IRIS POWER

RFA*II*-S™

Periodic Rotor Flux Analyzer: an advanced tool to find rotor winding shorted turns in large salient pole motors and hydro generators during service

One of the top 100 inventions of 2007

RFA*II*-S

ON-LINE MAGNETIC FLUX MONITORING

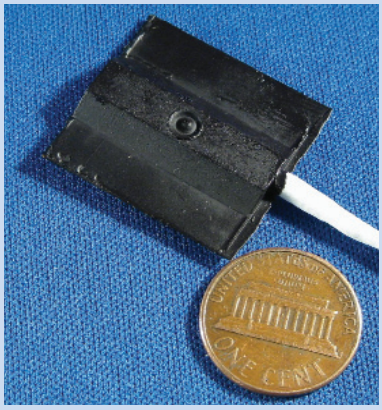
The condition of the rotor pole insulation is difficult to assess during minor or major generator maintenance outages. Access to the poles is severely restricted without some disassembly and removal of components. Off-line tests like the pole-drop test for detection of shorted turns can also be frustratingly ineffective due to the frequently intermittent nature of the faults at speed and at standstill. These off-line tests are also time-consuming, tying up resources and personnel that during an outage could be better utilized elsewhere. Consequently, on-line measurements are preferred to off-line tests and inspections. Through research funded by EPRI and the New York Power Authority, novel new algorithms for analyzing flux signatures on salient pole motors and generators have been developed to detect rotor pole shorted turns, and incorporated into the RFA*II*-S instrument.

The RFA*II*-S instrument employs algorithms that revolutionize the analysis of the flux data on salient pole rotors by providing diagnosis of the rotor winding condition regardless of generator load changes. This technology, when connected to the TFProbe™ (total flux probe), can accurately detect and locate the presence (or absence) of turn shorts.

Once the RFA*II*-S is configured, its high-speed acquisition, high resolution capability, and novel analysis algorithms provide a definitive answer or a cumulative profile of the condition of the rotor insulation. This information is invaluable in helping to plan an outage, or in evaluating the effectiveness of rotor pole refurbishment.

THE TFProbe™ SENSOR

The on-line measurement requires the permanent installation of a flux probe on the stator to measure the air-gap flux. Iris Power offers a unique flux probe for this application. The TFProbe is a small, thin, flexible, printed circuit board transducer affixed to a tooth of the stator. The TFProbe can be installed with the rotor still in place if there is at least 5 cm distance between adjacent poles.



CONSEQUENCES OF SALIENT POLE ROTOR PROBLEMS

Salient pole rotor winding insulation must withstand severe electrical, mechanical and environmental stresses. Insulation failures can result from many factors including:

- mechanical wear, e.g. caused by frequent start/stop cycling;
- distortion, breakage and cracking due to centrifugal mechanical loading and thermally induced expansion/contraction cycles;
- overheating due to overloading, over excitation or inadequate/diminished cooling;
- local overheating at high resistance joints and at the shorted areas of the winding;
- contamination from brake dust or other environmental factors that result in surface tracking between pole turns, or to ground;
- over-voltage induced from system events or from firing circuits in static exciters.

An insulation failure can translate into electrical connections (shorts) between turns in a pole, and eventually a fault to ground.

A turn-to-turn short is the most frequent rotor insulation failure mechanism and can result in:

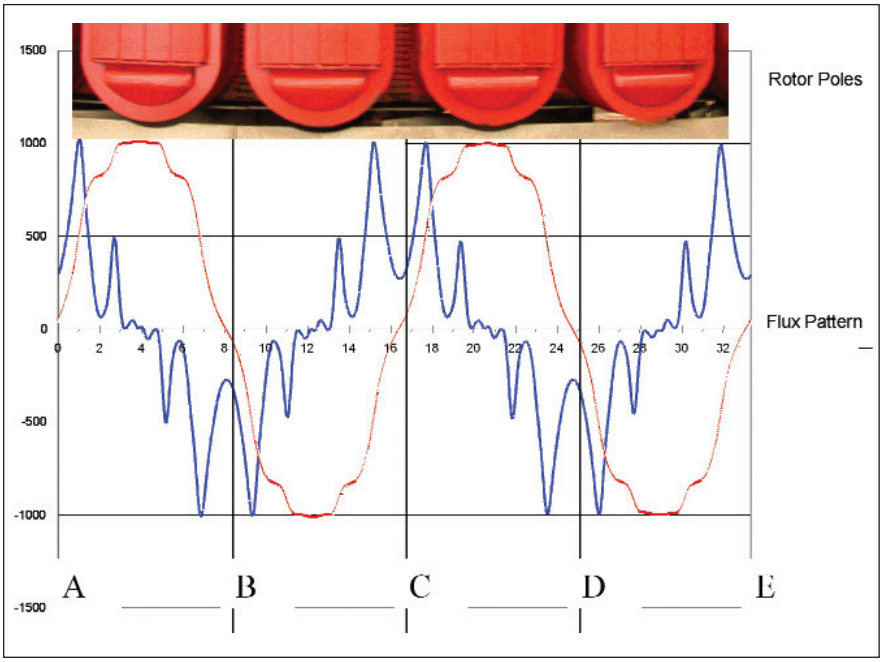
- thermal imbalance of the rotor pole and spider leading to increased mechanical vibration;
- magnetic imbalance in the flux resulting in mechanical vibration;
- increased rotor pole temperature and accelerated insulation degradation, ground insulation failure and a risk of catastrophic second ground fault;
- decreased generator power due to higher electrical losses;
- inability to reach the rated MVA rating for that machine.

