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Power electronics systems and equipment – Operation conditions and characteristics of active infeed converter applications

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IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland
Email: inmail@iec.ch
Web: www.iec.ch

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colour inside

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POWER ELECTRONICS SYSTEMS AND EQUIPMENT –

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FOREWORD

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Technical specifications are subject to review within three years of publication to decide whether they can be transformed into International Standards.

IEC 62578, which is a technical specification, has been prepared by IEC technical committee 22: Power electronic systems and equipment.

The text of this technical specification is based on the following documents:

Enquiry draft	Report on voting
22/145/DTS	22/160/RVC

Full information on the voting for the approval of this technical specification 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 maintenance result 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

- transformed into an International standard,
- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

IMPORTANT – The "colour inside" logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this publication using a colour printer.

INTRODUCTION

This technical specification is necessary because Active Infeed Converters (AIC) are a state of the art technology in power electronic products but which have not been described very well by standardization up to now.

AICs are necessary to feed back some inertia or braking power from a load back to the power supply system

Dispersed power generating equipment is using such AICs to synchronise their voltages and currents to the power supply system.

Therefore the advantage of using AICs in industrial as well as in domestic premises becomes more and more interesting under light of the energy efficiency discussion.

Different possible topologies of AICs are described in this technical specificaton with their specific advantages in order to introduce them and to give an overview for users.

Also utilities are interested in information how the correct application of AICs can additionally help to mitigate harmonics in the power supply system.

POWER ELECTRONICS SYSTEMS AND EQUIPMENT –

Operation conditions and characteristics of active infeed converter applications

1 Scope

This technical specification describes the operation conditions and typical characteristics of Active Infeed Converters (AIC) of all technologies and topologies which can be connected between the electrical power supply system (lines) and a current or voltage stiff d.c.-side and which can convert electrical power (active and reactive) in both directions (generative or regenerative).

Applications with AIC are realized together for example with d.c.-sides of adjustable speed Power Drive Systems (PDS), Uninterruptible Power Systems (UPS), active filters, photovoltaic systems, wind turbine systems, etc., of all voltages and power sizes.

Active Infeed Converters are generally connected between the electrical power supply system (lines) and a current or voltage d.c.-side, with the objective to disburden the system from low frequency harmonics (e.g. less than 1 kHz) by a sinusoidal approach of the lines current. Some of them can additionally control the harmonic distortion of an applied voltage or current.

AIC are able to control the power factor of a power supply system section by moving the electrical power (active and reactive) in both directions (generative or regenerative), which enables energy saving in the system and stabilization of the power supply voltage.

The following is excluded from the scope:

- requirements for the design, development or further functionality of active infeed applications;
- probability of interactions or influences of the AIC with other equipment caused by parasitic elements in an installation as well as their mitigation.

2 Normative references

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

IEC 61800-3, *Adjustable speed electrical power drive systems – Part 3: EMC product standard including specific test methods*

IEC 61800-5-1, *Adjustable speed electrical power drive systems – Part 5-1: Safety requirements -electrical, thermal and energy*

IEC 62040-1, *Uninterruptible power systems (UPS) – Part 1: General and safety requirements for UPS*

IEC 62040-2, *Uninterruptible power systems (UPS) – Part 2: Electromagnetic compatibility (EMC) requirements*

IEC 62103, *Electronic equipment for use in power installations*

3 Terms and definitions

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

3.1
Active Infeed Converter
AIC
self-commutated electronic power converters of all technologies, topologies, voltages and sizes which are connected between the a.c. power supply system (lines) and a stiff d.c.-side (current source or voltage source) and which can convert electric power in both directions (generative or regenerative) and which can control the reactive power or the power factor

Some of them can additionally control the harmonics to reduce the distortion of an applied voltage or current.

Basic topologies may be realized as a Voltage Source Converter (VSC) or a Current Source Converter (CSC).

NOTE In the IEV, these terms (VSC and CSC) are defined as voltage stiff a.c./d.c. converter [551-12-03] and current stiff a.c./d.c. converter [551-12-04]. Most of the AICs are bi-directional converters and have sources on the d.c. side. So, they are known as voltage source converters and current source converters in this technical specification.

3.2
active infeed application
application using the advantages of an Active Infeed Converter

3.3
active filter
AIC operating as a filter to control the specific a.c.-side harmonic and interharmonic voltages or currents usually without a d.c.-side load

3.4
PWM converter
converter generally using a pulse-width modulation technique in order to control the switching of its semiconductor valve devices

3.5
switching frequency
mean value of the frequency with which the semiconductor valve devices of a PWM converter are operated

NOTE In some converters the switching frequency may not be the same for all semiconductor valve devices.

3.6
pulse frequency
frequency, resulting from the switching frequency and the converter topology, which characterizes, together with the selected pulse pattern, the lowest frequency of non-controllable harmonics or interharmonics at the In-plant Point of Coupling (IPC)

NOTE The switching frequency itself may not be present as a harmonic or interharmonic.

