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Hybrid STATCOM + Capacitor/Filter Bank Solutions

OVERVIEW / KEY FUNCTION

System-fit, medium-voltage Hybrid STATCOM + Capacitor Bank solutions designed to provide fast dynamic reactive power support together with economical steady-state power factor correction for demanding medium-voltage power systems.

VarStec's Hybrid STATCOM architecture combines a fast-responding STATCOM with conventionally switched capacitor bank stages so that each technology performs the duty it handles best. The STATCOM provides the rapid dynamic VAR response required for flicker control, voltage sag support, voltage stability, voltage unbalance correction, fast reactive power regulation, and sub synchronous oscillation damping. The switched capacitor bank, or when required, harmonic filter, provides the bulk steady-state MVAR required for plant power factor correction, long-duration voltage support and harmonic mitigation at a much lower cost per MVAR than a full-STATCOM-only solution.

This coordinated approach improves project economics without sacrificing performance. By reserving the converter for fast and transient conditions while assigning the steady-state VAR burden to switched capacitor stages, VarStec delivers a practical hybrid solution that improves grid support, lowers installed cost, and reduces unnecessary converter oversizing.

IMAGE/S HERE TBD

INDUSTRY APPLICATIONS & SPECIALIZED SOLUTIONS

Our Hybrid STATCOM + Capacitor Bank solutions are engineered for applications where both fast dynamic reactive support and economical steady-state compensation are required. Because standard catalog solutions often force customers into either an oversized STATCOM or a switched-bank-only solution with limited dynamic performance, VarStec develops a coordinated system-fit architecture matched to the operating behavior of the site. For example:

- **Semiconductor & Precision Manufacturing**
  Delivering the fast dynamic response, transient-free switching, and voltage stability required for facilities where even short-duration disturbances can disrupt production.
- **Data Centers & Sensitive Loads**
  Supporting facilities that require voltage sag mitigation, stable power factor, and disturbance-free switching in order to protect sensitive UPS systems, servers, chillers, and other critical infrastructure.
- **Steel & Primary Metals**
  Addressing rapidly fluctuating reactive power demand, flicker, and highly dynamic process loads by combining STATCOM performance with bulk switched compensation and harmonic filtering.
- **Mining & Remote Weak Grid**
  Improving voltage stability and power quality on weak or isolated systems where large motor starts, long feeders, remote utility connections, and high harmonic loads challenge plant operation.
- **Oil, Gas & Petrochemical**
  Supporting remote compressor stations, pump stations, and process facilities that need both steady-state power factor correction and fast voltage support during system disturbances.
- **Renewable Energy & Large Industrial Interconnections**
  Providing coordinated dynamic and steady-state reactive support to help wind, solar, battery, and large industrial generation projects satisfy interconnection requirements, support POI voltage, and strengthen performance on weak grids.
- **Heavy Industrial Motor-Intensive Plants**
  Enabling plant-wide motor starting strategies where a central Hybrid STATCOM solution can support across-the-line starts without the footprint and complexity of multiple RVSS or VFD lineups.

TECHNICAL DETAILS & ENGINEERING APPROACH

VarStec applies disciplined system studies, practical equipment knowledge, and coordinated control philosophy to deliver Hybrid STATCOM systems aligned with the specific objectives, constraints, and operating requirements of each project.

Coordinated Hybrid Architecture

In a VarStec Hybrid STATCOM solution, the capacitor bank is assigned the steady-state MVAR duty, while the STATCOM is reserved for the fast and continuously variable reactive power duty. This division of labor allows the overall system to deliver fast dynamic performance without forcing the converter to carry the entire plant reactive load under normal operating conditions.

Voltage Sag Mitigation for Sensitive Facilities

For voltage-sag-sensitive applications such as data centers, semiconductor fabrication plants, and other critical process facilities, VarStec applies the Hybrid STATCOM concept as a plant-level voltage sag mitigation solution. In this architecture, a current-limiting reactor is applied ahead of the protected plant to create the impedance needed for injected VARs to support the downstream bus during upstream and nearby fault events. The STATCOM delivers the fast injected VAR response needed to hold plant voltage above trip-sensitive thresholds, while the switched capacitor bank offsets the poor steady-state regulation introduced by the reactor and restores plant power factor.

