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IEC 62747

Edition 1.0 2014-07

INTERNATIONAL STANDARD

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colour inside

Terminology for voltage-sourced converters (VSC) for high-voltage direct current (HVDC) systems

Terminologie relative aux convertisseurs de source de tension (VSC) des systèmes en courant continu à haute tension (CCHT)

IEC 62747:2014-07(en-fr)

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

COMMISSION ELECTROTECHNIQUE INTERNATIONALE

PRICE CODE
CODE PRIX V

ICS 29.200; 29.240

ISBN 978-2-8322-1702-3

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TERMINOLOGY FOR VOLTAGE-SOURCED CONVERTERS (VSC) FOR HIGH-VOLTAGE DIRECT CURRENT (HVDC) SYSTEMS

FOREWORD

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International Standard IEC 62747 has been prepared by subcommittee 22F: Power electronics for electrical transmission and distribution systems, of IEC technical committee 22: Power electronic systems and equipment.

The text of this standard is based on the following documents:

CDV	Report on voting
22F/301/CDV	22F/317A/RVC

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

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

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

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- withdrawn,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

The contents of the corrigendum of February 2015 have been included in this copy.

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TERMINOLOGY FOR VOLTAGE-SOURCED CONVERTERS (VSC) FOR HIGH-VOLTAGE DIRECT CURRENT (HVDC) SYSTEMS

1 Scope

This International Standard defines terms for the subject of self-commutated voltage-sourced converters used for transmission of power by high voltage direct current (HVDC).

The standard is written mainly for the case of application of insulated gate bipolar transistors (IGBTs) in voltage sourced converters (VSC) but may also be used for guidance in the event that other types of semiconductor devices which can both be turned on and turned off by control action are used.

Line-commutated and current-sourced converters for high-voltage direct current (HVDC) power transmission systems are specifically excluded from this standard.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

IEC 60617, *Graphical symbols for diagrams*

3 Symbols and abbreviations

3.1 List of letter symbols

Essential terms and definitions necessary for the understanding of this standard are given here; other terminology is as per relevant parts of IEC 60747.

The list covers only the most frequently used symbols (see Figure 1). IEC 60027 shall be used for a more complete list of the symbols which have been adopted for static converters. See also other standards listed in the normative references and the bibliography.

U_{d} direct voltage

U_{dc} converter d.c. voltage

U_{dpe} pole-to-earth direct voltage

U_{dpp} pole-to-pole direct voltage

U_{dppN} rated pole-to-pole direct voltage

U_{dpeN} rated pole-to-earth direct voltage

U_{L} line-to-line voltage on line side of interface transformer, r.m.s. value including harmonics

U_{Le} line-to-earth voltage on line side of interface transformer, r.m.s. value including harmonics

U_{LN} rated value of U_L

U_v line-to-line voltage on valve side of interface transformer, r.m.s. value including harmonics

U_{ve} line-to-earth voltage on valve side of interface transformer, r.m.s. value including harmonics

U_c line-to-line converter voltage, r.m.s. value including harmonics

NOTE U_c is equal to U_v minus the voltage drop across the phase and valve reactors. However, U_c has only a clear meaning during balanced conditions (steady state).

U_{ce} line-to-earth converter voltage , r.m.s. value including harmonics

U_{valve} voltage between terminals of a valve (any defined value)

I_d direct current (any defined value)

I_{dN} rated direct current

I_L current on line side of interface transformer, r.m.s. value including harmonics

I_{LN} rated value of I_L

I_v current on valve side of interface transformer, r.m.s. value including harmonics

