



Metro Protection & Control Solution



Perfect & Reliable Solution for Metro Power

NR Electric Co., Ltd.



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Company Profile



Specialized in technical research, product development, manufacture & sales and engineering service in digital protection and control field, Nanjing Nari-Relays Electric Co., Ltd. (NR Electric) is the largest R&D center and industrialization base in this field in China. NR Electric is a major typical player of national self-dependent innovation, national important new high-tech enterprise, national important software enterprise, one of the top 100 software enterprises of China and R&D center for power protection and control of National Energy Administration.

Centering on “relay protection theory of power frequency variation principle” built by Academician Shen Guorong, NR Electric has developed a series of relay protection and power automation products with proprietary intellectual property rights, which provided key national projects such as Three Gorges Project, West-East Electricity Transmission Project, Olympic project, Shenzhou Spacecraft Launching Base and ultra-high voltage grid construction with reliable power protection and control systems. Through years of development, NR Electric has created enterprise culture with “Practice, Improvement, Cooperation and Innovation” as the core values, and has always insisted on a sustainable development strategy of “Refining Core Business, Exploring New Business”, committing to provide electric secondary integration solutions for each industry and each field.

NR Electric is one of the leading brands in the electric system and industrial field. Our products occupy more than 45% market share in relay production market of 220kV or above power system nationwide. According to the reports issued by famous international research institution NEWTON-EVANS, NR Electric has become one of the five largest international suppliers of power protection and control products (ABB, AREVA, NR Electric, SEL, Siemens). Our products command a ready market in 68 countries and regions, which makes us one of the most influential enterprise in China and in Asia in this field.

Oriented on process management, NR Electric has established and implemented Integrated Management System (IMS) based on requirements of Quality Management Standard (ISO9001:2000), Environment Management Standard (ISO14001:2004) and Occupation Health Safety Management Standard (OHSAS18001:1999); NR Electric further integrates other management systems, such as Capability Maturity Model Integration (CMMI) for software, Enterprise Resource Planning (ERP) and etc., to establish a better management system. Operation of IMS represents that the company’s management system has stridden forward an international management level.

Solution Features



Based on the leading position in digital protection field and technical advantages in power electronic field in China, NR Electric provides “Advanced, Practical, Perfect & Reliable” solutions for the Metro power system.

■ The Intelligent Protection Solution for Metro Power Supply System

- The Intelligent Protection Solution for Metro Power Supply System.
- Reduce the busbar fault clearance time to 50ms.
- Solve the 22kV bus coupler flashover problem.
- Capacitive current compensated fiber optical current differential protection (PCS-9613).
- Compatible to IEC 61850 standard, GOOSE message is used to instead of hardwire for interlock function.

■ Protection Solution for Metro 750V DC Feeder

- Passed the technical evaluation of Electric Engineering Society.
- PCS-9683 DC feeder relay has been put into service for more than 3 years in Shanghai Metro Line.
- High reliable hardware which is more suitable for Metro environment.

■ SVG Solution for Metro Medium Voltage Power Supply System

Intelligent Protection Solution of Metro Power System



Our intelligent protection solution aims at reducing the time delay of overcurrent (OC) protection and improving the security for Metro medium voltage (MV) power system. Based on the characteristics of Metro MV power system, large number of mature products and technologies are adopted in this solution. Based on the GOOSE communication and “self-adaptive discrimination of fault area technology”, digital overcurrent protection (DOP), an instantaneous OC protection with absolute selectivity, is the key for the fast operation.

■ Solution Features

- The performance of DOP wouldn't be reduced with the number of Metro substations increased in series in a power supply block. The fault clearance time is less than 50ms wherever the fault occurs in the system.
- Adaptable to “Big series ring power supply mode”. When more than 10 Metro power substations are connected in series in a block, the supply mode is called “Big series ring power supply mode”. When the Metro power system is operated in this mode, our solution can effectively solve the problem of large time fault clearance time in the upstream Metro power substations.
- Realize the coordination of fiber optical current differential protection (FO CD protection) and digital overcurrent protection (DOP). FO CD protection is the main protection of interconnect cables, which connected to neighbour Metro power substation, and the DOP relay is used as busbar main protection.
- Improve the performance of selectivity and speed.

