ABB generation protection and control systems
Subsynchronous oscillations

As the owner/operator of critical generation assets and considering the increased installation of HVDC, Series Capacitors and SVCs, your generators are susceptible to torsional stress and fatigue. ABB generation protection solutions monitor and detect subsynchronous oscillations, safeguarding your assets.

Challenges
Your unit was delivered more than 10 years ago and is approaching its first, or perhaps second, protection upgrade. Regulatory requirements, grid modernization phenomena such as subsynchronous oscillations, operational and footprint challenges are all driving the requirements for your next upgrade decision. Your current system has served you well, but aspects of its design will become increasingly problematic:

- It is based on electromechanical or first generation microprocessor generator protection relays deploying antiquated protection philosophies, exposing generation assets to greater risk.
- It shuts down when the frequency is less than 55 Hz, leaving your unit unprotected.
- It does not offer protection against stator or rotor winding earth faults.
- NERC/PRC regulations have significantly increased your disturbance reporting obligations and maintenance efforts.
- It cannot detect and respond to subsynchronous oscillations and subsynchronous resonance coming from your grid connection.
- It is not compatible with the latest protection and control technologies available in the digital world.

Situational analysis/background
Improvements in grid stability have increased the utilization of series compensated transmission lines, high voltage direct current (HVDC), static VAR compensators (SVC) and flexible AC systems (FACTS). While improving system stability and power flow, the addition of these modern transmission systems may have a significant impact on turbine generators as they can create subsynchronous oscillations that adversely affect the generator. The SSO phenomena can also be present if your generator is in proximity to wind farms, where the farms’ active control can result in oscillations onto the grid.

Subsynchronous oscillations (SSO) fall into subcategories: torsional interaction (TI) and torque amplification (TA).

- **Subsynchronous torsional interaction (SSTI)** occurs when the electrical system operation causes mechanical damping at the generator, and that is sufficiently large to exceed the inherent mechanical damping of the shaft at a natural torsional frequency of the mechanical system. This can occur because of a subsynchronous resonance (SSR) with series capacitors, or because of the control action of devices such as HVDC converters, SVCs and STATCOMS.
• **Torque amplification** occurs when the resonance between a series capacitor and a machine results in shaft stresses following a disturbance higher than would be experienced without the resonance. 

Subsynchronous phenomena effects on a turbine generator can be understood by:

• Representing two masses on the ends of the generator shaft where the masses interact to establish torsional oscillations.
• Perturbations of the mechanical system stimulate these oscillations resulting from a sudden change in torque from the governor system, or sudden changes in electrical torque caused by faults or rapid load changes.

These oscillations occur at the natural frequency of the system as determined by the relative sizes of the masses and the stiffness of the shaft connecting them. At the generator, the rotational speed increases and decreases in an oscillatory manner, resulting in currents that have frequencies above and below the grid frequency, by the frequency of the shaft oscillations. If the system conditions at these new, off-nominal frequencies align with series capacitors or active devices, these oscillations may be sustained for significant durations.

Generators connected in relative proximity to these modern transmission stability systems (e.g., series capacitors) are at greatest risk to torsional oscillations and the conditions creating the perturbed mechanical state. The off-nominal frequency interaction fatigues the generator shaft and, with persistence, can result in a catastrophic mechanical failure, or greatly diminish the generator shaft life.

**Points to consider**

• What components of your generator protection and control system are original equipment?
• Which components have previously been upgraded?
• When were the upgrades performed?
• When is your next planned generator outage?
• Upgrade outage?
• Do you operate as a base load unit or as a peaking unit? If peaking, roughly how many starts per year?
• Do your existing generation assets utilize advanced protection solutions capable of protecting 100% of the stator and rotor windings from earth faults?
• Have you been impacted by subsynchronous oscillations or subsynchronous resonance?

• Are you in proximity to:
  - HVDC devices
  - Series capacitance, STATCOM, SVC or other active devices
  - Wind farms

• Are you able to comply with all the requirements of NERC/PRC as it pertains to generators?

**The solution**

ABB can deliver the power of one solution for protection and control increasing the capability in a significantly smaller footprint, while safeguarding aging generation assets. ABB's REG670 protection solution is the first of its kind to introduce SSO detection in a modern generator protection system. Although SSO control is best addressed at the source (HVDC, SC, wind farm, etc), plant owners should monitor the transmission interconnect to detect if generator assets are at risk of damage due to subsynchronous phenomena.

The advanced SSO detection application makes ABB's generator solutions the keystone in meeting your plant demands. ABB also has domain experts that can assist in the power system analysis of SSOs in proximity to your generation assets.

**Advanced applications**

• Generator and unit transformer protection in one protection device
• ABB's patented turn-to-turn winding detection for ultrafast fault detection and clearance
• ABB's patented frequency tracking algorithm to protect the asset during generator startup and shutdown
• Smaller footprint, reduced control system wiring and integrated control for flexible automation
• NERC/PRC compliant trending, reporting and display
• Synchronizing and excitation systems for automatic voltage regulations for synchronous generators

**Next steps**

Arrange a visit from our technical team to discuss

• The latest technological advances in generator protection and control
• SSO and the impact on your system
• Requirements for your next generator protection and control upgrade and a budgetary estimate for ABB solutions