Case Study

NR's Magnetically Controlled Shunt Reactor System

Dynamic reactive compensation in Angola for 400kV transmission stabilization and its capacity increase

NR Electric Co., Ltd.

Project Overview

The Angola WACO KUNGO 400kV substation is an important hub for grid connection in northern, central and southern Angola. The length of the LAÚCA-HUAMBO 400kV connection line is about 400km. Due to the capacity rise effect of the line, there will be a problem of higher operating voltage after commissioning, which safe and stable operation of the power grid. By installing a magnetically controlled high-impedance system, the voltage difference between the start terminal and the end terminal of the line is effectively reduced, and the power supply area of the WACO KUNGO and HUAMBO areas is increased, then the power quality of the area and the support of the local low-voltage distribution system are improved.

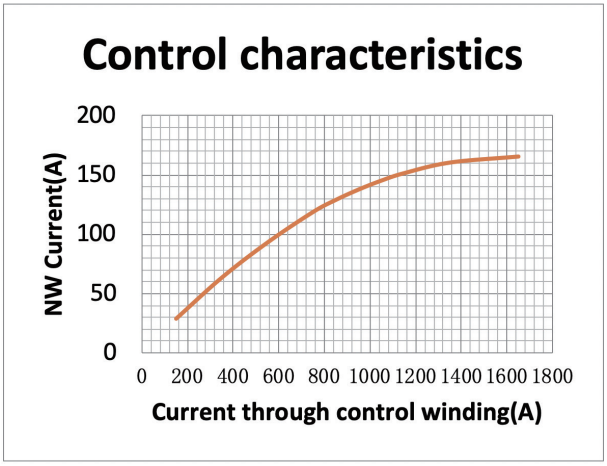
As a general contractor of magnetically controlled shunt reactor (hereinafter referred to as MCSR), NR Electric provided 5 sets of MCSR equipment for the project, of which one set of 400kV/30MVar and two sets of 400kV/40MVar were installed in KUNGO substation, while One set of 400kV/40MVar and one set of 400kV/60MVar were installed in DANGO substation. At the same time, NR also undertakes the system design, system simulation analysis. Starting from undertaking the project, the project team worked closely together to conduct in-depth research and perfect simulation analysis on many technical issues such as system response time, harmonic suppression, overvoltage protection, excitation switching, and sequence start & stop. After field operation test, the key technical indicators of the system fully meet the contract requirements.

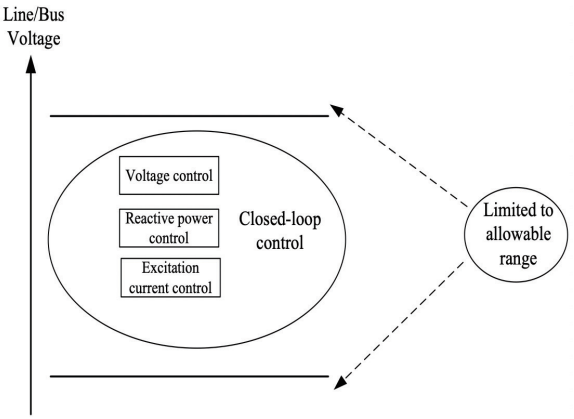
The Solution

Principle

The magnetically controlled shunt reactor (MCSR) can be installed at line terminals or any substation bus and regulate its absorbed inductive reactive power through changing its equivalent impedance according to line voltage or reactive power fluctuation.

The MCSR can realize continuous capacity regulation through changing iron core' s saturation extent, i.e. equivalent magnetic conductivity, by controlling the value of DC current flowing in the control winding. The control system samples the reactor' s electrical variables and control commands to regulate the excitation voltage & current output by the rectifier in real time according to the change of electrical variables so as to realize the closed-loop regulation with the line voltage or reactive power as its control target. Finally, the voltage level of the line can be maintained and the stability of the power system can be improved.

