

Measuring Motor Shaft Voltage and Bearing Currents with the Fluke 190 Series II ScopeMeter

Application Note

Voltage pulses from a variable speed drive can couple from a motor's stator to its rotor, causing a voltage to appear on the rotor shaft. When this rotor shaft voltage exceeds the insulating capacity of the bearing grease, flashover currents (sparking) can occur, causing pitting and fluting

of the motor bearing race, damage that can cause a motor to fail prematurely. This application note explains how to use the Fluke 190 Series II ScopeMeter® and a shaft voltage probe to measure motor shaft voltage and bearing currents.

Shaft voltage and bearing currents

Capacitive coupling between a motor's stator and rotor can create a voltage on a motor shaft. For this reason, bearings in electric motors can suffer from wear and tear caused not only by the rotation of the shaft but also by electric currents flowing from the motor shaft to ground by way of the bearings. Motors powered by sine wave ac power may have a shaft/bearing-to-frame voltages of about 1 V to 2 V. Motors powered by the rapidly switching waveforms of Variable Frequency Drives (VFDs), however, may have shaft/bearing to frame voltages as high as 8 V to 15 V. Voltages at these levels can overcome the insulating properties of bearing grease, and the resulting sparks can cause pitting, fluting, fusion craters, and eventually, premature failure of the bearings and motor.



Fluting of a bearing race caused by bearing currents (Photo courtesy of Electro Static Technology).

Shaft voltage probe

Measuring the voltage of a rapidly spinning motor shaft can be difficult and dangerous. A shaft voltage probe helps to make shaft voltage measurements safer and more convenient by extending your reach, making the electrical connection to a motor shaft by means of a small conductive brush mounted on the VPS420-R voltage probe. The reference contact of the probe is connected to ground at the motor housing. For this study an i400s Current Probe was clamped on one of the cables between the VFD and the motor.



Measuring motor shaft voltage with an Aegis shaft voltage probe (Photo courtesy of Electro Static Technology).

Measuring device

Shaft voltages and current spikes caused by the pulse-width-modulated output of motor drives can be exceedingly brief, often in the microsecond measurement range. The high bandwidth (up to 200 MHz) and fast sampling rate (up to 2.5 Gs/s) of the Fluke 190 Series II ScopeMeter® make it ideally suited for measuring rapidly changing voltages and currents—far superior to a digital



The Fluke 190 Series II ScopeMeter can simultaneously record and display four signals.

multimeter. Connect-and-View™ triggering automatically displays stable waveforms with virtually any signal, while ScopeRecord™ enables you to store waveforms in memory for later viewing. And because 190 Series II ScopeMeters can record and display four signals, you can simultaneously view both current and voltage from more than one source.

Measurement results

The oscilloscope screen captures show three measurements that were made with a Fluke 190 Series II ScopeMeter on a motor and drive.

All signals were measured on the T1, T2 and T3* of the Motor Drive. A typical measurement result is given in Figure 1 and can be explained as follows:

- Channel A (red trace) shows motor shaft voltage. Spikes can clearly be seen from the flashovers on the shaft through the bearing.
- Channel B (blue trace) shows current spikes on top of the current signal measured by the current clamp. The spikes give a clear indication of when a peak occurs, confirming a flash or spark. It is assumed that these currents pass through the bearing.

The presence of multiple inputs allows for a more detailed study of the common mode current as more than one current clamp can be connected.

In principle the total current through the T1, T2 and T3* line, referred to as Sigma current, should be equal to the current measured through the Protective Earth, referred to as PE current. In case there is a discrepancy, it is assumed that current is leaking through the bearing caused by parasitic capacitive coupling between the stator and rotor in combination with high frequency circulating currents. Both Sigma current and PE current are made visible on the screen captures as shown in Figure 2 and 3.

The erratic behavior of sparks can be seen on the captured screen of the Sigma current which is related to the bearing current.

- Channel C (black trace) shows the output of the motor drive. The quality of this signal determines the efficiency of the motor. A fast rise time in conjunction with a high electrical capacity of the stator/rotor will contribute to the flashovers.

The ScopeMeter® is a useful tool for a wide range of additional tests on motors and drives, including analysis of harmonics present in the supply voltage, using the built-in fast Fourier transform (FFT) software. Because harmonics play an important role on the efficiency of the motor, it is useful to know about their presence and amplitudes.

*Also referred to as U,V and W.

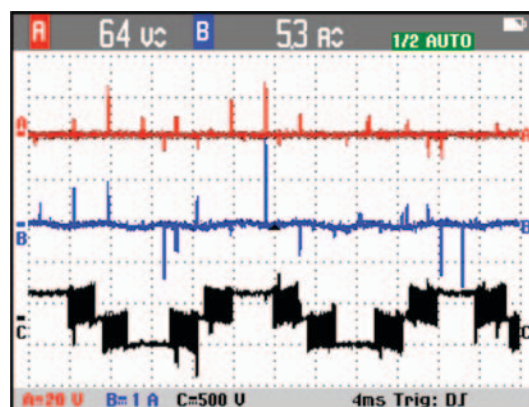


Figure 1. Shaft voltage, common-mode current, and motor drive output displayed on a Fluke 190 Series II ScopeMeter®.

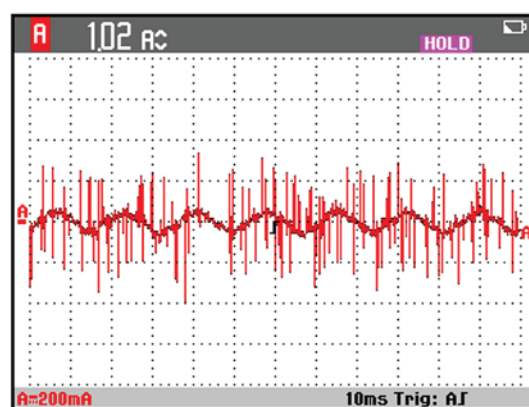


Figure 2. Sigma current.

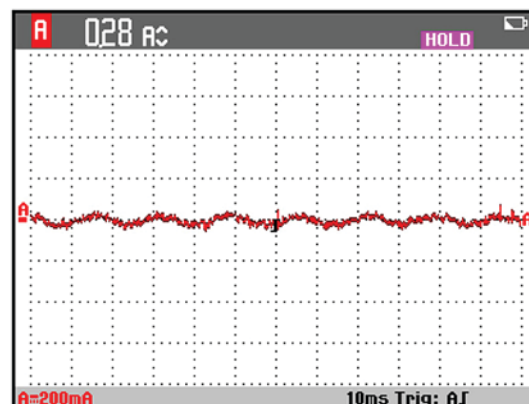


Figure 3. PE current.

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