Pumping/VSD Installations – What do you do about RCCB Protection?

To safely install pumping equipment containing VSDs and EMC filters connected to a circuit covered by the Wiring Regs (BS7671) requires a detailed understanding of the operational leakage currents and residual currents associated with the EMC filter / VSD / Motor combination including the local environmental conditions, pump availability and earthing facilities.

Applications such as remote pumping stations associated with clean and dirty water installations can be subjected to wide temperature changes, direct sunlight during the day and frost at night which create conditions for condensation on de-energised electrical equipment. Power electronic based converter systems (PECS[1)] including VSDs can be susceptible to the effects of condensation, moisture contamination of the associated PCBs for poorly designed installations. A build-up of dust on insulated surfaces, which are subjected to condensation or moist damp conditions, can create an additional fire hazard. Under these conditions relatively low levels of leakage current[2] - less than 80mA travelling across an insulated surface can ignite combustible material and fluids containing simple contaminates such as detergents. Scintillations forming on the insulation surface create conductive tracks which result in a cascade effect and increased leakage current and resultant fire hazard.

If the electrical specification for the installation does not cover the detection of safe levels of earth leakage current there is an increased risk of an electrical fire, especially if equipment is mounted out of sight and or subject to infrequent maintenance. Where conventional protective bonding cannot be relied on to achieve the required level of electrical safety, and RCD protection is required under the regulations, only Type B RCDs can be used with 3 phase VSDs: see GAMBICA Installation Guide 4th Edition[3] - Page28. 4.2.3.

BS7671 Compatibility of Electrical Equipment

Installing equipment containing 3 phase VSD and EMC filters (**see Fig 1**.) requires a detailed assessment of the leakage current associated with the equipment to ensure the installation is designed to and conforms to the minimum safety requirements detailed in BS7671. Regulation: 331.1 deals with the requirement to make an assessment of any characteristics of the equipment that impact on the safety of the installation – referred to as "*harmful effects*". This includes amongst other safety issues; earth leakage currents, high protective conductor current present under normal operation, d.c. feedback and high-frequency oscillations, which are particularly pertinent to the design of an installations containing VSD's. The optimum word her is design – leaving it until the equipment is on site can result in expensive re-design and remedial work with unforeseen costs which can be substantial.

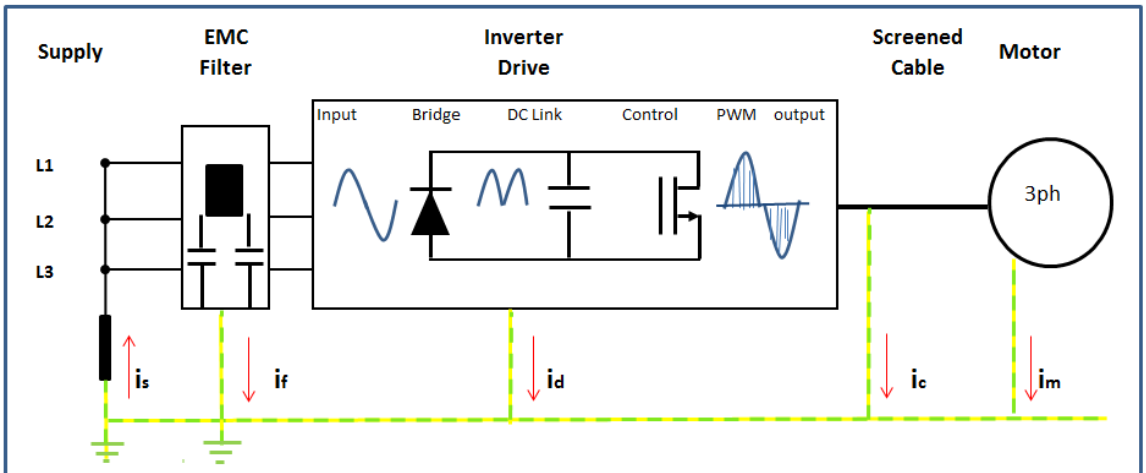

Fig. 1 Simplified diagram - leakage currents associated with VSD installation

Operational Leakage currents and residual currents associated with VSD installations

Drive installations produce operational leakage currents across a wide frequency spectrum **see Fig 2**: In this particular example, the installation had to be designed for use with 30mA RCDs to achieve the required level of protection at 50Hz. Under normal operating conditions the leakage currents flowing in the protective conductor should not cause unnecessary operation of the RCD. By comparing the operational characteristics of the drive installation against the RCD characteristic, it can be seen that the DFS4 B NK 30mA will offer 30mA protection at 50Hz (most dangerous frequency for human heart) but also restrict leakage currents above 1kHz up to 100kHz to 300mA reducing the risk of electrocution and or fire from high frequency currents (maximum of 300mA level allowed under Regulation 532.1).

