Bearing Currents

Introduction

This application note is designed to instruct the reader about bearing currents. Bearing currents wear down the inner and outer races of the bearing and cause them to fail. This application note will briefly cover some of the main causes of bearing currents and how bearing currents can be prevented.

What are Bearing Currents?

Bearing currents occur when there is an induced voltage on the motor shaft that is high enough to over-come the breakdown voltage on the bearing lubricant. This is typically greater than 50V. These shaft voltages will either:

1.) Cause current to flow directly from the shaft, through a bearing, then through the motor or load frame and then into ground as shown in Fig. 1 (a).

2.) Cause current to circulate from one side of the shaft, through a bearing, through the motor frame, back into the opposite bearing, and then back into the shaft as shown in Fig. 1 (b).

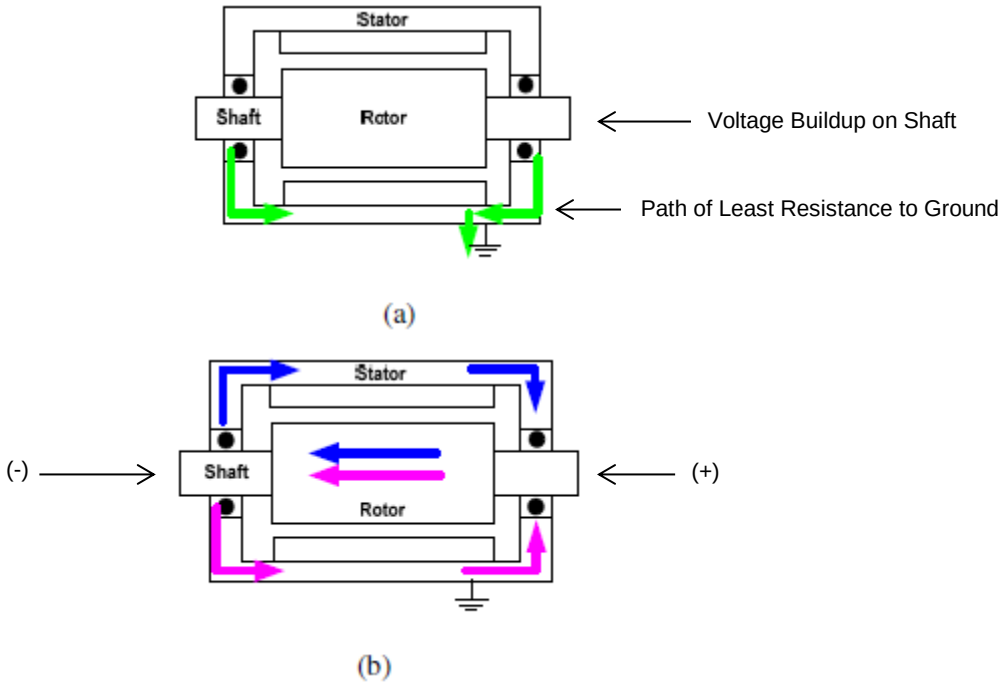

Figure 1. (a) Current Flow from Shaft to Ground(b) Circulating Current Flow in Motor [1]

Either type of current results in “fluting” in the bearing race and therefore the bearing rotation is no longer smooth. This can be seen in Fig. 2.

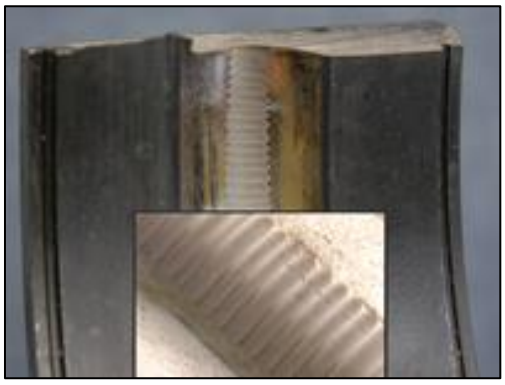

Figure 2. Fluting in Bearing Race Caused by Bearing Currents [2]

How do Bearing Currents Happen?

