

# Application Note

## Static Exciter Upgrade for Cross-Compound Turbine Generators

**Cross-compound turbine generators, popular from the 1960s through the 1980s, consist of a high-pressure (HP) and low-pressure (LP) turbine generator.** The outputs of the two generators are connected, sharing a common generator breaker, which causes the two generators to act as one synchronous machine. Steam exiting the HP turbine is recirculated at reduced pressure through the LP turbine to maximize the power produced. See Figure 1.



Figure 1. Cross-Compound Machine

Each generator is controlled by its own excitation system and, depending upon the age of the plant, has likely experienced a variety of excitation equipment changes through its lifetime. In these applications, a rotating exciter is driven by a motor-generator (MG) set with a dc field breaker and discharge resistor at the exciter output. A reserve exciter serves as a backup in case of a main exciter failure. Early designs used a rheostat to adjust the exciter field current to control the generator voltage. Eventually, these rheostats were replaced by analog voltage regulators to provide automatic regulation of the generator voltage. Here, a dc field current regulator was used to provide constant current to the exciter field during startup.

Because the HP and LP turbine generators are bussed together at the output, they employ a unique startup characteristic. For the majority of machines, excitation is applied to the fields of the HP and LP turbine generators simultaneously while operating at a very low speed.

This locks the magnetic fields of the two rotors together, causing the two generators to act as one large synchronous machine. As analog excitation systems at these large plants approach the end of their service life, obsolescence and support become concerns. In these applications, an excitation upgrade goes beyond replacement of the analog voltage regulator. In most cases, it includes replacement of the rotating exciter. Reasons for replacing the rotating exciter include:

- Brush maintenance
- Carbon dust issues in the commutator bars
- Shorted windings
- Commutator end of life

Although the rotating exciter replacement is part of the excitation upgrade, a static exciter becomes the retrofit solution. The static exciter replaces the voltage regulator and dc rotating exciter MG set for a system designed to work directly into the slip rings of the main generator field. The static exciter's power source should be 10 times the rating of the excitation system. This minimizes the contribution of SCR harmonics into the bus.

### New Equipment Solution

The operator of a coal-fired power plant with a cross-compound generator decided to replace the rotating exciters and analog voltage regulators with static exciters. The combined output of the generators is 352 MW, with the HP machine contributing 197 MVA and the LP machine contributing 155 MVA. The main field requirement of the HP machine is 2,260 Adc at 375 Vdc and the main field requirement of the LP machine is 730 Adc at 375 Vdc. The rotating exciter and all controls of the original system were replaced with static exciters. Each static exciter has redundant controls and N+1 power rectifier bridge capacity. If a power bridge fails, the N+1 bridge compensates and provides full power to the field. Power drawers, shown in Figure 2, provide online maintenance capability. This permits online power drawer replacement (wearing suitable arc-flash protective attire) or timely replacement during scheduled downtime for a machine. In

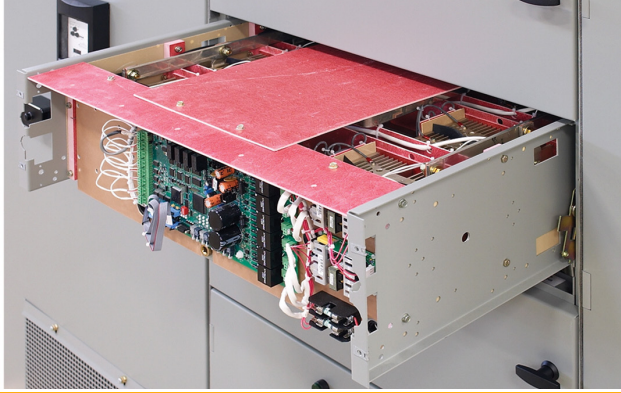


Figure 2. Pull-Out Drawer for Bridge Replacement

many cases, as true for this system, the new static exciters receive power from the same station bus as the original MG sets. A power analysis of the station bus confirmed that there are “no harmonic contribution concerns” from the new excitation system.

