Power Electronics

- Static VAR Compensators (SVC)
Today’s power grid is under mounting stress as utilities face the constant need to increase transmission and distribution volume without service interruptions. Expanding networks and greater loads mean voltage drops, line losses, and poor power transfer. To compensate, high voltage power electronics solutions have been developed to enable power systems to operate at optimal capacity.

Manually operated synchronous condensers were once the primary means of compensation and regulation. Today, advanced power electronics systems like Static Synchronous Compensators (STATCOMs) and Static Var Compensators (SVCs) have automated the process for greater protection. These systems balance the supply and demand of active and reactive power by providing fast and continuous capacitive and inductive power. The result is a tremendous improvement in the overall stability and performance of the transmission system.

Mitsubishi Electric has been a worldwide leader in the development, design and manufacture of power electronics solutions since the early 1970s. In 1979, Mitsubishi Electric developed the world’s first Voltage Sourced Converter (VSC) based STATCOM system. In 1984, Mitsubishi Electric installed the world’s first commercial conventional SVC using direct Light Triggered Thyristor (LTT) technology. Since then, Mitsubishi Electric has supplied more than 180 power electronics systems throughout the world.

Mitsubishi Electric Power Products, Inc. was founded in 1985 to supply power products, services and systems to utility companies throughout North America. Mitsubishi Electric Power Products offers engineering, procurement, scheduling, management, construction and commissioning support for all aspects of these complex turnkey projects.

Applications and Ratings
Mitsubishi Electric Power Products sells a wide variety of high-performance, power electronics based systems ranging from transmission system voltage levels of 69kV to 765kV, with typical overall ratings from 50MVAr to 800MVAr. Applications include:
- Voltage Control
- System voltage regulation improvements under varying load conditions
- Increased steady state power transfer capacity
- Greater transient stability
- Voltage instability prevention
- System damping augmentation
- HV/DC link performance improvement
- Subsynchronous resonance mitigation

Key Components of a Power Electronics System
Power electronic systems typically consist of a Thyristor Controlled Reactor (TCR), a Thyristor Switched Capacitor (TSC) and a Fixed Capacitor (FC) in a harmonic filter arrangement. The TCR consists of reactors and thyristor valves which continuously direct the reactive power by varying the current amplitude flowing through the reactors. The TSC consists of capacitors, reactors, and thyristor valves which switch the capacitors on and off. AC filters are also used to provide fixed reactive power and absorb the harmonic currents generated by the other branches of the circuit.

Designed to suit each individual application, these systems:
- Regulate transmission line voltage
- Balance three-phase voltage
- Strengthen transient stability
- Improve steady-state stability
- Dampen power oscillation
- Increase power transfer capacity
- Minimize line loss
- Compensate reactive power

Basic power electronics configurations are comprised of a TCR and an FC, while more advanced systems also incorporate a TSC. In these systems, the TSC and TCR coordinate to provide a linear sum of reactive power, and can be tuned to minimize losses at the most frequent operation point. Applications using only TSCs are also available to provide stepwise control of capacitive and reactive power.
Thyristor Valves

Thyristor valves are used to control the level of inductance and capacitance applied to the system. The thyristor valves use solid-state silicon controlled rectifiers (thyristors) connected in anti-parallel pairs to control AC current. These anti-parallel pairs are then connected in a series to operate at distribution voltages. The thyristors control the reactors and capacitors in the circuit, and can operate on a per-cycle basis, allowing fast, precise voltage control.

Capacitor Banks

Capacitor banks are switched on and off by the thyristor valves. If the system’s load is inductive, these banks switch on to provide VARs to the system in order to raise the system voltage. The capacitor switching operation is completed within one cycle of the fundamental frequency and does not generate any harmonic currents.

Reactors

The amplitude of the current through the reactors can be changed by varying the firing angle of the thyristor valves. This angle can be varied from zero to 90 degrees and can be fully changed within one cycle of the fundamental frequency. This provides smooth and fast control of reactive power to the system. Reactors can be installed as single phase structures or stacked vertically to optimize the station footprint.

Fixed Capacitor (FC) Harmonic Filter

Harmonic filter banks are primarily used to mitigate the harmonics generated by the TCR branches.

Coupling Transformer

To maximize the performance of the thyristor valves, coupling transformers are used to step the current down from the transmission system operating voltage to levels between 10kV and 34.5kV.

Valve Cooling System

Forced air systems are traditionally applied for cooling small capacity valve stations. However, Mitsubishi Electric Power Products has also developed a high-efficiency liquid cooling system for large capacity stations. Using a combination of water and glycol, these cooling systems can operate at high temperature, eliminating the need for a cooling tower. The amplitude of the current through the reactors can be controlled by varying the firing angle of the thyristors, allowing for precise voltage control.

Station Control System

A digital controller is supplied with every power electronics system. Using a LINUX-based operating system, the controller incorporates data from high-precision digital signal processors (DSP) through multiple processing units to control the thyristor valves and all auxiliary equipment throughout the station. The digital technology offers high flexibility, reliability and easy maintenance. The digital controller is also suitable for LAN and SCADA communication.

Employing an easy-to-operate Human Machine Interface (HMI) users can:
- Verify operating status
- Adjust station parameters
- Sequence and record events
- Regulate voltage and reactive power through automatic or manual controls
- Perform continuous condition monitoring

SVC’s with Light Triggered Technology

Mitsubishi Electric further advances the standard SVC by offering Direct Light Triggered Thyristor (LTT) technology. Since its introduction, more than 65 SVCs using LTTs have been installed around the world.

