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Application Note

Modernizing DC Rotating Exciters with Static Excitation Systems

Today, while most new excitation systems for synchronous machines employ brushless rotating exciters, the dc rotating exciter has had a long history, which continues today. The technique of converting ac power to dc power through a commutator and transferring the energy to the main field through brushes remains in widespread use. This method of excitation brings challenges that include brush and commutator maintenance, costly exciter rewinds stemming from brush wear that spreads conductive carbon dust throughout the machine, and qualified maintenance personnel to maintain the brushes and commutators.

This application note discusses the wear and maintenance issues that affect the life of a dc rotating exciter. It also examines the maintenance and efficiency advantages gained from replacement of a dc rotating exciter with a static excitation system.

Rotating Exciters

The rotating exciter has a long history along with several issues that make it less attractive today as everything moves toward less maintenance and improved operating efficiencies.

Exciter Brush Wear

Exciter brushes conduct the rectified dc output from the commutator and send it to the main field slip rings, which also use brushes. Exciter brushes are plentiful on the dc machine. With an estimated 50 Adc of capacity for each brush, a machine requiring approximately 1,500 Adc will need approximately 30 brushes on the positive side of the field winding. Another set of brushes will be needed on the negative side of the field winding. As these carbon brushes wear over time, they require regular replacement by qualified personnel. The brush material breaks down, creating a conductive dust that disperses and falls into the generator windings, particularly for vertical shaft hydro turbine generators. This causes the generator windings to run warmer, requiring regular cleaning. The same can be true for the rotating exciter winding depending upon how it is arranged.

For safety reasons, many plants require a machine to be shut down when brushes are replaced. This means the synchronous machine is out of production and not generating revenue.

Brush dust also falls between the commutator bar segments, which diminishes the dielectric property of the commutator insulation. This can result in commutator sparking that causes the carbon brushes to wear even faster.

Additionally, the spring tension of the brush holders is extremely important to maintain constant pressure to ensure proper seating and surface contact of the brush to the commutator.

Commutator Wear

Constant wear from the brushes causes grooves to develop over time on the commutator ring (Figure 1). This condition can cause sparking so operators must be vigilant in maintaining a smooth ring surface. Additionally, the commutators have a limited operating life and eventually require a costly commutator ring replacement.

Issues developing with the brush seating on the commutators can cause a variety of challenges including ghosting, streaking, and brush jumping. These conditions also require surveillance and preventive maintenance.

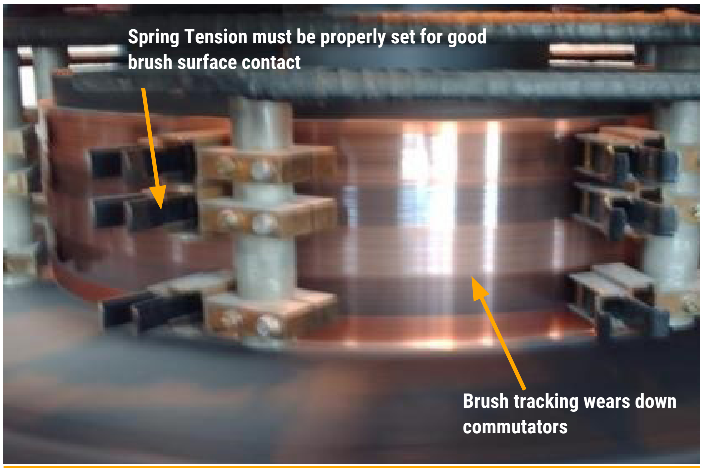

Figure 1. Commutator Wear

Rotating Exciter Rewinding

The rotating exciter is subject to wear and eventually will require rewinding, often many times in its lifetime. Rewinding is needed because of winding insulation breakdown. This is due to a variety of causes, such as excessive heating due to carbon dust accumulation, general loading, and dielectric breakdown of the winding insulation due to brush dust, age, or high voltages induced from the rotor.

A salient-pole, vertical-shaft hydro machine is shown in Figure 2 and a horizontal generator with a belt-driven exciter is shown in Figure 3.