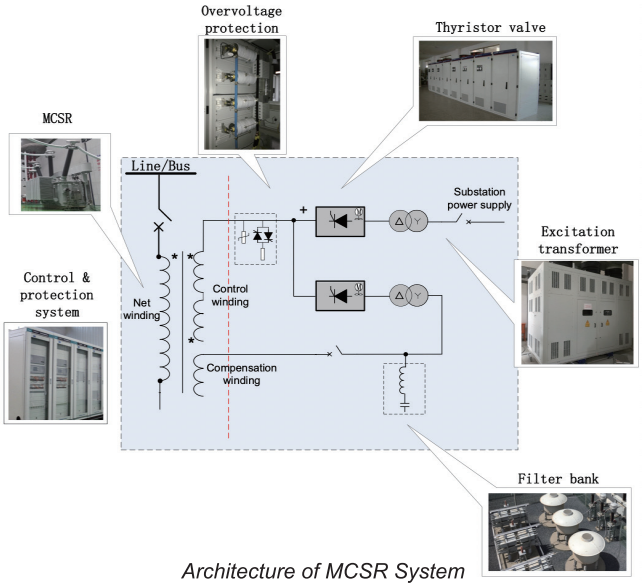




MCSR system is developed as a new generation control system based on the rich experience of NR' s generator excitation system. The system is designed to be reliable, advanced, stable, easy to use and can meet the application requirements on various capacity and voltage. In addition, it can not only implement the protection & control functions, but also realize the on-line real-time measurement & control for the whole system, provide a friendly human-machine interface, support application requirements for digital substations, meet the requirement on IEEE and related standards.

MCSR Components

MCSR system comprises two parts: one part is a primary power equipment including MCSR body, power rectifier, excitation transformer, overvoltage protection device, filter bank, and auxiliary equipment; the other part is a secondary control devices such as monitoring system, regulation devices, protection devices, coordination control units and so on. These above equipment can be flexibly selected & customized based on site and customer requirements.



Architecture of MCSR System

Parameters and Performance

There are five sets of MCSRs being installed in two extended substations at 400kV.

Three sets of MCSR with each rated at 40Mvar are three-phase oil-immersed ONAN type, with two of which installed in WACO KUNGO substation and one of which installed in BELÉM DO DANGO Substation.

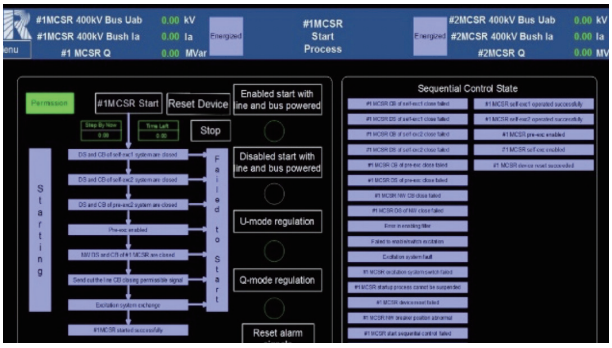
- Rated voltage: 420/17/12kV
- Rated capacity in continuous output: 40MVar
- Cooling mode: ONAN

One set of three-phase oil-immersed ONAN type of 60Mvar MCSR is installed in BELÉM DO DANGO Substation.

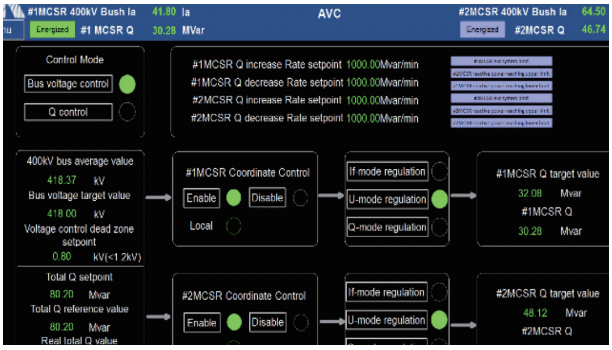
- Rated voltage: 420/23/12kV
- Rated capacity in continuous output: 60MVar
- Cooling mode: ONAN

One set of three-phase oil-immersed ONAN type of 30Mvar MCSR is installed in WACO KUNGO Substation.

