

Operating

Protecting an inaccessible motor

For many applications, VSD motors are set far away from the pumps they run, which can cause bearing damage and motor failure. Steve Hughes, managing director of REO, explains how new filter technology can protect these hidden motors.

For flexibility and process optimisation, many modern motors are controlled using Variable Speed Drives (VSDs). These use a frequency inverter employing fast Pulse Width Modulated (PWM) switching, using IGBTs, of the drives internal DC link voltage to produce the motor drive frequency necessary for speed control. This switching, typically at frequencies between 2 to 20 kHz, means that a typical VSD produces a considerable amount of common-mode (asymmetrical) and differential mode (symmetrical) radio frequency interference (rfi), which adversely affects the Electro-Magnetic Compatibility (EMC) of the drive and the product into which it is incorporated.

In addition to this issue, the high frequency change of voltage causes fast rise time (dV/dt) voltage peaks and high frequency ringing in the motor cables. This is exacerbated by industry's move

towards higher switching frequencies, higher performance and smaller semiconductor package sizes.

Motor cable length, cross sectional area, construction, drive switching frequency and motor power all influence these peaks with longer cable lengths tending to increase their amplitude. These peaks and their subsequent ringing and magnification appearing at the motor terminals can have a direct negative impact on motor insulation, motor bearings, drive performance and system longevity. Other unacceptable phenomena such as power losses, high acoustic noise levels and parasitic earth currents, may also be experienced.

Reducing differential noise

Traditional passive mitigation methods, such as conventional sinusoidal filter or motor chokes (low pass filters), work

very well to reduce the differential noise appearing between phases. For example, a standard REO Sinus filter will typically improve the phase-to-phase current to something approaching a sinewave with a ripple content of less than 5% (Figure 1). However, the filters do not significantly reduce the high frequency noise appearing between motor cables and the earth conductor.

Typically, bearing damage occurs when this high frequency noise interacts with the inherent capacitance of the motor. Stator-to-rotor capacitance allows charging and discharging of the shaft via an unwanted dielectric effect in the bearings. This generates unwanted currents through the bearings, often with peaks high enough to cause electro-erosion of the bearings and the characteristic 'fluting,' which eventually leads to motor system failure (Figure 2).

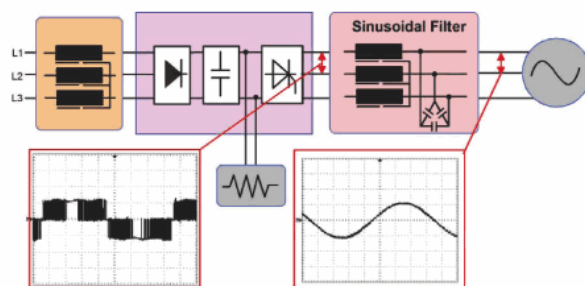


Figure 1: Conventional sinusoidal filter circuit.

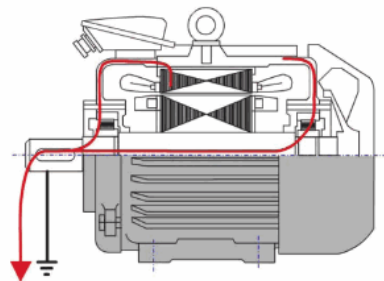


Figure 2: Diagram showing the earth paths for high-frequency current passing through the motor bearings to the drive-shaft.

Conventional mitigation techniques and considerations for this problem could be insulated or coated bearings, motor shaft grounding or even reduced motor drive voltages, but often these measures are not easily retro-fitted, do not provide adequate protection at higher frequencies or cannot be considered for economical reasons.

Eliminating bearing damage

There is a solution to this problem which involves the combined use of a conventional differential mode and a common-mode output filter made by REO Inductive Components. This filter eliminates damage to bearings caused by heat and pitting resulting from circulating, pulsing currents. The REO Sinus Plus++ filter provides a means of allowing the common-mode interference to flow back to the DC link instead of through capacitive coupling to earth via the drive shaft. This easy-to-install retrofit solution is particularly suitable for protecting motors that are used in critical processes or where motor replacement is prohibitively expensive.

Other benefits of the retro-fit include:

- Unlimited cable lengths between the frequency inverter and motor can be used
- Higher switching frequencies > 8 kHz can be used
- Audible noise is reduced
- Reduced cable and eddy current losses so a smaller drive may be employed (cost saving)
- Additional filtering on the main supply side is not required if the inverter has an integrated filter
- Radiated interference from cables is reduced to a minimum
- Unshielded motor cable can be used (cost saving)
- Hazardous voltages and leakage currents are prevented

It can be seen from Figure 3 that the filter is connected back to the DC link and so provides a low impedance path to source for parasitic currents.

