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NR STATIC SYNCHRONOUS COMPENSATOR (STATCOM)

Intelligent Solution for Stability Support & Quality Power



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Effective Way to Enhance Power Quality and Stabilize Power Grids

Power quality is of great importance for the development of modern society. However, electrical power grid is facing great challenges that lead to weaken the power quality. Such challenges include voltage fluctuation and harmonics injection through unstable renewable energy penetration; large system collapse and blackout caused by voltage instability; flicker and three phase unbalance resulted from industrial loads, etc.

Voltage adjustment, power factor correction, power stability improvement, three phase current and voltage unbalance mitigation can effectively compensates reactive power and improves power quality. NR Electric' s PCS-9583 STATCOM is the latest reactive power compensation solution based on a voltage-source converter (VSC) and is a fully-controlled power electronics device. It is able to work as either a source or sink of reactive AC power to an electricity network.

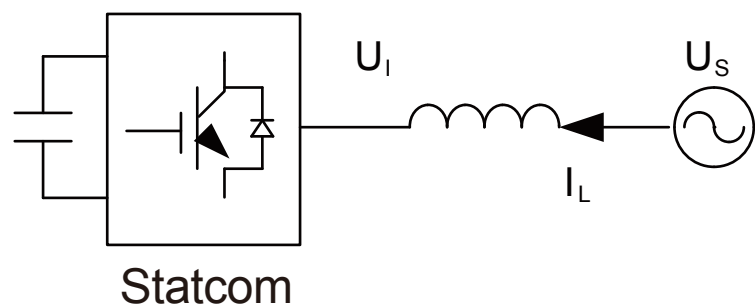
STATCOM also improves the efficiency of transmission systems, increasing the power transmission capacity as well as reducing the risk of voltage collapses and blackouts. It is mostly used to enhance the efficiency of long-distance power transfer, relieve transmission bottlenecks, and safely integrate intermittent energy sources like wind and solar power into the grid.

A New Generation Compensating System with Advanced Features

Shunt compensations system has experienced a development of three generations, which are shunt capacitors, thyristor-based SVCs and VSC-based Static Synchronous Compensator (STATCOM). Although SVC is more widely used and economical than STATCOM, STATCOM features more advantages and is replacing SVC as the main shunt compensation device.

The STATCOM/ SVG functions as a voltage source. The magnitude of the voltage source can be adjusted in a very fast manner. By adjusting the magnitude of the voltage source the reactive power output from the STATCOM can be changed.

The following figure shows fundamental topological structure of STATCOM.



Typical Structure of Statcom



Operating mode	Waveform	Description
No load		When $U_i=U_s$ or $I_L=0$, no compensation is provided
Generate reactive power		Adjust $U_i > U_s$ or current I_L leads grid voltage U_s , then STATCOM generates capacitive reactive power, which can be adjusted continuously
Absorb reactive power		Adjust $U_i < U_s$ or current I_L lags grid voltage, then STATCOM absorbs capacitive reactive power, which can be adjusted continuously.

Statcom Basic Concept

The complete set of STATCOM system provided by NR has a good compensation effect and high quality. This complete set of STATCOM system includes the following main equipment:

- Connection reactor
- Start-up equipment
- Power valve tower
- Switchgears
- Current and voltage transducers
- Forced Air/water cooling system
- Control and protection system
- HMI system
- Step-down transformer (optional)

	SVC	STATCOM
Switching component	Thyristor- half controllable	IGBT- full controllable
Category	Second generation	Third generation
Response time	fast	faster
Losses	small	medium
Footprint	medium	1/3~2/3 of SVC at same rating
Flicker reduction	good	better

Table 1. Comparison between SVC and STATCOM

STATCOM Applications

Power Transmission and Distribution



- Reactive power compensation
- Stabilized system voltage
- Reduce transmission losses
- Increase line capacity with dynamic voltage support
- Improve transient stability
- Provide power oscillation damping

Mining Hoists and Industrial



- Improve power factor
- Reduce reactive power loss
- Improves harmonic pollution through active power filtering
- Enhance line terminal voltage
- Improve power supply security
- Reduce voltage fluctuation and flickers

Electrified Railway



- Active power factor control
- Voltage regulation for weak grid
- Eliminate negative sequence 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
- Improve low-voltage ride ability