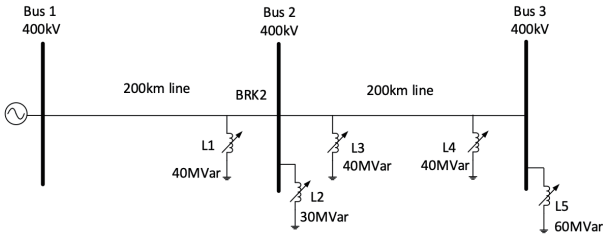
- Rated voltage: 420/15/12kV
- Rated capacity in continuous output: 30MVar
- Cooling mode: ONAN



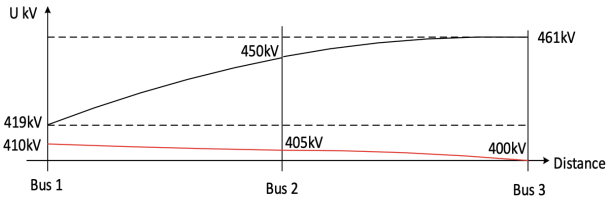
One-Button Start/Stop Design



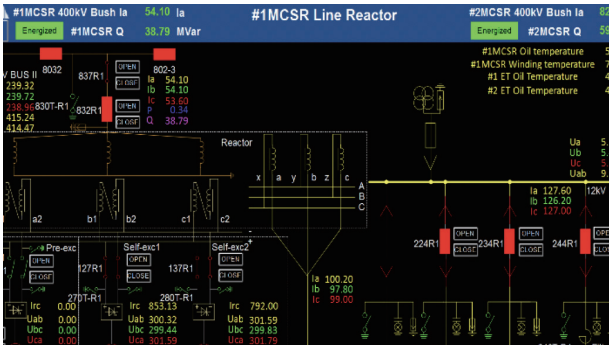
Automatic Voltage Control HMI



Power transmission with MCSR



Voltage distribution along transmission line with/without MCSR, where voltage curve in black is without MCSR, and voltage curve in red is with MCSR.



Online Operating HMI

Indoor Facilities

Site Delineations

The compact and orderly site equipment layout is as follows.

Outdoor Facilities

Outdoor Facilities

Operation Training

Operation Training

NR's MCSR Features

NR' s MCSR consists of a Magnetically Controlled Shunt Reactor, a capacitor bank and capacitance compensation filters. This system allows for flexible control of reactive power and tension stability within the network.

- Management of the reactive power stabilization
- Improving the carrying capacity of electrical transmission lines
- Reducing loss of power within the network
- Reducing the number of equipment overhauls and improving overall performance issues

Advantages

- Supply a quick response reactive power compensator with good static, dynamic and transient stability to adapt different grid voltages and various network scale.
- Continuously regulate reactive power from 5% to 100% of rated capacity, together with a shunt capacitor bank in some conditions to implement capacitive reactive power output.
- Furnish one-button start/stop design, comprehensive monitoring of the reactor & control system and the automatic operating control.
- Employ the compound control model with multiple electrical variables, to ensure fast capacity regulation under high forced excitation voltage and to guarantee excitation current & reactive power in safe range.
- Produce less harmonic at network side by installation of 5th and 7th filters at medium voltage if necessary.
- Regulate the output capacity of the high-voltage reactor through changing the excitation current in the low-voltage control winding using the easy-achievable and high-reliable rectifying facility.
- Improve observability, controllability and maintainability of the excitation system with intelligent excitation control architecture design.
- Configure the intelligent measurement and control unit for the rectifier in order to realize the intelligent exiting of rectifier cabinet (to support on-line maintenance), the intelligent current equalization (to support component-level dynamic current equalization) and intelligent protection.

Solution Benefits

Field Adaptability

- Full-independent double-redundant excitation control system
- Redundant configuration of the excitation power transformer and the power rectifying panel' s excitation power circuit so that whichever becomes abnormal to exit cannot affect the reactors operation because of there being on-line maintenance.
- Three-layered DC overvoltage protection design with low-voltage large-capacity zinc-oxide resistor, overvoltage protector and thyristor-bypass circuit so as to ensure low-voltage excitation equipment's safety.
- Coordination control device configured in each substation to distribute the required capacity output of multiple MCSRs installed at the same substation and to coordinate the work between them according to the grid work condition.

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