For the faults occurred in the upstream Metro power substation in a block, our solution will reduce the operation time dramatically from 1.5s to less than 50ms.

- The existing protection solution has insufficient sensitivity to intermittent faults, which may cause serious damage to primary equipment, such as switch cabinet. DOP relay has a better sensitivity to such defects and can quickly clear intermittent faults as fast as 50ms.
- The solution keeps mature relays with functions such as FO CD protection, backup overcurrent protection and automatic switching so that the safety of the system operation will be remained even when the DCP is out of service.
- “Self-adaptive discrimination of fault area technology”, the core of DCP, is a mature protection principle. It has been widely implemented over 500 intelligent protection solutions in power system and other industrial areas.
- The products adopted in this solution are based on our most mature and advanced UAPC hardware platform and support modularity configuration and imaging configuration technology. The number of UAPC products currently in service all over the world is more than one hundreds thousands.
- Higher reliability. More hardware resources and stronger immunity capability to interference. Especially the triple-proof technology adopted in PCB board production can effectively reduce the risk caused by high humidity when the devices operate in underground Metro station.
- Optional GOOSE interlock function. GOOSE

Intelligent Protection Solution of Metro Power System



interlock can dramatically reduce cables and wiring work and site commissioning work.

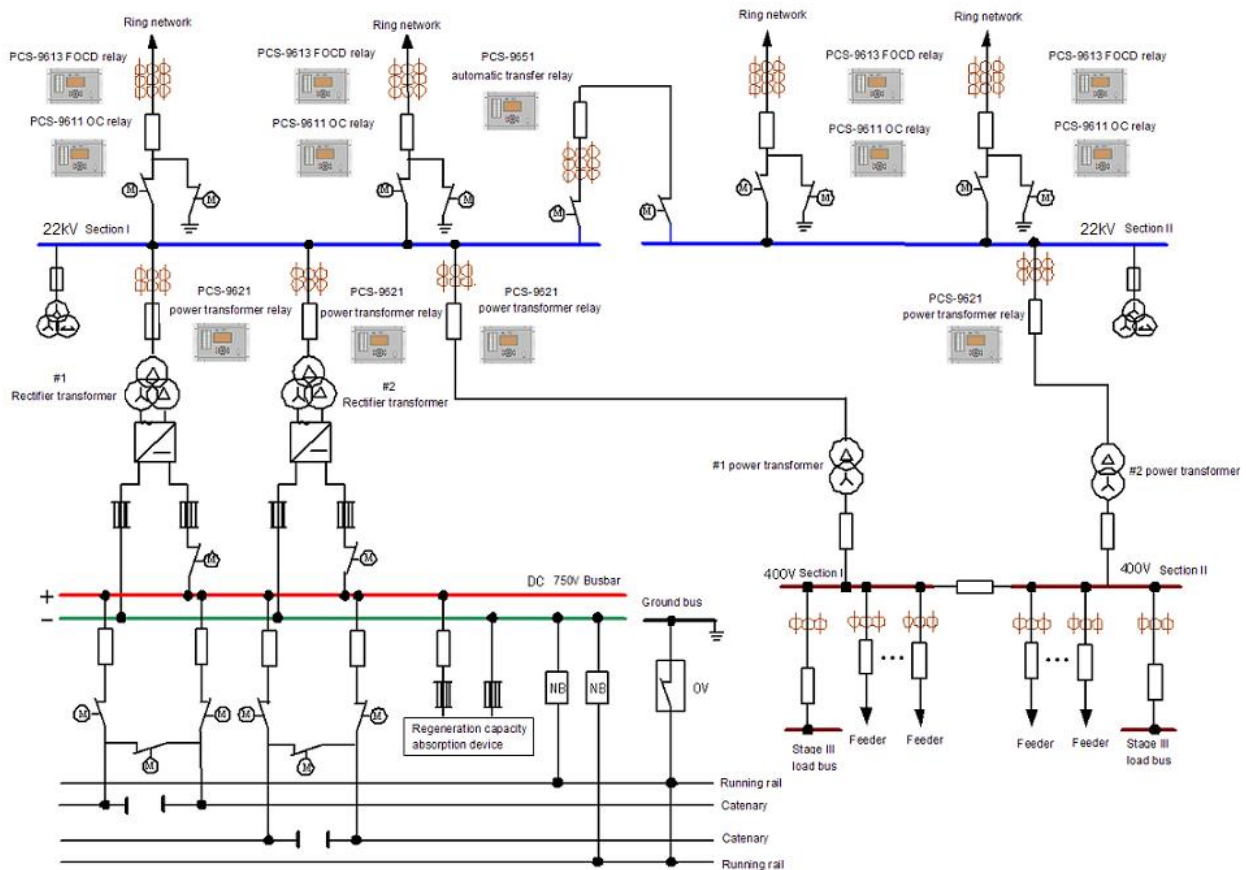
- Bring the international advanced intelligent protection solution into Metro protection field. This can reform and upgrade the technologies in Metro protection field and achieve a more stable and reliable new Metro protection system which is easier to be maintained and expanded.

