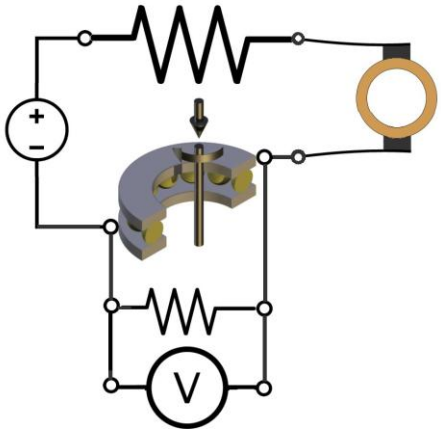
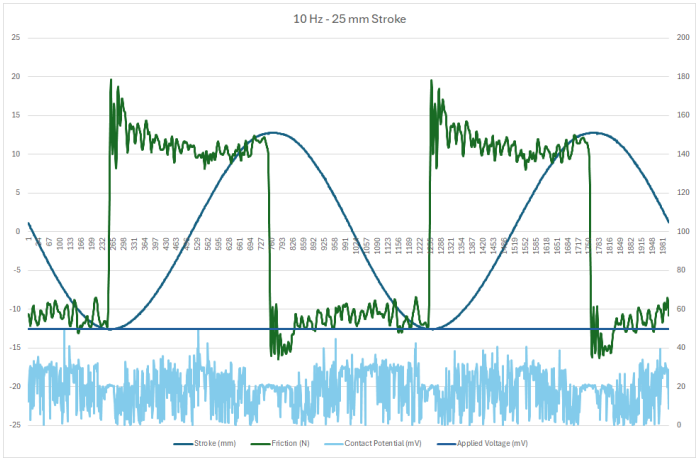
Guidance - Electrification, Electrical Discharge & Tribo-electric Effect

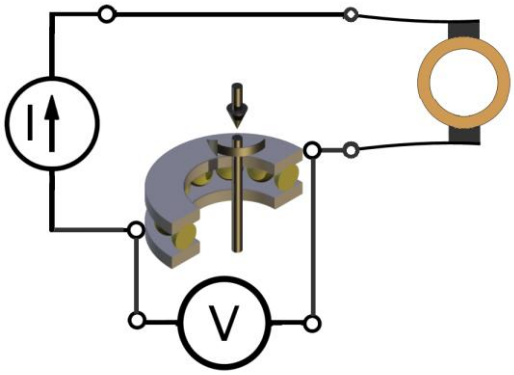
Contact Resistance Measurement – Lunn-Furey Circuit

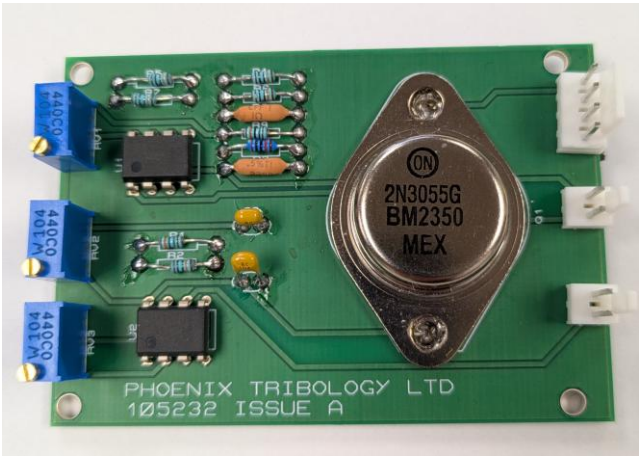




The original Lunn-Furey Electrical Contact Resistance Circuit is fitted to numerous different tribometers. It is essentially a high ratio potential divider with the tribo-contact acting as an electrical switch, in parallel with the low resistance side of the potential divider, with the resulting voltage being measured. The voltage across the tribo-contact is typically set to a maximum of between 20 and 50 mV. See Guidance – Electrical Contact Resistance Signal for further information on interpretation of the signal.

