FLEXIBLE AC TRANSMISSION SYSTEMS
SOLUTIONS TO OPTIMIZE NETWORK PERFORMANCE
Today’s fast-growing global energy demand is faced with a rapidly evolving energy market. Globalization and market deregulation continue to pave ways for renewable energy integration and distributed energy resources.

This, however, adds a layer of complexity to the ageing transmission grid, which now increasingly experiences bottlenecks and overall power transmission instability. With some networks built as early as the 1960s, these grid infrastructures were simply not meant to handle large amounts of power transmission across long distances and at higher voltage levels. This raises the question of transmission cost-effectiveness because of power losses on an inadequate infrastructure.

Flexible AC Transmission Systems (FACTS) address such challenges by improving power transmission system performance, quickly and efficiently with minimal infrastructure investment.

**Key FACTS benefits**

- Increased grid stability and power quality
- Flexibility and uptime from short lead times
- Balance reactive power to provide fast voltage control
- Easy integration with existing substations
- Quick return on investment
Growing energy demand has dramatically increased the volume of power flowing through the networks, and with it, greater volatility. While building new efficient transmission lines is one solution, it is a significant financial and long-term investment. Getting approvals and permits for suitable electricity transmission “corridors” is difficult and time-consuming, to say nothing of the undesirable carbon footprint associated with such investments.

As the 21st century grapples with the restructuring of the grid, Flexible AC Transmission Systems (FACTS) have emerged as an attractive solution for boosting performance of existing transmission and distribution assets.

Over the past 50 years, Alstom has installed more than 450 FACTS projects worldwide, developing a comprehensive range of cost-effective solutions for our customers with the following aims: increased productivity, reduced utility charges and improved equipment life.
As one of the world’s leading providers of grid solutions and a global leader in power electronics, Alstom has developed a range of cost-effective solutions to optimize power quality and security. This in turn maximizes asset availability, enhances service quality and reduces operating costs. Our comprehensive portfolio of FACTS devices is dedicated to enhancing the power quality and performance of our customers' AC transmission systems around the world.

The difference in more control

Alstom’s FACTS equipment are designed to give network suppliers and industrial energy managers more control. With FACTS, grid operators can gain accurate control of reactive power and voltage in the network, maximize power flow along existing lines and improve steady-state and dynamic stability within the system.

A FACTS solution installed in an industrial power supply give the energy manager control over stability while managing acceptable voltage fluctuations created by rapidly varying reactive power demands. The results are increased productivity, reduced utility charges and improved equipment life.

Alstom’s innovative expertise and turnkey approach to FACTS technologies provide customers with a flexible solution that has minimal infrastructure investment, low environmental impact and rapid implementation time.
Transmission Systems
with greater flexibility

As one of the world’s leading providers of grid solutions and a global leader in power electronics, Alstom has over 50 years of experience in FACTS solutions and over 450 projects installed worldwide.

Alstom covers the entire value chain with a full range of competences

Shunt compensation
Shunt compensation devices are connected in parallel with the power system. Such devices regulate voltage, stabilizes the network, improve transient stability and increase power transmission.

Series compensation
Series capacitors are connected in series with the transmission lines. They reduce transmission losses and voltage line drop, while also increasing active power transfer capability.

State-of-the-art for customers
Alstom’s team of highly qualified experts use state-of-the-art technology to continue advances in equipment and project design. The use of computerized modelling has brought significant gains in efficiency over the last decade and Alstom has been at the forefront of these efficiency increases, knowing that it brings higher output for our customers.

Our sophisticated technology includes a real-time digital simulator (RTDS) that guarantees exact and prompt modelling of customer specific applications. The development and testing of our systems in the RTDS environment reduces project risk, accelerates commissioning, saves cost and ensures that the final technical solution meets customer requirements.

