QUALITROL-IRIS POWER IS THE WORLD'S LARGEST PROVIDER OF MONITORING AND TESTING EQUIPMENT FOR MOTOR AND GENERATOR WINDINGS

IRIS POWER
A QUALITROL Company

Iris Power RFAII-R™

Periodic Rotor Flux Analyzer: a second generation advanced tool to find rotor winding shorted turns in turbine generators and high speed synchronous motors during service

Technology winner of the
2014 IEEE PES Best Paper Award

IRIS POWER ON-LINE PRODUCTS

QUALITROL
Defining Reliability

IRIS POWER RFAII-R

The Iris Power RFAII-R technology is a second generation rotor flux analyzer that revolutionizes the analysis of the flux data by providing an initial diagnosis of the rotor winding condition usually even if the generator load is constant! This portable instrument can collect and analyze flux data from any flux probe in real time, providing the user with data on potential shorted turns. The Iris Power RFAII-R's high-speed acquisition, high resolution capability and totally new analysis algorithms allow it to collect and analyze data over an entire unit run-down or start-up (with the shaft sync signal connected). Once configured, the Iris Power RFAII-R requires no user intervention and is ideal for profiling the rotor insulation condition before a machine outage or after a refurbishment.

SYNCHRONOUS GENERATOR AND MOTOR ROTOR WINDINGS

The insulation in round rotors must withstand severe electrical, mechanical and environmental stresses. Insulation failures can result from many factors including:

- mechanical wear, especially that caused by frequent start/stop cycles
- distortion, breakage and migration due to centrifugal mechanical loading and thermally induced expansion/ contraction during load cycles
- overheating due to overloading/ over excitation or inadequate or diminished cooling
- local overheating at high resistance brazed joints and at shorted turns
- contamination in cooling gas or copper dusting resulting in surface tracking between turns or to ground
- overvoltages induced from system events or from firing circuits in static exciters.

An insulation failure can translate into electrical connections between turns, and eventually a winding to ground fault.

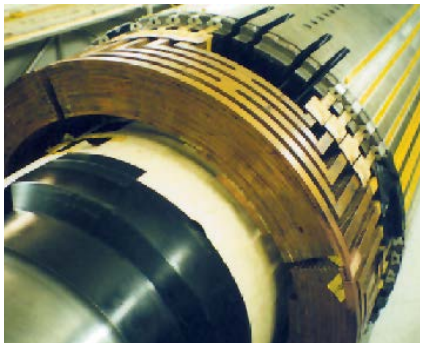
A turn-to-turn short is the most frequent rotor insulation failure mechanism. Turn shorts can result in:

- thermal imbalance of the rotor leading to mechanical vibrations
- magnetic imbalance in the flux resulting in mechanical vibration of the rotor
- increased rotor temperature and subsequent insulation degradation
- overheating resulting in insulation failure and a ground fault with the potential for a second catastrophic ground fault
- inability to reach the rated MVA rating for the machine.

Magnetic flux monitoring via permanently mounted air gap flux probes is a proven technology in synchronous machines to determine if turn-to-turn shorts have occurred in the rotor winding. Flux measurement provides the most direct means of monitoring the condition of rotor windings on-line, yielding information on the integrity of the coils' interturn insulation. This information is critical in planning maintenance, diagnosing abnormal vibrations, and verifying new and rewound rotor integrity.

CAPABILITIES

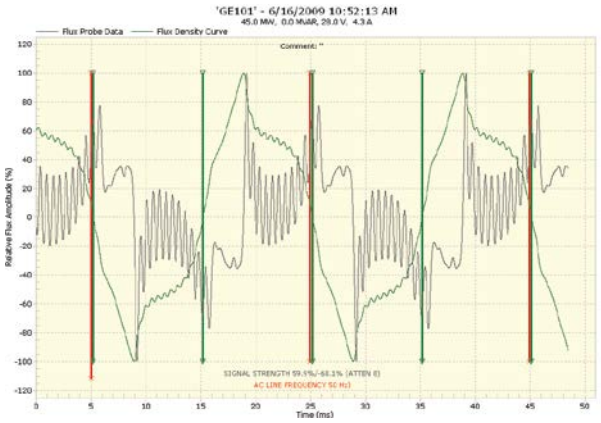
- Instant analysis of round rotor winding condition usually at any operating load
- Where needed, ability to analyze tests at different loads for a more certain prediction of rotor winding condition
- Able to perform a spot measurement, or automatically acquire results over days during normal generator load changes, without operator intervention
- Works with conventional wedge-mounted flux probe, or the stator tooth-mounted Iris Power TFProbe™, which can often be retrofitted with the rotor in-place