Steel Plant and Rolling Mill



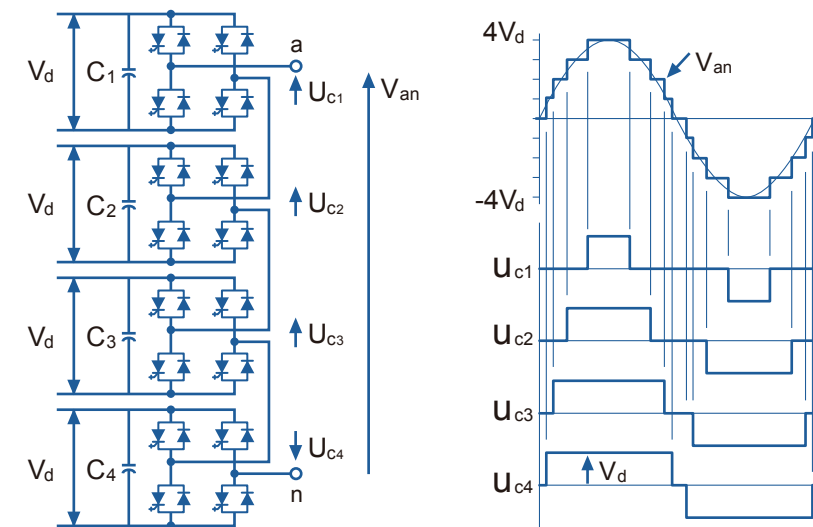
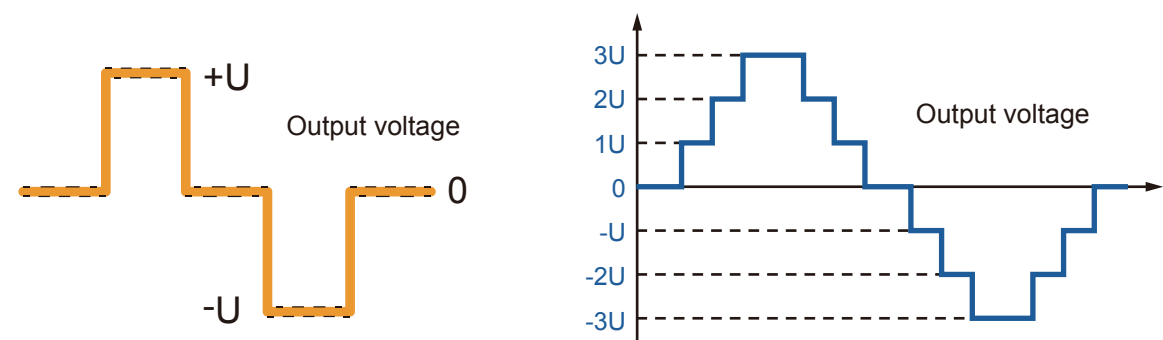
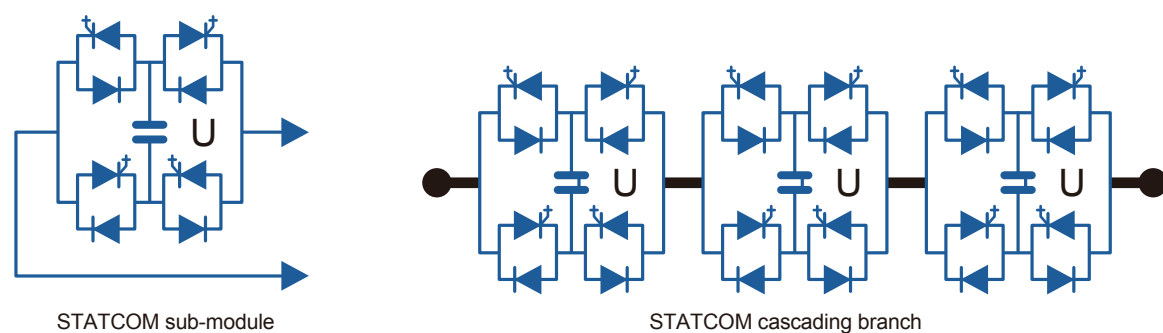
- Provide harmonic filtering
- Compensate unbalanced voltage
- Reduce voltage fluctuation and flicker
- Limit reactive power impact
- Control power factor



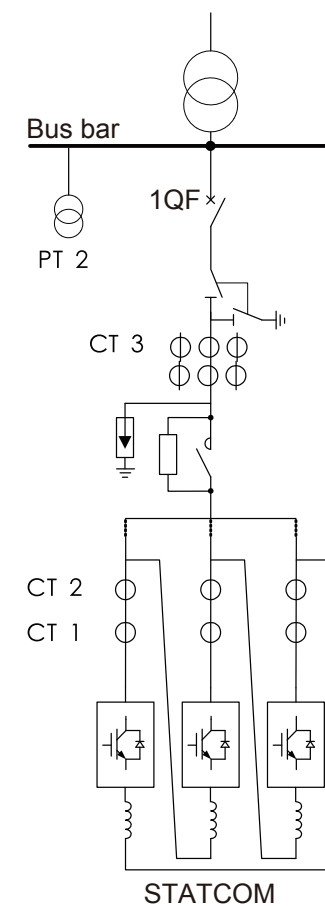
Field-Proven H-Bridge Technology

NR Electric's PCS-9583 STATCOM adopts novel cascaded multi-level topology. This technology enables

