STANDARDS

Another EMC resource
from EMC Standards

EMC design of high-frequency power switchersÂ•and choppers

Helping you solve your EMC problems

9 Bracken View, Brocton, Stafford ST17 0TF T:+44 (0) 1785 660247 E:info@emcstandards.co.uk

EMC design of high-frequency power "switchers" and "choppers"

A brief digression on the latest draft standard for Active Infeed Converters (AICs) – IEC TS 62578 Ed.2

First published in The EMC Journal, Issue 101, May 2012

Keith Armstrong, Cherry Clough Consultants Ltd, www.cherryclough.com

The other article with the same heading in this Issue (No.101) of The EMC Journal introduces itself by describing my attempt – in this series of "Stand Alone" articles – to cover the entire field of switch-mode power converters, so I won't repeat that text here.

I have just read an IEC Technical Specification (TS) which will probably be a full international standard one day, and which is very relevant to the subject matter of this series:

> IEC/TS 62578/Ed.2/CD, entitled: "Power electronics systems and equipment – Service Conditions and Characteristics of Active Infeed Converter Applications including recommendations for Emission limits below 150kHz".

The acronym CD shows that it is a Committee Draft, and it was recently circulated amongst the British National Committee on EMC as BSI document GEL/210/12_12_0093. Unfortunately, by the time this Journal is posted the last date for submitting comments on it (27 July 2012) will have passed.

IEC/TS 62578 covers what are officially called "Active Infeed Converters" (AICs), which are switch-mode power converters that are connected between the AC electrical power supply system ("the mains") and the DC-Link in a power converter – replacing the AC rectifier in an ordinary AC-DC converter or AC-AC inverter. Figure 1 shows an example of block diagram for the semiconductor chopper used in one of the several types of AIC.

Figure 1 shows a single-phase AIC's chopper without any filters, feedback, or other circuits required for it to function correctly. A three-phase AIC chopper only needs to add another IGBT totem-pole to the two shown.

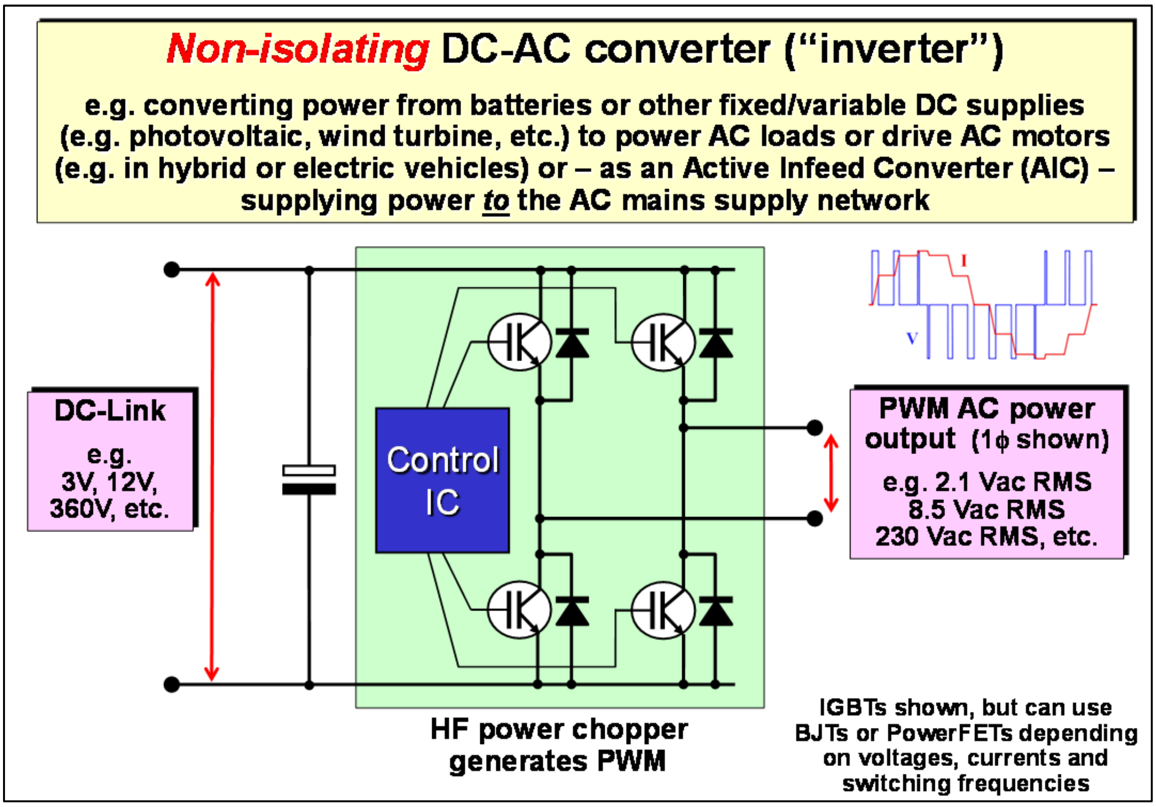

Figure 1 "Chopper" block diagram for a voltage source type of AIC

Unlike an ordinary mains rectifier, AICs can transfer electrical power (both active and reactive) in both directions – from AC mains to DC-Link, or from DC-Link to AC mains – and the direction can be controlled millisecond-by-millisecond.