IRIS POWER RFAII-R

THEORY OF FLUX MONITORING

Flux monitoring relies on measurements of the local magnetic field emanated by each coil in the rotor. The leakage flux is determined by the total ampere-turns from each rotor slot. Any change in the ampere-turns within a coil due to shorted turns produces a change in the leakage flux.



Typical voltage waveform from a flux probe

To measure the leakage flux, a flux probe sensor is permanently installed on the stator. During machine operation, the flux from each passing slot will induce a voltage in the flux probe. The difficulty in measuring the leakage flux is that the main radial magnetic flux is orders of magnitude greater than the leakage flux. To maximize the sensitivity to shorted turns in all rotor coils, the signals from the flux probe need to be measured under different load conditions ranging from no load to full load. At a zero crossing of the total flux (which is the function of the real and reactive load of the machine), the sensitivity to the leakage flux is the highest. Thus the flux readings with the older, first generation equipment must be taken at various load points depending on the number of slots in a pole.

The graph shows a typical voltage waveform from a flux probe. Each peak of the voltage represents the leakage flux around one rotor coil. An inter-turn short in a coil reduces the peaks associated with the two opposite slots containing the faulted coil. By analyzing the voltage waveforms at various generator load points, it is possible to identify any slots with shorted turns. The new technology used in the Iris Power RFAII-R usually does not require the load changes.

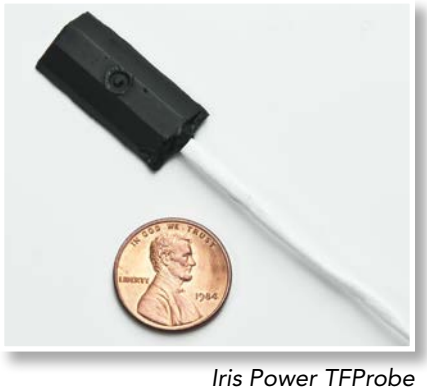
TYPICAL APPLICATION

The condition of the rotor winding insulation is difficult to assess during minor or major generator maintenance outages. Access to the winding is severely restricted without removal of the retaining rings and of the winding wedges. The off-line tests for detection of shorted turns and ground fault locations can also be frustratingly ineffective due to the frequently intermittent nature of faults at speed and at standstill. Therefore, on-line measurements are much preferred to off-line tests and inspections.

On-line measurements require the permanent installation of a flux probe on the stator to measure the slot leakage flux. Qualitrol-Iris Power makes two kinds of flux probes. The first is a foldable probe called the FFProbe™ which is attached to a stator winding wedge protruding into the airgap. We also offers an alternative probe, the Iris Power TFProbe™, which is a small, thin, flexible, printed circuit board transducer affixed to a tooth of the stator. It is designed for generator airgap <50mm. The Iris Power TFProbe measures the total airgap flux, rather than just the leakage flux. The Iris Power TFProbe is easy to install. Frequently, it can be installed with the rotor still in place! In the case of hydrogen-cooled machines, the leads from the flux probe are routed out of the machine through a hermetically sealed feed-through.

Regardless of the probe technology, data from permanently installed flux probes can be measured via software, with the Iris Power RFAII-R, or continuous on-line monitors like the Iris Power FluxTracII™. Once the data are acquired, analysis techniques must be applied to compare the flux measurements across various rotor slots to determine if the turn shorts are present.

