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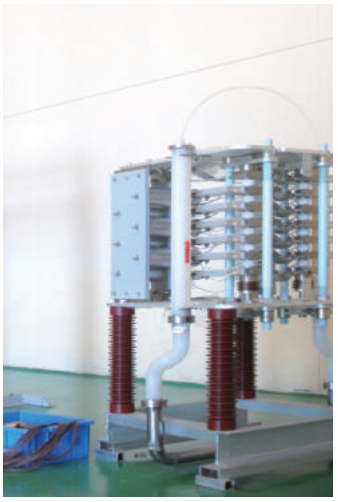
Solution for STATCOM Systems



Breakthrough solution to reactive power compensation

There are more and more power electronics equipment and nonlinear loads applied in the power grid. These heavy industrial applications will affect the reactive power balance in a grid and result in voltage unbalance, distortion or flicker, voltage sags, poor power factor or even voltage instability. Usually, a modern power system may come across the following problems during its operation:

- Insufficient reactive power regulation
- Spread of system oscillations
- Low voltage or voltage collapse in load center due to the shortage of fast reactive power supply
- Low power factor and productivity
- Lower grid voltage, voltage fluctuations and flicker caused by insufficient reactive power. In severe cases, the switch gear and the protection devices may work improperly and power outage may occur.
- Increased network losses and production costs
- Large amount of harmonic currents are the potential risk of grid.

- Malfunctions of protection and control devices may occur.
- The amplification of capacitor resonance and harmonic current will cause capacitor overload or overvoltage, or even burned.
- The increased transformer losses can result in high temperature during transformer operation.

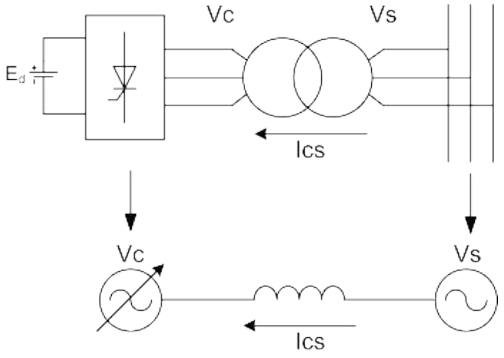
  The harmonic current can lead to power equipment heating, motor torque unstable or even damaged.
- The aging of insulation is accelerated that the electrical devices are easy to breakdown.
- The harmonic current also reduces the production efficiency of electric arc furnace, and thus the power losses are increased.
- Interference with communications signals will happen.

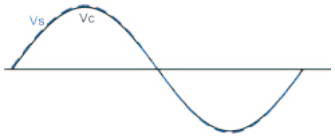
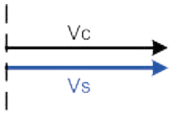
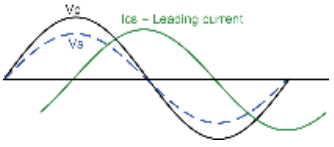
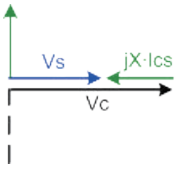
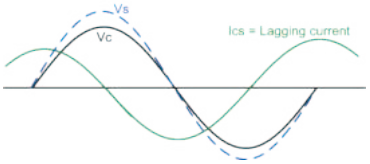
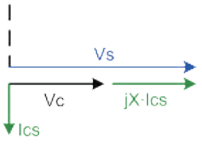
• Phase unbalance caused by the injection of negative sequence current to the motor rotor vibration.

Reactive power control can solve these problems by improving power factor or enhancing voltage stability. Reactive power supplied by generators or capacitor banks is too slow for the sudden-change load. The most advanced solution is using a Voltage Source Converter (VSC), such as Static Synchronous Compensator, to provide variable and fast reactive power to the grid.

Operation Principle

The Static Synchronous Compensator is a voltage regulating device based on voltage source converters (MOSFET). It acts as a source or a sink of reactive power which is independent of ac system voltage. STATCOM can operate as a part of Flexible AC Transmission System (FACTS) to detect and compensate voltage fluctuations or flickers instantly, correct unbalanced loads and control power factor.