They are commonly used with the DC-Links of variable-speed power drive systems, to absorb the inertial energy of the rotating motor and its load in the AC mains supply during regenerative braking. This is generally regarded as being better than wasting the energy as heat in a braking resistor, helping to save the planet by reducing the CO_2 emissions from burning fossil fuels to make electricity, and at the same time reducing energy bills (but only when a suitable electricity meter, that measures energy put back into the supply, is installed).

AICs are also used in photovoltaic, wind, and all other types of 'green energy' electricity generation schemes, at all voltages and power sizes, so that their excess energy (beyond what is consumed by their locally connected loads) can be sent to the AC mains supply to earn money for their owners.

They are also used in uninterruptible power systems (UPS), motor drive systems, and active filters, to help control low-frequency AC mains harmonics. They do this by synthesizing a sinusoidal AC current. Some of them can additionally compensate the pre-existing harmonic distortion of a given supply side voltage.

AICs can also be used 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 stabilizes the power supply voltage or enables coupling of renewable energy sources or electrical energy storage devices to the supply.

The use of AICs in "green energy generation" is a very rapidly growing industrial sector, with a significant future impact on the performance, power quality and stability of national electricity power supply networks (often called national electricity grids).

Their use is also important for the operation of Smart Grids – the generic name chosen for national electricity power supply distribution networks with embedded computer-based control that continually balances the mix of electricity generators and their loads to optimise overall efficiency (and hence meet national targets for reducing CO_2 emissions and help save the planet) and also maintain power quality and stability (hence maintain or improve the availability of supply, its "uptime").

Given the rapid increase in, and very large future numbers of AICs, and their national and international importance, it is of course necessary to have standards for their operation and EMC.

IEC/TS 62578 describes the operation conditions and typical characteristics of all types of AICs. It also provides a practical and analytical approach for emission limits for AICs in power supply systems, based on the latest results for line impedance values between 2 kHz and 9 kHz and on the withstand capability of capacitors connected directly to the supply. This approach also results in recommendations for emission limits below 150 kHz.

Copies can be obtained from the UK's National Committee (GEL/210/12), by a Trade Association with members who represent them on that committee, which includes: EMCTLA, EMCIA, IABM, PLASA, AMDEA, IET, BEAMA-TACMA, LIF, LA, RSGB, ACE, UK Weighing Federation, GAMBICA, ENA and Intellect.

If you are not based in the UK, you will need to obtain copies from Trade Association representatives that attend your equivalent National Committee (the National Committee will know their names).

Some large manufacturers and government agencies have representatives on the appropriate committees, and if you work for those organisations you can obtain copies from your appropriate colleagues.

Although by the time you read this it will be too late to submit comments on this CD to your National Committee, there will be many future opportunities to do so.

Here are some of the especially interesting sections of IEC/TS 62578/Ed.2/CD in the context of these articles:

- 4.1 Basic topologies and operating principles
- 4.2.1 Converter rating under sinusoidal conditions
- 4.2.2 Converter rating in case of harmonic currents
- 4.2.3 Converter rating under dynamic conditions
- 5.1.3 Power supply system impedances in the range between 2 kHz to 20 kHz

  The values of the power supply system impedances in the range of the pulse frequency of an AIC and its harmonics might have significant influence on the conducted emissions of an electric or electronic device. With increasing impedance values, the voltage disturbance level increases approximately in proportion.

  The power supply system impedances at the IPC (the point of connection to the MV or HV grid network) in various industrial and public supply systems in Central Europe have been examined in a dedicated research project, and conclusions drawn on the values to be used when simulating or testing an AIC to determine its harmonics and conducted emissions.

5.1.4 Proposal of an appropriate line impedance stabilisation network (LISN)

In order to predict system perturbations by means of simulations, analytical models of power system impedance are necessary. In this clause a model that can be used for simulation is shown.

5.1.5 Recommendations for setting emission limits in the range of 2 kHz to 9 kHz

5.1.5.1 Immunity of power capacitors which are connected to the power supply system and recommendation for the compatibility level in the frequency range 2-9 kHz

5.1.6 Justification of reasonable AIC emission levels below 150 kHz

5.1.7 Effects on industrial equipment in the frequency band 2 kHz – 9 kHz

5.2 High-frequency phenomena (> 150 kHz)

5.4 Leakage currents

5.5 Aspects of system integration and dedicated tests

6 Characteristics of a PWM Active Infeed Converter of Voltage Source Type and Two Level Topology

7 Characteristics of a PWM Active Infeed Converter of Voltage Source Type and Three Level Topology

8 Characteristics of a PWM Active Infeed Converter of Voltage Source Type and Multi Level Topology

9 Characteristics of a F3E AIC of the Voltage Source Type

An F3E AIC consists of a standard diode bridge with antiparallel connected IGBTs. If the current flows in the direction of the load (e.g. a PWM motor inverter) it goes through the diodes. If the current flow is in the direction of the power supply system it goes through the IGBTs.

10 Characteristics of an AIC of Voltage Source Type in Pulse Chopper Topology

11 Characteristics of a two level PWM AIC of current source type