

Application Note

Alterrex System Response Using Alterrex Output Power Versus an External Station Power Source

The Alterrex excitation system was developed in the early 1970s for large steam plants. The excitation system consisted of an ac rotating exciter known as the Alterrex, whose output was rectified via stationary diode rectifier bridges mounted in the doghouse of the generator. Despite years of successful operation, today it is becoming increasingly popular to replace the Alterrex voltage regulator for a new excitation system as obsolescence has resulted in maintenance and performance issues with the existing analog voltage regulator.



Figure 1: Large steam turbine generators often utilized the Alterrex excitation system.

As voltage regulator retrofits are becoming common, one issue today is where to derive power for the new voltage regulator. In the original configuration, the excitation system obtained its power from the Alterrex output via a power transformer that stepped down the ac Alterrex output voltage to an acceptable voltage level for the voltage regulator rectifier bridge. For the time, excitation response was considered acceptable since power system stabilizers were not very common and high initial response excitation systems were not required to satisfy transient stability needs. But that was then and today with blackouts in the Northwest and Northeast, accompanied by the passage of the 2005 Energy Act, system reliability has become an increasingly important issue.

Reliability translates into a number of issues that need to be addressed, one of which is predictable generator and excitation performance during and after a fault. Transient and steady state stability are primary concerns that involve how a generator and excitation system will respond after a disturbance. Very fast excitation systems help provide the transient stability needed to bring the generator rotor back to its steady state position after a system fault. While steady state stability involves the ability for the synchronous machine to remain stable after the first and second rotor swing.

The characteristic response of the excitation system involves a number of factors including:

- Excitation Controller Gain
- Magnitude of Field Forcing, both positive and negative
- Exciter Saturation

Performance Measure

For new excitation systems combined with the addition of a power system stabilizer, optimum performance is achieved when the voltage regulator response has aggressive rise time and minimum phase lag over a bandwidth of at least 3 Hertz. The paper "Criteria to Determine Excitation System Suitability for a PSS in the WSCC System" presented in January 1993 discusses that optimum power system stabilizer performance is achieved when the maximum phase lag of the voltage regulator at 1 Hertz is not more than 135 degrees phase lag. To reach this performance, the voltage regulator requires a fast rise time.

Whether bridge power is obtained from either the Alterrex output or from station power will dramatically affect the generator and excitation performance.

Alterrex Powered Excitation System

Choosing the power from the Alterrex exciter ac output as in the past will limit the response and provide nonlinear control into the exciter field, particularly when power

system stabilizers are required. The problem using the Alterrex output is that it is nonsymmetrical. The field forcing capacity goes up when boost occurs, but does not go proportionally negative when the output of the Alterrex voltage drops due to a decaying voltage into the bridge. Therefore, it causes a nonlinearity into the field that will affect the generator voltage response. See Figure 2.

External Powered Excitation System

Optimum control is provided under any system condition when the bridge power is derived from an external power source, maximum field forcing is achieved under any condition, and linear generator performance is obtained. See Figure 3. The additional benefit of a fast excitation system is optimum fault clearing time and the avoidance of pole slip due to too slow of a voltage regulator response. Using an externally powered excitation system, performance gained is significant. Raise time is ten times faster and phase lag is reduced significantly requiring less filtering for the power system stabilizer.

A number of simulations were created to demonstrate the two approaches of where bridge power is derived. The Alterrex system was modeled using a RTDS (Real Time

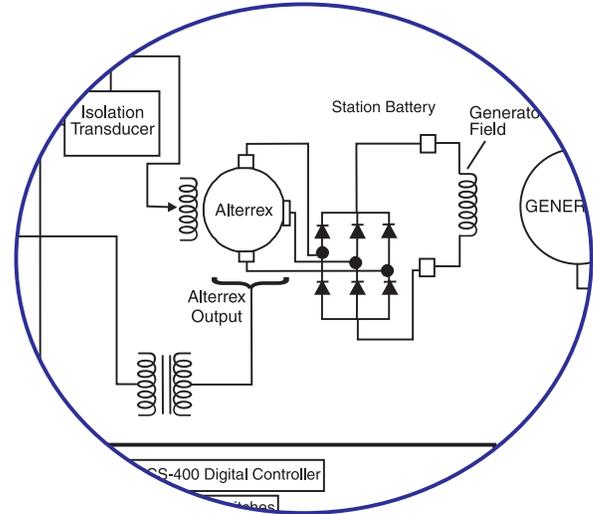


Figure 2: Alterrex power output driving the excitation rectifier

Dynamic Simulator) program. Two systems have been simulated to check the effectiveness of one power source versus another. In one system, the Alterrex output is used, having non-linearity, and the other utilizes a separate power input of negative forcing. With negative forcing, a high regulator gain is achieved providing faster response in the simulations.

