



# PCS-8200

## Unified Power Flow Controller(UPFC)

Unified Power Flow Controller (UPFC), as the representative of the third generation of FACTS devices, is by far the most comprehensive FACTS device. In the steady state of electrical system, it can implement power flow regulation, reasonable control of line active power and reactive power and improvement of the transmission capacity of power system. In the transient state of power system, it can realize fast-acting reactive power compensation, dynamical support of the voltage at the access point and improvement of system voltage stability. Moreover, it can improve the system damping and the stability of power angle.

By adjusting the phase angle and amplitude of output voltage of series transformer via converter valve and control system, UPFC can realize the optimal control of power flow and system voltage. According to the injected voltage characteristics, UPFC control functions can be classified into the following four types:

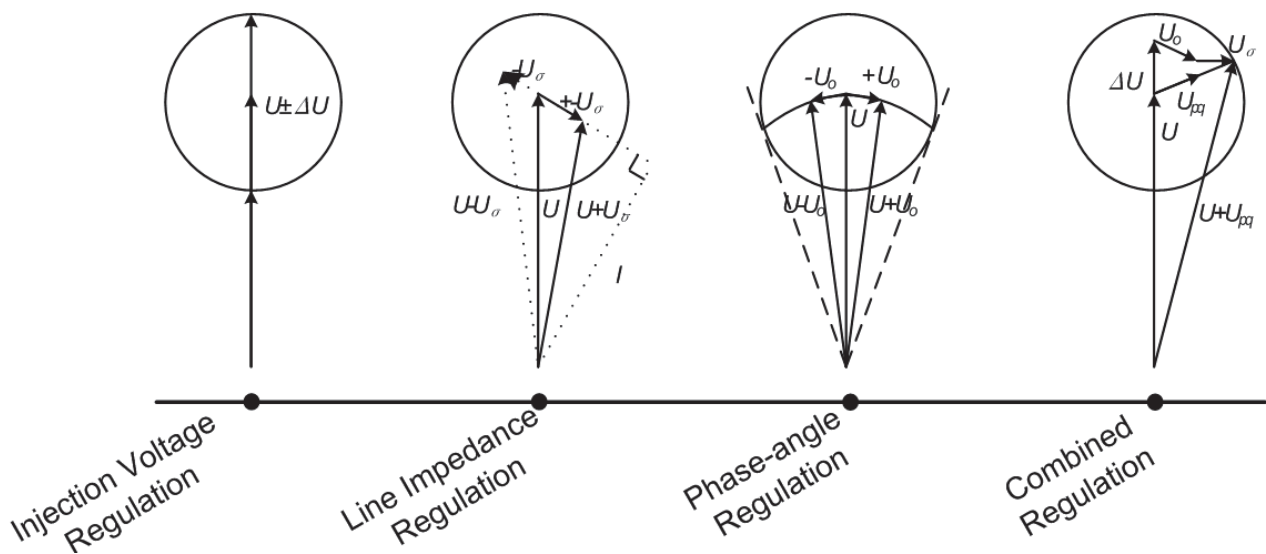


Figure 1 UPFC Control Modes

## System Configuration

PCS-8200 UPFC mainly consists of the following three parts:

- Control and protection system
- Thyristor Bypass Switch (TBS)
- Voltage Source Converter (VSC) valve

### Control and Protection System

- Adoption of embedded software and hardware technology, distributed architecture and object-oriented approach for function division.
- Realization of all the operation modes of UPFC and switchover between different modes, including UPFC mode, Static Synchronous Series Compensator (SSSC) mode and Static Synchronous Compensator (STATCOM) mode.
- Smooth start/stop function to solve the series converter charging problem, and the series transformer can be put in service without disconnecting the transmission line.
- Proposal of multi-inverter double-circuit line control strategy via automatic selection of master control unit.
- Reasonable distribution of UPFC with full protection for different modes of operation without dead zones.

### Thyristor Bypass Switch

TBS is installed in valve side of series transformer and is in parallel with the mechanical bypass switch. It is used to bypass the series converter quickly, prevent converter fault from affecting AC line and prevent AC line fault from affecting converter.



Figure 3 Control and Protection System of 220kV UPFC Project in Nanjing, China

- Utilization of fast thyristor switching technology to isolate converter from electrical system in case of fault.
- With high withstand capability of short-term high current, high-power thyristor valves and fast bypass switch technology. So, it is not necessary to use thyristor in parallel or water cooling.
- Adoption of natural cooling for TBS, damping resistance and static equalization resistance for convenient maintenance and high controllability.
- Horizontal structure and three-phase superposition arrangement save installation space.