Figure 2. Salient-Pole, Vertical-Shaft Hydro Machine

Figure 3. Horizontal Generator with Belt Driven Exciter

Rheostat Inefficiency

For some plants, the old manual rheostats (Figures 4 and 5) continue to be used. The power loss for these devices can be upward of 6 kW, increasing the heat load on the plant significantly during the summer months.

Figure 6 illustrates a schematic of a rotating exciter with rheostat control.

Figure 4. Manual Rheostat

Figure 5. Wire-Wound Rheostat (one per machine)

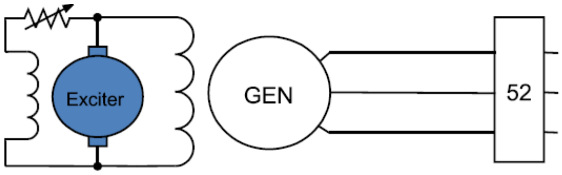

Figure 6. Rotating Exciter with Rheostat Control

Maintenance Personnel

Today, many power plants operate with a reduced number of personnel. Eliminating the rotating exciter reduces maintenance, training requirements, and costs.

Static Exciters

Replacement of the rotating exciter with static excitation is the prevailing norm today. Although one set of brushes remains on the slip rings, the total quantity of brushes is reduced by half, requiring half the maintenance. Operating efficiency increases as the losses of the rotating exciter are eliminated with a static exciter that has high operating efficiency and, subsequently, less heat load.

Beside the previously mentioned maintenance concerns, today's tendency to replace the rotating exciter can be related to the uprating of the turbine and generator. In this scenario, the existing rotating exciter does not have enough capacity to meet the new full-load requirements of the main field. This is a significant motivator for conversion to a static exciter system.

A one-line diagram of a static exciter simplex system is shown in Figure 7.

The static exciter provides many new capabilities:

- Online maintenance capability of the rectifier bridges using the power drawer technology.
- N+1 redundancy of the power bridges: in the unlikely event of an SCR failure, the system will be able to continue to provide full output capacity.
- Optional Digital Controller Redundancy, 100% backup of control electronics, including voltage regulator, limiters, power system stabilizer where applicable, etc.
- Exciter maintenance is minimized since a static exciter has essentially no moving parts.
- The static exciter unit response is much faster than a rotating exciter voltage regulator system because one field constant is removed from the generator system. This makes the new excitation system dynamically faster to improve the system fault clearing time with less than 20 ms voltage response time and 0.1% voltage accuracy.
- An optional integrated power system stabilizer is available for plants that require NERC compliance or for those plants that have power stability issues due to a voltage-weak transmission connection.
- Testing Tools (Figure 10) that provide easy strategies for MOD-026 compliance testing for modeling using the Basler BESTCOMS*Plus*® and BESTCOMS™*Pro* operating software. See Figure 10.
- BESTspace is provided with BESTCOMSPlus for default commissioning monitoring screens to speed startup.
- Dynamic System Analyzer for performing generator frequency response for modeling and power system stabilizer tuning along with accompanying Phase Plot Compensator that helps to evaluate the Power System Stabilizer lead/lag filters selection.
- Real Time Chart Recorder provided via BESTCOMS*Plus*® or BESTCOMS™Pro operating software.
- PID auto tuning for "Best Selection" of determining voltage regulator gains for the generator system.
- Ethernet communications or USB interface for commissioning setup.
- Auto Synchronizing (Device 25A) option.

Long Life Expectancy of the Static Exciter

A manufacturer's approach to equipment life expectancy varies, but there are three main elements that make up an excitation system and affect its longevity. They are:

- Control electronics (voltage regulator, excitation limiters, power system stabilizer, etc.)
- Power rectifier bridge(s)
- Power potential transformer

Power Potential Transformer

The power potential transformer has long life; operates in an relatively clean environment, and is proven to have a history of excellent equipment reliability.