3.7
pulse pattern
pattern of the switched voltages or currents, measurable at the terminal of the converter, resulting from pulse frequency and modulation schemes used

3.8
In-plant Point of Coupling
IPC
point on a network inside a system or an installation, electrically nearest to a particular load, at which other loads are, or could be, connected

NOTE The IPC is usually the point for which electromagnetic compatibility is to be considered. In case of connection to the public supply system the IPC is equivalent to the Point of Common Coupling (PCC).

3.9
d.c.-side load
electrical device optionally connected to the d.c.-Side

NOTE The load may either consume or feed electrical energy.

3.10
short-time energy storage device
one or more inductors or capacitors providing rated power for about 1 ms to 10 ms and directly connected to the d.c.-Side

3.11
long-time energy storage device
device connected to the d.c.-link directly or by a semiconductor valve device, providing rated power for typically seconds to minutes

3.12
DC filter
a filter on the DC side of a converter, designed to reduce the ripple in the associated system

[IEV 551-14-18]

3.13
AC filter
a filter on the AC side of a converter, designed to reduce the circulation of harmonic currents in the associated system

[IEV 551-14-19]

3.14
supply impedance
the actual resulting impedance of the power supply system at the IPC

3.15
total impedance
resulting impedance consisting of the supply impedance and the supply-side filter impedance of the AIC

NOTE In the range of controllable harmonics the total impedance can normally be approximated as purely inductive.

3.16
effective supply-side filter impedance
effective impedance of the supply-side filter of the AIC for frequencies in the range of the controllable harmonics or interharmonics

NOTE If no value for this range of frequencies can be given, the value for the fundamental frequency should explicitly be given

3.17
control
purposeful action on or in a process to meet specified objectives

[IEV 351-21-29]

3.18
fundamental component (of a Fourier series)
sinusoidal component of the Fourier series of a periodic quantity having the frequency of the quantity itself

NOTE For practical analysis, an approximation of the periodicity may be necessary.

[IEV 551-20-01]

3.19
harmonic frequency
frequency which is an integer multiple greater than one of the fundamental frequency or of the reference fundamental frequency

[IEV 551-20-05]

3.20
harmonic component
sinusoidal component of a periodic quantity having a harmonic frequency

NOTE For practical analysis, an approximation of the periodicity may be necessary.

[IEV 551-20-07]

3.21
controllable harmonics or interharmonics
set of harmonic or interharmonic components which can be influenced directly by the control strategy of the AIC

3.22
generated harmonics or interharmonics
set of harmonic or interharmonic components which result from the pulse frequency and the pulse pattern

3.23
electric power supply flux (supply flux)
arithmetical flux quantity resulting from integrating the supply voltage

3.24
converter flux
arithmetical flux quantity resulting from integrating the supply-side converter voltage

3.25
controlled freewheeling circuit
a secondary circuit with a controllable valve device, not with a freewheeling diode

3.26
short circuit power
$\mathbf{S_{SC}}$
value of the three-phase short-circuit power calculated from the nominal phase-to-phase system voltage $U_{nominal}$ and the impedance Z of the system at the Point of Common Coupling (PCC)

$$S_{SC} = U^2_{nominal} / Z$$

Where Z is the supply impedance at the power frequency

3.27
rated apparent power of equipment
$\mathbf{S_{equ}}$
value calculated from the rated r.m.s. line current I_{equ} of the piece of equipment stated by the manufacturer and the rated interphase voltage U_i. 1)

$$S_{equ} = \sqrt{3} \times U_i \times I_{equ} \quad 1)$$

3.28
short circuit ratio
R_{SCe} 1)
characteristic value of a piece of equipment derived from the short circuit power S_{SC} divided by the rated apparent power of the equipment (S_{equ})

$$R_{SCe} = S_{SC} / S_{equ} \quad 1)$$

3.29
F3E-infeed (F3E = fundamental frequency front end)
voltage source converter with its commutation capacitor on the a.c. side which uses line-frequency switched semiconductor valve devices and has a regenerative capability.

NOTE The d.c.-link capacitor which is normally a electrolytic capacitor is basically replaced by an a.c. line side filter, designed to limit the voltage distortion caused by the PWM currents of the inverter stage.

3.30
converter topology
converter topology is the family term for different possible arrangements and their connections

3.31
reactive power converter
converter for reactive power compensation that generates or consumes reactive power without the flow of active power except for the power losses in the converter

[IEV 551-12-15]

4 General system characteristics of PWM AIC Connected to the power supply system

In this clause, the voltage source AIC, which is used in large numbers, is chosen as the example.

4.1 Basic topologies and operating principles

4.1.1 General

Active infeed applications are mainly available with capacitive (VSC) and inductive (CSC) smoothing on the d.c. side. Some converter concepts use no or nearly no d.c.-side smoothing. The majority of installed units utilize capacitive smoothing.

Depending on the rated power and the power supply system availability the connection to the power supply system may be single-phase or three-phase. The three-phase version is selected for the examples.

1) for balanced three-phase equipment.