As demonstrated in Figure 4, the conventional sinusoidal filter does not remove the common mode disturbance, but the Sinus Filter Plus ++ does. It also reduces the RFI on the input side. The

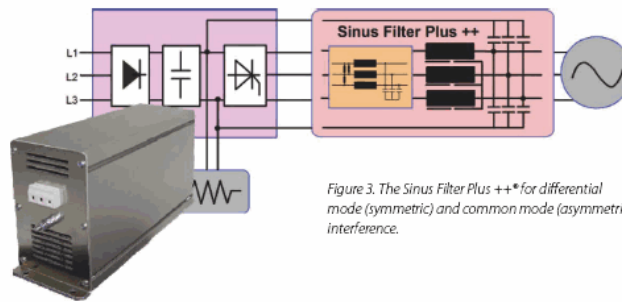


Figure 3. The Sinus Filter Plus ++ for differential mode (symmetric) and common mode (asymmetric) interference.

trace shown in Figure 5 shows conducted emissions of a test system with a Sinus Filter Plus ++ connected. This system failed the test without the filter connected.

Typical applications

One typical application for the Sinus Filter Plus ++ is for protecting the bearings of an underground pump motor used in a combined geothermal/solar panel heating system.

The cable run from the frequency inverter to the pump is often very long and the water column provides a low impedance path back to ground. This encourages current pulsing through the motor bearings and consequently increases the risk of

bearing electro-erosion. To replace or repair the pump would be a costly and onerous operation.

A REO Sinus Filter Plus ++ is connected to the output terminals of the frequency inverter to reduce the common-mode disturbances that would otherwise cause premature bearing failure.

The general EMC of the equipment is also greatly improved. As these types of system are gaining popularity in domestic environs, this is a major advantage.

Bearing failure isn't the only problem that can be solved by applying the Sinus Filter Plus ++. The diagram below shows a water abstraction bore hole. These are often situated in remote locations, perhaps in the middle of a forest. Typically the VSD is

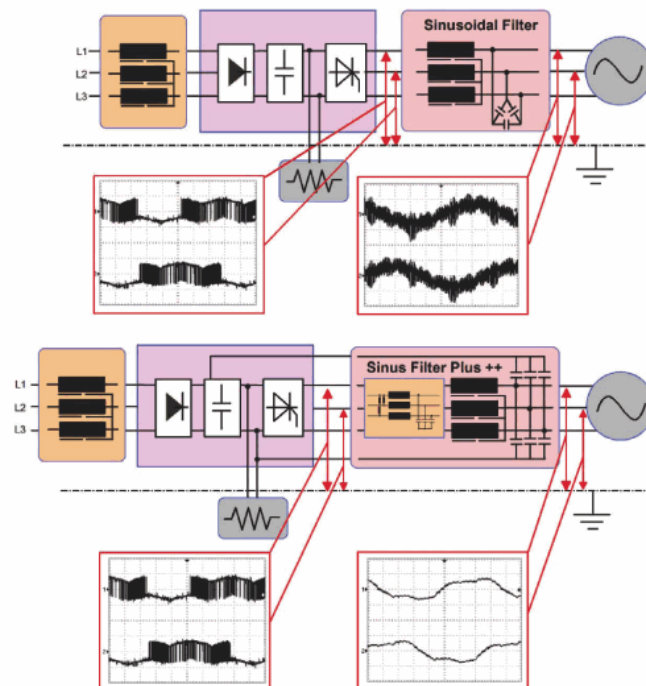


Figure 4. Voltage traces taken between U - PE and V - PE.

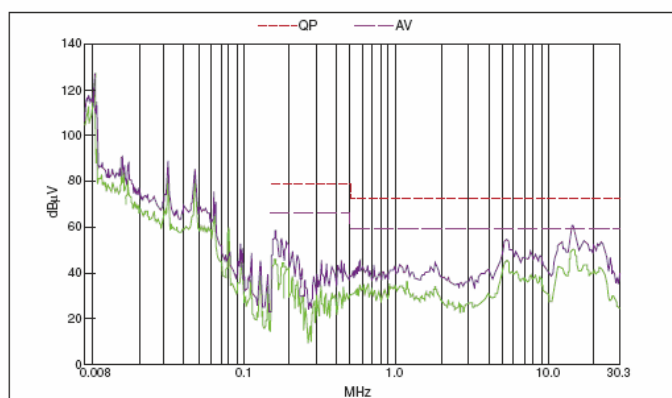


Figure 5. Trace with Sinus Filter Plus ++ connected.

located in a drive kiosk and connected to the pump motor via a termination at the pump head works. The illustration shows the flow pipe lined with a non-conductive, food safe coating.

