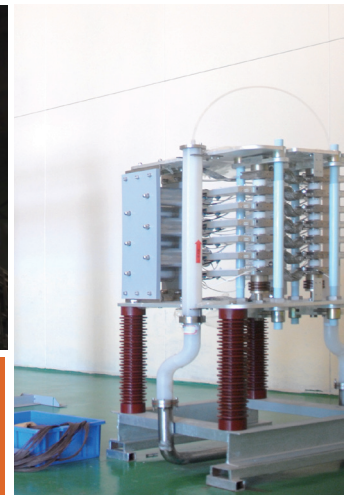




Solution for Static Synchronous Compensator



Breakthrough solution to reactive power compensation





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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.



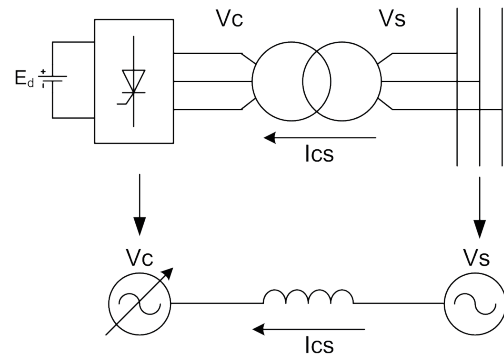
- Malfunctions of protection and control devices may occur.
- The amplification of capacitor resonance and harmonic current will cause capacitor overload or overvoltage, or even burned.
- The increased transformer losses can result in high temperature during transformer operation. The harmonic current 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 (IGBTs). 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			$I_{cs} = 0$, if $V_s = V_c$
Capacitive output			If $V_c > V_s$, I_{cs} is leading current. Since the current amplitude can be continuously controlled by adjusting V_c , STATCOM works as a capacitor whose capacitance can be continuously controlled.
Inductive output			If $V_c < V_s$, I_{cs} is lagging current. At this point, STATCOM operates as a reactor whose inductance can be continuously controlled.

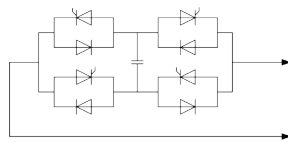
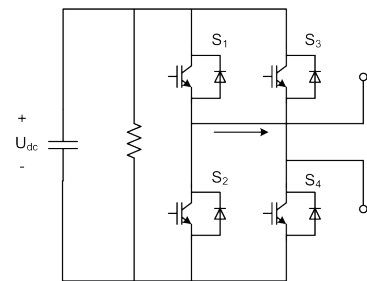
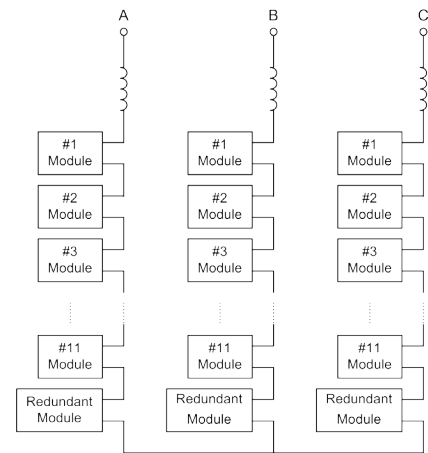
H-Bridge Cascading Scheme



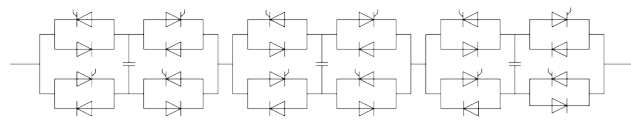
The cascading scheme is a multi-level topology that consists of many H-bridge power units with monopole multiplier modulation to achieve three-level output on AC side. Each phase adopts the carrier phase modulation method to obtain better voltage output waveform with much more level numbers. The cascading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

Benefits

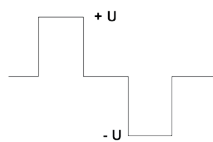
- The H-Bridge cascading scheme can generate multi-level voltage waveform, while effectively reduces the network voltage distortion rate and the harmonic current injected to the grid.
- The modular design enables easy installation and free maintenance.
- The cascading scheme is capable of redundant operation 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.



