Abstract

In the recent years, pulse width modulated (PWM) variable frequency drives (VFDs) are commonly used in modern control of electro-mechanical drive systems. Although the presence of insulated-gate bipolar transistor (IGBT) and higher switching frequencies help to reduce harmonics and increase operation efficiency, they subject motors to a high frequency common-mode (CM) voltage and resultant CM current. Bearing currents induced by the CM voltage and its steep rising edges have the potential to create premature failure inside motor bearings, such as frosting, fluting and pitting. Consequently, new drive installations can fail within months after start-up, which results in unplanned and costly system downtime. Thus, it is significantly important to understand the different cause-and-effect chains of different types of bearing current, to find cost-effective mitigation techniques for a certain drive configuration. A prototype with commercial inverter and a 5.5 kW induction motor is developed to analyze the mechanism of bearing degradation.

One efficient remedy is the design of CM filter to reduce the CM current entering the induction machine so as to weaken the circulating bearing current which is dominant for large-sized machines. Optimized CM filter design requires accurate knowledge of both source and the termination impedance. In order to measure the source and termination impedance, methods for online impedance extraction are reviewed, such as inductive coupling method and two-port ABCD network approach. However, existing methods require further improvement when it comes to the motor drive system due to the lack of phase information or insufficient signal-to-noise ratio. An improved in-circuit impedance extraction method is proposed to determine the CM impedance for a motor drive system.

Proposed method offers increased signal-to-noise ratio with amplifier while protecting the test instrument with either bidirectional coupler or external attenuator. The validity of the proposed method is demonstrated on several measurements of passive elements. Based on the measured source and termination impedances, an optimized CM choke is designed systematically to achieve the required attenuation without a trial-and-error approach. With the information of noise termination impedances, one can also evaluate the effect of the mode transformation on the CM filter design in a quantitative way.

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