Power Rectifier Bridge

The rectifier bridge arrangement consists of N+1 bridges which means, should an SCR fail, the unit will still be able to provide full output capacity. A bridge with a defective SCR can be easily drawn out and replaced with a spare drawer when it is convenient for the plant. The failed drawer can then be sent to the factory for repair. An SCR failure is unlikely, however, since RTDs are used to monitor the temperature of each SCR. The SCR firing circuit uses a skip-firing strategy to maintain safe SCR temperatures. A patented firing algorithm maintains equal (±2°C) temperature across each SCR in all bridges connected in parallel. As a result, the SCRs used in the system have a long life of availability.

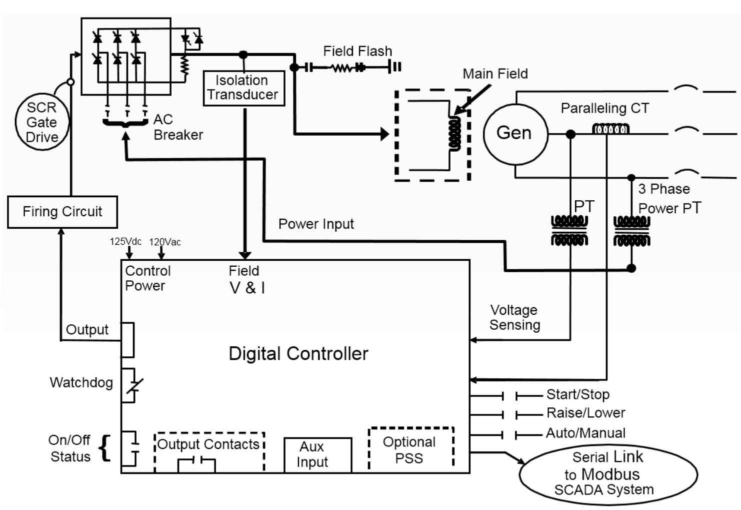

Figure 7. Static Exciter Simplex System

Control Electronics

In this digital world, the control electronics have a limited lifespan due to the continued advancements in technology that renders older technology obsolete. Basler Electric has different solutions to address this issue that include new designs (Figures 8 and 9) that can be retrofitted in place of old hardware.

For more information

For assistance with product orders, questions, additional information, application notes, product bulletins, and instruction manuals, visit www.basler.com, contact your Application Engineer, or contact Technical Support at +1 618.654.2341.

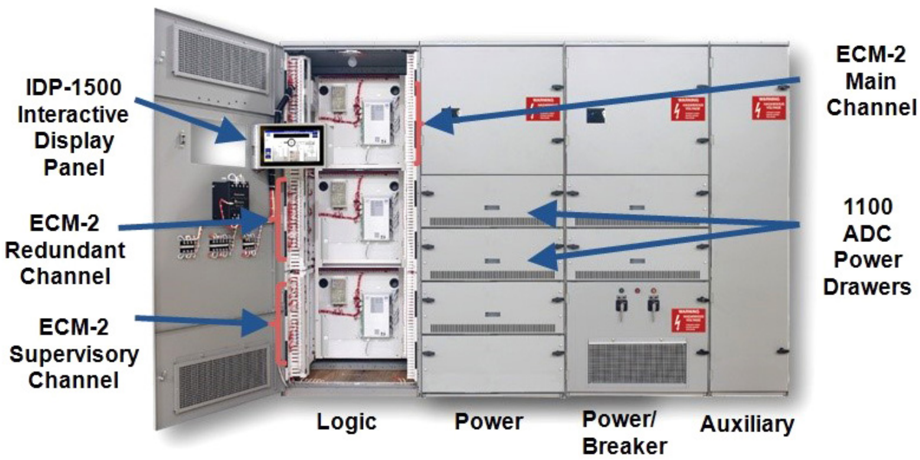

Figure 8. Redundant DECS-2100 Static Excitation System

Figure 9. Non-Redundant DECS-450 Static Excitation System

Figure 10. Software Tools to Simplify NERC Compliance (MOD-026) Testing

Basler Electric®

Highland, Illinois USA
Tel +1 618.654.2341
Fax +1 618.654.2351
email: info@basler.com

Suzhou, P.R. China
Tel +86 512.8227.2888
Fax +86 512.8227.2887
email: chinainfo@basler.com

Quality System Certification ISO 9001:2015