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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

IEC 60633:2019-04(en-fr)

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HIGH-VOLTAGE DIRECT CURRENT (HVDC) TRANSMISSION – VOCABULARY

FOREWORD

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

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

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

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

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

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

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

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- withdrawn,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

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

HIGH-VOLTAGE DIRECT CURRENT (HVDC) TRANSMISSION – VOCABULARY

1 Scope

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

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

2 Normative references

There are no normative references in this document.

3 Symbols and abbreviated terms

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

3.1 Letter symbols

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

3.2 Subscripts

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

3.3 Abbreviated terms

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

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

4 Graphical symbols

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

5 General terms related to converter circuits

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

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

5.1
conversion
<HVDC> transfer of energy from AC to DC or vice versa, or a combination of these operations

5.2
converter connection
electrical arrangement of arms and other components necessary for the functioning of the main power circuit of a converter

5.3
bridge converter connection
double-way connection comprising six converter arms such that the centre terminals are the phase terminals of the AC circuit, and that the outer terminals of like polarity are connected together and are the DC terminals

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

5.3.1
uniform bridge
bridge where all converter arms are either controllable or non-controllable

5.3.2
non-uniform bridge
bridge with both controllable and non-controllable converter arms

5.4
converter arm
part of a bridge connecting two points of different potentials within a bridge, for example, between an AC terminal and a DC terminal

5.4.1
controllable converter arm
converter arm in which the start of forward conduction may be determined by an externally applied signal

5.4.2
non-controllable converter arm
converter arm in which the start of forward conduction is determined solely by the voltage applied to its terminals

5.5
by-pass path
low resistance path between the DC terminals of one or several bridges excluding the AC circuit

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

5.5.1
by-pass arm
unidirectionally conducting by-pass path connected only between DC terminals, commonly used with mercury arc valve technology

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

5.5.2
by-pass pair
two converter arms of a bridge connected to a common AC terminal and forming a by-pass path

SEE: Figure 2.

5.6
commutation
transfer of current between any two paths with both paths carrying current simultaneously during this process

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

5.6.1
line commutation
method of commutation whereby the commutating voltage is supplied by the AC system

5.7
commutating group
group of converter arms which commutate 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 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

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.