Plant-Wide Motor Starting Support

The Hybrid STATCOM solution can also be configured as a plant-wide motor-start support system. Instead of applying multiple reduced-voltage soft starters, VFDs, E-Houses, synchronous bypass switchgear lineups, and the associated controls throughout a plant, the Hybrid STATCOM system can provide centralized dynamic voltage support that enables multiple large motors to be started across the line throughout the entire plant. This reduces equipment count, simplifies the electrical architecture, and improves overall plant power quality by also providing ongoing voltage support and power factor correction after the motor-start event.

Flexible Physical Arrangements & Converter Options

The coordinated STATCOM platform can be configured in cabinet, container, or building-based arrangements depending on project size and site constraints. Available solutions include air-cooled and water-cooled converter configurations, modular multilevel cascaded H-bridge topology, and transformer-based or transformer-less arrangements where applicable. This flexibility allows the hybrid system to be adapted to both retrofit and greenfield applications.

TECHNICAL DETAILS & ENGINEERING APPROACH (CONT'D)

Advanced Switching with ABB VD4-CS & VD4-CS1

VarStec coordinates switched capacitor stages with advanced ABB VD4-CS and VD4-CS1 switching platforms where application conditions warrant. These technologies provide transient-free closing and restrike-free opening, reducing switching disturbances on sensitive plant systems. The rapid reclose capability of the VD4-CS1 allows capacitor stages to return to service on a time scale not possible with conventional switching devices, which helps the hybrid system extend its useful dynamic operating range.

Dynamic Range Extension Through Fast Switched Stages

By pairing the STATCOM with fast, transient-free switched capacitor stages, the hybrid system can exploit converter overload capability more effectively. When a large dynamic VAR swing is required, the STATCOM responds immediately while the switched stages are sequenced in and out to reposition the steady-state operating point. This coordinated control philosophy broadens the practical operating range of the hybrid system and improves overall capital efficiency.

System Studies, Controls & Integrationt

Every Hybrid STATCOM project should be supported by the studies needed to confirm proper application and controller coordination. VarStec evaluates load flow, reactive power requirements, motor starting performance, voltage sag exposure, harmonic environment, resonance risk, short-circuit constraints, and switching duty as required. The result is a technically correct hybrid system with coordinated control of the STATCOM and switched capacitor stages, aligned with the actual electrical behavior of the site.

STRATEGIC BENEFITS & VALUE ENGINEERING

Lower Installed Cost

Because the switched capacitor/filter bank supplies the bulk steady-state MVAR, the converter can be sized for the dynamic duty rather than the entire reactive load. This provides a more economical solution than to solve both dynamic and steady-state needs with STATCOM capacity alone.

Fast Response Where It Matters

The STATCOM provides the rapid response required for flicker control, voltage sag support, voltage stability, and fast reactive trimming, while the capacitor bank handles the less time-critical steady-state MVAR requirement.

RATINGS, CONFIGURATION & OPTIONS SYSTEM-FIT TO SPECIFICATIONS

STATCOM Electrical Ratings & Configuration

- **System Type:** Hybrid STATCOM + switched capacitor bank
- **Operating Voltage (L-L):** Medium-voltage application as specified
- **Reactive Power Rating, Dynamic Portion:** As specified for project duty
- **Reactive Power Range, Overall Hybrid System:** As specified
- **Frequency:** 50 Hz | 60 Hz
- **Connection Arrangement:** Star | delta | transformer-based | transformer-less, as applicable
- **Physical Arrangement:** Cabinet | Container | building | E-House, as specified
- **Redundancy / Parallel Modules:** As specified

