GE
Energy

Series Compensation Systems



imagination at work

Realizing maximum power transfer at the lowest possible cost is one of the greatest challenges today for transmission system operators. In meeting this challenge, **series compensation systems** represent a very cost effective and reliable means of increasing bulk power transfer and relieving power transmission bottlenecks.

Over the past three decades, the application of series compensation has steadily increased worldwide as transmission grid operators recognize the many benefits of these systems. Series compensation systems counteract the natural impedance of transmission lines, thereby increasing the power transfer capability.

Series compensation may also be applied to increase the dynamic stability of the transmission grid, reducing voltage variation, or to balance load between parallel transmission paths, thereby relieving transmission bottlenecks. These systems can be installed for a fraction of the cost of building new transmission lines. Series compensation has been economically justified when applied to transmission lines as short as 100 miles or less, and systems typically have a payback period of less than two years. The environmental impact is minimal—series compensation systems have typically been installed within existing substations.

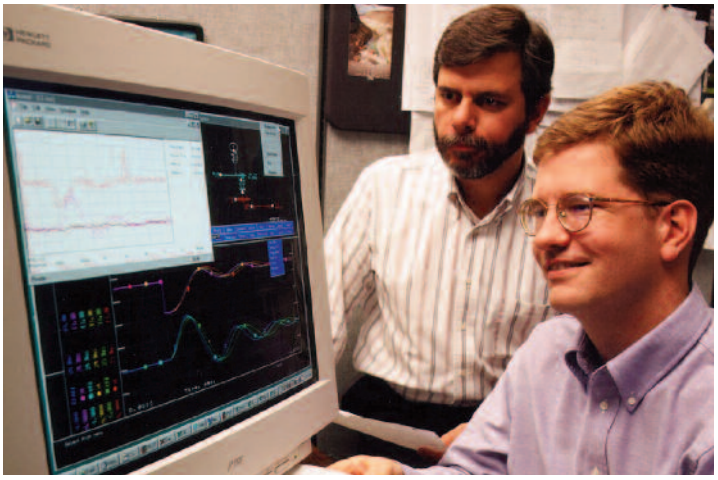
Series compensation systems are comprised of equipment that is familiar to substation operating personnel. The systems are self-regulating and, in many cases, are placed in remote unmanned substations. Maintenance requirements are minimal. Systems we have built have delivered outstanding availability over 30-year life spans.

Our experience in series compensation systems dates back to 1928, when we pioneered this technology with the first installation on the emerging US transmission grid. Our company has installed more than 100 systems globally, representing more than 30 GVAr of compensation.

Unequalled Power System Expertise

Our Energy Consulting group, located in Schenectady, New York, originated over 100 years ago with the early Edison Electric Laboratories and has been involved throughout the evolution of transmission systems worldwide. The expertise of this group is unparalleled when it comes to understanding electrical transmission system operation and reliability.

This organization maintains experts in the phenomena associated with series compensation such as sub-synchronous resonance (SSR)—a harmonic interaction with turbine-generators directly connected to a compensated transmission line.



Depth of Experience in Series Compensation Application

GE engineers have applied dozens of systems over the past decade in a wide variety of power system situations. As a result, GE possesses a unique depth of experience and insight into detailed application considerations. GE's application expertise, when combined with its power system expertise, assures that series compensation may be applied with confidence regardless of transmission system topology.

Superior Equipment & System Design

Our series compensation systems are based on robust, proven equipment and technology. The principal component is the power capacitor. Our All Film Capacitor with patterned foil was first introduced in the early 1970s. This robust capacitor design continues to deliver outstanding reliability with a field failure rate in series applications of less than 0.02%. We continue to enhance the quality and reliability of this proven capacitor design.

Our design flexibility enables our customers to choose among fuseless, externally fused or internally fused capacitor units.