I_{valve} current through a valve

3.2 List of subscripts

0 (zero) at no load

e earth

p pole

N rated value or at rated load

d direct current or voltage

L line side of interface transformer

c converter

v valve side of interface transformer

valve through or across one valve

max maximum

min minimum

n pertaining to harmonic component of order n

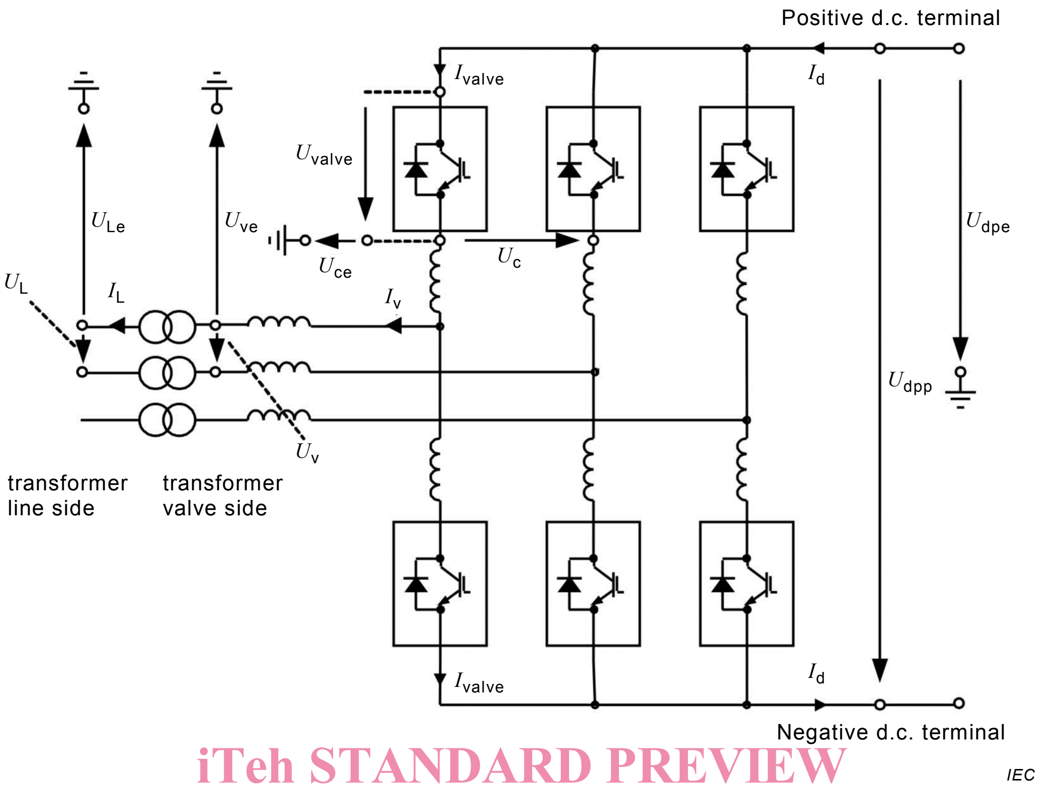


Figure 1 – Converter symbol identifications

3.3 List of abbreviations

The following abbreviations are always in capital letters and without dots.

CTL cascaded two-level converter

ERTB earth return transfer breaker

ESCR effective short-circuit ratio

FWD free-wheeling diode

HF high frequency

HVDC high-voltage direct current

IGBT insulated gate bipolar transistor

MMC modular multilevel converter

MRTB metallic return transfer breaker

MTDC multi-terminal HVDC transmission system

MVU multiple valve (unit)

NBS neutral bus switch

NGBS neutral bus grounding switch

PCC point of common coupling

PCC-DC point of common coupling – d.c. side

SCR short-circuit ratio

VBE valve base electronics

VCU valve control unit

VSC voltage-sourced converter

NOTE Even though the word “breaker” is used in the abbreviations, it does not necessarily imply the ability to interrupt fault currents.

4 Graphical symbols

Figure 2 shows the specific graphical symbols which are defined only for the purposes of this standard. IEC 60617 shall be used for a more complete list of the graphical symbols which have been adopted for static converters.