The thyristor valve is the most critical component of an SVC and the thyristor itself is of particular importance. Though earlier SVCs and High Voltage DC (HVDC) systems used Electrically-Triggered Thyristors (ETT), Mitsubishi Electric pioneered the application of Direct Light-Triggered Thyristors (LTT) for HVDCs in 1983 and SVCs in 1984.

With this technology, firing pulses, independent of the AC system voltage, eliminate the need for auxiliary energy within the valve itself. Compared to traditional ETT devices, these thyristors are fired directly through optical fibers requiring less complicated circuitry and no high-voltage insulation.

LTTs also provide a voltage divider with simple standard components instead of specialized circuits. The result is an optimized wiring module with less risk of accidental damage, quick and easy maintenance, and a reduced need for mandatory spare parts. LTT technology substantially reduces the number of electrical components in the valves, providing higher reliability by eliminating the possibility of electromagnetic interference (EMI).

LTT valves contain 90 percent fewer components when compared to similar ETT devices. Over a 30-year period that includes more than 100 large scale installations, Mitsubishi Electric has documented a 70 percent reduction in inspection time, 85 percent reduction in maintenance costs, and a thyristor valve forced outage availability rating of more than 99.9 percent.

MSC Bank

Coupling Transformers

Reactors

Thyristor Valves

Control System

Filter Bank

Advanced Designs for Greater Efficiency

Advanced power electronics provide near-instantaneous response to changes in the system voltage. These systems also offer greater capacity and are more reliable and cost effective when compared to other dynamic compensation schemes, including synchronous condensers or mechanically switched systems.
Sophisticated STATCOM Systems Using GCT

STATCOM systems developed by Mitsubishi Electric use Gate Commutated Turn-off (GCT) Thyristors. GCT Thyristors are advanced self-commutated devices that have improved gate structure and gate drive circuitry compared to conventional GTO and IGBT devices. By design, GCT devices require fewer electrical components, less wiring, and no snubber circuits used in conventional switching operations. The result is a simplified, cost-effective system with lower operating losses.

World-Class R&D, Manufacturing, and Testing Facilities

Mitsubishi Electric's focus on progressive research, development and testing over the past 40 years is evident through its technological advancements in high-performance power electronics systems. These include the advanced SVC and STATCOM systems, innovations in converter and valve designs, power semiconductor technology and the use of optimal control techniques. Each of these innovations yields higher operating efficiencies, a more compact size, fewer losses and a greater return on investment.

All Mitsubishi Electric substation products are manufactured at ISO 9001 and ISO 14001 qualified facilities, where engineers develop and design products to suit each unique application. Individual components are manufactured and tested according to global standards and customer specifications. Complete systems are then assembled and tested, assuring precise fit and full operational compliance.

A special quality assurance program, applied for power electronics valves and controllers, exceeds ISO-9001 quality control requirements and other standards. Mitsubishi Electric implements a Zero Defect (ZD) policy with strict guidelines that include:

- Use of rigorously qualified and proven components
- Intensive design reviews supervised by expert personnel
- Implementation of aging tests after full assembly
- Factory tests that exceed the requirements of related standards

Turnkey Solutions

Mitsubishi Electric Power Products commits to providing quality engineering, procurement and construction services that meet or exceed the application's technical requirements for complete substations. Mitsubishi Electric Power Products offers total vertical solution integration including:

- Planning / studies
- Engineered solutions
- Development
- Testing

- Procurement
- Logistics
- Civil work
- Installation
- Commissioning
- Training and support

Using internal resources and a network of subcontractors across North America, Mitsubishi Electric Power Products offers comprehensive project management for:

- Design
- Civil, electrical, and structural construction
- Testing
- Commissioning – Experienced construction and site-management personnel
- Engineers from all pertinent disciplines who develop system designs compliant with industry standards, customer specifications, and expectations for safety, risk, maintenance and reliability
- Detailed schedule management and manpower planning with special attention to deliveries, outage management tasks, installation sequencing and in-service dates for prompt and efficient project execution

- Premium substation equipment, including primary components from Mitsubishi Electric's factories in Japan and complementary products from vendors selected through rigorous pre-qualification processes
- Execution of commissioning and cutover plans to ensure all equipment is thoroughly tested and synergistically interfaced with adjoining substations
- Detailed QA/DC and safety programs

Mitsubishi Electric Power Products corporate values focus on providing the highest standards in individual performance, integrity and customer commitment. Over time we have developed a comprehensive and detailed approach that underlines successful performance in all disciplines.

Quality Assurance and Continuous Improvement

Mitsubishi Electric Power Products is committed to providing products and services of the highest possible quality. A documented Quality Assurance Program specifies product performance standards from design and manufacturing, through installation, to the end of the commissioning process. The program offers prescriptive details for engineering procedures, accounting, material handling, tool calibration assembly, workmanship evaluation, testing and reporting.

Continuous improvements on engineering processes and product strategy are made on each project. Events are analyzed to identify root causes and actions defined to correct or avert. This proactive approach supports the on-going improvement and refinement of the Mitsubishi Electric products and services.

Site Services

Mitsubishi Electric Power Products field engineers perform new equipment installation and commissioning tasks. High and low-voltage testing of switchgear and transformers is performed using sophisticated test equipment owned by Mitsubishi Electric and brought to each site. Routine diagnostics and examination of high-voltage problems developed on customer’s pre-existing equipment are also available, in addition to full turnkey replacement or repair.

Available field engineering services include:

- Installation supervision
- Commission testing
- Personalized training
- Diagnostics

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