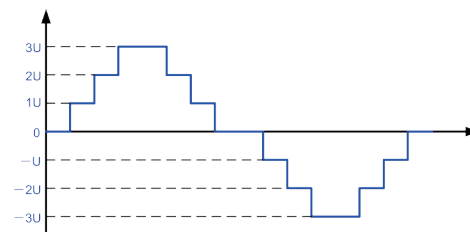
STATCOM sub-module



STATCOM cascading branch



Output voltage



Technology Advantages



› Faster Response Time

NR STATCOM system has fast response time less than 5ms. 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 .

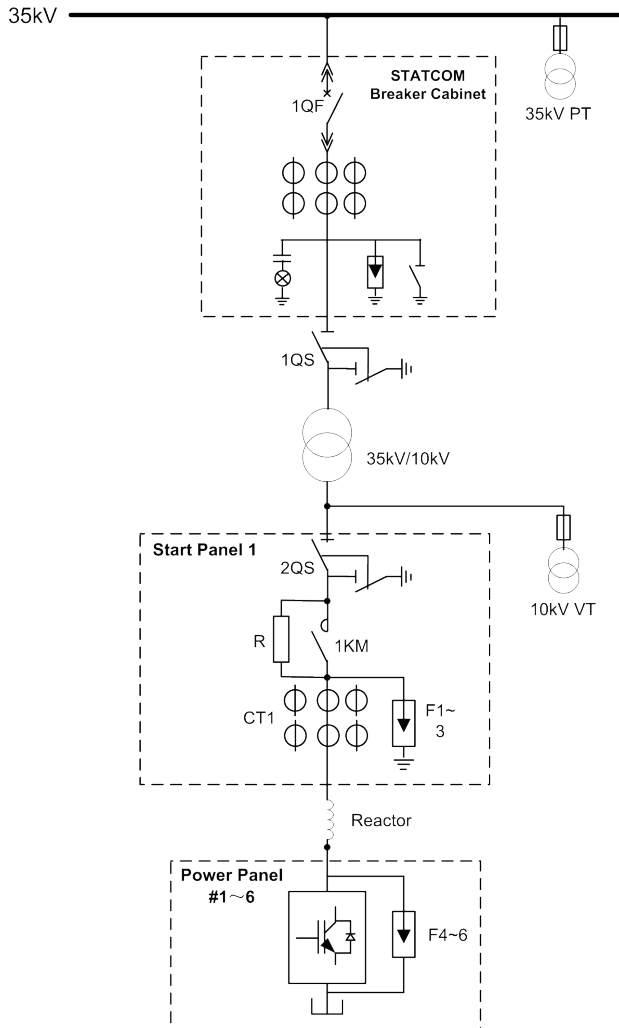
› Small Site Space

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

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

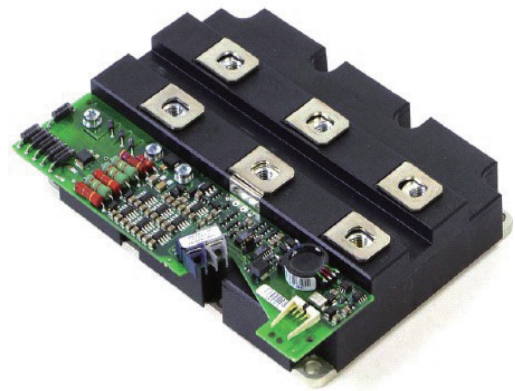
Main Components



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.

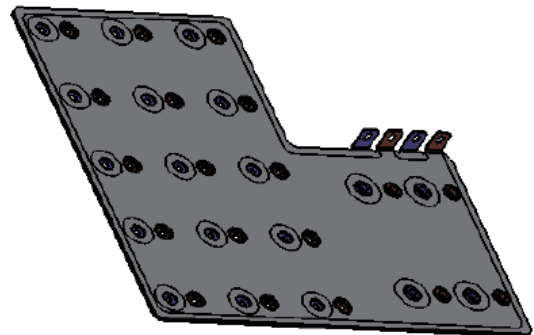
- The power unit uses the following high-quality switching devices
 - The latest generation of chip design
 - Superior resistance to current, voltage peak capacity
 - Module margin design
 - Over 500Hz switching frequency in operation design.



- High quality film capacitors specified for IGBT
 - 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 IGBT effectively reduces the parasitic inductance of the loop to avoid IGBT turn-off voltage peak, thereby ensuring the operation reliability of device and eliminating unacceptable equipment failures.