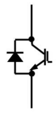
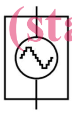
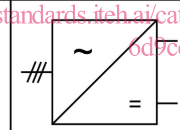
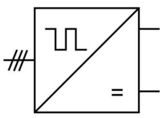
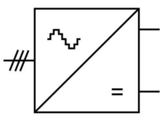
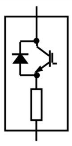
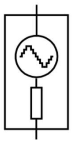
No.	Symbol	Description
1		IGBT-diode pair
2		Valve of “switch” type
3		Valve of “controllable voltage source” type
4		VSC unit (of unspecified type)
5		VSC unit using switch type valves
6		VSC unit using controllable voltage source type valves
7		Dynamic braking valve of “switch” type
8		Dynamic braking valve of “controllable voltage source” type

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Figure 2 – Graphical symbols

5 General terms related to converter circuits

5.1
conversion
in the context of HVDC, the transfer of energy from a.c. to d.c. or vice versa, or a combination of these operations

5.2
converter
in the context of HVDC, the device employed to transfer of energy from a.c. to d.c. or vice versa, it connects between three a.c. terminals and two d.c. terminals

5.3
voltage-sourced converter
VSC
electronic a.c./d.c. converter having an essentially smooth d.c. voltage provided by e.g. a common d.c. link capacitor or distributed d.c. capacitors within the converter arms

5.4
arm
converter arm
part of a converter connecting the a.c. phase terminal with the d.c. pole terminal

5.5
commutation
transfer of current between any two paths with both paths carrying current simultaneously during this process

5.6
line commutation
method of commutation whereby the commutating voltage is supplied by the a.c. system

5.7
self-commutation
commutation where the commutating voltage is supplied by components within the converter or the electronic switch

5.8
commutating voltage
voltage which causes the current to commutate, provided either by the system or by a switching action of valve/semiconductor devices

5.9
commutation inductance
total inductance included in the commutation circuit, in series with the commutating voltage

Note 1 to entry: The commutation inductance is typically referred as stray inductance or loop inductance.

5.10
coupling inductance
equivalent inductance referred to the converter side of the interface transformer between the point of common coupling (PCC) and the d.c. terminal of the valve

6 VSC topologies

6.1
two-level converter
converter in which the voltage between the a.c. terminals of the VSC unit (see 7.6) and VSC unit midpoint (see 7.28) is switched between two discrete d.c. voltage levels

6.2
three-level converter
converter in which the voltage between the a.c. terminals of the VSC unit (see 7.6) and VSC unit midpoint (see 7.28) is switched between three discrete d.c. voltage levels

6.3
multi-level converter
converter in which the voltage between the a.c. terminals of the VSC unit (see 7.6) and VSC unit midpoint (see 7.28) is switched between more than three discrete d.c. voltage levels

6.4
modular multi-level converter
MMC
multi-level converter in which each VSC valve (see 7.8, 7.9) consists of a number of MMC building blocks (see 7.11) connected in series

Note 1 to entry: See also Figure 4.

6.5
cascaded two-level converter
CTL
modular multi-level converter in which each switch position consists of more than one IGBT-diode pair connected in series

Note 1 to entry: See Figure 5.

7 Converter units and valves

7.1
turn-off semiconductor device
controllable semiconductor device which may be turned on and off by a control signal, for example an IGBT

7.2
insulated gate bipolar transistor
IGBT
turn-off semiconductor device with three terminals: a gate terminal (G) and two load terminals emitter (E) and collector (C)

7.3
free-wheeling diode
FWD
power semiconductor device with diode characteristic

Note 1 to entry: A FWD has two terminals: an anode (A) and a cathode (K).

Note 2 to entry: The current through FWDs is in the opposite direction to the IGBT current.

7.4
IGBT-diode pair
arrangement of IGBT and FWD connected in inverse parallel

Note 1 to entry: An IGBT-diode pair is usually in one common package, however, it can include individual IGBTs and/or diodes packages connected in parallel.

7.5
converter unit
indivisible operative unit comprising all equipment between the point of common coupling on the a.c. side (see 9.25) and the point of common coupling – d.c. side (see 9.26), essentially one or more VSC units, together with one or more interface transformers, converter unit control equipment, essential protective and switching devices and auxiliaries, if any, used for conversion

Note 1 to entry: See Figure 3.

7.6
VSC unit
three VSC phase units, together with VSC unit control equipment, essential protective and switching devices, d.c. storage capacitors, phase reactors and auxiliaries, if any, used for conversion

Note 1 to entry: See Figure 3.

