Maximizing Benefits of Temporary Generator Overexcited Capability: A Special Technical Session on New Operating Concepts

J. C. Agee, Senior Member, Chair
jagee@ieee.org
Bureau of Reclamation
Denver, CO

Abstract: This special technical session brings together experts in power system voltage stability, synchronous machine design, excitation system design, and power system operation to evaluate the best methods for obtaining the most benefit to the power system from temporary overexcitation of synchronous generators.

Keywords: *Power System Voltage Stability, Overexcitation Limiter, Rotor Current Protection, Synchronous Machine Excitation Control*

1. Background

When power system voltage is depressed in a particular area, nearby generator voltage regulators increase excitation to counteract the voltage decline. If enough voltage support is available the voltage will be restored; however, voltage regulator action may cause some generators to operate beyond their steady-state field current limits.

To prevent damage most generator excitation systems include limiters and/or protection to prevent operation above rated field current for an extended time. When these devices operate to reduce excitation, the original problem of depressed voltage may reoccur and become even worse as other generators subsequently overload and become limited.

Transmission system operators would prefer generators to provide voltage support for longer periods of time so other remedial actions can be taken before the support from generators is lost. Generation owners, on the other hand, want to prevent damage to their machines by removing all overloads quickly. Getting the most benefit from each generator while still protecting it from damage will require new standards, methods, and procedures.

2. Field Winding Overload Standards

The current standard for field winding short-time thermal capability is found in ANSI C50.13. [1] Machines designed to this standard must withstand temporary field current overloads as defined in Table 1. This standard provides minimum requirements for synchronous machines; however, many machines may have significantly more rotor thermal capability than this minimum level. Deciding when and how to use this additional capability is a challenge for generation owners.

Table 1 - Field Winding Short-Time Thermal Capability

Time (s)	10	30	60	120
Field Voltage (%)	208	146	125	112

C50.13 also provides armature winding overload requirements as shown in Table 2. These levels may also be reached during times of depressed voltage and excitation boosting; however, generation owners will probably not be as likely to operate beyond this curve as most machines are not built with excess armature thermal capability. In fact, operators (or new digital regulator armature current limiters) may reduce excitation further in an effort to remove overloads. In some cases, generators may trip off-line due to (voltage-restrained or voltage-controlled) overcurrent relay action.

Table 2 - Armature Short-Time Thermal Capability

Time (s)	10	30	60	120
Field Voltage (%)	226	154	130	116

3. Field Winding Protection Methods

Generator field windings can be protected by both limiting and protective devices. Field winding current limiters, known as OELs (Overexcitation Limiters), are feedback control loops associated with voltage regulators that control the field current or voltage to a variable setpoint that is based on the ANSI field winding capability. Field winding protection may transfer control from the voltage regulator to a fixed field level, transfer to a manual field regulator that can be controlled only by a plant operator, or may take the drastic step of tripping a unit off-line. Modern excitation systems employ both limiters and protection; however, older units may have only protection. Most of these devices do not use field temperature.

If a generation owner decides to operate beyond the ANSI field winding curve, a temperature-based limiting and protection scheme will probably be used. Therefore, determining the field winding temperature will be required. Several of the session papers address systems of this type. In addition, this may cause the most restrictive limiting factor to shift from field current to armature current. Thus a method for detecting armature current overloads should be used in voltage stability studies. [2]

4. Procedures to Avert Voltage Collapse

When a transmission line trips out of service and causes voltages to sag, system operators have less than two minutes to perform remedial actions if traditional generator OELs are active. But this vital information on the status of OELs is not normally available to system operators. Augmenting power system status with this type of information, whether communicated from generation owners or inferred from other plant states, coupled with enhanced use of field winding capability may prevent voltage collapse.

In addition to technical enhancements, economic incentives may be required to persuade generation owners to perform studies, invest in new equipment, or readjust existing field current protective equipment, since the benefit is to the overall power system. Operating beyond traditional field current limits gives the perception of additional risks, whether real or imagined. In the restructured power system environment, risk without reward will most likely not be pursued.

5. Conclusions

To maximize the benefits of temporary generator overexcitation, transmission system operators must work with generation owners to determine the location of critical units and ensure that these units have the resources to provide temporary voltage support in emergencies. Other countermeasures may still have to be employed; however, implementing some of the ideas and equipment proposed in this session may buy extra time for system operators to prevent widespread blackouts.

References

[1] ANSI C50.13-1989, *American National Standard for Rotating Electrical Machinery – Cylindrical-Rotor Synchronous Generators*, American National Standards Institute, Inc., New York, January, 1989.

[2] C. W. Taylor, *Power System Voltage Stability*, McGraw-Hill, Inc., New York, 1994.

Biography

J. C. Agee received his BSEE degree from Rose-Hulman Institute of Technology in 1979. Upon graduation, he joined the Bureau of Reclamation as a power systems engineer. He is currently employed in the Hydroelectric Research and Technical Services Group as a technical specialist in the fields of governor control, excitation control, and power system stability. His research interests include feedback control systems, microprocessor control, and power system stability analysis. He is a senior member of IEEE and is currently chair of the IEEE Excitation Systems Subcommittee.