MONITORING AND INTERPRETATION OF FLUX DATA

Flux monitoring relies on measurements of the local magnetic field emanated from each rotor pole. Factors affecting the magnetic field from each pole include:

- change in air-gap,
- rotor out-of-round or off-centre,
- loose pole – key migration,
- stator migration,
- natural variations of the pole's physical position,
- shorted rotor turns.

During normal machine operation, the flux from each passing pole will induce a voltage in the TFProbe sensor. In salient pole machines, the radial magnetic flux profile across each pole depends on the loading of the machine. The RFA*II*-S instrument acquires, in real time, the flux signal over several machine rotations and averages and compares these readings to identify shorted poles.



*Flux pattern measured by RFA*II*-S*

The figure shows a typical voltage waveform from a flux probe on a hydro generator (blue trace) as well as the real time integrated flux trace (red trace). Each peak of the voltage represents the magnetic flux around one rotor pole. An inter-turn short in a coil reduces the peaks associated with that pole.

Analyzing the voltage waveforms in real time, comparing average and discrete flux readings, and trending readings from all poles helps to identify anomalies in the flux due to shorted turns.

CAPABILITIES

- The test enables instant analysis of rotor winding insulation condition, even during varying operating loads.
- The instrumentation allows for a spot measurement, or automatic acquisition of results over several days and during normal generator operation, without intervention from an operator.
- The method eliminates the need for static off-line tests, such as the pole drop test, which are intrusive, costly in terms of time, and often misleading since the rotor is not spinning.

TYPICAL APPLICATION

The most common method of monitoring flux involves using a portable instrument, the RFA*II*-S, which is moved between machines that are fitted with flux probes. The instrument is configured by means of a computer and includes Windows™–based control and data display software.

Alternatively, for remote monitoring, continuous monitoring systems are available from Iris Power. These can be integrated with plant SCADA using OPC protocol interface and a variety of other plant data acquisition and monitoring protocols.

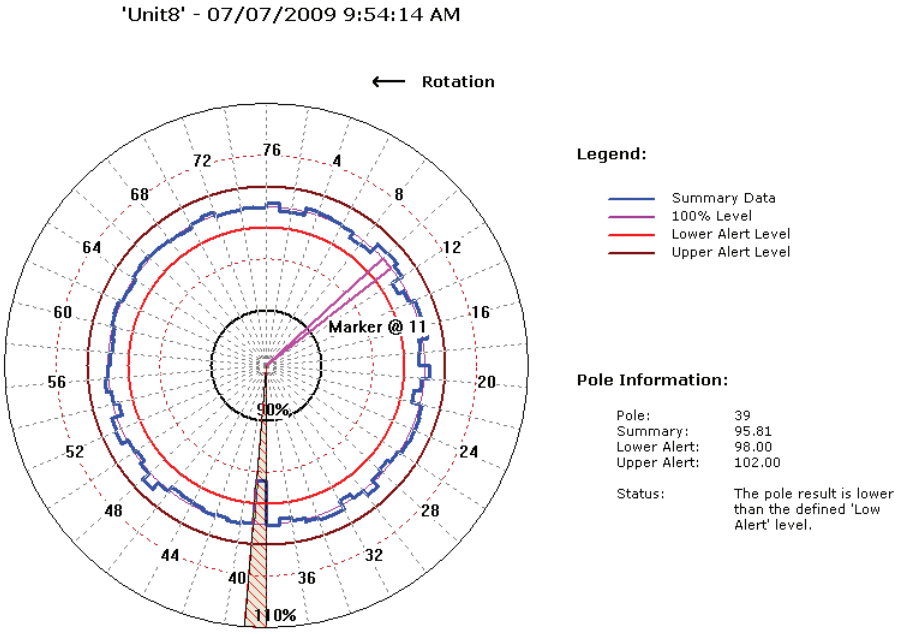
RFA*II*-S

FEATURES

- Rugged portable instrument with USB and Ethernet interfaces
- Custom built, ultra-high resolution digital data acquisition module, including on-board switchable attenuation for maximum resolution measurements using virtually any flux probe
- High speed acquisition capability creates a table of results covering each pole and each load point
- Deep memory for complete and accurate data collection, e.g. capable of storing over 150 flux waveforms
- Can be synchronized to a power frequency signal, or ideally to an external shaft sync signal so that the poles with shorts can be located

SOFTWARE FEATURES

The operation of the RFA*II*-S is configured by software that can be installed on any Windows computer. The software also ensures data storage and provides instant analysis of results. There is a clear indication of the presence and location (assuming a shaft sync is installed) of any poles with shorted turns.



Polar plot showing shorted turns on pole 39 of a 76-pole hydro generator rotor

IRIS POWER LP HAS BEEN THE WORLD LEADER IN MOTOR AND GENERATOR WINDING DIAGNOSTICS SINCE 1990, PROVIDING A FULL LINE OF ON-LINE AND OFF-LINE TOOLS, AS WELL AS COMISSIONING AND CONSULTING SERVICES.

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