Protection Configuration

The intelligent protection solution, which based on

IEC61850 standards, includes following relays:

- PCS-9613 FOCD relay.
- PCS-9611 digital OC relay.
- PCS-9621 power transformer relay.
- PCS-9621 rectifier transformer relay.
- PCS-9651 automatic transfer relay.
- PCS-9882 optical fiber switch dedicated for GOOSE network.



Intelligent Protection Solution of Metro Power system



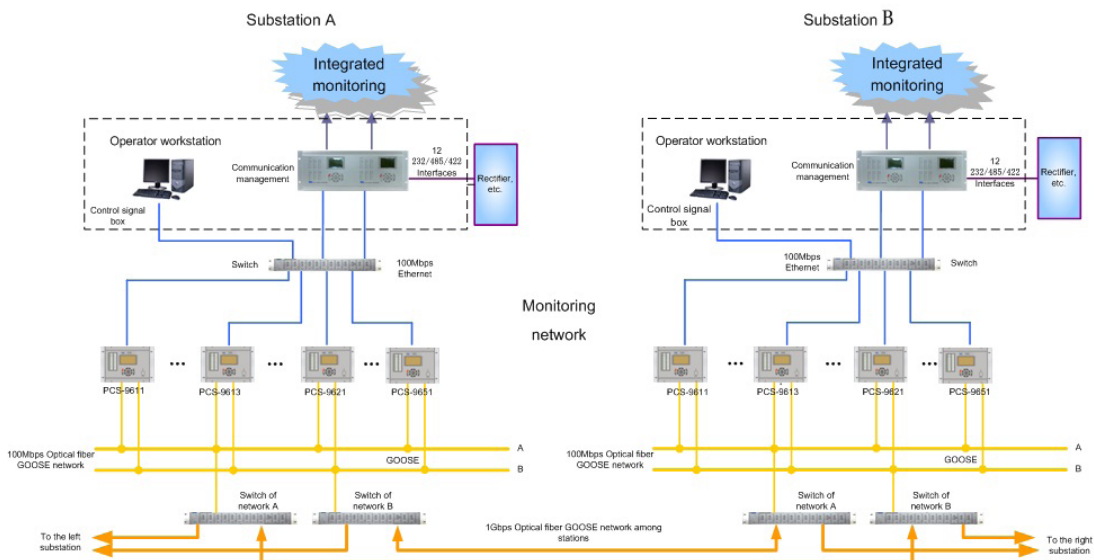
These relays provide the whole set control and protection functions of 22kV MV power supply system, including ring network cable protection, busbar protection, backup over-current protection (integrated in PCS-9611), transformer protection, decompression automatic switching and differential automatic switching. All these protection relays are switch cabinet installation mode supportive. The schematic diagram of screen cabinet configuration is shown as follow:

| Incoming cabinet | Outgoing cabinet | Power transformer | Rectifier transformer | Bus coupler cabinet |
|-------------------|-------------------|-------------------|-----------------------|---------------------|
| PCS-9613 PCS-9611 | PCS-9613 PCS-9611 | PCS-9621 | PCS-9621 | PCS-9651 |
| | | | | |
| | | | | PCS-9882 |