The primary protection of the capacitor under electrical system disturbances is provided by the **Metal Oxide Varistor** (MOV). We pioneered the introduction of MOVs in power system applications, placing into service the world's first varistor-based protection system for series compensation in 1979. We have installed more series compensation systems featuring an MOV only protection scheme than any other supplier. The field reliability of the GE varistors has been excellent, with a reported failure rate below 0.01%.

In many applications, cost and operational requirements call for the protective circuit to include a bypass triggered air gap. Working with physicists at GE's Global Research Center, GE design engineers developed a **Triggered Air Gap** utilizing a unique Plasma Injection System based on a proprietary GE polymer. This Plasma Injection System features full redundancy, a passive triggering system, and the fastest conduction speed in the industry, all of which result in a more robust system with greater design margin. This gap design has been rigorously tested in the lab and during natural transmission line faults, as well as staged fault testing in the field.

We have also developed a digital programmable logic controller-based **Protection & Control System** specifically for transmission series compensation applications. All protection logic is implemented in software, at ground level utilizing a robust industrial-grade PLC. Monitoring and control is available via a graphical HMI. The Protection and Control System features an open-architecture, modular design based on commercially available hardware and software. This system offers a high level of flexibility in a compact design.

These major components are integrated into a total series compensation system tailored to meet the specific requirements of each application. The project engineering team has a broad spectrum of design disciplines, depth of experience, and works to ensure that each system design fully meets the specific requirements of the application.

Excellence in Project Management

Each series compensation project, from the supply of an equipment package to a full Engineer, Procure, Construct (EPC) system, is assigned an experienced and dedicated project team. This team is clearly identified and involved from the project kickoff through commissioning. A project manager, who has primary responsibility for the implementation of the project and provides a single point of contact between our company and the owner, leads the team. Our project management approach follows a well-established set of processes and procedures, certified to ISO 9001 standards.

Center of Excellence

Our extensive resources and expertise in series compensation are coupled with those of the EPC sub-station and switchyard projects organization. We will engage a team of experienced engineers, administrators, purchasing personnel, site managers, designers, and draftspersons under a dedicated project manager with one mission: to be certain that every series compensation project is a positive experience for our customer.

Post-Installation Service

Our dedication to quality remains in place over the life of the equipment. We have an extensive network of field engineering offices and service centers capable of responding immediately to any urgent situation that may arise once the equipment is placed in service. Advancements in the Protection and Control system allow our engineers to monitor, diagnose, and in some cases correct issues remotely on a moment's notice in the rare event that our system experiences a problem. A qualified representative is only hours, if not minutes away, to ensure world-class responsiveness to in-service issues.

A Projects Team Driven by Six Sigma Quality... Certified ISO Compliant

World-class quality is a way of life at GE; it's our culture. We strive to achieve customer satisfaction by meeting all aspects of our customers' expectations. Across GE, the Six Sigma quality initiative is bringing intensity, focus and discipline to improving how products and services are designed and delivered.

Processes that have been improved through the rigor of Six Sigma include:

- Standardization on many engineering-intensive sub-system designs, resulting in faster delivery of design documentation and greater utilization of proven designs
- Reduction in the overall delivery cycle of critical path items, allowing faster project completion cycles and a greater assurance that critical project dates will be met
- Development of a sourced equipment order tracking software tool to assist the GE team in being certain that all elements of a project are proceeding on schedule
- Expansion of GE's digitalized design libraries, giving engineers greater access to prior system designs and allowing customers full benefit from GE's prior system design experience

Six Sigma is a vision that GE strives toward, and a philosophy that is imbedded in our business culture. It has changed the DNA of GE, focusing us on delivering greater value to our customers. In short, Six Sigma is "the way we work."

In 1997, our quality system was assessed by Underwriters Laboratories Inc. (UL) and found to be compliant with ISO 9001 for the design of reactive compensation systems. More recently, UL re-certified our group to be compliant with the 2000 ISO standards. ISO 9001 is a global quality assurance model used by companies that design, produce, inspect, test, install, and service items.

For more information on Series Compensation Systems, please contact your local GE Energy sales representative or visit us at ge.com/energy.

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