The end user performed demolition and equipment installation and Basler Electric provided commissioning services. To achieve NERC compliance, tests to validate models of the new excitation system with the generator for expected performance were completed.

With the equipment installed and ready to operate (Figure 3), the turbine generator started as it had previously, except with more flexibility and precision.



Figure 3. New DECS-2100 HP Excitation System

At startup, the HP and LP generator fields have a base field current value as the turbines accelerate from start on the turning gear. The base field current magnetically locks together the two rotors of the generators’ fields. As the turbine speeds up, the machines follow a volts per hertz characteristic to rated terminal voltage. The DECS-2100 includes multiple pre-position setpoints to accommodate different control strategies. When the system reaches full speed, it is transferred to automatic voltage regulator control. Because the two generators are bussed together, each machine must provide its share of reactive current to avoid circulating current between machines. To help with this, either reactive droop compensation or reactive cross-current compensation can be used. However, many plant operators prefer using reactive cross-current compensation which maintains a flat generator voltage characteristic that provides greater reactive support during a disturbance. Reactive cross-current compensation is accomplished by using CT communication between the HP and LP generators or through Ethernet communication between the HP and LP excitation systems to maintain the generator voltage setpoint. Once the turbine generator is up to rated speed, the commissioning engineer validates generator voltage response with the new excitation system and sets the excitation limiters to meet NERC requirements.

### Features and Benefits

A key benefit of a new digital excitation system is the operating software that speeds tedious commissioning processes. Built-in software testing and commissioning tools include:

- Generator voltage step testing for model test validation, see Figure 4.
- A dynamic system analyzer to determine the associated generator frequency response with the new excitation system and an automatic Bode plotter, for modeling validation.
- A real-time chart recorder to measure the dynamic testing of the generator voltage response. Measured parameters, including generator voltage, MW, Mvar, field voltage, and field current, are captured.
- Scalable menu viewing screens that enable a user to create preferred screens of data collection during repeated testing.
- Easily obtainable event records from oscillography with provided viewing files.