7.7
VSC phase unit
equipment used to connect the two d.c. terminals to one a.c. terminal

Note 1 to entry: In the simplest implementation, the VSC phase unit consists of two VSC valves, and in some case, it may include also valve reactors. The VSC phase unit may also include control and protection equipment, and other components.

7.8
VSC valve
<switch type> arrangement of IGBT-diode pairs connected in series and arranged to be switched simultaneously as a single function unit

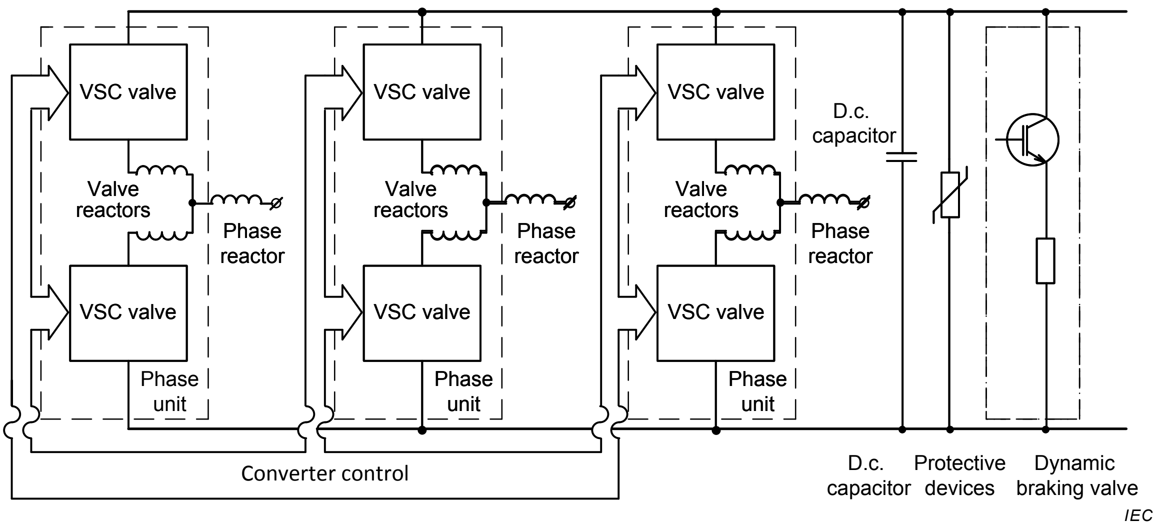

Figure 3 – Voltage-sourced converter unit

Note 1 to entry: In some designs of VSC, the phase reactors may fulfill part of the function of the converter-side high frequency filter. In addition, in some designs of VSC, part or all of the phase reactor may be built into the three “phase units” of the VSC unit, as “valve reactors”.

Note 2 to entry: In some designs of VSC, the VSC d.c. capacitor may be partly or entirely distributed amongst the three “phase units” of the VSC unit, where it is referred to as d.c. submodule capacitors.

Note 3 to entry: Valve and/or phase reactors shown above show optional configurations which may not be included in all schemes.

Note 4 to entry: Just a typical example of how a VSC unit could look like is shown in Figure 3, differences may exist at all levels.

7.9
VSC valve
<controllable voltage source type> complete controllable voltage source assembly, which is generally connected between one a.c. terminal and one d.c. terminal

7.10
VSC valve level
the smallest indivisible functional unit of VSC valve

Note 1 to entry: For any VSC valve in which IGBTs are connected in series and operated simultaneously, one VSC valve level is one IGBT-diode pair including its auxiliaries (see Figure 4). For MMC type without IGBT-diode pairs connected in series, one valve level is one submodule together with its auxiliaries (see Figure 5).

7.11
MMC building block
self-contained, two-terminal controllable voltage source together with d.c. capacitor(s) and immediate auxiliaries, forming part of a MMC

7.12
switch position
semiconductor function which behaves as a single, indivisible switch

Note 1 to entry: A switch position may consist of a single IGBT-diode pair or, in the case of the Cascaded Two Level converter, a series connection of multiple IGBT-diode pairs.

7.13
submodule
MMC building block where each switch position consists of only one IGBT-diode pair

Note 1 to entry: See Figure 4.