- Compact structure
- Convenient maintenance
- Chain-link multi-level topology
- Perfect sinusoidal output
- Low switching frequency
- Built-in redundant cells in series
- Leading technology in DC voltage balancing
- Well-proven drive and sub-control board



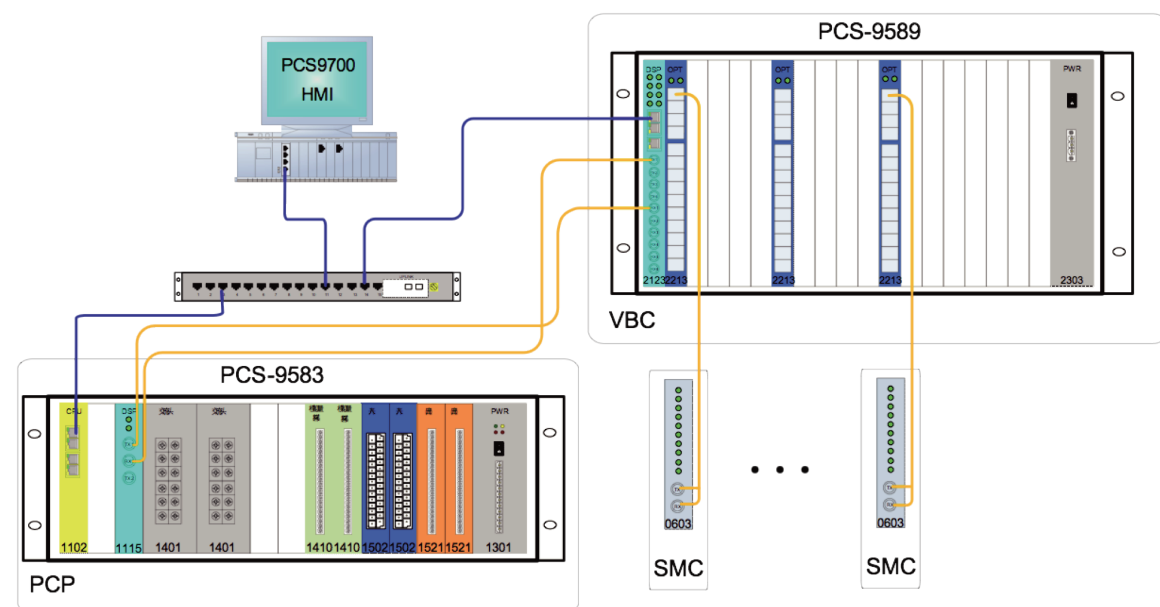
Multi-level output of cascaded H-bridge Circuit



Typical SLD of STATCOM engineering

STATCOM Protection & Control

The control and protection system of STATCOM system consists of PCS-9583 PCP (Pole Control and Protection), PCS-9589 VBC (Valve base Control) unit, SMC (Sub-module controller), interposing relay set, network switch and other protection devices. PCP, VBC, interposing relay set, network switch and other protection devices are normally installed in a cabinet, while SMC is installed inside of power valve bank.



Protection and Control System

PCS-9583 PCP are mainly responsible of receiving, calculation, and processing of sampling data, synchronous phase locking, the control of active power and reactive power; logic calculation, processing of binary inputs and outputs, equipment management, communication with HMI, receiving summary information of valve bank uploaded by VBC and sending control commands to VBC.

PCS-9589 VBC samples and gathers status information of each power valve bank and DC capacitor voltage, and uploads them to PCP via optical cable, at the same time receiving signals from PCP via optical cable, so as to realize distribution of active power and reactive power among power valve banks and balance of capacitor voltage among links.

SMC samples status information of each power valve bank and DC capacitor voltage, and uploads them to VBC via optical cable, at the same time receiving relevant control commands and pulse triggering signals from VBC.

For the detailed information about control and protection system, please refer to the corresponding instruction manuals.

STATCOM Technology Makes the Differences

Safe Electrical Shielding Prolongs Valve Lifecycle

NR Electric' s Sub-module determines STATCOM electrical performance, volume size, effectively isolates internal primary and secondary components to eliminate magnetic coupling.

