Technical Paper

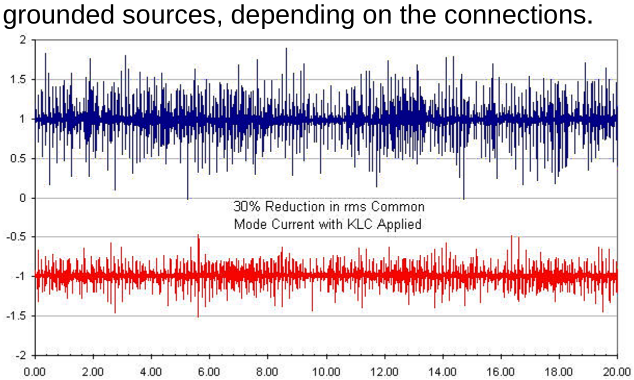
Filtering Increases Motor Bearing Life

Addition of KLC Significantly Reduces Common Mode Current

Written By:
Neil Wood
Principal Engineer, TCI, LLC

In order to understand how TCI's filters can reduce Common Mode (CM) Motor Bearing Current problems, it is best to understand some of the mechanisms contributing to the phenomenon.

CM voltage occurs when the voltages on the three output lines of a drive do not sum "instantaneously" to zero. Thus, there is a net voltage with respect to the drive's ground path. Normal balanced "sinusoidal" 3 phase voltage is by definition always instantaneously summed to zero (volts) with respect to ground. PWM line voltages are on or off, (the transition times are small with respect to pulse width and are not used for zero summing anyway), thus cannot sum to zero with respect to ground. The drive's ground path, essential to CM current flow, is through the heat sink and possibly other upstream grounded sources, depending on the connections.



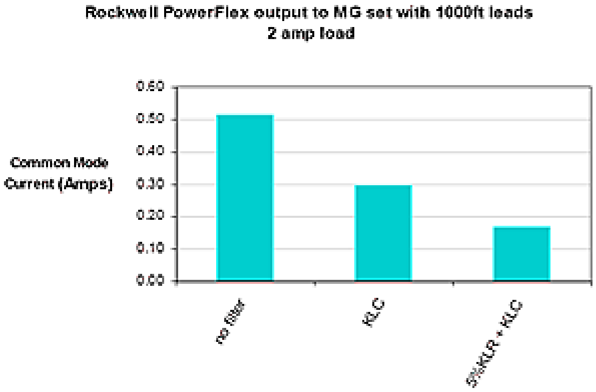
Motor bearings form a circuit coupled through capacitance. A capacitor consists of two plates of different charge (voltage) levels. If an electric field can be generated between the plates, then there is capacitance. Both air and grease act as dielectrics through which such a field can be established. Once the field is established, the following fundamental equation holds true: I = C * dV/dt. This means that the current flowing through the capacitor (bearings, grease & air, bearing race) is proportional to the rate of change of voltage between plates and the dielectric quality of the grease and air (capacitor). If periodically the bearings exhibit metal to metal contact with the bearing race, then the capacitor is short circuited and more current can flow.

Worse yet, when the bearings lose contact with the race, an arc may be drawn until the available energy is depleted for a given time period. The source voltage impedance (here, the drive is the source) is also a controlling factor in the amount of CM current flowing. Thus the equation truly looks like: Icm = (C * dV/dt) bearing factor + Z, where Z is the summation of all the CM circuit impedances other than the bearing impedance. For example, line impedance, ground impedance, shaft impedance, etc.

Now that we have established a driving force, CM Voltage and a CM Current Loop, we can begin talking about how to change the results.

Capacitive coupling is directly affected by switching speed. As noted in the equation: I = C * dV/dt. As switching speed rises, capacitive coupling impedance drops, thus increasing the amount of CM current for a given CM voltage. So, a desirable change would be to slow down dV/dt. Increasing common mode line impedance by the addition of a common mode inductor will limit CM Current. Optimum performance with this solution is achieved by custom inductors designed for each specific application. Common mode inductors are susceptible, however, to both saturation and high frequency permeability degradation. Another important factor is cost. Custom-designed common mode inductors can be expensive.

Extensive testing has demonstrated that TCI's KLC filter is effective at reducing Common Mode Currents, without costly customization. The KLC substantially slows down the rate of change of the PWM switching as seen by the load. The slowing of the rate of



change of the PWM switching increases the capacitive coupling impedance between bearings and bearing races. The increase in capacitive coupling, in turn, reduces the damaging Common Mode Currents and increases motor up-time.

The KLC has demonstrated success in protecting the cable and motor insulation by limiting the damaging effects of reflective wave. As shown by the evidence provided in this paper, an added value of a KLC or KLCUL filter in a Motor and Drive system is the reduction in Common Mode Current. Just one more reason to select TCI products for your motor protection needs.

TCI, LLC
W132 N10611 Grant Drive
Germantown, WI 53022
(414) 357-4480
Fax (414) 357-4484
PQ Helpline (800) TCI-8282
www.transcoil.com