The high frequency nature of the noise and distance between system elements makes equi-potential bonding and elimination of unwanted currents difficult.

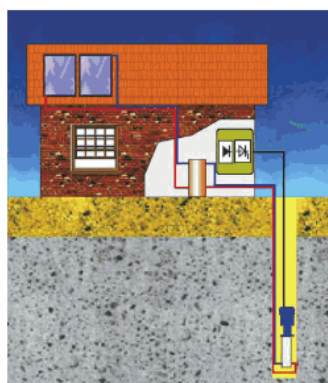


Figure 6. The Sinus Filter Plus ++* can protect the bearings of an underground pump motor.

So, in normal use it can be determined that there may be a significant current flowing back to the drive through the low impedance path provided by the pumped fluid via parasitic capacitances in the drive system. Of course if the pipe were unlined and conductive then the unwanted current would flow to earth via its close proximity to the soil.

A normal condition for an abstraction license is for an accurate record to be maintained of the water pumped out of the bore hole and non-invasive flowmeters are often used in applications involving the extraction of potable water. These types of flowmeters typically operate on Faraday's law of electromagnetic induction, which states that a voltage will be induced when a conductor moves through a magnetic field, the liquid serves as the conductor; the magnetic field is created by energised coils outside of the flow tube. The voltage subsequently induced is directly proportional to the velocity of the water and as the diameter of the pipe is known the flow rate can be

deduced and an accurate reading taken. Understandably, stray currents flowing either through the pumped liquid or meter itself can cause spurious readings and it is essential that they are eliminated.

In normal instances it is understood that the use of grounding rings and appropriate connection to a system ground provide a shunt path for unwanted currents around the meter. However, because of the high frequency nature of the noise they may not always provide the complete answer. A more efficient solution is REO's new Sinus Filter Plus ++* filter. Designed to provide a low impedance path for the noise back to the drives DC link, current flowing in the pumped fluid is reduced whilst the high frequency component is virtually eliminated, ensuring that meter readings would be more reliable and that bearing erosion would not occur.

Another application where the Sinus Filter Plus ++* would be beneficial is where there are several motors connected in parallel to a single frequency drive, as in the case of a process employing several dosing or transfer pumps driven from one inverter. In this example both the cumulative cable length is long and the increased equivalent capacitance of the cabling (especially if it is screened to reduce EMC radiated emissions) mean that the issues described above could be magnified. Use of the Sinus Filter Plus ++* not only solves this problem but actually negates the requirement to use costly screened cable.

As use of VSDs becomes more common place in pump applications, for example where reduced water tables mean that variable speed is useful to mitigate against problems caused by silt, as an energy saving measure, or, as seen above, to regulate the pumping to ensure compliance to extraction quotas, problems concerning their application will become more prevalent.

At the moment REO manufactures the Sinus Filter Plus ++* to 60 Amps per phase but there are plans to increase this range in response to demand from the industry. ■

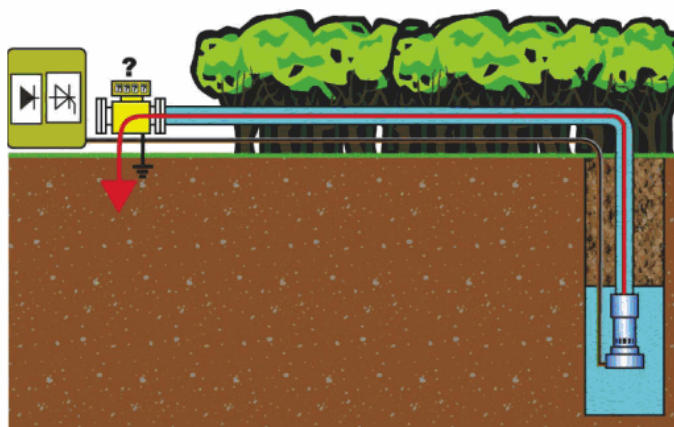


Figure 7. This diagram shows the flow pipe lined with a non-conductive, food safe coating.

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