PCS-9578

Controllable Shunt Reactor (CSR)

NR Electric's PCS-9578 Controllable Shunt Reactor (CSR) is a shunt-type reactive power compensation system for supplying step-changing reactive power with fast response time and low-cost maintenance. It is designed based on high leakage reactance transformer and high-power thyristor semiconductor technology.

CSR is used to solve the contradiction between reactive power compensation and restraining over-voltage especially in an extra-high voltage and long distance power transmission system. It can adjust the reactive power to stabilize the line voltage and achieve a reasonable power flow distribution. Furthermore, CSR can also restrain the secondary arc current to improve reclosing success rate. So far, it has been used successfully in electric power system.

Operating Principle

There are two types of CSRs, multi-stage CSR and magnetically CSR.

For multi-stage CSR, it is connected to the power grid in parallel via by the primary winding of high leakage impedance transformer. Through the combination of thyristor valves and bypass circuit

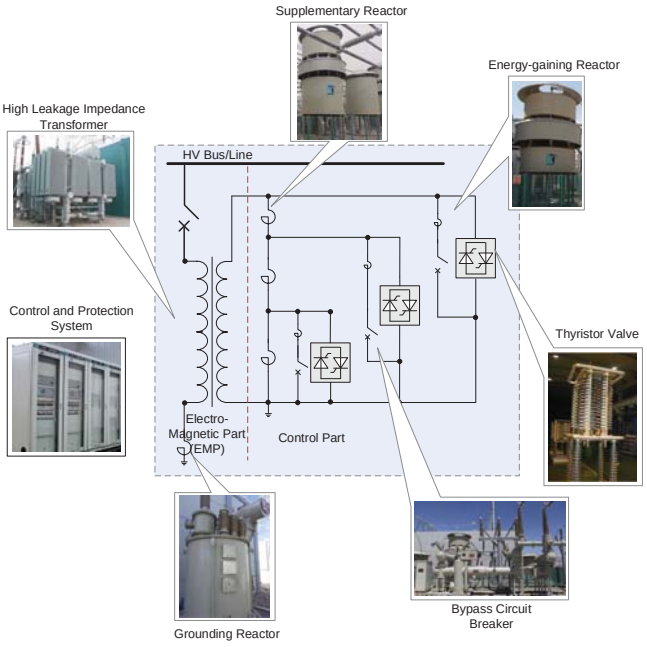

Figure 1 Multi-stage CSR

breakers, the reactance value of the secondary winding of transformer is adjusted step by step, so that the absorbed reactive power can be changed.

For magnetically CSR, by using the non-linear characteristic of magnetization curve of ferromagnetic materials, the saturation degree of the iron core is changed adjusted by adjusting changing the magnitude of dc excitation current of control winding, and then the equivalent magnetic permeability of the iron core is changed to realize continuous regulation of the inductance value and reactive capacity of the reactor.

Functions

- Suppress the overvoltage and compensate the system reactive power
- Adjust and stabilize the system voltage.
- Restrain the secondary arc current and improve reclosing success rate
- Increase the transmission capacity of lines.
- Improve the power flow distribution

System Configuration

- Multi-stage CSR
  - High Leakage Impedance Transformer
    It is the main part of CSR system with high leakage impedance rate over 90%. The primary winding is connected to power grid in parallel, and the secondary winding is connected to the control part.
  - Supplementary Reactor
    The supplementary reactor is used to absorb the reactive power, all supplementary reactors are linked in series and connected with secondary winding of high leakage impedance transformer.
  - Energy-gaining Reactor
    Each energy-gaining reactor is connected with an bypass circuit breaker in series, and provides power supply for thyritor control unit to ensure that the thyristor can be triggered on timely.
  - Bypass Circuit Breaker
    Each bypass circuit breaker is connected to the correponding supplementary reactor in parallel, and they operates when CSR starts to change level. All circuit breakers act in sequence according to a certain control and protection strategy.
  - Thyristor Valve
    As an auxiliary switchgear, the thyristor valve bank is quickly turned on before the bypass breaker operates, avoiding the opening or closing of circuit breaker with current and prolonging its service life. After the operation of the circuit breaker, the thyristor valve bank is turned off and is not used as a long-term flow device.
  - Control and Protection System
    The control and protection system is composed of merging unit, valve control unit, reactor relay and other control and protection devices, and it can cooperate with other FACTS devices and AVC system.