Operation Mode	Waveform	Phasor Diagram	Remark
No-load			Ics = 0, if Vs = Vc
Capacitive output			If Vc > Vs, Ics is leading current. Since the current amplitude can be continuously controlled by adjusting Vc, STATCOM works as a capacitor whose capacitance can be continuously controlled.
Inductive output			If Vc <Vs, Ics is lagging current. At this point, STATCOM operates as a reactor whose inductance can be continuously controlled.

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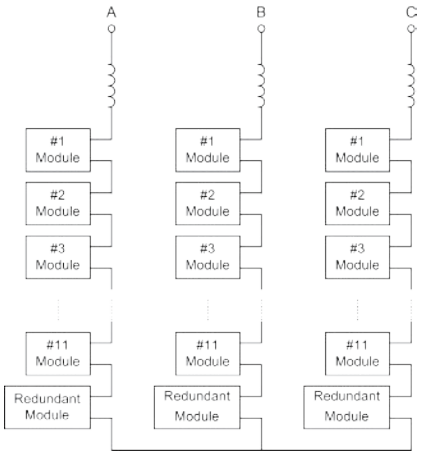
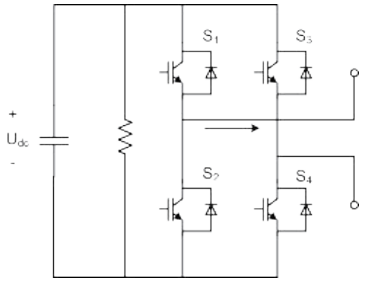
H-Bridge Cascading Scheme

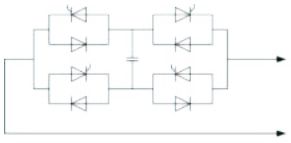
The cascading scheme is a multi-level topology that consists of many H-bridge power units with monopole multiplier modulation to achieve three-level output on AC side. Each phase adopts the carrier phase modulation method to obtain better voltage output waveform with much more level numbers. The cascading scheme can output phase voltage with 2N +1 levels if each phase comprises N +1 chain (i.e. the H-bridge power unit).



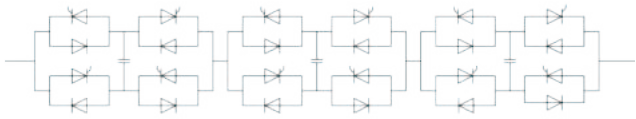
Benefits

- The H-Bridge cascading scheme can generate multi-level voltage waveform, while effectively reduces the network voltage distortion rate and the harmonic current injected to the grid.
- The modular design enables easy installation and free maintenance.
- The cascading scheme is capable of redundant operation to enhance system reliability.
- The site area is reduced due to the removal of connection transformer with multiply level.
- Independent sub-phase control can effectively balance three-phase.

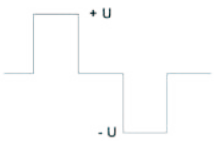




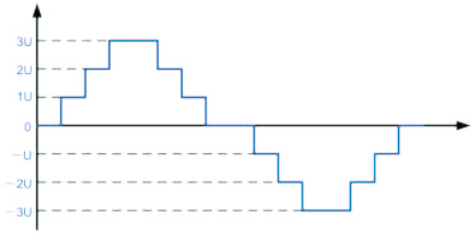
STATCOM sub-module



STATCOM cascading branch



Output voltage



Technology Advantages

Faster Response Time

STATCOM system has fast response time less than 15ms. The conversion can be completed in a very short time from the rated capacitive reactive power to the rated inductive reactive power. The response speed can vary with the impact load demand.

High Voltage Flicker Reduction

The voltage flicker reduction factor of STATCOM system is 5:1 or even higher so as to eliminate the voltage flicker for heavy impact load.

Wide Operating Range

The STATCOM system can operate independently of system voltage in the range between rated capacitive and inductive reactive power. It can offer rated current in under-voltage mode.

Various Compensation Functions

The STATCOM system provides variety of compensation functions, including load reactive power compensation; load harmonic compensation; load imbalance compensation, and compensate both the load reactive and harmonic simultaneously.