The partition-isolation design effectively avoids physical damage to the secondary circuit and normally bypasses faults and ensures normal operation of the machine. Meanwhile, the partition-isolation design achieves the overall plug-in secondary circuits, simplifying production process and improving the maintainability of equipment.

Easy Maintainability with Detachable Capacitors

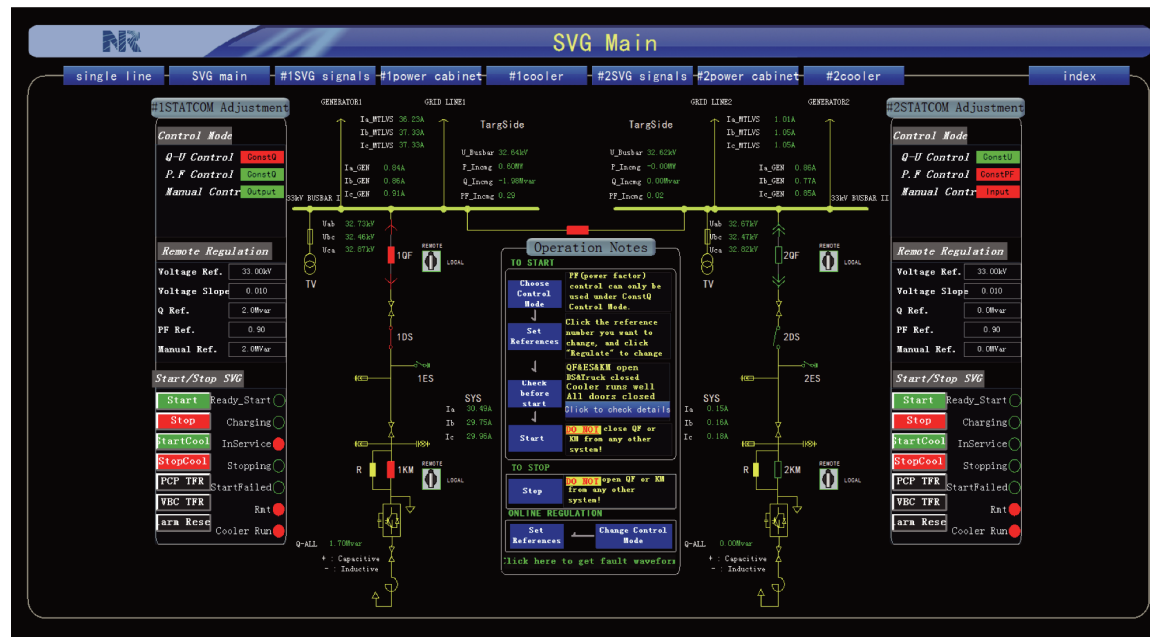
- Independent space for secondary control system
- Detachable capacitor design improves scalability and versatility and reduces cost
- Capacitor tray base frame design enhances the structural strength and simplifies the installation of sub-module into the valve frame work.

Unique Heavily-Integrated Valve Control

NR Electric' s multi-channel parallel bus technology enables integration of sub-module control, redundant hot-swappable maintenance and supports a maximum of 224 sub modules, which can be applied to different voltages and different capacities. This unique design requires fewer controller and fewer footprints with less overall cost.

Hierarchical Comprehensive Protection & Control

- Integrated three-level protection and control system of PCS-9583 STATCOM provides quick fault clearance and prolongs component lifecycle.
- The element-level protection has an operation time of less than ten microseconds and protects the system if any overcurrent overvoltage or driving signal abnormalities occurred.
- The device-level protection has an operation time ranging from 100 to 1000 microseconds and protects in case of device overload, DC high voltage and other abnormal operating conditions.
- The system-level protection has an operation time ranging from 5 to 2000 ms and 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.



Professional System Design & Analysis

NR Electric believes that each project has its own specific requirements. For tens of years, relying on groups of experts, NR Electric is dedicated to offer customized and cost-effective solutions to every single project. We work with utility and industrial customers to study the problems they are facing, tailoring a STATCOM system that can truly improve power quality and bring investors benefits.

Our professional R&D group analyses each specific project. Based on analysis results, NR Electric offers complete solutions to clients including valve installation locations, capacity and optimal control strategies.

Strict Project Management

NR Electric considers an effective project management can facilitate the successful implementation of a project, avoiding potential risks and saving engineering budget. For these reasons, NR Electric has built a well-trained project management team to manage and supervise each progress during project implementation. Our experienced project managers work closely with clients and have gained high reputations for their hard works.