Iris Power FFProbe glued to a turbine generator stator tooth

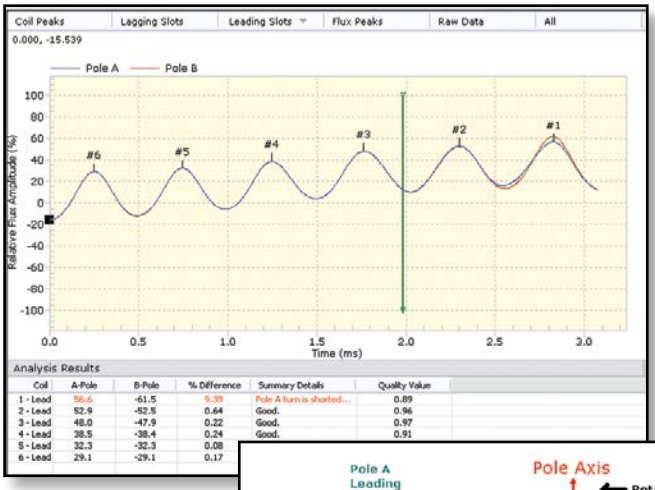


Iris Power TFProbe

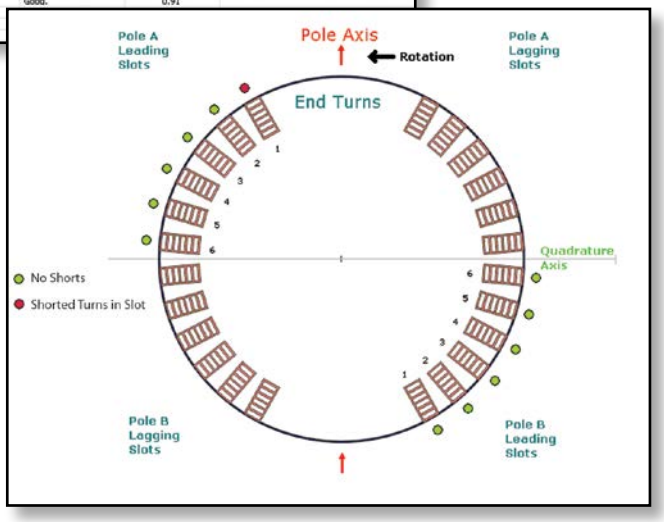
IRIS POWER RFAII-R

FEATURES

- Rugged portable instrument with USB and Ethernet computer interfaces
- Custom built, ultra-high resolution digital data acquisition and on-board switchable attenuation for maximum resolution measurements using any manufacturer's flux probe
- High speed acquisition with deep memory for complete and accurate data collection
- Capable of storing over one hundred and fifty flux waveforms
- Usable with the Iris Power FFProbe, TFProbe and older style flux probes
- Can be synchronized to a power frequency signal, or ideally to an external shaft sync signal (key phasor)
- Use with 2-pole or 4-pole rotors
- Predictions of turn-shorts in any slot, often regardless of the generator load point during data acquisition
- A high-speed acquisition mode immediately creates a table of results covering each coil at each load point, including flux waveforms
- Stand-alone mode where the Iris Power RFAII-R can collect data automatically as the generator goes through normal load changes
- User friendly Windows™ based software for data display, analysis, and trending
- Analysis software capable of reading and analyzing data files from other manufacturers' portable instruments
- Systems are available for remote and continuous monitoring
- Optional mode for finding shorts in spin pits with the rotor operating at different speeds
- Optional instrument that can be used with both round rotors and salient pole rotors



Pole A to Pole B Comparison



Software output showing location of turn shorts

QUALITROL-IRIS POWER 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 COMMISSIONING AND CONSULTING SERVICES.

IRIS POWER
A QUALITROL Company
www.irispower.com
www.qualitrolcorp.com

Iris Power LP
3110 American Drive
Mississauga, ON, Canada L4V 1T2
Phone: +1-905-677-4824
Fax: +1-905-677-8498
Sales.iris@qualitrolcorp.com

Qualitrol Company LLC
1385 Fairport Road
Fairport, NY, USA 14450
Phone: +1-585-586-1515
Fax: +1-585-377-0220

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