordre d'allumage**

β

temps, exprimé en unités d'angle électrique, entre l'instant du début de conduction du courant direct et le passage à zéro de la tension de commutation sinusoïdale idéalisée

Note 1 à l'article: L'angle d'avance β est lié à l'angle de retard α par $\beta = \pi - \alpha$ (voir Figure 4).

7.22**angle d'empiètement**

μ

durée de la commutation entre deux demi-bras de convertisseur, exprimée en unités d'angle électrique

VOIR: Figure 4 et Figure 5.

7.23**angle d'extinction**

γ

temps, exprimé en unités d'angle électrique, entre la fin de conduction du courant et le passage par zéro de la tension de commutation sinusoïdale idéalisée

Note 1 à l'article: γ dépend de l'angle d'avance β et de l'angle d'empiètement μ et est déterminé par la relation $\gamma = \beta - \mu$ (voir Figure 4 et Figure 5).

7.24**intervalle de retenue**

temps séparant l'instant auquel s'annule le courant direct dans une valve commandable et l'instant auquel cette même valve est soumise à une tension directe

Note 1 à l'article: L'intervalle de retenue, lorsqu'il est exprimé en unités d'angle électrique, est souvent désigné sous l'appellation d'angle d'extinction. Cependant, il convient de noter la distinction entre le concept d'angle d'extinction et celui d'intervalle de retenue, comme indiqué à la Figure 5.

7.24.1**intervalle critique de retenue**

intervalle de retenue minimal pour lequel le fonctionnement en onduleur peut être maintenu

7.25**intervalle de conduction**

partie d'un cycle pendant laquelle une valve est à l'état conducteur

VOIR: Figure 6.

7.26**intervalle de blocage****intervalle de repos**

partie d'un cycle pendant laquelle une valve est à l'état non conducteur

VOIR: Figure 6.

7.27**intervalle de blocage direct**

partie de l'intervalle de blocage pendant lequel une valve contrôlable est à l'état bloqué et soumise à une tension directe

VOIR: Figure 6.

7.28**intervalle de blocage inverse**

partie de l'intervalle de blocage pendant lequel une valve est à l'état bloqué et soumise à une tension inverse

VOIR: Figure 6.

7.29**allumage intempestif****raté d'allumage**

allumage d'une valve à un instant imprévu

7.30**défaut d'allumage**

impossibilité d'obtenir l'allumage d'une valve pendant toute la durée de l'intervalle de tension directe

7.31**raté de commutation**

impossibilité de commuter le courant direct d'un demi-bras en période de conduction au demi-bras suivant d'un convertisseur

7.32**rapport de court-circuit****RCC**

rapport entre la puissance de court-circuit du réseau en courant alternatif (en MVA) à la tension de 1 p.u. au point de raccordement du jeu de barres alternatif du poste CCHT, et la puissance assignée en courant continu du poste CCHT (en MW)

Note 1 à l'article: Cette définition du RCC est différente de la définition donnée dans l'IEC 60146-1-1.

7.33**rapport de court-circuit efficace****RCCE**

rapport entre la puissance de court-circuit du réseau en courant alternatif (en MVA) à la tension de 1 p.u. au point de raccordement du jeu de barres alternatif du poste CCHT, réduite de la puissance réactive de bancs de condensateurs et de filtres shunts à courant alternatif connectés à cette barre (en Mvar), et la puissance assignée en courant continu du poste CCHT (en MW)

7.34

amorçage déclenchement

action de commande en vue de l'allumage d'une valve ou d'un thyristor individuel

7.35

état de fonctionnement

condition dans laquelle le poste CCHT est sous tension et où les convertisseurs fonctionnent avec une puissance de sortie active ou réactive non nulle au point de couplage commun (PCC) au réseau en courant alternatif

7.36

état bloqué

condition dans laquelle toutes les valves de l'unité de conversion sont bloquées

7.37

tension de valve

différence de tension entre la borne d'anode de la valve et sa borne de cathode

8 Systèmes et postes CCHT

8.1

système CCHT

système électrique de puissance destiné au transfert de puissance sous forme de courant continu à haute tension entre deux ou plus de deux jeux de barres à courant alternatif

8.2

système de transport CCHT

système CCHT utilisé pour transférer la puissance électrique entre deux ou plus de deux localisations géographiques différentes

8.2.1

système de transport CCHT à deux extrémités

système de transport CCHT comprenant deux postes de transport CCHT et la ou les lignes de transport à courant continu d'interconnexion

VOIR: Figure 8.

8.2.2

système de transport CCHT multiterminal CCMT

système de transport CCHT comprenant plus de deux postes CCHT séparés et les lignes de transport CCHT d'interconnexion

VOIR: Figure 9 et Figure 10.

8.2.3

système CCHT dos-à-dos

système CCHT qui transporte de l'énergie entre des jeux de barres à courant alternatif, situés en un même lieu

8.3

système CCHT unidirectionnel

système CCHT prévu pour transporter l'énergie dans une seule direction

Note 1 à l'article: La plupart des systèmes CCHT sont de nature bidirectionnelle. Certains systèmes peuvent toutefois être optimisés pour transmettre l'énergie dans une direction préférentielle unique. Ces systèmes peuvent toujours être considérés comme "bidirectionnels".

8.4**système CCHT bidirectionnel**

système CCHT prévu pour transporter l'énergie dans les deux directions

Note 1 à l'article: Un système CCHT multiterminal est bidirectionnel si un ou plusieurs postes sont bidirectionnels.

8.5**pôle de système CCHT**

partie d'un système CCHT comprenant tout l'équipement des postes CCHT et les lignes de transport d'interconnexion, le cas échéant, qui présentent une même polarité de tension continue par rapport à la terre, pendant un fonctionnement normal

VOIR: Figure 8.

8.6**bipôle de système CCHT**

partie d'un système CCHT consistant en deux pôles de système CCHT pouvant être actionnés indépendamment, qui en fonctionnement normal, présentent des polarités de tension continue opposées par rapport à la terre

8.7**monopole symétrique**

partie d'un système CCHT comprenant tout l'équipement des postes CCHT et les lignes de transport d'interconnexion, le cas échéant, présentant en fonctionnement normal des polarités de tension continue égales et opposées par rapport à la terre, mais sans montage en série des convertisseurs dans chaque poste de conversion

Note 1 à l'article: Le terme "monopole symétrique" est utilisé même en présence de deux polarités avec des tensions en courant continu, un seul convertisseur ne pouvant fournir la redondance normalement induite par le terme "bipôle".

8.8**système CCHT bipolaire**

système CCHT ayant deux pôles de polarités opposées par rapport à la terre

Note 1 à l'article: Les lignes aériennes des deux pôles, si elles existent, peuvent être suspendues aux mêmes pylônes, ou à des pylônes différents.

VOIR: Figure 8.

8.9**système bipolaire rigide à courant continu**

système CCHT bipolaire sans connexion de neutre entre les deux postes de conversion

Note 1 à l'article: Puisqu'il n'existe que deux conducteurs (pôles), aucun courant asymétrique entre les deux pôles n'est possible. Dans le cas d'une interruption du transfert d'énergie d'un pôle de convertisseur, le courant doit également être interrompu de l'autre pôle (au moins pendant une durée limitée pour permettre une reconfiguration du circuit en courant continu).

8.10**système CCHT monopolaire****système CCHT asymétrique**

système CCHT ayant un seul pôle

8.11**système CCHT monopolaire symétrique**

système CCHT avec un seul monopole symétrique