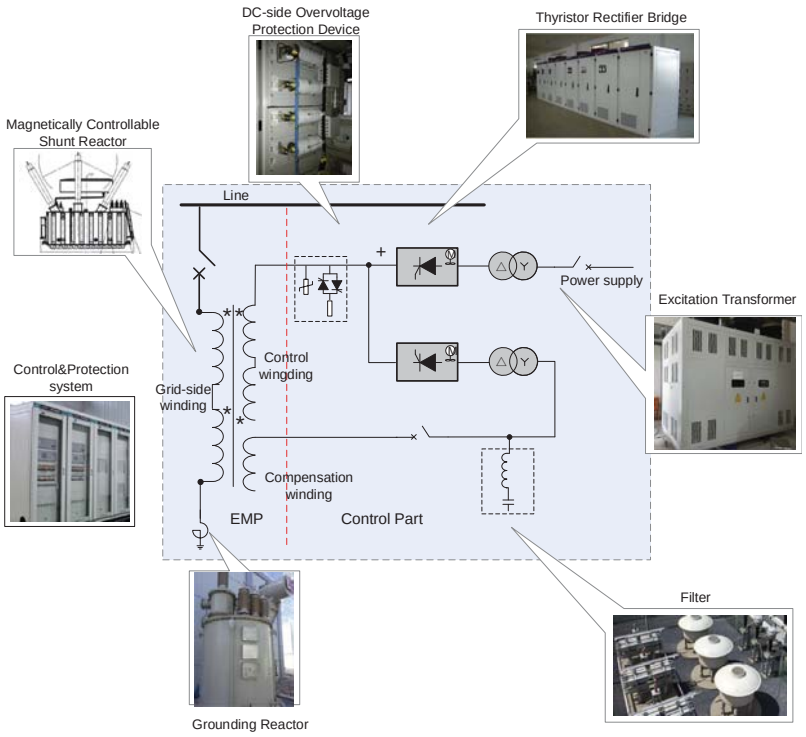

Figure 2 Magnetically CSR

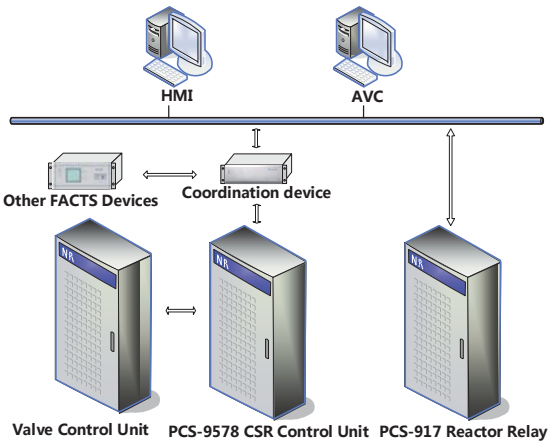

Figure 3 Control and Protection System of Multi-stage CSR

- Magnetically CSR
  - Magnetically Controllable Shunt Reactor
    The magnetron controllable shunt reactor consists of grid-side winding, control winding and compensation winding. The grid-side winding is connected in parallel to the system. The control winding is connected to the excitation system, and it realizes reactor impedance adjustment by changing the current flowing through the winding. The compensation winding is connected to the filter bank or or supplies power to the excitation system.
  - Excitation Transformer
    The excitation transformer is used to provide power for the excitation system. It can be set in two modes: self-excitation and separated excitation: the self-excitation power supply is taken from the compensation winding of reactor, and the separated excitation power is taken from the station power supply.
  - Thyristor Rectifier Bridge
    Through thyristor rectification, the alternating current is converted to direct current to provide a field current for the control winding. Generally, several thyristor valve banks with low-voltage and high-current are used in parallel operation, and the actual number of valve banks is configured according to engineering requirements.
  - DC-side Overvoltage Protection Device
    The large-capacity varistor and the linear resistor are used to provide over-voltage protection for the low-voltage equipments of the excitation rectification system, they can absorb the over-voltage energy and suppress the DC-side overvoltage in case of fault.
  - Filter
    In the side of compensation winding, 5th and 7th filter branches are configured to reduce the influence of harmonics generated by the main body on the system.
  - Control and protection system
    The control and protection system is composed of monitoring system, control devices, protection devices and coordination devices, etc, and it can cooperate with other FACTS devices and AVC system.

Features

- Multi-stage CSR
  - Optimization designed thyristor valve
    Thyristor valve features compact structure, light weight, small land space and easy installation and maintenance. Moreover, the valve adopts self-cooling structure design, no needing additional cooling equipment, with well cooling effect and less land space.
  - Superior harmonic performance
    The phase locking and fast conduction performance of thyristor ensure that the harmonic content of multi-stage CSR is very small during the adjustment process.
  - Extensive coordination and control functions
    There are a variety of coordination and control strategies between multiple sets of CSR, between CSR and other reactive power compensation equipments in station, between CSR and AVC, and between CSR and stability control system, which greatly expands the regulation ability of CSR.
- Magnetically CSR
  - Integrated design of control and protection system
    The integrated control and protection solution is provided based on unified hardware and software platform, unified communication interface and system architecture, covering monitoring system, excitation, protection, recording and other specialties, with improved overall automation level and higher reliability.
  - Reactive power rapid adjustment
    Through the overall optimization design of exctitaion system, the dynamic response time of reactor is effectively shortened, and the magnetically CSR can quickly adjust reactive power output, which has better capability of suppression of voltage and reactive power fluctuation.
  - High current thyristor valve
    The heat dissipation system with forced fan cooling + parallel air duct design + heat pipe radiator is adopted and it effectively improves the cooling efficiency and the output capability of thyristor valve.
  - Intelligent current distribution of thyristor valve
    The component-level dynamic intelligent current distribution technology is adopted to realize the precise current distribution control of thyristor valve banks in parallel operation.
  - Pulse transmission by optical fiber
    Optical fiber communication is used between the excitation devices to improve the anti-interference ability of thyristor valve banks during the process of trigger pulse transmission, and the operation is more reliable.
  - Overvoltage protection trigger for online energy-gaining
    Based on the DC-side over-voltage triggering and protection design scheme of online energy-gaining, the circuit design is simple and the operation is reliable.