Converter Topology & Cooling

- **Converter Topology:** Multi-level cascaded H-bridge VSC or approved equivalent
- **Semiconductor Technology:** IGBT-based converter
- **Cooling Method:** Forced-air | water cooled, as specified
- **Auxiliary Cooling Equipment:** Integral or remote skid, as applicable
- **Efficiency / Harmonic Performance:** Manufacturer standard or as specified
- **Footprint Constraints:** To be coordinated with project layout and access requirements

Dynamic Compensation Functions

- **Primary Functions:** Dynamic reactive power control | voltage support | power factor correction
- **Additional Functions, When Required:** Flicker mitigation | voltage unbalance support | selective harmonic mitigation | POD function | voltage sag support
- **Control Objective:** Automatic fast response to dynamic system events
- **Steady-State Trim:** Coordinated with switched capacitor bank stages
- **Sequence Compensation:** As specified, when negative-sequence or unbalance support is required

Hybrid Coordination with Switched Capacitor or Filter Stages

- **Hybrid Control Philosophy:** STATCOM to provide fast dynamic VARs; switched stages to provide bulk steady-state VARs
- **Automatic Sequencing:** Voltage | power factor | kvar | hybrid supervisory logic | remote dispatch
- **Switched Stage Coordination:** Capacitor bank | harmonic filter bank | switched reactor, as applicable
- **Fast Stage Return to Service:** Supported where coordinated fast switching technology is applied
- **Controller Integration:** STATCOM controller to coordinate with switched-stage controller and plant control system
- **Harmonic Filter Variant:** Optional where harmonic mitigation or resonance control is required

Switching, Interconnection & Protection

- **Incoming Connection Method:** Breaker | switchgear lineup | transformer interface, as specified
- **Coordinated Stage Switching:** ABB VD4-CS | VD4-CS1 | approved equivalent where specified
- **Switching Performance:** Transient-free closing | restrike-free opening, where applicable
- **Protection Functions:** Overcurrent | over/undervoltage | converter protection | cooling alarms | harmonic / unbalance alarms | auxiliary system alarms, as specified
- **Instrument Transformers / Sensors:** CTs | PTs/VTs | auxiliary metering as required
- **Grounding / Isolation Provisions:** As specified by system design

RATINGS, CONFIGURATION & OPTIONS SYSTEM-FIT TO SPECIFICATIONS (CONT'D)

Controls, HMI & Communications

- **Control Modes:** Local | remote | automatic | supervisory hybrid mode
- **HMI:** Local operator interface with alarms, status, trends, and commands
- **Remote Interface:** SCADA / plant control system interface, as specified
- **Operating Targets:** Voltage control | power factor control | reactive power control | staged hybrid optimization
- **Diagnostics:** Event logs | alarm logs | operating history | system health monitoring
- **Time Synchronization / Data Requirements:** As specified

Environmental, Mechanical & Installation Requirements

- **Installation Environment:** Indoor | outdoor | building-mounted | containerized, as specified
- **Ambient Conditions:** Site-specific temperature, humidity, altitude, and pollution severity
- **Accessibility:** Front access or project-specific maintenance access
- **Protection Degree / Enclosure Construction:** Manufacturer standard or as specified
- **Noise Limits:** As specified by project requirements
- **Cable Entry / Exit:** As required by layout
- **Civil / Structural Interface:** To be coordinated for foundation, routing, and clearances

Engineering, Testing & Compliance

- **Required Studies:** Load flow | reactive power study | voltage sag analysis | motor-start analysis | harmonic / resonance screening | EMT analysis, as required
- **Factory Documentation:** Single-line diagrams | schematics | layout drawings | control philosophy | manuals
- **Testing:** Routine factory tests | functional tests | site commissioning | performance verification, as specified
- **Applicable Standards:** Applicable IEEE, IEC, utility, and project-specific requirements
- **Interconnection Compliance:** Coordinated around utility or grid-code reactive power and voltage support requirements at the POI
- **Training & Support:** Site training, startup support, and long-term technical support as specified