Our experts also carry out complete studies for the design of the series capacitor bank, including system transient, fault analysis, seismic studies, protection coordination and other required studies.
Alstom tailors its Static VAr Compensation (SVC) solutions, based on standard components, to customer needs. Because of its fast response times, SVC ensures grid stability with a reliable means of balancing the reactive power at the point of connection, thus providing fast voltage control. SVC absorbs inductive reactive power when the voltage is too high, and generates capacitive reactive power when the voltage is too low. By maintaining voltage stability via reactive power control, SVC improves network dynamic stability while increasing power transfer capability.

Shunt compensation

Alstom has over 350 installations worldwide

Customer benefits

- Improves efficiency of AC transmission systems
- Allows better integration of renewable energies into networks
- Balances reactive power to provide fast and accurate voltage control
- Improves network stability
- Improves power quality
- Offers quick return on investment
As utilities move away from fossil fuel generation to make way for renewable and distributed energy sources, grid networks have become increasingly destabilized, posing a real challenge for network managers.

Alstom’s expertise in FACTS paves the way for a more powerful grid.

Static VAr Compensation (SVC)
Fast voltage support for grid stability

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SVC MaxSine™ (STATCOM)
Dynamic support

SVC MaxSine™ is a STATCOM solution with Alstom’s patented direct current control. These dynamic voltage source converter-based compensators offer even faster response times than SVCs with improved range of operational voltage and a smaller overall footprint.

SVC MaxSine™ can compensate fundamental reactive power, control voltage and eliminate harmonic current depending on the selected operation with a high dynamic performance, ideal for rapidly fluctuating network conditions.
Alstom has over 350 static var compensation projects installed worldwide. We have been manufacturing state-of-the-art, high quality equipment for over half a century, with expert services specially catered to unique customer needs.

**BEAULY (SCOTLAND)**

The world’s first Static VAr Compensator with Alstom’s patented blocking reactor. Turnkey project including studies, design, equipment delivery and commissioning.

Client: Scottish & Southern Energy  
Rating: ±150 MVAr, 275 kV  
Project completion: 2013

The Beauly project began at the end of 2010 and was delivered 3 month early to the customer, successfully passing tests to meet Scottish & Southern Energy’s requirement for superior harmonic performances.

**LA MERLATIERE AND DOMLOUP (FRANCE)**

Client: Réseau de Transport d’Electricité  
Rating: ±250 MVAr, 225 kV  
Project completion: 2013

**KANGASALA (FINLAND)**

The first SVC dedicated to power oscillation damping in the Finnish transmission network. Turnkey project including studies, design, equipment delivery and commissioning.

Client: Fingrid  
Rating: -200/+240 MVAr  
Project completion: 2009

This first SVC was installed in the Finnish transmission network to address the increase of new, large power generation units and HVDC connections in the grid. Because Finland, Norway, Sweden and Denmark all belong to the same Nordic transmission system, the SVC was installed to maintain grid stability and inter-regional transmission capacity, delivering superior performance since 2009.

**Harmonic performance**

The main reactor concept efficiently isolates harmonics in a two-way manner, from network to SVC and from SVC to network, even in demanding network conditions.

Because of improved harmonic performance, fewer harmonic filters are necessary and thus, enabling a compact, optimized SVC layout.

**Patented SVC configuration with main reactor**

Alstom recently developed an innovative SVC configuration, consisting of a main reactor, that significantly improves harmonic performance. The patented concept, which has already been successfully executed in two projects, highlights the continued importance of SVCs as a FACTS solution that is both cost- and performance-efficient.

Traditionally, the SVC bus is connected directly to the SVC main transformer secondary. In the new configuration, the SVC bus is separated from main transformer by the main reactor. The new arrangement results in two different secondary buses. The bus between the main transformer and main reactor is the connection point for auxiliary transformer due to its more stable voltage. The bus after the main reactor is the connection point for TCR and harmonic filters, and is therefore exposed to a larger voltage fluctuation.