### VSC Valve

Based on the rich experience on engineering, NR developed the UPFC IGBT converter valve with the advantages of high reliability, small installation space and easy maintenance.

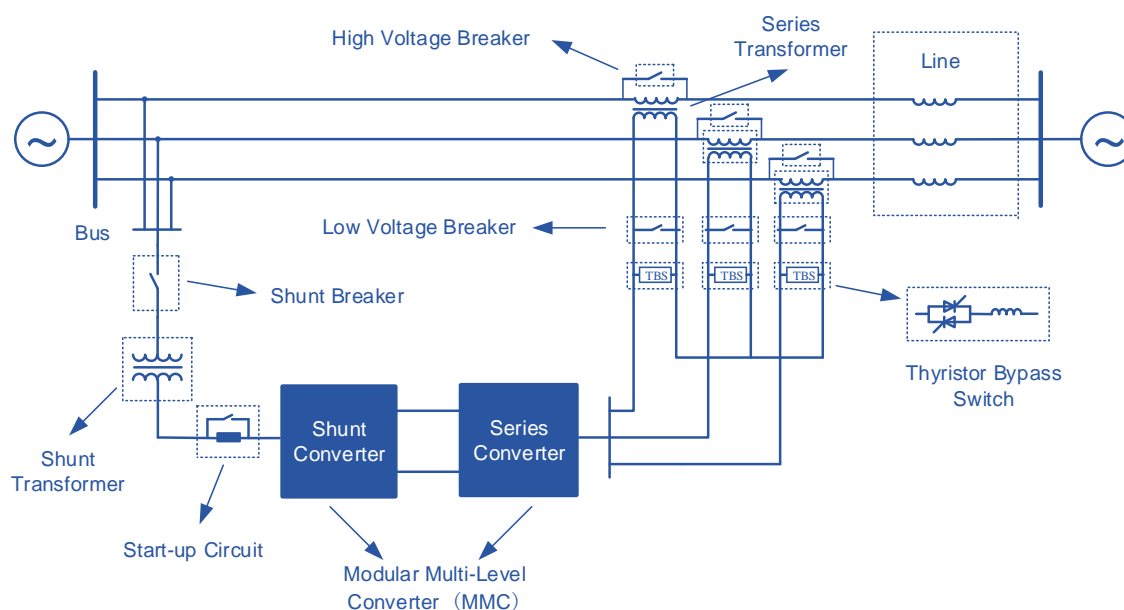


Figure 2 Typical UPFC Connection Diagram



Figure 4 TBS of 500kV UPFC Project in Suzhou, China

- Adopting compact vertical integrated structure for converter valve with hierarchical and phase-segregated design for UPFC low DC voltage applications. This structure promotes electrical symmetry of three-phase arm of converter valve, reduces external electromagnetic radiation and saves installation space.
- According to IGBT valve's charging characteristics during the start of UPFC, an ultra-low supply voltage and active voltage equalization strategy are adopted to prevent the possibility of uncontrolled state during the startup and operation of converter valve.
- For the operational safety margin, an ultra-low leakage inductance and digital driving technology are adopted. This maximizes the rational utilization of the power devices' operating parameters, increases the operational efficiency of converter valve and reduces the electrical stress of core power components.

- Based on hardware detection and state prediction technology, it realizes the monitoring and protection of electrical and non-electrical quantities of IGBT valve in full range. Real-time state information of converter valve and sub-modules is sent to the monitoring system according to IEC61850 protocol.
- The valve control unit with microsecond control precision increases the dynamic response of converter valve, and it provides overvoltage/overcurrent protection for sub-modules according to the complete monitoring.
- The utilization of separable power modules, pluggable boards in the module and standard connectors facilitate troubleshooting and maintenance.

## Features

- Flexible adaptation to different electrical network structures.
- Modular structure, easy extension, convenient installation and maintenance.
- Low switching-frequency MMC and low converter loss.
- Flexible control modes.
- In parallel side: controlling AC voltage and dynamic reactive power at grid-connection point.
- In serial side: controlling terminal voltage, phase, impedance and combined flow.
- Support of steady state and transient state analysis for different AC systems.
- Customized system strategies.



Figure 5 VSC Valve of 500kV UPFC Project in Suzhou, China