Bearing currents in modern drive systems

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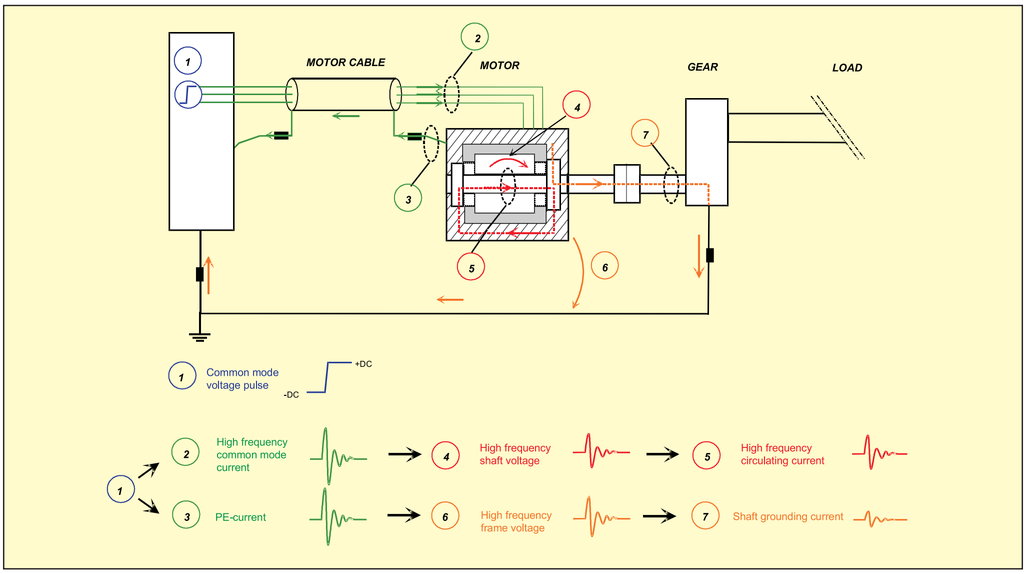
What are bearing currents and why are they a problem?

Some new drive installations can have their motor bearings failing only a few months after start-up. This can be due to bearing currents induced in the motor shaft and discharged over the bearings.

Modern motor design and manufacturing practices have nearly eliminated bearing failures under normal circumstances, but the rapid switching in modern drive systems generate high frequency currents that can damage bearings.

When these currents find the path to earth over the bearings, metal transfer between the ball and races occurs. This is known as electric discharge machining or EDM.



The rapid switching in modern drive systems can damage bearings unless adequate earthing is provided

What is the source of bearing currents?

Bearing currents are due to the existence of a common mode voltage in the drive system. A typical three-phase sinusoidal power supply is balanced and symmetrical under normal conditions. Normally, the neutral is therefore at zero volts. But with the PWM switched three-phase power supply, perfect balance between phases cannot be achieved instantaneously. This creates a potential between the inverter output and earth which will force currents through stray impedances in the motor cables and motor windings. This is known as common mode current.

How are high frequency bearing currents generated?

- In large motors, above 100kW (frame sizes IEC 315 and up), high frequency bearing currents are induced in the motor shaft due to asymmetrical flux distribution in the motor. Voltage pulses fed by the inverter contain such high frequencies, that the leakage capacitances of the motor winding provide paths for currents to leak to earth. This induces a voltage between the shaft ends. If the induced voltage is high enough to overcome the impedance of the oil film of the bearings, a circulating type of high frequency bearing current occurs.
- When leakage current returns to the inverter via the earthing circuit, it tends to seek the paths with the lowest impedance. If the motor shaft is earthed via the driven

Stray currents in the bearings are causing an increasing number of bearing failures in modern drive systems. ABB has commissioned research in its own laboratories as well as in conjunction with Tampere University of Technology in Finland on how to prevent these problems.

As a world leading manufacturer of AC motors and frequency converters, ABB can offer the most appropriate solution in each case as well as detailed instructions on proper earthing and cabling practices.

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TECHNICAL NOTES

machine, a part of the leakage current can flow through the bearings, shaft and driven machinery back to the inverter. This type of bearing current is referred to as shaft earthing current and is caused by poor stator grounding.

- In small motors, less than 30kW, due to the relative sizes of internal stray capacitances, the internal division of the common mode voltage may be such that it causes shaft voltages high enough to create high frequency bearing current pulses. This can happen in installations where the shaft is not earthed via the driven machinery.

Spotting bearing damage

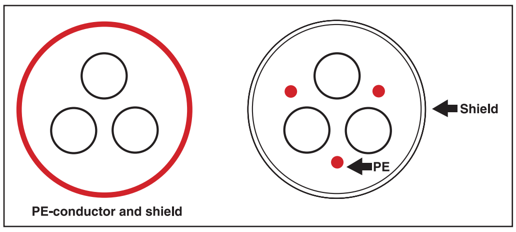
The time it takes for bearing damage to occur varies with the drive set-up, but is typically detected after a few months of use. Sectional drives are more prone to bearing current damage than stand-alone ones, as several parallel inverter-motor circuits result in a lower impedance for the common mode current.

Bearing damage can be detected by a loud running noise, or by using continuous vibration monitoring. The damaged bearing should be replaced before its total destruction causes loss of production. Current damage can be verified if the rolling tracks of the bearing are fluted or frosted, and the rolling elements have a grey, dull finish.

How can damage be prevented?

There are three approaches used to affect the high frequency bearing currents: **a proper cabling and earthing system; breaking the bearing current loops;** and **damping the high frequency common mode current.**

Use symmetrical multicore motor cables. The protective earth (PE) conductor must be symmetrical to avoid bearing currents at fundamental frequency. The symmetry is achieved by a conductor surrounding all the phase leads or a cable that contains symmetrical three phase leads and three earth conductors.



Use only symmetrical motor cables, either with a conductor surrounding all the phase leads or a symmetrical arrangement of three phase leads and three earth conductors

Define a short, low impedance path for common mode current to return to the inverter. The best and easiest way to do this is to use shielded motor cables. The shield must be continuous and of good conducting material, i.e. copper or aluminium and the connections at both ends need to be made with 360° termination.

Add high frequency bonding connections between the installation and known earth reference points to equalise the potential of affected items, using braided straps of copper 50 -100mm wide; flat conductors will provide a lower inductance path than round wires.

Break the bearing current loop by insulating the non-drive end bearing, by insulating the shaft from the frame, or by using an insulated coupling between the motor and the driven machinery.

Dampen the high frequency common mode current by using dedicated filters, which add impedance in the common mode loop.

Finally, in many inverters the carrier frequency can be adjusted between 1 kHz and 10 kHz. In cases where bearing damage has occurred, some short term relief can be achieved by reducing the carrier to the 1-3 kHz range.

If bearing currents are suspected after commissioning, measurements can be made on the running machine. Instructions and measuring services are available from ABB Motors Oy or ABB Industry Oy on request.

For further information, see: Technical Guide No 5/Drives; or Grounding and cabling of the drive system, 3AFY 61201998 R0125; or The Motor Guide GB 98-12.

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