PCS-9882 is our dedicated industrial level GOOSE switch for intelligent protection solution. It has obtained Class A certification of State Grid Corporation of China (SGCC) (applicable to the process level of intelligent protection solution (IPS)) and KEMA certification of Netherlands; it has passed the technical evaluation of National Energy Administration. PCS-9882 switch meets the harsh standard of electromagnetic compatibility, with the zero packet loss under strong electromagnetic interference and can be installed in a bus-coupling switch cabinet.

■ Networking Solution of GOOSE Network

The communication in IPS of Metro power supply system is based on GOOSE network. In order to ensure the reliability of GOOSE network, the network configuration in the solution has following characteristics:



Intelligent Protection Solution of Metro Power system



- Redundant GOOSE network, seamless switching between two networks, one network failure does not affect communication. support QoS priority control of GOOSE signals.
- Two optical fiber ring networks. Monitoring network and GOOSE network are independent and separated. The bandwidth of interconnection fiber ports among the stations are all 1000Mbps. Fast speed, high reliability and strong anti-interference capability.
- The specific “link-break detection mechanism” of GOOSE can detect communication fault of GOOSE network rapidly and locate the fault accurately.
- Devices are equipped with high performance GOOSE communication card with independent DSP processor. Our GOOSE signal processing time is in μm level and the delay time of single signal transmission is shorter than 5ms.

■ Table of Protection Configuration

| Name of protected unit | | Protection relay | Protection configuration | Remark |
|------------------------|-----------------------|---|--|--|
| 22kV substation | 22kV incoming cabinet | PCS-9611 overcurrent relay PCS-9613 optical fiber current differential relay | <ul style="list-style-type: none"> • Overcurrent protection • Optical fiber current differential protection • Time delay overcurrent protection • Zero sequence current protection • Loss of voltage protection | Time delay overcurrent protection and digital current protection integrated realization in a device. |
| | 22kV outgoing cabinet | PCS-9611 overcurrent relay PCS-9613 optical fiber current differential relay | <ul style="list-style-type: none"> • Overcurrent protection • Optical fiber current differential protection • Time delay overcurrent protection • Zero sequence current protection • Loss of voltage protection | Time delay overcurrent protection and digital current protection integrated realization in a device. |

Intelligent Protection Solution of Metro Power system



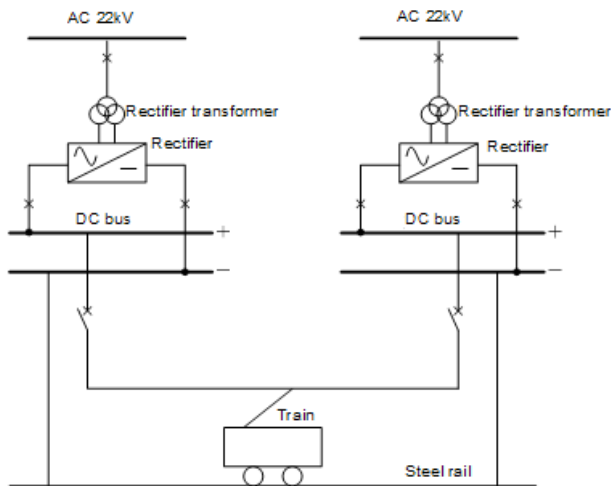
| Name of protected unit | | Protection relay | Protection configuration | Remark |
|------------------------|---|-----------------------------------|---|--------|
| 22kV substation | 22kV bus coupler cabinet | PCS-9651 automatic transfer relay | <ul style="list-style-type: none"> Instantaneous overcurrent protection with time delay Zero sequence current protection Loop closing protection Auto switch over decompression Auto switch over differential motion | |
| | 22kV feeder cabinet: connect with rectifier units | PCS-9621 transformer protection | <ul style="list-style-type: none"> Current quick break protection Overcurrent protection Overload protection Zero sequence current protection Temperature protection Rectifier internal protection | |
| | 22kV feeder cabinet: connect with power transformer | PCS-9621 transformer protection | <ul style="list-style-type: none"> Instantaneous overcurrent protection Overcurrent protection Overload protection Zero sequence current protection Temperature protection | |
| | dedicated GOOSE switch | PCS-9882B GOOSE switch | <ul style="list-style-type: none"> Certified by KEMA of Netherlands Support QoS priority control Network storm suppression function Support VLAN configuration working temperature range : -40°C-70°C | |