**Benefits of the main reactor concept**

- Superior harmonic performances  
- Increased availability of grid network  
- Improved power quality with lower power losses  
- Compact design with reduced footprint compared to classic SVC
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**LA MERLATIERE AND DOMLOUP (FRANCE)**

Client: Réseau de Transport d’Electricité  
Rating: ±250 MVAr, 225 kV  
Project completion: 2013

La Merlatière and Domloup were two French communes selected by RTE for SVC installations to ensure high availability and dynamic performances. The two large SVCs are each configured with blocking reactors for superior harmonic performances. Turnkey project including studies, design, equipment delivery and commissioning.

**KANGASALA (FINLAND)**

Client: Fingrid  
Rating: ±200+/240 MVAr  
Project completion: 2009

This first SVC was installed in the Finnish transmission network to address the increase of new, large power generation units and HVDC connections in the grid. Because Finland, Norway, Sweden and Denmark all belong to the same Nordic transmission system, the SVC was installed to maintain grid stability and inter-regional transmission capacity, delivering superior performance since 2009.

**The largest Static VAr Compensators in France**

The world’s first Static VAr Compensator with Alstom’s patented blocking reactor. Turnkey project including studies, design, equipment delivery and commissioning.

Client: Scottish & Southern Energy  
Rating: ±150 MVAr, 275 kV  
Project completion: 2013

Superior harmonic performances  
Increased availability of grid network  
Improved power quality with lower power losses  
Compact design with reduced footprint compared to classic SVC
Alstom has nearly 100 FSC installations worldwide, with a total reactive power output of over 40,000 MVAr

Fixed Series Compensation (FSC)

Fixed series compensation makes the transmission line appear to be electrically shorter in distance than it actually is by increasing the loadability of the transmission line. FSC capacitor banks are switchable and inserted in series with a long transmission line to compensate for the inductive voltage drop, effectively increasing power flow capacity.

It is an economic method of improving power transmission capability, and is the preferred solution for large transmission corridors. FSC increases AC system stability while reducing system losses. Its implementation is rapid and generates a quick return on investment by avoiding costly and time-consuming investments in additional transmission circuits.

Alstom’s expertise in FSC has been well tested in even the most extreme of weather conditions (±50° C), with each project specially catered to customers’ individual needs.
Fixed series compensation

More than 40,000 MVAr installed worldwide

Alstom is a pioneer in large series compensation solutions, and has delivered series compensation systems to many power utilities worldwide, including BC Hydro, Fingrid, Western Area Power Administration, and more. With over 40,000 MVAr of installed reactive power output, Alstom is your go-to supplier for a project well executed.

JACQUES CARTIER (CANADA)
Client: Hydro Québec
Rating: 659 MVAr, 735 kV
Alstom delivered the project turnkey, including studies, design, equipment delivery and commissioning of two 659 MVAr, 735 kV-rated fixed series compensation systems banks at the Jacques Cartier substation north of Quebec City.

MADINAH-EAST - QASSIM II (SAUDI ARABIA)
Turnkey project including studies, design, equipment delivery and commissioning.
Client: Saudi Electricity Company
Rating: 474 MVAr, 380 kV
Project completion: 2013
Increasing power transmission capability between central and western region to meet growing demand.

SHENBAO (CHINA)
Turnkey project including studies, design, equipment delivery and commissioning.
Client: NCGC
Rating: 575 MVAr, 500 kV
Project completion: 2008

KHANDWA (INDIA)
Turnkey project including studies, design, equipment delivery and commissioning.
Client: Power Grid
Rating: 1006 MVAr, 400 kV
Project completion: 2007
The digital control system measures voltages and currents at the point of connection and initiates corrections to either generate or consume reactive power; this helps keep voltage within setting limits and stabilizes the network. The control system software and hardware, based on commercial circuit boards, is designed by Alstom’s engineers; this system communicates easily with the utility’s other systems.

**Fully modular and scalable control platform**

Alstom has accelerated control system development to deal with increasingly complex systems, while optimizing computation technology to enable real-time performance. Using only state-of-the-art hardware and software, Alstom has increased the lifespan of the control system up to 25 years while delivering productivity and quality. The digital control platform is fully modular and scalable to any FACTS application, including fixed series compensation, static var compensation and STATCOM.

