EX-VR45 • February, 2024
Published for the Basler Electric Power Systems Group

Application Note

Retrofit of the VR 45 Voltage Regulator Made Easy

Excitation retrofits are common as old, obsolete analog excitation systems become reliability concerns.

Component availability issues and technical support are important considerations for operating the synchronous generator reliably to meet market requirements. Older excitation systems were essentially discrete components; each element of control had its own hardware module. The voltage regulator only regulated generator terminal voltage, an excitation limiter was in a separate independent module, and a motor operated potentiometer was an independent module used for remote control of the voltage setpoint.

For a generator excitation system in Billings, Montana, a more complex control was applied. It used redundant VR 45 analog voltage regulators (Figure 1) powered by a single-phase, 360 Hertz permanent magnet generator. The synchronous machine was rated for 65 MW, 13,800 Vac. Because the system was located in the WECC (Western Electric Coordinating Council) region, the excitation system was required to have a power system stabilizer (PSS) as a supplementary control to the voltage regulator to dampen power system oscillations. A var limiter was also incorporated, shared by both voltage regulators but active with only the controlling unit. In the event of the controlling voltage regulator failure, the redundant controller was manually transferred to the backup AVR (Automatic Voltage Regulator) to become the operating controller.

Figure 1. The original VR 45 voltage regulators, transducers, power supplies, and PT/CT test switches

A PSS, installed in the 1970s, represented an early, yet advanced, technology for power system stability of that era. A large amount of panel space was required for the early style PSS, which carried a very expensive purchase price and expensive implementation.

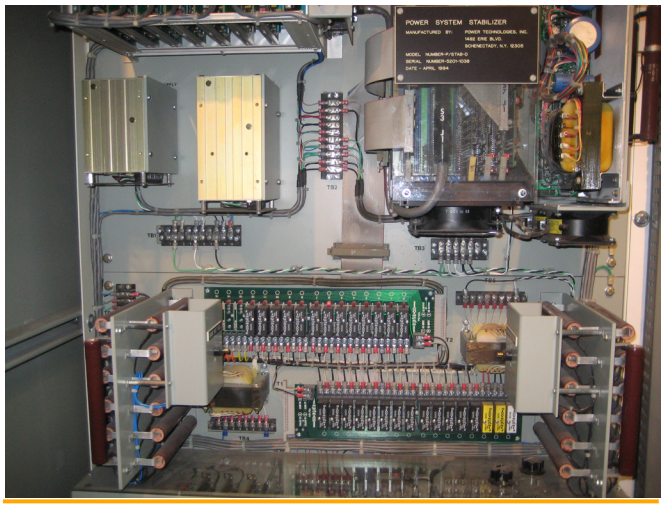

Figure 2. The power system stabilizer, which consumed a large amount of panel space

The technology was based on the integral of accelerating power (PSS2A) that uses a two-input base; one is compensated frequency and the other is electrical power. The PSS provided bidirectional control into the voltage regulator summing point and its control responded by dampening the frequency/power system oscillations.

Retrofit replacement represents the best upgrade solution

Because of a 40-year installation base with parts issues and challenges with the operating equipment, it was decided to replace the old hardware. Dual DECS-250N excitation controllers were selected to maintain redundancy in the application. The advanced features of the DECS-250N controllers provided functionality unavailable in the original equipment.

The original cabinet was reused, so the available space was measured in order to provide a replacement panel that would fit into the same location (Figure 6). Accessories were also evaluated, including automatic synchronizing capability, which is offered with the DECS-250N. The original synchronizer was eliminated and the auto synchronizer function within the DECS-250N was enabled to provide raise/lower control to the governor to synchronize. All of the programming needed for successful

synchronizing was accomplished through the BESTCOMS*Plus*® software. See Figure 3.

DECS-250N testing tools include a dynamic system analyzer and a step test generator. The dynamic system analyzer can be used to determine the generator frequency response to derive the time constants used in the lead/lag filters of the integrated PSS.