Certificate and Test

NR Electric is one of the International accredited certified and testing groups. The company has its own certification and test labs for HVDC/EHVAC instruments test. NR Electric' s STATCOM valve type test is also approved according to IEC standard.

The advanced test facilities can assist to achieve the optimized results, such as installation capacity & location, system configuration & control strategies, finally resulting in better system performance, reasonable power distribution and optimal harmonics filtering scheme.

Case Study

±200 MVar STATCOM for Secure and Stable Grid Interconnection in South China

China Southern Power Grid, a state-owned enterprise plans to build a massive HVDC link of capacity ±500 kV, 3000 MW and connecting Yongren to Funing for China' s Jinsha river hydropower corridor. However possible severe voltage drops in AC line and large amount of reactive power consumption through HVDC transmission made the project more exposed to frequent communication failure and system instability.

To overcome the technical problem NR Electric will supply two sets of its state-of-art SVC module having capacity of 35 kV/±100 MVar for the whole compensation project. It will be installed on the converter station locating in China's Yongren

Each STATCOM can operate separately and is not influenced by operation conditions of other STATCOM. NR Electric provides #1 and #2 STATCOM, and is responsible for coordination control of all three STATCOM.

Standardized Workstation Offers Easy Access

- The Operator Workstation (OWS) of PCS-9583 STATCOM system fully supports IEC60870-5-103, IEC61850 and other international standards. It offers interfaces to conventional substations, digital substations and power plants with voltage levels ranging from 35kV ~ 1000kV.
- The 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.

Work with NR Electric Professional Experts

Turnkey Service

To ensure the total performance, NR Electric offers turnkey service to solve clients' exact specifications. Our turnkey service covers consulting, design, supply, installation, commissioning, training and operation.

Performance

This obtains quick response against system voltage fluctuations with wide range support for bus bar voltage.

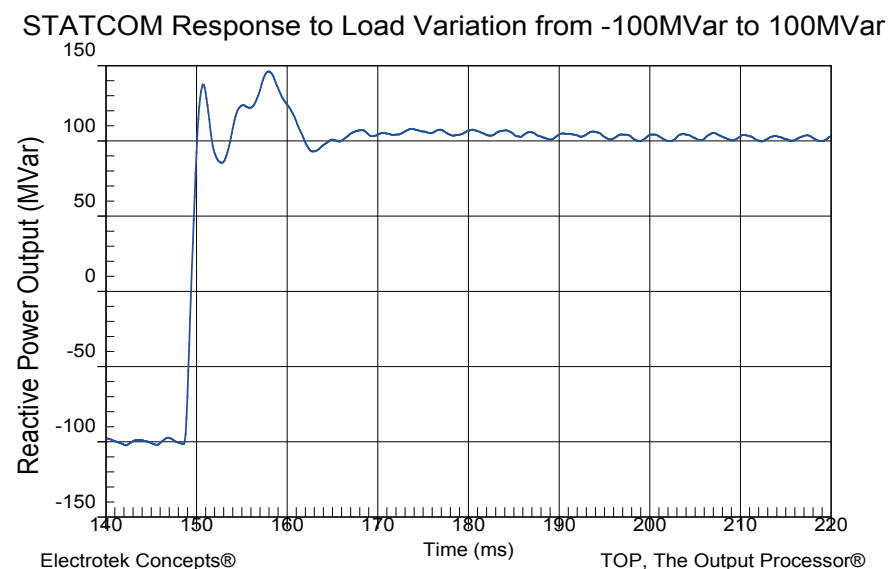
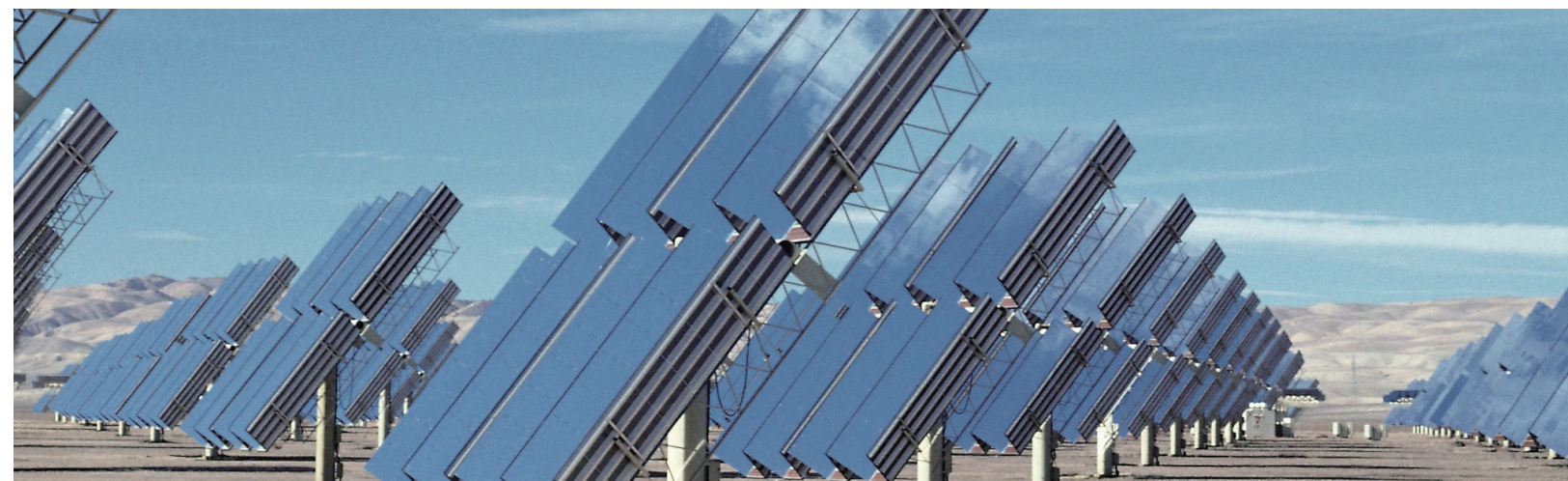