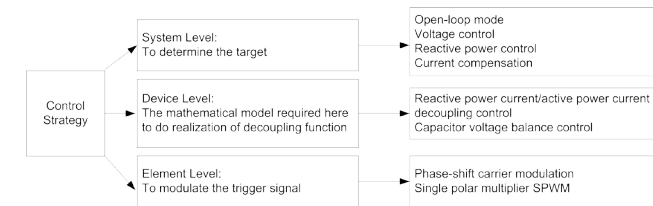
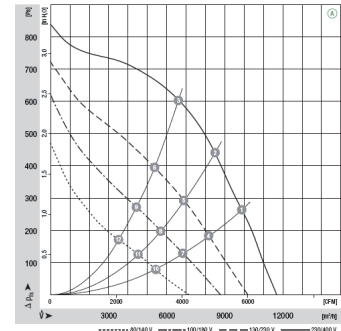


Main Components



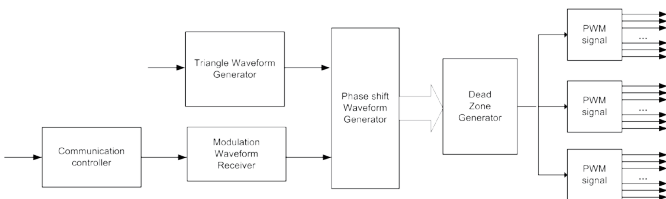
Fan

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 NR'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.



Application 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

Performance & Features



› Professionally Designed Power Modular

- Well proven design principals
- Compact structure, high reliability
- Easy maintenance

› Redundant Design

- Reduce system failure rate, and increase system reliability
- Zero impact on module failure to keep normal operation

› Hierarchical Protection Function

- The operation time of element-level protection shall not exceed ten microseconds. If there are overcurrent, overvoltage or driving signal abnormalities occurred in the system, the device-level protection can be quickly provided by hardware.
- The operation time of device-level protection ranges from 100 to 1000 microseconds. Device-level protection is activated in case of device overload, DC high voltage and other abnormal operating conditions.
- The limit of system-level protection operation time is from 5 to 2000 ms. It is enabled in case of system out of power, system overvoltage, system overcurrent and cooling system failure.
- The control unit is used as the backup protection for protection unit, while the monitoring unit is used as the back-up protection for control unit.

› Advanced OWS

- The OWS of STATCOM system full supports IEC60870-5-103, IEC61850 and other international standards. It can be applied to conventional substations, digital substations and power plant with voltage levels from 35kV ~ 1000kV.
- NR OWS covers the entire substation monitoring based on 103/61850 standard, including STATCOM operation monitoring, control, operation and alarm events. It offers flexible access to the third party OWS to provide the full range of text messages and increase the flexibility of system monitoring function.

› Advanced Control and Protection Platform

- The control and protection platform is designed based on advanced IC technology and network communication technology, featuring high performance, low power consumption, and well reliability.

Performance & Features



- The patented HTM bus can achieve large-capacity data and reliable exchange in realtime between plug-in boards.
- The hardware and software adopt modularization design. Each module can be smoothly upgraded upon users' requirements.
- Complex functions can be distributed simultaneously on multiple CPU in parallel, reducing the mutual influence and ensuring system reliability.
- Supporting visual programming and on-line debugging.
- Supporting hierarchical and distributed control and protection system. I / O system can be locally installed. Data exchange with control and protection system is implemented via fiber-optic point-to-point or network.
- Full supporting IEC 61850 (GOOSE, SV), IEEE1588 and other standards.

› Integrated Wave Recording Function

- The whole dynamic operation data can be recorded when STATCOM system fails, including the changes of system electrical paramete and protection module action after large disturbance occurs.
- The recorded wave data includes transient waves and steady-state waves. The recording frequency of transient wave can reach 9.6kHz in order to increase transient recording efficiency.
- The steady-state wave recording are continuously performed at 1Hz ~ 1.2kHz.
- The device has a large capacity high-speed FLASH memory card to ensure the security of dynamic data recording and storage.
- Supporting IEEE COMTRADE format to facilitate post-acquisition and analysis.

› DC voltage balancing techniques

- The STATCOM system adopts innovative proposed balance method with both chain balance algorithm and phase balance algorithm.
- Effectively control of chain-capacitor voltage is provided without adding any additional hardware devices.
- The complexity of module is reduced to minimize the costs and lower the power loss of the entire system.

› Powerful Experimental Conditions

NR possesses a full range of testing laboratories to implement digital simulation tests and analogue simulation tests. Schematic main circuits and control circuits can be built to check the dynamic and static performance of STATCOM, providing important information and data support for the design commissioning and maintenance of STATCOM system.

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