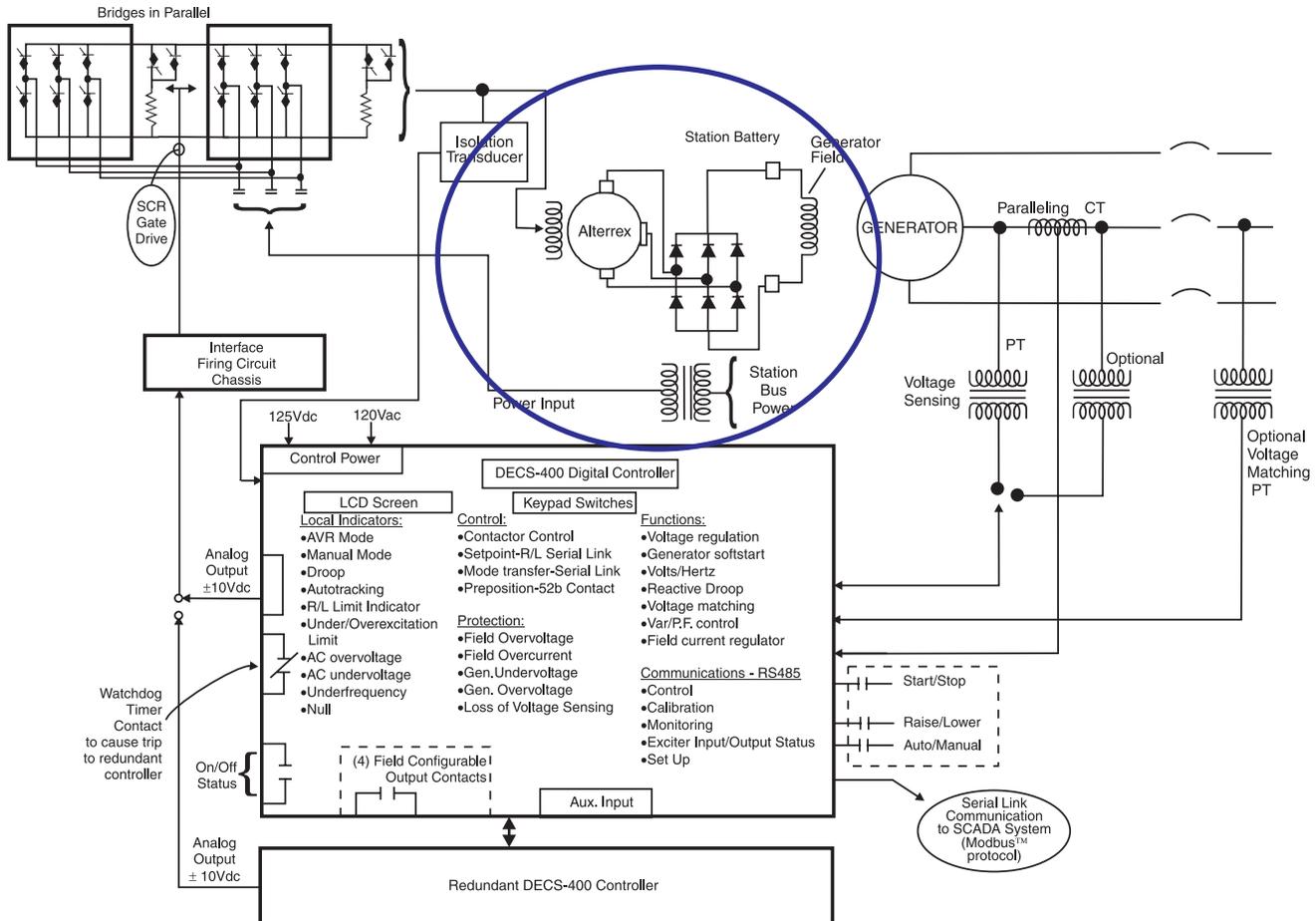


Figure 3: System block diagram showing the excitation system using the external power source for the bridge

Simulation Analysis

Figure 4 (a) illustrates a nonnegative field forcing excitation system having slower system response. The voltage regulator response is 2 seconds and the phase lag at 1 Hertz is -156 degrees, which exceeds the recommended criteria for phase lag.

Figures 5 (a) and (b) demonstrate the faster excitation system with negative forcing using an external station power source. Note the negative forcing regulator output. In Figure 5 (b) increased controller gain and improved generator response is exhibited using external power. Here, the voltage response is only 0.5 seconds and the phase delays at 1.0 Hz is only -88 degrees.