Lower Harmonic

STATCOM can realize active filtering by producing very low harmonic content and load harmonics compensation .

Small Site Space

The STATCOM system has advantages of small site space. It is composed of start-up cabinets, power cabinet, connecting reactor and control cabinet.

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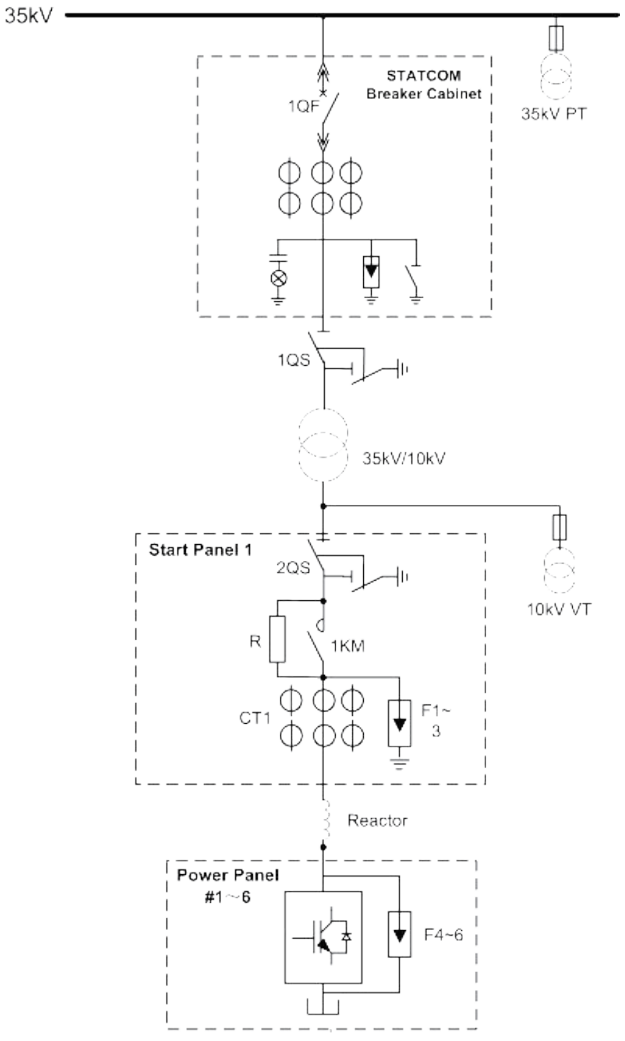
Main Components

The STATCOM device consists of five parts: control cabinet, power cabinet, start panel, connection reactor and power transformer.



Start Panel

The key parts of start panel are start switch, charging resistor, isolating switch, and grounding switch.

In startup mode, the start panel provides self-excitation to the system. After the main switch is closed, the supply voltage across the charging resistor charges the DC capacitor in power unit. When the charging voltage reaches 80% of the rated value, the control system closes start switch, and then the charging resistor is bypassed.

Isolating switches and grounding switches are used for security guarantees during system maintenance.

Connection Reactor

Series-connection reactor in the start panel is used to achieve energy buffer.

After t the main switch is closed, the supply voltage across the charging resistor can reduce the output current ripple and common mode interference.

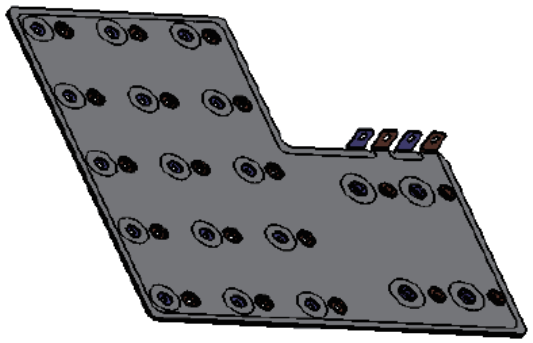
Main Components

Power Cabinet

The number and the size of cabinets are subject to the voltage level and the rated power of STATCOM. The power panel contains H-bridge power units and cooling fan.