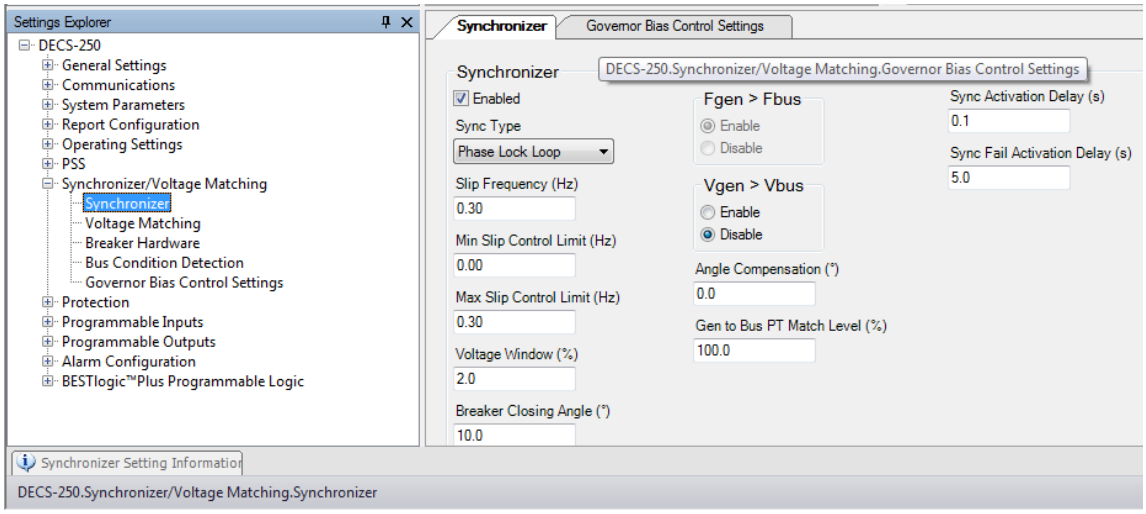

Figure 3. Some of the adjustable parameters for the DECS-250N Auto Synchronizer function

The step test generator can be used to modulate the generator voltage when determining generator voltage response. Figure 4 illustrates the BESTCOMS*Plus* tools available for performing voltage step responses.

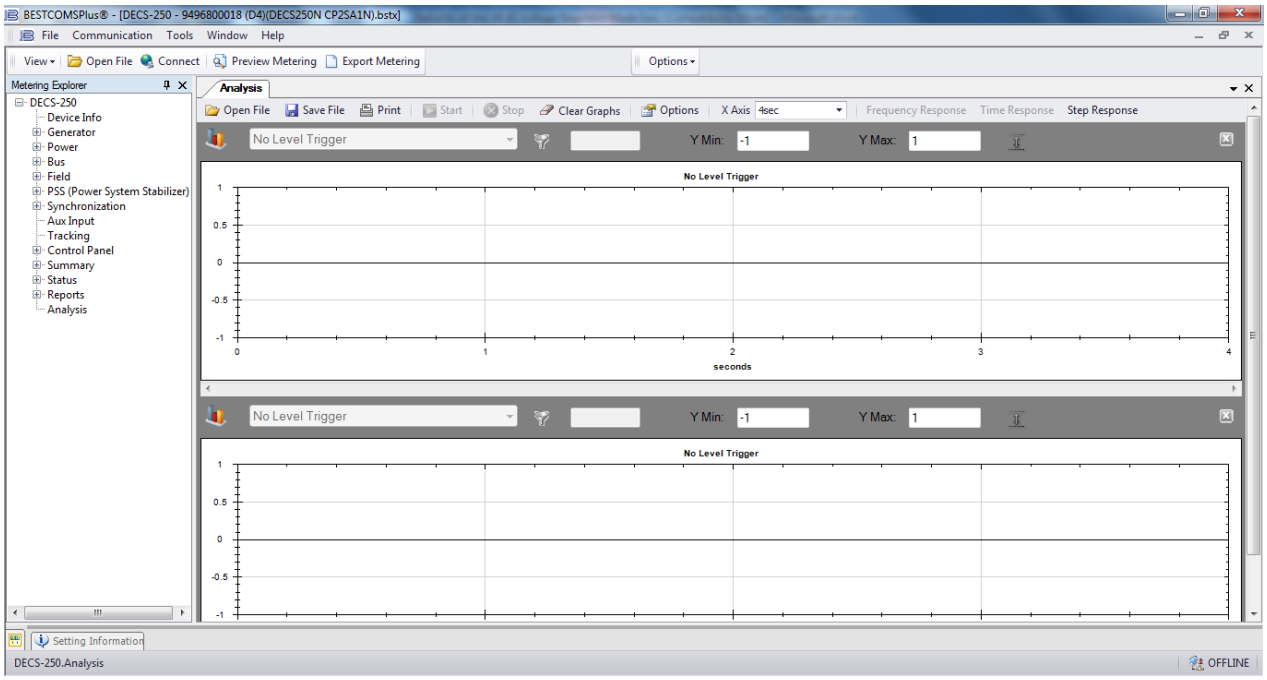

Figure 4. Real-Time Chart Recorder and Voltage Step Response Test Screen for performance recording and evaluation

Performance

The original VR 45 analog voltage regulator had an inherent voltage response of approximately 2 seconds for a 5% voltage step change with a 2-second voltage recovery time and 15% voltage overshoot. The DECS-250N offers a much more favorable response with no voltage overshoot. Figure 5 illustrates a 0.2 second voltage response for a 2% voltage step change that provides excellent transient stability following a system disturbance. Unique to the DECS-250N are two PID setting groups for the gains. The two setting groups are used in applications that utilize the PSS. One PID group is used when the PSS is off, providing a much slower voltage response to ensure good stable response under all circumstances. The second, more aggressive PID setting group is used when the PSS is enabled. During a disturbance, the more aggressive gains provide maximum synchronizing torques that help stabilize the rotor.

