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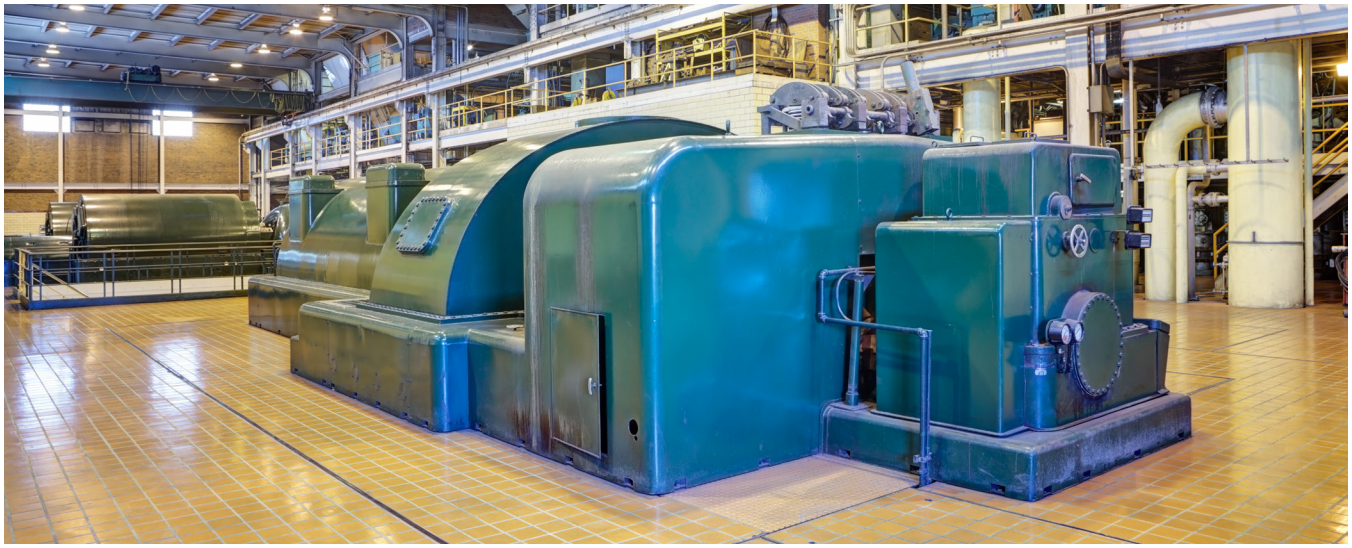
MTS SYSTEMS CORPORATION



EARTH FAULT RESISTANCE MONITORING

OF BRUSHLESS EXCITER GENERATORS/ MOTORS

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Application: Earth Fault Resistance Monitoring of Brushless Generators/ Motors

Monitoring the resistance across the insulation from the field winding to rotor ground on brushless AC synchronous machines allows users to detect the onset of ground faults and prevent severe rotor damage.

Industry: Power

Product: Earth Fault Resistance Monitor - EFREM

Parameters measured: Ground Fault Resistance, Field Voltage, and Fault Location

Accumetrics supplies the EFREM system to major manufacturers of large AC synchronous generators and motors as well as the end users of these machines. This unique system replaces simple protective relay ground fault detectors with an active continuous monitoring system. On brushless exciter based machines, the field winding is normally not accessible without the use of troublesome slip rings, and in many cases these are only infrequently applied with solenoids that engage the brushes for momentary measurements (for instance, once every 24 hours). The result is an intermittent and often unreliable ground fault protection.

In contrast, the EFREM employs digital wireless telemetry technology to provide continuous monitoring, quantitative measurements and early detection of faults before they can lead to severe and very costly rotor damage. Trending of the measurement data provides an understanding of the effects of humidity, contamination and aging on the health of the rotor insulation systems.

The system determines whether the insulation resistance has dropped below either of two user settable alarm thresholds and responds by activating alarm outputs, alerting the operator or in some cases, tripping an automatic plant shutdown. When the fault resistance is sufficiently low, it provides an indication of the fault location along the length of the winding. The system also reports the field excitation voltage. The digital data transmission used by the EFREM allows robust communication without disruption from other electromagnetic interference (EMI) sources.

The EFREM system consists of three major physical components, a rotor mounted transmitter, a stationary pickup antenna coil adjacent to the transmitter and a nearby receiver mounted in a conduit junction box, which connects through a coaxial cable to the pickup. The most standard EFREM systems use a transmitter that mounts at the exciter end of the machine, on the centerline, at the end of the shaft. However, in some cases, the end of the shaft is not easily accessible, so a mid-shaft version utilizing a split clamp-on shaft collar is employed.

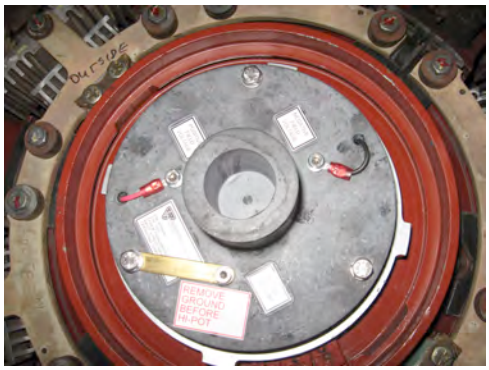

Figure 1

Figure 2

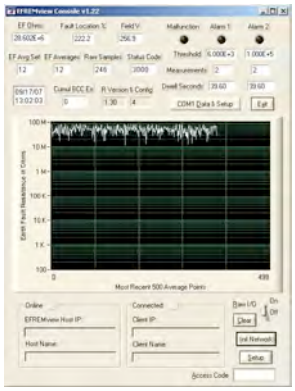

Figure 3

Figure 4

Figure 5

Description of Figures

Figure 1 shows an end of shaft mounted rotating transmitter for the EFREM. Figure 2 shows all of the components of the end of shaft version of the system. Figure 3 shows the display panel from the EFREMview control and display software, with a display of insulation resistance vs. time, as well as other data. Figure 4 shows the mid-shaft version of EFREM mounted between a brushless exciter and a main generator. Figure 5 shows a typical Receiver unit.

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Accumetrics, Inc. provides digital telemetry systems used in a variety of applications such as aerospace, marine, defense, agriculture, transportation, milling operations, energy, and power generation. Systems transmit sensor data from rotating structures using wireless techniques, preserving the integrity of the data even in environments with high levels of electromagnetic interference. Measurement solutions range from single channel products, such as strain gage torque measurements, to advanced custom multichannel systems. Accumetrics, Inc. is a subsidiary of PCB Piezotronics, Inc., and PCB® is a wholly owned subsidiary of MTS Systems Corporations.

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MTS SENSORS

MTS Sensors, a division of MTS Systems Corporation (NASDAQ: MTSC), vastly expanded its range of products and solutions after MTS acquired PCB Piezotronics, Inc. in July, 2016. PCB Piezotronics, Inc. is a wholly owned subsidiary of MTS Systems Corp.; IMI Sensors and Larson Davis are divisions of PCB Piezotronics, Inc.; Accumetrics, Inc. and The Modal Shop, Inc. are subsidiaries of PCB Piezotronics, Inc.