	Response time	Phase delay at 1.0 Hz	Negative forcing
Slow system	2.0 sec	-156 degree	Not available - Alterrex Output
Fast system	0.5 sec	-88 degree	With Negative Field Forcing: External Power

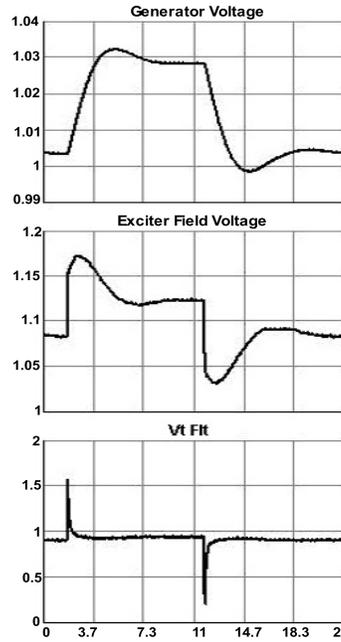


Figure 4a: Slow system

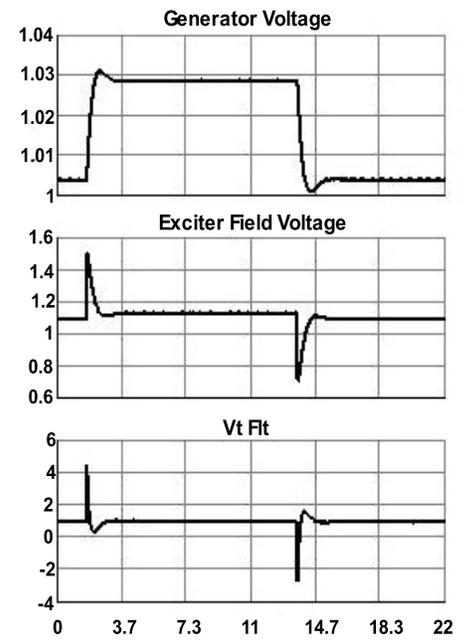


Figure 4b: Fast system

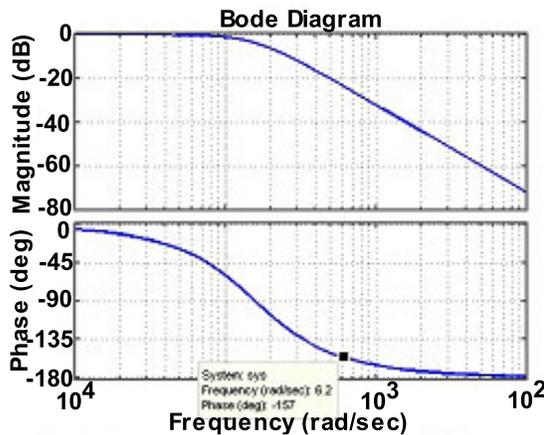


Figure 5a: 2.0 second response time Alterrex Exciter Power -157 Degree Phase Lag at 1 Hertz

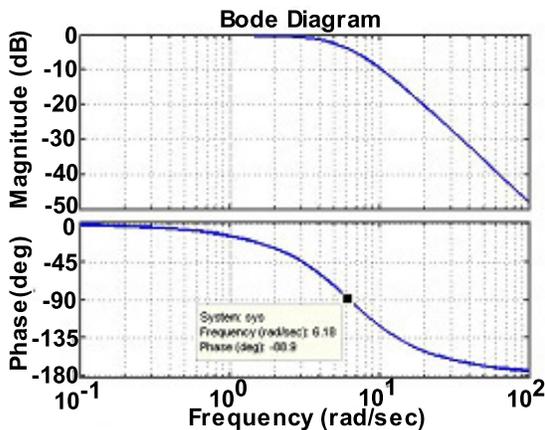
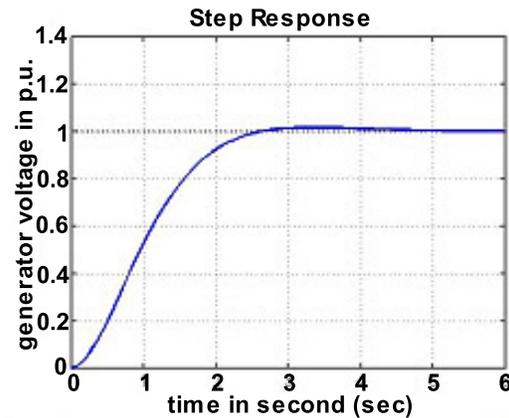


Figure 5b: 0.5 second response time- External Power -88 Degree Phase Lag at 1 Hertz

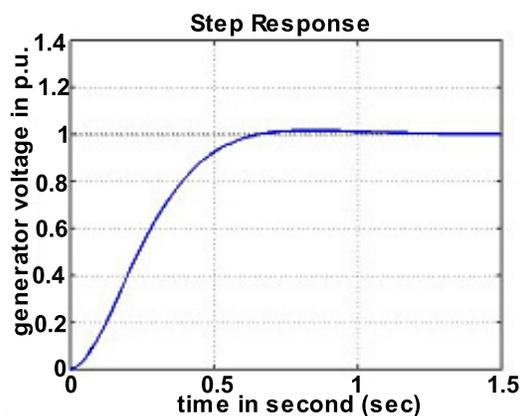


Figure 5a and b: Phase delay at 1 Hz for the system with various response times. (Minimum phase lag delay for proper application of a power system stabilizer is -135 degrees.)