Protection Solution for 750v DC Feeder



PCS-9683 is the new generation digital direct-current feeder protection relay with integrated control and monitoring functions, it can provide complete protection, measurement and control for the feeders of DC power supply system of metro and light rail. PCS-9683 can perfectly adapt to the load characteristics impact and mobility in the DC power supply system. It can be installed in panels, also can be installed in local cabinet. The typical application is as follows:

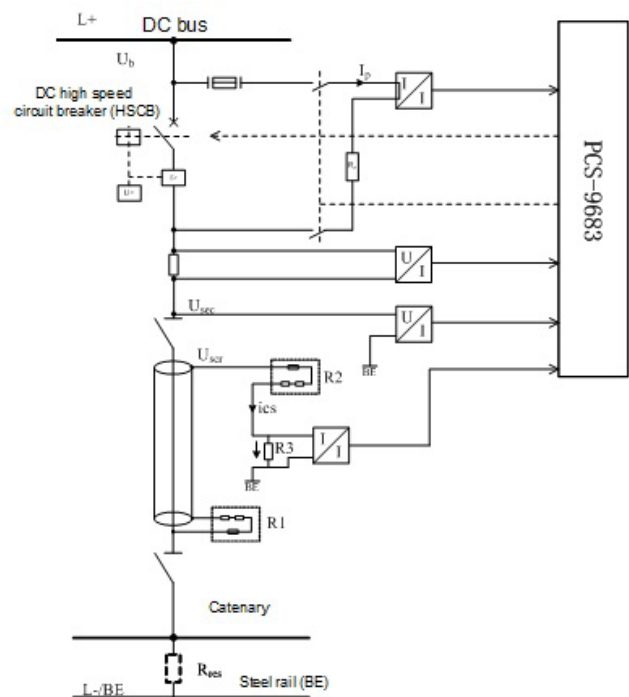
- Improved event records and fault recording functions, make the post-fault analyze easier.
- Provide ancillary test equipment for the pre-commissioning and commissioning test of PCS-9683. Adjust the setting of the test equipment to output required mA signal to verify the function of PCS-9683.
- Totally seal casing, power circuit and signal circuit are strictly separated. New design is software highly improves the anti-interference capacity of the relay; external electromagnetic radiation also meets relevant standards.



■ Solution Features

- With complete protection, measurement and control functions.
- User-friendly human-machine interface.
- Flexible communication, and support various protocols such as PRPFIBUS-DP/V0.

■ Typical Application



Protection Solution for 750v DC Feeder



■ Major Functions

Protection functions

- Instantaneous overcurrent protection.
- Definite time overcurrent protection.
- Current instantaneous rise rate protection.
- Definite time current rise rate protection.
- IDMT thermal protection.
- Line test and auto reclosing.
- Cable insulation monitoring.
- Fault recording.

Measurement and control functions

- CB test-close and test-trip.

- CB trip/close.
- Inter-trip in the neighbor substation.
- CB test-close and test-trip.
- Bypass isolation switch trip/close.
- I, P, U and other measurements.