A BE1-11*g* Generator Protection System was also added. Its sync-check function serves as a permissive for both manual and automatic generator synchronization.

The DECS-250N-based retrofit offers long-term reliability along with many valuable new features. These features include oscillography, sequence-of-events recording, overexcitation, underexcitation, and var limiters, and autotracking between controllers and operating modes for "bumpless" transfers.

Additional protection features include loss of sensing voltage protection and backup field overcurrent protection. Loss of sensing protection enables continued generator operation in the event of a voltage sensing fuse failure. Backup field overcurrent monitoring stops excitation during an extended period of overexcitation.

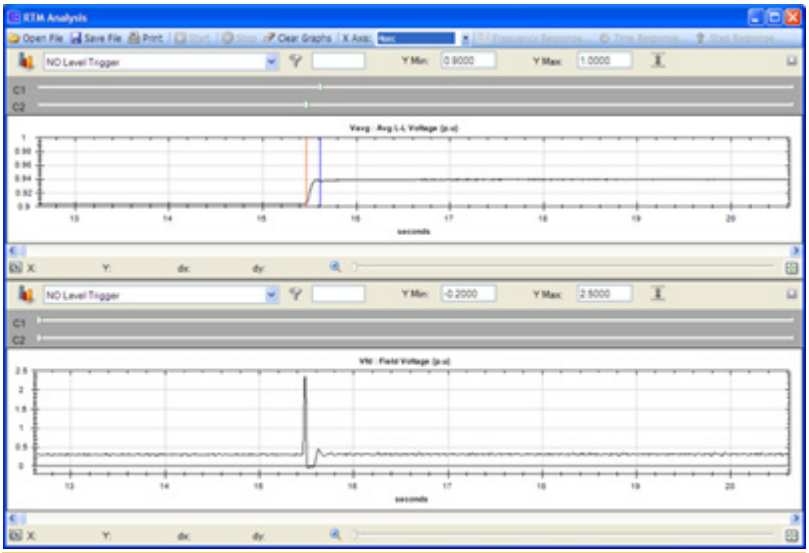

Figure 5. DECS-250N voltage response of 0.2 seconds and essentially no voltage overshoot

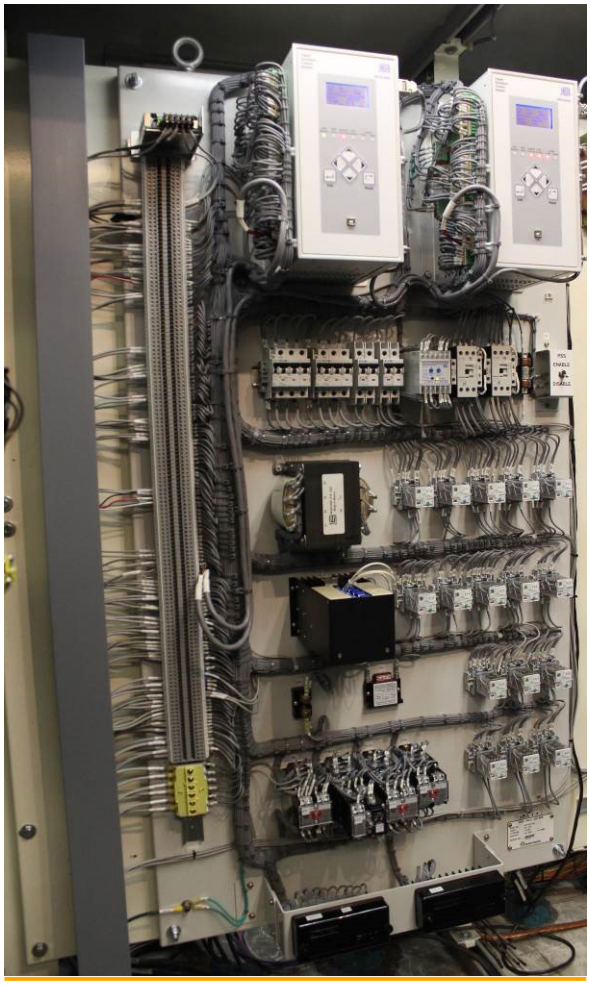

Figure 6. Newly Installed DECS-250N Sub-Panel with Power System Stabilizer and Auto Synchronizing

Figure 7. IDP-801 Interactive Display Panel and legacy controls

Conclusion

The retrofit was successful and added new functionality that provides increased generator reliability. The DECS-250N provides enhanced performance over its VR 45 predecessor while NERC and WECC regional testing requirements are more easily accomplished with the testing tools built into the new excitation system.

For more information

For further assistance with product orders, questions, additional information on BESTCOMS*Plus* software, application notes, product bulletins and instruction manuals, go to www.basler.com, contact your Application Engineer, or contact Technical Support at +1 618.654.2341.

Figure 8. The BE1-11*g* Generator Protection System

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

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