Figure 4. Reactive Power Output in Transient State



5th order harmonic suppression strategy	Before Installation	After Installation
Fundamental current /A	50.541	44.476
5 th harmonic/A	21.136	1.62
Percentage/%	41.81	3.64

Table 3. Harmonic Suppression Results

Enhancing Power Quality for Aluminum Company

Heavy impedance and inertial load of Yongjie Aluminium Company caused a lot of harmonics and low power factor problems. Nevertheless after installation of two sets of (1 X 12 MVA + 1 X 8 MVA) to their 10kV busbar I and II respectively, it exclusively resolves the concerned technical problem and provides overall customer satisfaction.

Harmonic Suppression Strategy

As one of the important strategy, the specially designed STATCOM effectively suppresses the 5th harmonics up to 95 %.

Power Factor Control

The #2 STATCOM operates as a constant power factor mode, to enhance the power factor of internal grid. It provides about 3.4MVar of reactive power, to control the power factor of incoming bus segment-II at about 0.96.

Parameter Name	Value
System voltage (kV)	10
Rated power of (MVar)	12/8
Rated voltage of STATCOM (kV)	10
Voltage of STATCOM single link capacitor (V)	900
Switching frequency of a single link (Hz)	450
No. of links per phase	12

Table 2. System Parameters of Yongjie Aluminum Company

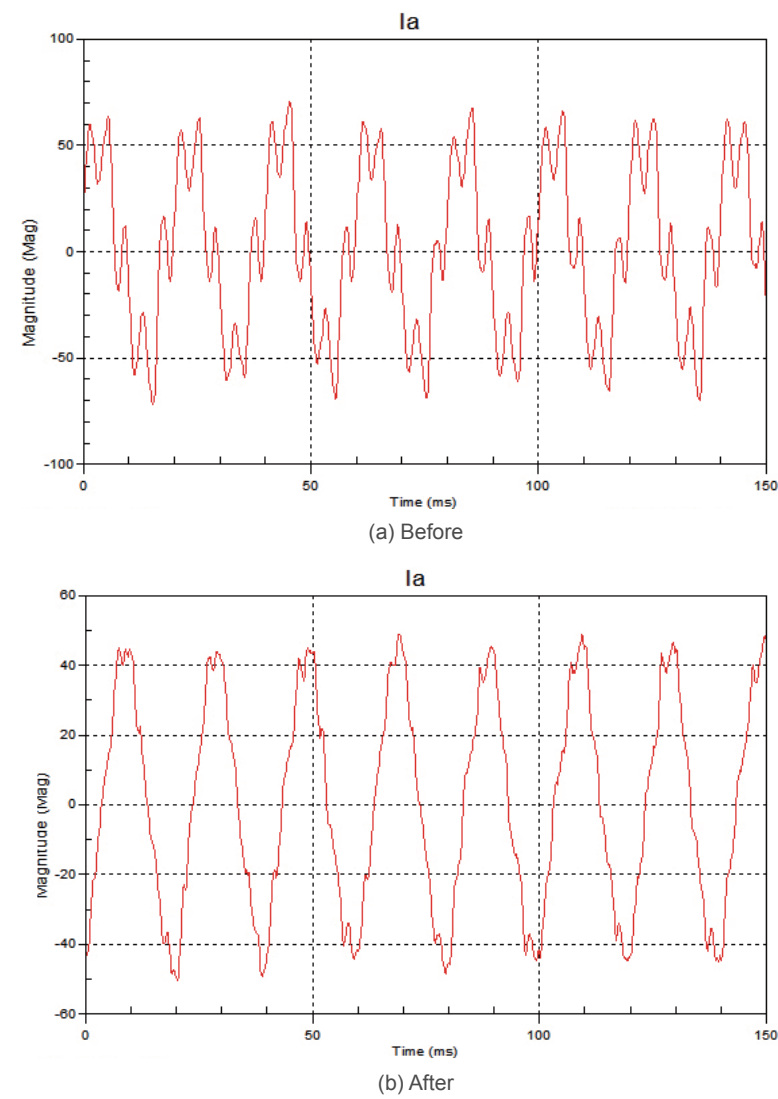


Figure 5. Bus coupler current wave before and after installation of STATCOM

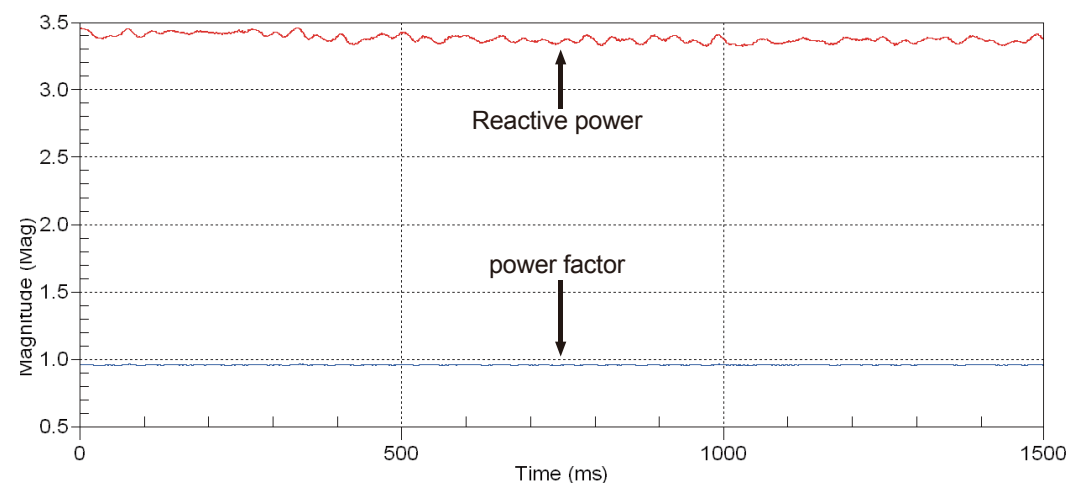
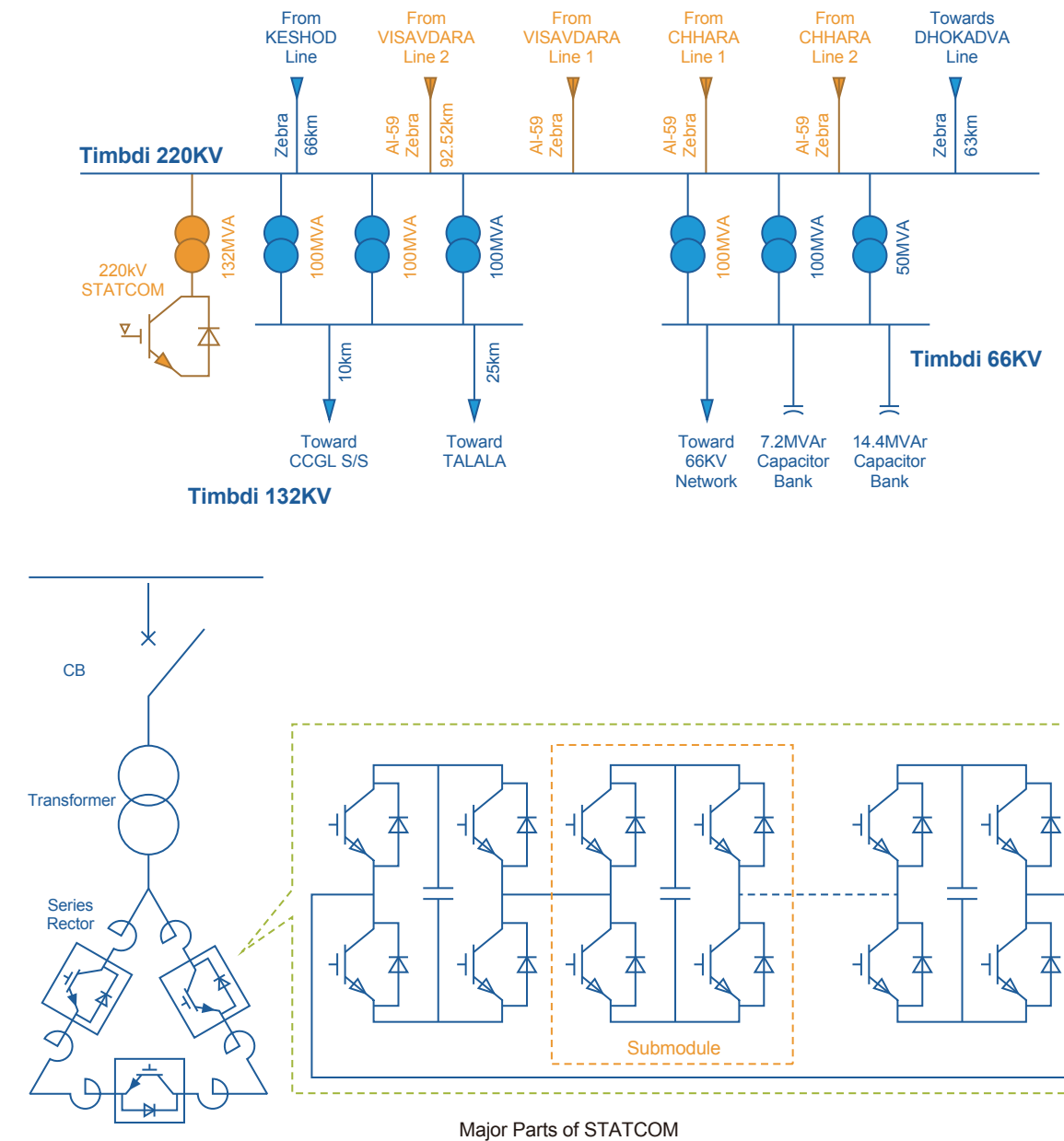