Voltage in the shaft is induced by the magnetic fields that are generated by current flowing through the motor windings. For motors connected across the utility line (i.e. not connected to a drive), these magnetic fields are ideally balanced and yield a net voltage of zero with respect to earth on the rotor and shaft. This is because the stator windings are ideally symmetrical. When motors have asymmetry within the windings, this can lead to a net voltage different than zero which can cause bearing currents.

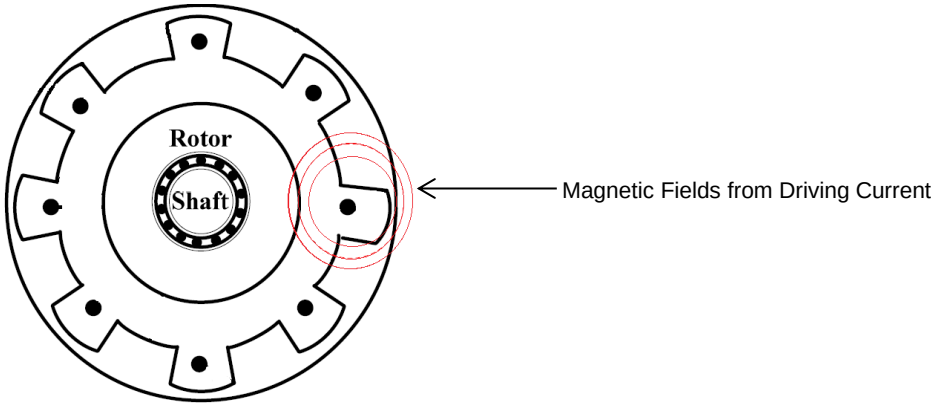

Figure 3. Magnetic Fields from Driving Current [1]

Drives can also cause imbalances in the supply voltage by nature of pulse width modulation (PWM). Motors supplied by PWM are instantaneously unbalanced because the motor is being supplied by pulses. This can result in a neutral point that is not equal to zero (i.e. a DC-offset). The new neutral voltage is proportional to the common-mode voltage, or DC link voltage, of the drive. An example of this common-mode voltage can be seen in Fig. 4.

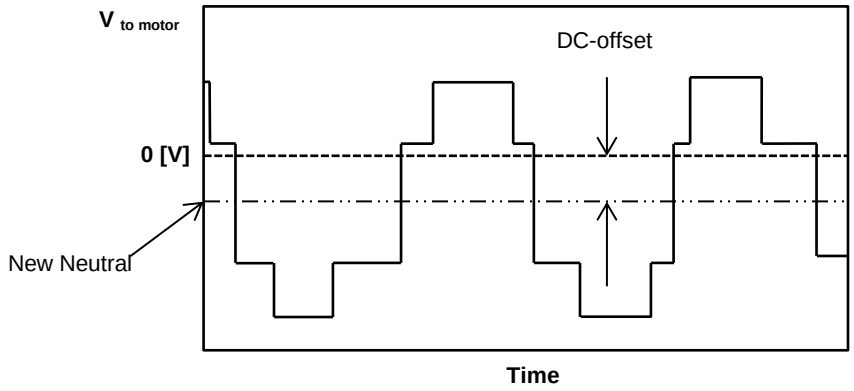

Figure 4. Three Phase Voltage Source Inverter Driving Voltage with Common Mode Other than 0 [V]

This new neutral voltage has a frequency equal to the switching frequency of the inverter and can yield high-frequency currents in the bearing that are limited in amplitude and duration. Motors and drives with proper low impedance grounding rarely exhibit bearing currents. Often times, bearing currents will occur because of unique conditions at an instillation.