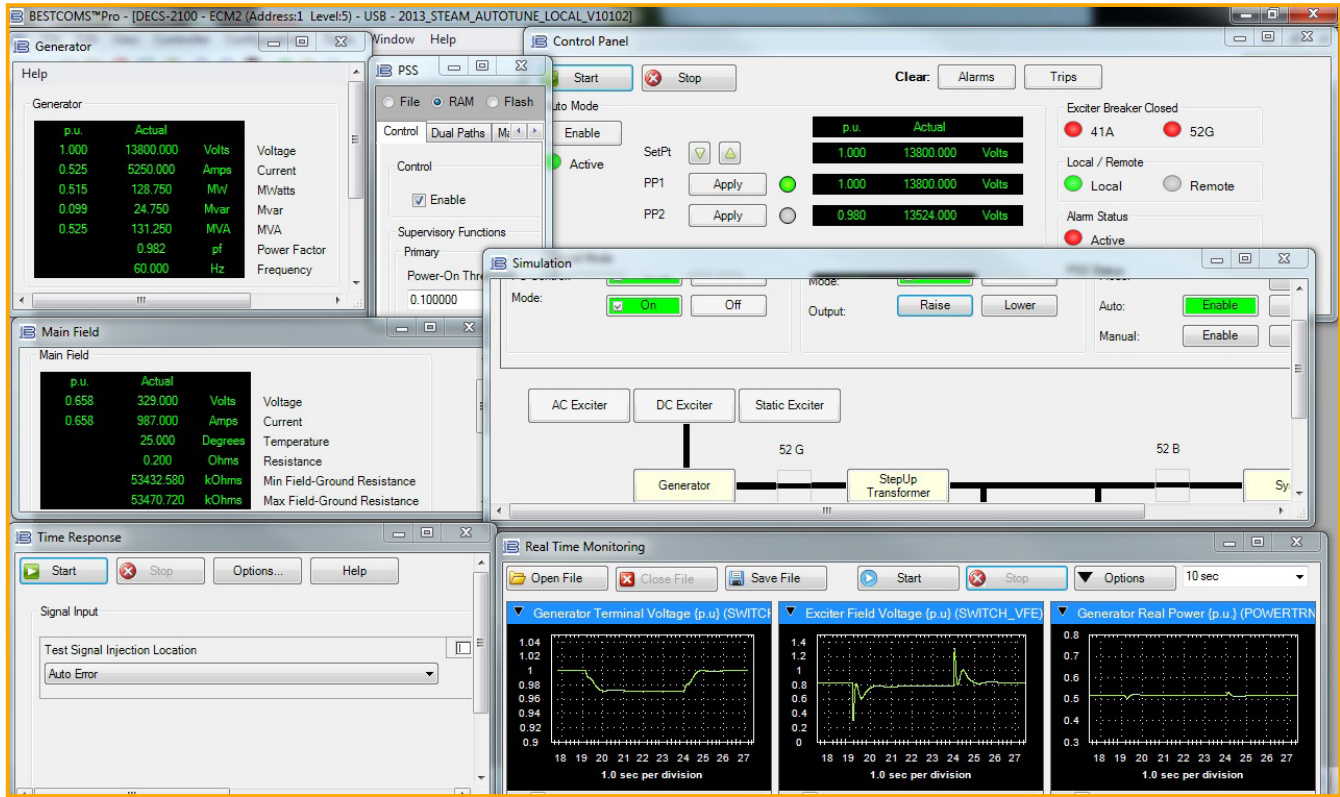


Figure 4. BESTCOMS™ Pro showing a step response with the PSS enabled

## DECS-2100 Features

- ±0.1% voltage regulation accuracy
- Control modes with auto tracking
  - Automatic Voltage Regulation (AVR)
  - Manual (Field Current and Voltage)
  - Var
  - PF
- High side voltage regulation mode
- Dual and supervisory channel options
- Integrated PSS type 2A/2B
- Interactive Display Panel (IDP-1500) for local and/or remote monitoring and control
- Real-time monitoring with up to six (6) parameters
- Sequence of events recording
- Oscillography
- System simulation mode
  - Time responses
  - Frequency responses
- Automatic synchronizing
- Auto tuning
- Programmable input/output terminations
- IRIG-B time synchronization
- Communication
  - Multiport Ethernet
  - USB
- Protection
  - Fiber optics for bridge firing
  - RS-485
  - Field overvoltage
  - Generator overvoltage and undervoltage
  - Bridge overtemperature
  - Field flashing
  - Field overtemperature
  - Loss of excitation
  - Loss of voltage sensing
  - Overcurrent
  - Overexcitation
  - PPT fuse failure
  - Thyristor conduction monitor
  - Volts per Hertz
  - Watchdog
  - Exciter or main field ground protection
- Limiters
  - Max field current
  - Min field current
  - Overexcitation
  - Underexcitation
  - Stator current
  - Temperature compensation
  - Volts per Hertz
- Dual PID settings groups

## Conclusion

Power plant modernization is a continuing process as the power industry and technology continue to evolve. Agency requirements to assure quality and reliable power delivery also continue to evolve. In this application, the advanced features of the DECS-2100 excitation system provided greater control. BESTCOMS™*Pro* software provided the tools needed for commissioning, troubleshooting, and model testing as required by NERC to validate new equipment.

## For more information

For further assistance with product orders or questions, contact Basler Electric Technical Support at +1 618.654.2341.

For additional information on BESTCOMS*Pro* software, including more application notes, product bulletins and instruction manuals, go to [www.basler.com](http://www.basler.com), contact your Application Engineer, or contact Technical Support at +1 618.654.2341.



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