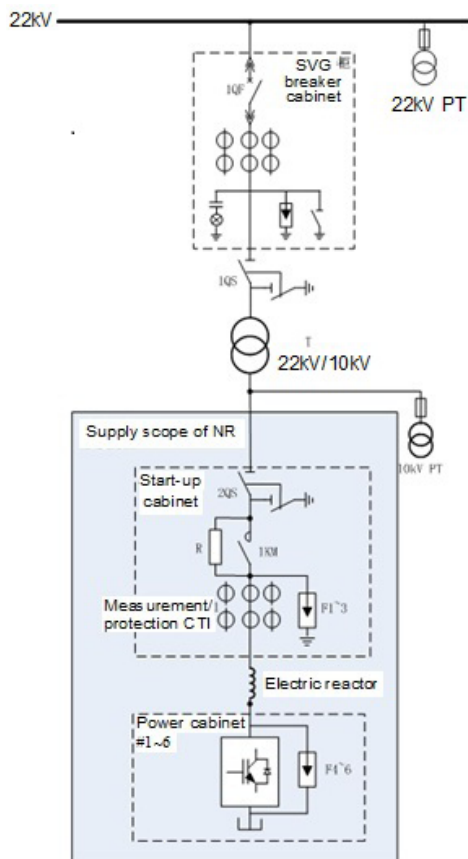
Auxiliary functions

- Support the IEC 60870-5-103 protocol (ethernet/RS485), serial port MODBUS protocol and PROFIBUS-DP/V0 protocol of the Ethernet or RS485 bus.
- Record up to latest 64 of trip, operation and self-inspection events, latest 256 SOE, latest 64 user operation reports and 8 disturbance waveforms With the maximum recording period 15s.
- Support time-sync and print functions.

SVG Solution for Medium Voltage Power Supply System



PCS-9583 SVG system has the capacity of bidirectional reactive power transmission, which can cater for the dynamic reactive impact in the system by controlling its reactive output and ensure the system power factor is above 0.95. SVG devices mainly consist of 5 parts: control cabinet, power cabinet, start-up cabinet, connected electric reactor and transformer. And its application bar net structure is as follows.



■ Solution Features

Reactive power can be transmitted through a high-frequency switch of high-capacity power electronic device controlled by PCS-9583. Compared to other traditional reactive power compensation devices, PCS-9583 has great technical advantages and its characteristics are described in details as follows:

- Short response time: less than 5ms , which is applicable to rapid impact load compensation.
- Excellent compensation performance: provide bidirectional reactive power and continuously dynamic adjustment; output reactive current is not related to system voltage; and it can meet the maximum requirements of power factor compensation.
- Great inhibiting ability for sudden voltage changes: the maximum inhibition ability of SVC on sudden voltage changes can reach 2:1, while SVG can reach 5:1 or even higher.
- Wide operation range: SVG is able to work in both rated inductive and capacitive ranges.
- Diversified compensation functions: be able to achieve diversified compensation functions, including reactive power compensation, voltage compensation, negative-sequence current compensation, harmonic current compensation and etc..

SVG Solution for Medium Voltage Power Supply System



- Less harmonic content: harmonic distortion rate of both output voltage and current are less than 3%, and there is no need to install harmonic filter branches.
- Less total volume: The whole set of SVG only includes start-up cabinet, power cabinet, connected transformer, control and cabinet; no filter bank needed.