Extensive self-diagnostic capabilities are built in to maximize reliability: any degradation of performances or fault of components is pinpointed in real-time and can be easily replaced. When availability is at stake, the control system is configured in a dual lane redundancy concept which allows for the highest availability.

Meanwhile, a built-in Event Logger with automatic timestamping of 1 millisecond resolution, and a synchronized Transient Fault Recorder with up to 10µs sampling will allow for post event detailed analysis by experts.

The control system can also be remotely accessed via internet using secured protocol. It allows remote monitoring (using the built-in real-time monitoring function) and fault detection including diagnostic.

To fulfill modern remote control interfacing requirements, the control platform supports extensive set of industry standard protocols such as IEC 61850, DNP3, IEC 60870, and more while custom protocol can be implemented as an option.
Alstom’s latest digital control platform is fully modular and scalable to any FACTS application, including fixed series compensation, static var compensation and STATCOM.

Based on commercial off-the-shelf (COTS) hardware, the control platform runs on VPX military technology, and meets all the requirements of the FACTS market. Depending on the application complexity, the control platform consists of single or multiple racks, interconnected by high speed serial fibre optic interfaces. The fibre optic interface enables the boards in different racks to communicate with each other as if they were installed in the same rack without any software change.

**Benefits of VPX**
- Military-based technology which allows for reliable and robust systems
- Real-time performance thanks to modern computational hardware and serial communication interfaces
- Wide acceptance by hardware manufacturers and on long lists of COTS
- Enhanced lifespan thus reducing effort for obsolescence management
- Nearly all components have a second source
- Scalability and modularity

**Control software**
The platform’s software, meanwhile, was completely reworked to include state-of-the-art features and technology. Using model based design, real-time algorithms are deployed to speed up development and reduce software design errors in the early stages of development.
A partnership for performance

When you choose Alstom, you are tapping into a huge reservoir of transmission and distribution know-how and experience. Our experts provide a large amount of data that we use to establish benchmarks and best practices. This makes a real difference to the long-term efficiency of grid networks.

The performance potential of any transmission and distribution network is only partially determined at the manufacturing and construction stages. The best design and construction would be of little benefit if operation and maintenance were not fully optimized. That is why Alstom operates a global network of local service centers that offer a full range of packages and services.

Our goals are to maximize network availability, improve energy efficiency and optimize component and system lifetimes through timely planned maintenance and suitable upgrades and retrofits.

As service and maintenance is not dependent on the origin of the components, all our solutions are offered for Alstom and non-Alstom equipment.

Reactive power compensation and harmonic filtering

In addition to turnkey FACTS solutions for grid stability, Alstom has over 60 years of experience providing Power Quality and Energy Efficiency solutions for electric utilities, industries and buildings. Reactive power compensation and harmonic filtering equipment improves power factor and reduces harmonics, enhancing installations’ performance via energy savings and improved power quality and energy efficiency.

Our products and solutions range from low to high voltages, spanning the electrical landscape from generation to consumption, including:

- Low and high voltage capacitor units and capacitor banks
- Harmonic filters
- Active filters
- Reactors (air-core, iron-core or encapsulated)
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Complementary offering

Alstom Grid has one clear mission: to develop innovative solutions for a flexible, reliable, affordable and sustainable electrical grid throughout the world.

Active in power transmission and distribution, Alstom Grid designs, manufactures and services the products and systems that empower the planet’s low carbon economy. It ranks among the top three players in the electrical transmission sector, with an annual sales turnover of €3.5 billion.

With over 130 years’ experience, Alstom Grid has become a trusted partner for all of its customers, from source to smart city.

Energising a smarter world... with Alstom.

Alstom

With a presence in over 100 countries and a broad range of products and services to serve the power generation, power transmission and rail transport infrastructure markets, Alstom is at the forefront of economic, social and environmental progress.

Alstom bases its success on the principles of ethics being rigorously implemented by its 93,000 employees, who work closely with the community of stakeholders that make up the Group’s ecosystem. These shared commitments are expressed in products and services that bear the stamp with Alstom.

Grid

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