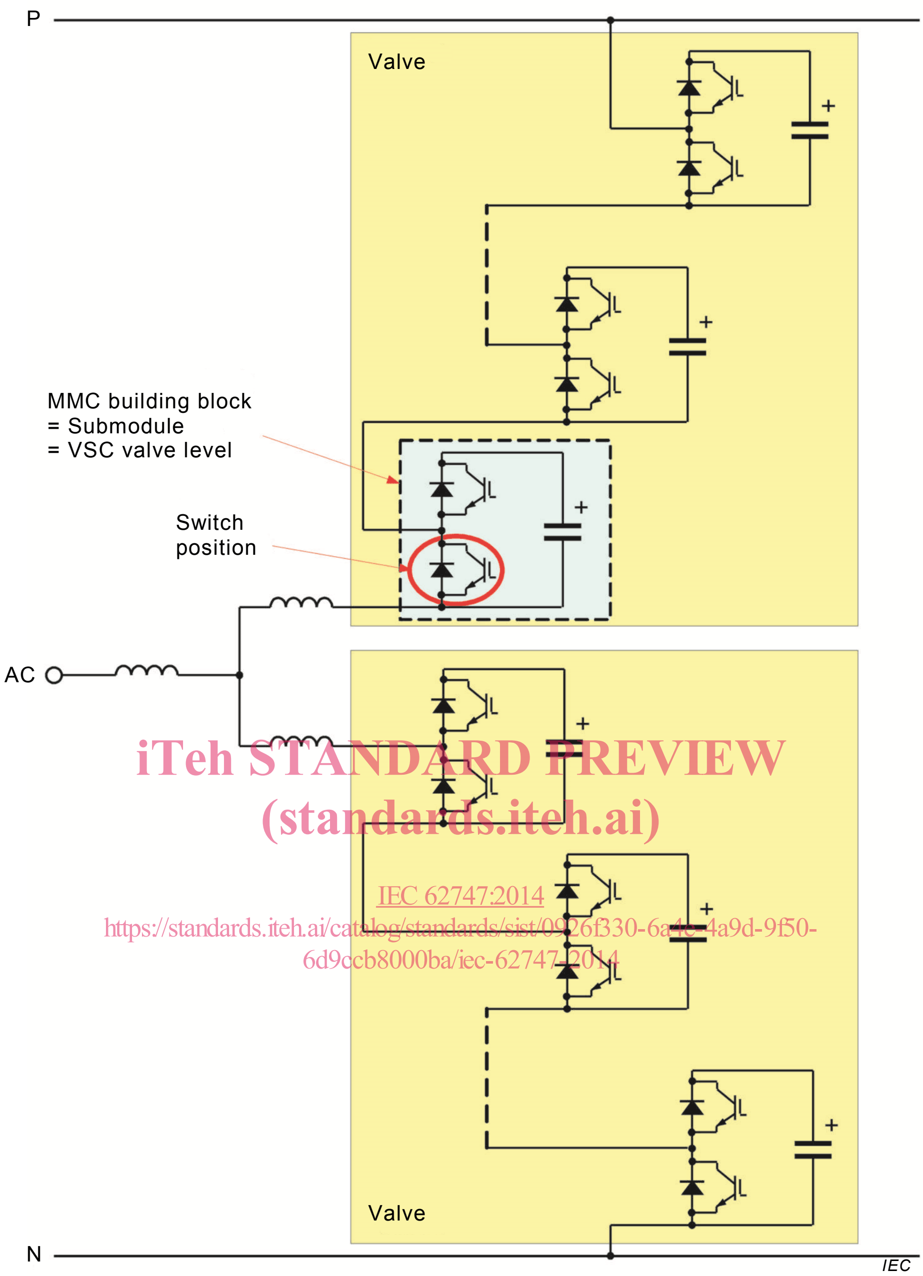

Figure 4 – Phase unit of the modular multi-level converter (MMC) in basic half-bridge, two-level arrangement, with submodules

7.14
cell
MMC building block where each switch position consists of more than one IGBT-diode pair connected in series

Note 1 to entry: See Figure 5.