■ Operating Mode

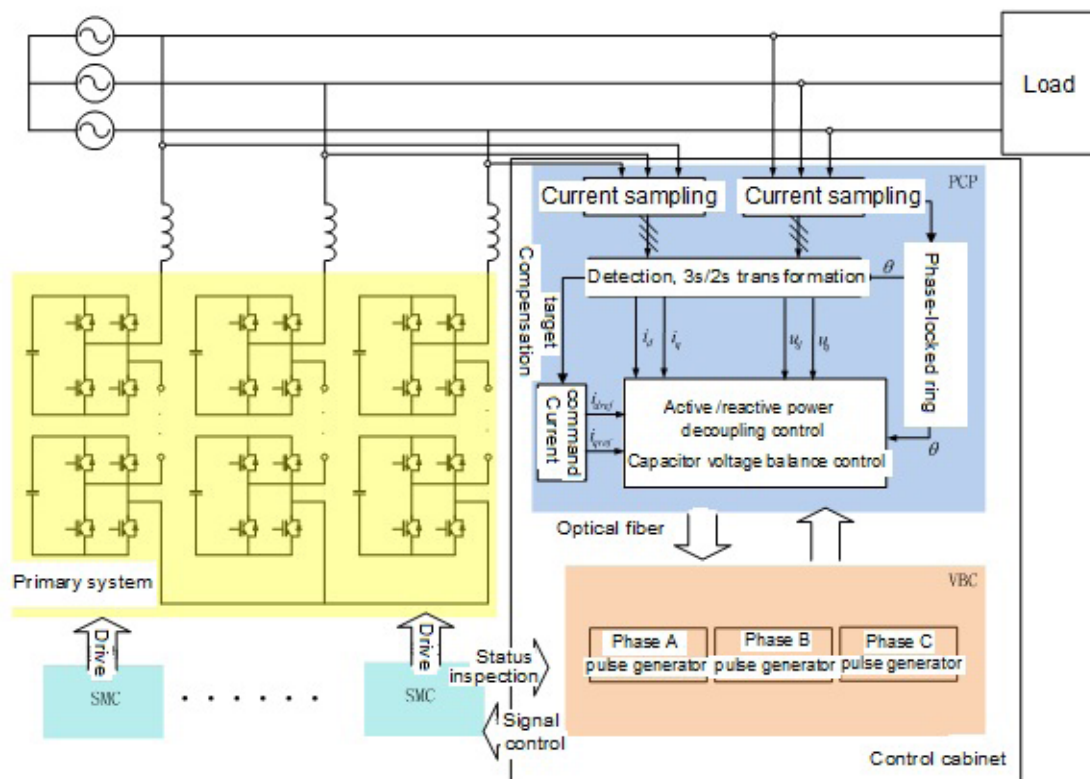
| Mode | Name | Desprition |
|------|-------------------------|--|
| 1 | Constant reactive power | Enable control device to output constant reactive power by setting rated reactive power values; "+" indicates output of inductive reactive power while "-" indicates output of capacitive reactive power. The referenced setting range of reactive power is -12~12Mvar, and the setting shall not be out of the rated capacity. In addition, the setting can be adjusted online by pressing the increase and decrease reactive power button on control cabinet panel. And the reactive output rate (kVar/ms) also be adjust through configuration. In this way, accuracy and step response speed of the device react to reactive power change can be measured. |
| 2 | Constant voltage | With the setting of allowed voltage variation range, the device will auto-adjust the amount of reactive power absorbed or output. When system voltage is lower than the pre-set voltage, the device would output inductive reactive power to raise the system voltage; but when the system voltage is higher than the pre-set value, the device would output capacitive reactive power to decrease system voltage. The mode also provides control parameters for lower limit of bus bar voltage and upper limit of change rate. When system voltage value or change rate value is beyond the limitation, the device would fully output capacitive reactive power to support system voltage rapidly. |
| 3 | Active power filter | Current output can be adjusted automatically by inspecting current in the load side of device to decrease harmonic and improve the quality of electric energy of load power. |

SVG Solution for Medium Voltage Power Supply System



■ System Control Principle

Based on the chained SVG topology, two levels control is adopted. The upper level control complete all the total control of active and reactive power, and the lower level control distribute the active power of each chain link of the same phase link on the basis of the upper level control to achieve the balance of each capacitor voltage. The chained SVG system control block diagram is shown below; decoupling control is used on the upper level, and then the voltage balance of DC capacitor is achieved through the method of balance control algorithm.



The upper control uses the common decoupling control algorithm: let the d-axis responsible for the active power to achieve the stable control of the DC side capacitor; let the q-axis responsible for the reactive power to achieve the control of the reactive power need of the system. To realize the DC capacitor balance algorithm of the chain link, the balance control algorithm can be added on the basis of modulation wave to ensure the balance of the DC side capacitor voltage.



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