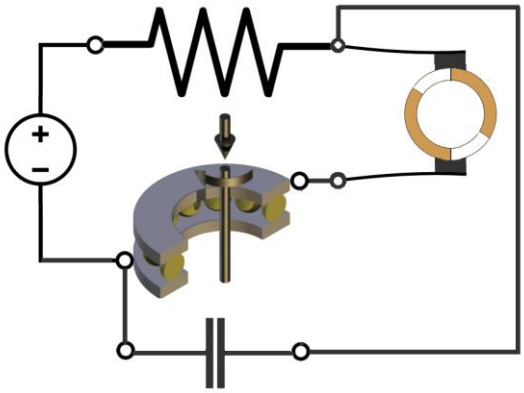
Low Impedance Contact Resistance – LCR Circuit





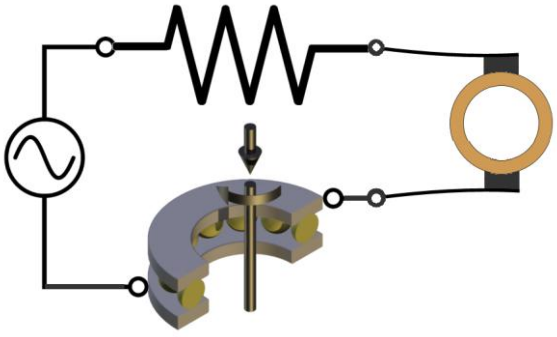
This is a schematic of the LCR Low Resistance Measurement Circuit, which incorporates a constant current source, producing a voltage output proportional to the resistance of the tribo-contact. Although schematically a very simple circuit, practical implementation is somewhat more complcated. This circuit is used, in conjunction with a low impedance slip-ring, to measure the true impedance of low resistance tribo-contacts, including in switches and between surfaces in lubricated rolling element bearings.

Electrical Discharge Machining – Pulsed Charge



This is an Electrical Discharge Machining (EDM) Circuit, in which a capacitor is mounted in parallel with the tribo-contact and split ring commutator. The capacitor charges during the non-conducting part of the cycle and will discharge, depending on the tribo-contact resistance, during the conducting part of the cycle. Applied voltages are typically in the range 6 to 24 volts. The number of discharge pulses are recorded. This arrangement is used for modelling the damage caused by common mode generated electical discharges in motor bearings. See YouTube Video for more information.

Electrical Discharge – Continuous Current



This is a Programmable Continuous AC/DC Current Source Circuit. It allows a current of up to 1 amp to be passed through the tribo-contact. This is the sort of continuous current that might be generated in large rotating electrical machinery.

Tribo-electric Effect & Electro-static Sensors

Background

Delaminating metallic particles carry electrical charges primarily due to contact electrification (triboelectric effect) and electron/ion transfer at the friction interface. When surfaces meet, electrons jump between them to align their work functions. When a particle breaks away, it retains this transferred electrical charge.

Additional Factors

Mechanical Separation (Tribo-emission)

The physical tearing of the metal ruptures the atomic bonds. As the crack propagates and the delamination occurs, high-energy electron emission and the breaking of these bonds leave the newly detached particle highly charged.

Asymmetry of Contact

Friction and sliding contacts create asymmetrical conditions (e.g., temperature differences, localized pressure, or differing surface compositions). This asymmetry unbalances the equilibrium, favouring a net charge on the resulting debris.

Insulating Layers

In lubricated contacts, non-conductive boundary layers, oil films, or additive deposits prevent the immediate discharge of the newly formed particles to the bulk material. In dry contacts, similar insulation is provided by newly formed, non-conductive metal oxides.

Electrostatic Discharges

As the delamination progresses, tiny micro-arcs or electrostatic discharges occur between the separating metal flake and the residual surface, locking a localized positive or negative charge onto the particle.

Predicting Transition to Failure

During normal, mild running conditions, machines produce small, uniformly charged micro-particles. When abrasive or adhesive wear accelerates, the electro-static sensor detects a sudden, massive spike in both pulse frequency and charge magnitude. This change indicates that large, severely delaminated fragments (often >20 µm) are breaking away.