Figure 6. Reactive power output of #2 STATCOM

±120 MVar STATCOM for GETCO Timbdi 220kV substation in India

STATCOM herein is installed to get voltage support during steady state, dynamic and transient system conditions by continuous and rapid control of reactive power at 220KV Bus, in order to enhance the steady state, dynamic and transient voltage stability and quality of power delivery, together with the control of temporary power frequency over-voltages, the prevention of voltage collapse, and the enhancement in damping system oscillations. A set of STATCOM rated at +/-120Mvar, connected to 220kV AC through coupling transformer, has been delivered by NR.





STATCOM picture on site

Robust Support for Renewable Energy to Access Grids

STATCOM has been installed to boost transmission of wind power to access power grids in South Africa. The Longyuan Mulilo De Aar Wind Power, located in Northern Cape Province of South Africa, was successfully put into service, with installation capacity of 244.5MW. South Africa has been implementing a significant penetration of renewable generation recently. Renewable sources of energy will play a significant role in the future of power. However, the intermittent nature of renewables can create many challenging problems between the transmission system and wind plant.

For upcoming high penetration of renewable generation in the South African grid, the transmission system operator, ESKOM, has enforced well-defined steady state regulation and dynamic requirements that all wind and solar farms have to comply with prior to connecting to the transmission grid.

Four sets of independent STATCOM systems, one at each collector bus, are installed in container type, with 14Mvar and 18Mvar, 21Mvar and 24Mvar, respectively in capacity at 33kV level.

These STATCOMs are utilized to overcome the challenges associated with wind farms and assist wind farms in appearing more like conventional synchronous generation to the rest of the grid.

An independent active/reactive power control device (also called as AGC/AVC) is here equipped in one wind farm to take an advantage of all of reactive resources to meet the wind farms overall reactive requirements.



Mobile Statcom Site

Mobile STATCOM Solution for Regulating Voltage in Utility

In the network of National grid due to large amount of inductive motor loads, there are several areas in the network where they are suffering voltage collapses. The reason for the voltage collapse is lack of reactive power MVAR support. During summer, any fault in the network causes a severe drop in voltage followed by delayed voltage recovery because the type of load is mostly motor load (window type air-conditions).

According to the information from National Grid, Summan Area is a remote area which is suffering from low voltage and voltage collapse.

There are several substations suffering low voltage, and then two mobile STATCOMs, each rated at 13.8kV/20Mvar, have been supplied by NR and successfully put into service. As a result of mobile STATCOM operating, the voltage at bus bar after fault clearing can recover to be not less than setting value, 0.95 p.u., specified by end-user.