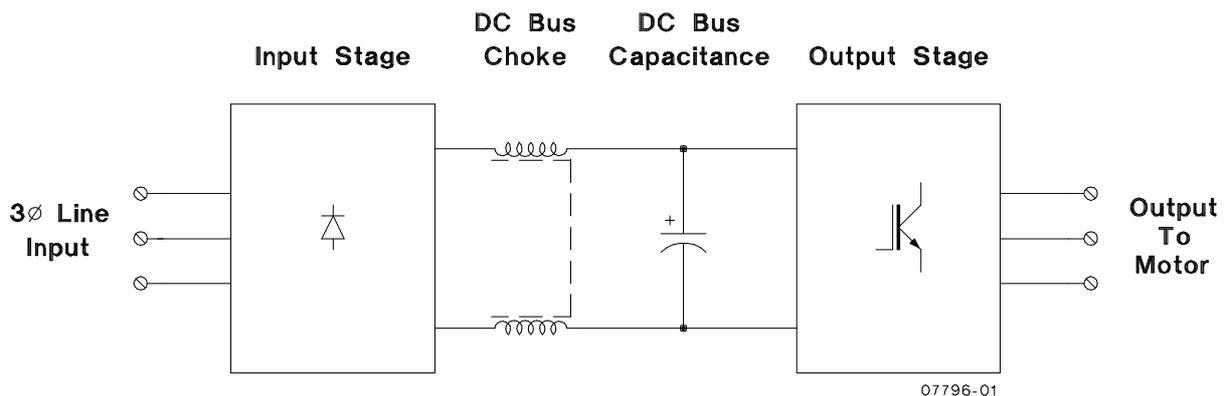


## Topic: Effectiveness of a DC Bus Choke

### Introduction

In Australia the limitations for disturbances in mains supply networks caused by industrial equipment, in terms of harmonics and voltage fluctuations, is specified by conformance with Australian Standard AS 2279, which is similar to the European VDE Specification 0160.

The foreword of AS 2279 states; "Electrical equipment should not be permitted to affect adversely the supply network characteristics, the supply voltage, or the performance of any other equipment connected to the supply network to which it may be connected. Provision must therefore, be made to limit such disturbing effects to achieve electromagnetic compatibility (EMC) between this equipment and other electrical equipment".



**Figure 1:** VSC 2000 power train block diagram showing the DC bus split-choke located between the rectifier and DC bus capacitor

### The DC Bus Choke

The DC bus choke is a solution that Zener has adopted to address the need to control harmonics and other forms of unwanted electromagnetic noise that can effect variable speed drives. The DC choke has been made a standard feature of the VSC 2000 motor speed controller. The DC choke (or inductor) is included in the input circuit of the DC bus between the rectifier and the DC bus capacitor as shown in Figure 1. A substantial choke is fitted here mainly to provide improved inverter performance on the input supply side (as per Australian Standard AS 2279 'Harmonic disturbance' type requirements) however, other benefits follow by using such a substantial choke.

The choke reduces the peak input currents significantly when compared with a capacitor only DC bus design. This reduces the harmonic currents injected into the electrical supply as well as providing a very effective supply transient filter for the inverter.

The reduction in peak current and current ripple in the input filter reduces stress on, and significantly enhances the life expectancy of the main power capacitors and input rectifier.

## Choke Design

The choke used in the VSC 2000 is actually manufactured as two coils on a common magnetic core, and is referred to as a split-choke flat conductor design. Built-in split-choke DC bus filtering offers a most cost effective and convenient method of addressing the mains harmonics disturbance standards for variable speed drives. Flat conductors provide a convenient means to make a compact choke with a good current rating.

The innovative design of the split choke exploits the fact that the magnetic coupling between the two coils is less than 100% so that the same choke has a significant common mode impedance at radio frequencies. The resulting common mode impedance significantly reduces Radio Frequency Interference (RFI) and Electromagnetic Emissions (EMI). The size of the choke inductance in millihenries is chosen to optimize reduction of these effects and to meet the harmonic performance needed at the site of application.

## Reduction of Harmonic Distortion<sup>1</sup>

The tolerance of a point of electrical supply to the harmonics created by an AC drive due to the drive input circuitry is dependent upon the characteristics of the supply system: the supply rating (usually in kVA or MVA), "Fault Level" and source impedance  $Z_s$ , and the level of existing harmonics at the point of common coupling (PCC). The 5th harmonic is the most significant for AC drives.

Two options available to reduce the harmonic contribution of a drive are to use *AC-side* chokes on the AC supply side of the drive input, or to use a substantial *DC-side* choke as in Zener Electric drives such as the VSC 2000.

For AC-side chokes, estimation of size required is made from the supply reactance which can be calculated from the fault level. For DC-side chokes it has been determined that a DC-side choke should have a minimum inductance of about <sup>2</sup>

$$L_{dc} = 40/(\text{motor rating in kW}) \text{ mH.}$$

Increasing the inductance much above this value does little to decrease the supply harmonics. Halving the above inductance may increase the 5th harmonic by 50%. The VSC 2000 is designed with a DC choke that exceeds the above design rule.

## Conclusion

Employing a DC bus choke in the design of a variable speed drive provides a highly effective means of reducing electrical disturbance associated with the effect of a variable speed drive's input circuitry on the supply. It allows for greater flexibility in the locations that the drive can be installed with confidence of trouble free operation on the available electrical supply.

Benefits gained with a substantial DC bus choke are,

- reduction of the drive's contribution to harmonic distortion making the drive more acceptable for a wide range of installation locations where the supply may be less than ideal because of its rating and or level of existing harmonics

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<sup>1</sup> Reference: GJ Sanders, 'Supply Harmonics caused by AC Variable Frequency Drives' Motor and drive technical note - number 1, Pacific Power Center for Energy Efficiency

<sup>2</sup> Kelly and Yadusky, IEEE Transactions on Power Electronics, Vol 7, No 2, April 1992, p332 in op. cit.

- Improvement in immunity of the drive to transient effects from the electricity supply
- reduction in stresses on input components in the drive that leads to greater life expectancy of significant components such as the rectifier and DC bus capacitors
- split bus choke design provides greater effectiveness in suppressing RFI and EMI
- Improved power factor (typically 0.95) when a substantial DC choke is used
- currents in each phase are more symmetrical for phase voltage imbalance conditions
- lower losses are achieved by reducing peak currents
- a built-in DC bus choke which makes for easier installation of a drive that is likely to comply with requirements for harmonic disturbance.