Actual Performance Analysis

Actual generator performance is compared with the simulations provided in Figure 5 (b) using an external power source for the power rectifier bridge. Here, a 600 MW generator with external power applied to the excitation system noted in the simulations. Figure 6 illustrates a voltage step response of 2%. Notice the voltage recovery time is only .2 seconds for the voltage step up and down. Using a dynamic system analyzer internal to the excitation system, a frequency response is performed providing the excitation system bandwidth, note the phase lag is -90 degrees at 1.0 Hertz characterizing a very fast excitation system for transient stability. See Figure 7.

Conclusion

Today, with limited transmission and the focus on system reliability mandated by the Energy Act of 2005, the need to provide optimum generator excitation performance is critically important. A fast excitation system affects the transient stability of the transmission system and the ability for the system to recover. Where power system stabilizers are becoming increasingly common for machines 35 MVA and above, the power source driving the power rectifier bridge becomes a critical component to the equation for generator excitation system response. With external power to the power bridge, the performance expectations of the system are achieved.

For More Information

For information on Basler's complete range of exciter solutions, visit the download section at www.basler.com to access product documentation, Application Notes, and Technical Papers.

To discuss your application, consult Basler at the factory at 618.654.2341.

Reference Papers

- Criteria to Determine Excitation System Suitability for PSS in WSCC System, WSCC Modelling Work Group, December 17, 1992
- Suitability of Excitation Systems for Power System Stabilizer Application, Beaulieu, R.E.; Coultres, M.E., Power Engineering Society General Meeting, 2003, IEEE Volume 3, Issue , 13-17 July 2003 Page(s): - 1791 Vol. 3

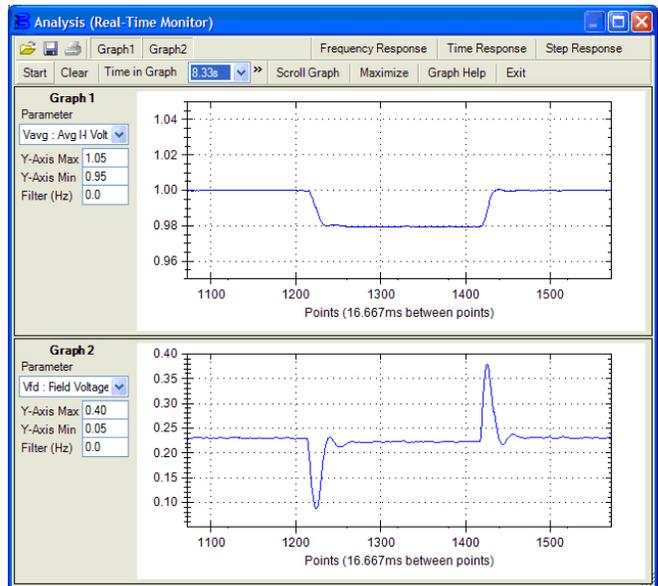


Figure 6: 2% voltage Step, 0.2 Second Voltage Recovery, No Voltage Overshoot 600 MW steam turbine generator with Alterrex Rotating Exciter and External Power

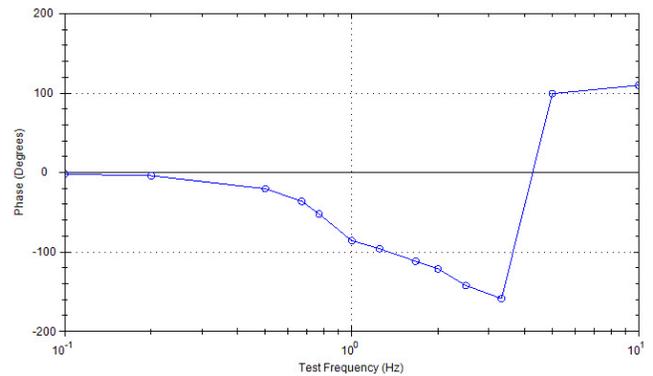


Figure 7: Generator Excitation Frequency Response, 1.0 Hertz -90 Degree Phase Lag. 600 MW steam turbine generator with Alterrex Rotating Exciter and External Power