- The power unit uses the following high-quality switching devices
  - The latest generation of chip design
  - Superior resistance to current, voltage peak capacity
  - Module margin design
  - Over 20KHz switching frequency in operation design.

- High quality film capacitors specified for MOSFET
  - Low equivalent series resistance.
  - Low equivalent series inductance.
  - High ripple current, 1.5 times overvoltage capability.
  - Active high current handling capability
  - Good capacitance characteristics under high temperature conditions.



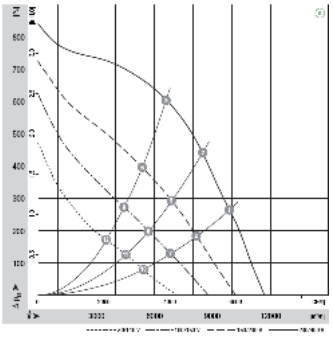
- Laminated busbar design

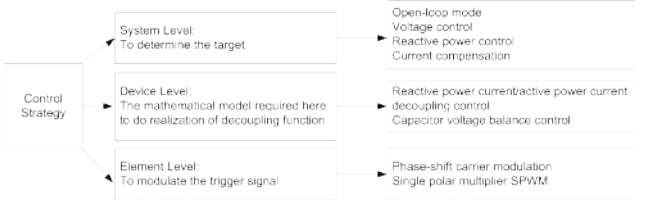
  The power cabinet adopts laminated design busbar structure. The connection between capacitors and MOSFET effectively reduces the parasitic inductance of the loop to avoid MOSFET turn-off voltage peak, thereby ensuring the operation reliability of device and eliminating unacceptable equipment failures.

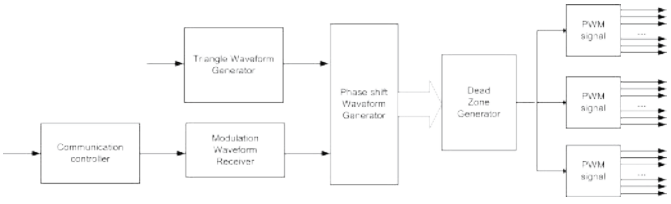
Main Components

Fan

High performance fan with low noise and long life time.







Control Cabinet

The control panel contains the core device of STATCOM system and the valve trigger unit of PCS-9589. PCS-9583 adopts Metadigitaly's graphical UAPC platform to perform control and corresponding protection in both system-level and device-level.

The PCS-9589 valve unit is used to trigger the control unit based on FPGA. The use of FPGA can easily construct multi-channel PWM generator to solve the problem of multiple triggers required by multi-level converter.

Operation Work Station

The monitoring of STATCOM system is implemented by PCS-9700 automation system that is developed for automatic control and monitoring of power plants. It provides the full range of realtime monitoring and control of converter system, transformers, FC filter, grid systems and environmental monitoring systems, etc. In addition, the PCS-9700 integrates powerful analytical processing capability, sophisticated monitoring and alarm mechanism.

Appliation Field

Power Transmission Substation

- Compensate line reactive power and stabilize system voltage
- Reduce transmission losses
- Increase line transmission capacity through the dynamic support of line terminal voltage
- Improve transient stability to prevent against transient voltage collapse
- Provide power oscillation damping

Mining Hoists and Industrial Mills

- Improve power factor, reduce reactive power loss and energy-saving
- Solve serious harmonic pollution problems, and improve power quality by active power filtering
- Enhance line terminal voltage, improve voltage stability and power supply security
- Reduce voltage fluctuation and flickers caused by heavy load during startup

Electricity Railway

- Provide power factor control to reduce power loss
- Supply voltage regulation to weak grid
- Compensate negative sequence/unbalance current or voltage
- Provide harmonic filtering

Wind Farm and Solar Energy

- Correct system power factor
- Reduce voltage fluctuation and flicker
- Filter harmonic current
- Balance three phase power
- Enhance voltage stability and improve low-voltage ride ability

Steel Plant and Rolling Mill

- Provide harmonic filtering
- Compensate unbalanced voltage
- Significantly reduce voltage fluctuation and flicker
- Improve productivity
- Reduce reactive power impact
- Control power factor

Thank you!

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