How to Prevent Bearing Currents

There are many methods of preventing bearing currents and, based on the cause, some are better options than others:

1.) Use shielded motor cables that have symmetrical “protective earth” wires. This will provide a low impedance path for currents caused by the high frequency common mode voltages to return to the drive.

2.) Another option is to utilize specially insulated bearings on the opposite drive end or insulated load coupling to stop the flow of current through them.

3.) Shaft grounding brushes can be used to dissipate voltage buildup along the shaft. This is a better option for low HP motors.

4.) Fine stranded grounding cables can be used on both the motor and the drive in order to more effectively ground high frequency currents.

5.) Finally, filtering can be applied to the motor side of the drive so as to remove these high frequency currents. There is not a universal filter to remedy bearing currents; therefore, this option is expensive and other options should be explored first.

These different options are highlighted on Fig. 5 below, where the **red arrow** displays shaft to ground currents, the **green arrow** displays circulating currents, and the **orange arrow** displays currents from the shaft through the load to ground.

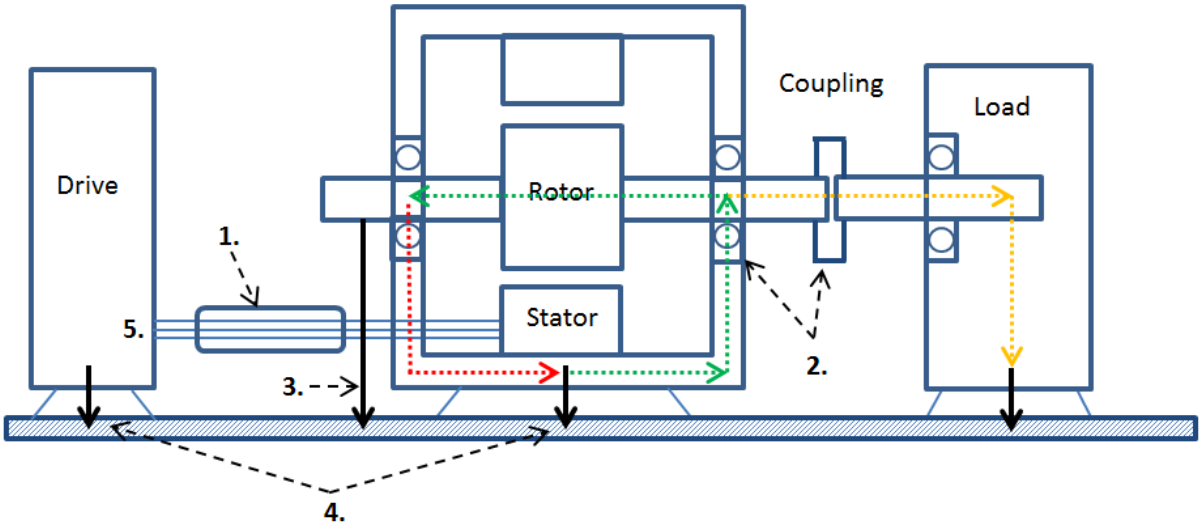

Figure 5. Three Phase Voltage Source Inverter Driving Voltage with Common Mode Other than 0 [V]

1.) Shielded motor cables
2.) Insulated bearings
3.) Shaft grounding brushes
4.) Fine stranded grounding cables
5.) Filtering

References

[1] *J.Adabi, F.Zare, , G.Ledwich, and A.Ghosh,* "Leakage Current and Common Mode Voltage Issues in Modern AC Drive Systems," Power Engineering Conference, 2007. AUPEC 2007
[2] Aegis SGR, Electro Static Technology, "VFD Induced Shaft Currents", 2014. <http://www.est-aegis.com/about_aegis.htm#>

Additional Help

In the US or Canada: please contact the Technical Resource Center at 1-877-ETN-CARE or 1-877-326-2273 option 2, option 6.

All other supporting documentation is located on the Eaton web site at www.eaton.com/Drives

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