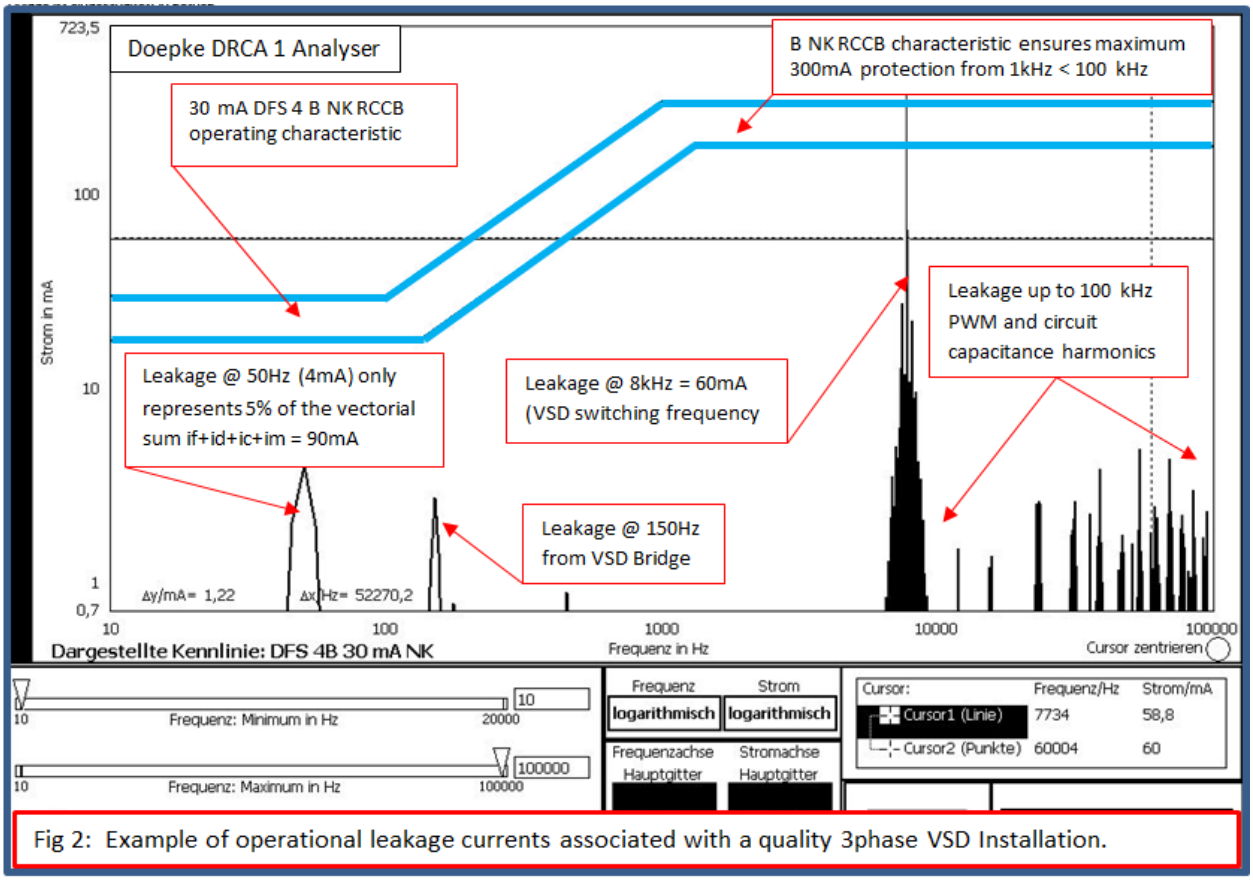

Fig 2: Example of operational leakage currents associated with a quality 3phase VSD Installation.

Fixed Leakage Current: The EMC filter - internal or external to the VSD produces a fixed leakage current to earth, with frequency components between 100Hz to 1kHz plus leakage currents in the resonant frequency range of the filter. Low cost filters can create high levels of leakage current that may not be compatible with the safety requirements of the installation. Low leakage current EMC filters are available for installations covered by Regulation 532. Purchasing filters without sufficient supporting technical data is likely to lead to safety problems when commissioning, with the possibility of not being able complete the installation sign-off.

Variable Leakage Currents: Varying the speed of the motor via the inverter will produce additional leakage current components > 1kHz: This is a function of the inverter switching frequency commonly 2, 4, 8 and 16kHz including the associated harmonic components and the leakage current component, due to screened cable which is connected to earth and therefore acts as a capacitor discharging at the associated frequency. If the switching frequency of the inverter is in the resonant frequency range of the external EMC filter (poor design specification), extremely high leakage currents can flow. Changing the switching frequency of the inverter may still produce a

multiple of the filter resonant frequency; consequently in the event of changing the motor speed the problem will still be present. From this it can be seen that the resultant leakage current seen by the RCD will be complex; vectorial sum of the capacitive, inductive and resistive elements of the leakage currents plus the various frequency components. The equipment manufacture has to provide sufficient information to enable safe installation under existing UK law. This information must be included in the design information to validate the design safety requirements for the equipment and installation.

Transient Leakage Currents: These occur during switch-on / switch-off and as result can cause the RCD to trip if the transients exceed the defined tripping characteristics of the selected RCD. Using switching devices with slow break contacts can substantially increase the risk of tripping and should be avoided - use switch disconnects with snap action contacts or contactors to connect the main supply to the drive installation. Type B RCCBs have a higher resistance to inrush residual currants with a maximum duration of 10ms.

RCD protection to meet existing Regulations

When there is a requirement to include RCD protection under the existing regulations due to the safety requirements of the installation, the standard BS EN 62477-1:2012 "Safety requirements for power electronic converter systems and equipment" for manufactures, recommends the use of Type B RCDs for 3 phase VSDs which produce smooth DC fault currents, this recommendation is also repeated in the Gambica Installation Guide. Doepke offer a free 64 page Technical Application Guide[4] covering the selection of RCDs for use with 3 phase VSD installations and measures for reducing associated leakage currents, to enable the design and specification of safe installations in-line with existing standards and regulations.

1: BSEN 62477-1:2012 "Covers safety aspects of PECS which may not be covered in the appropriate product standard"

2: Doepke Video: How RCDs prevent fire – access via Web site or You Tube

3: GAMBICA_Installation_Guide_Power_Drive_Systems Fourth Edition: 2012

4: www.doepke.co.uk/rcd/rcdR.html

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