



Case Study

NR's Static Synchronous Compensator

South African STATCOM for Boosting Transmission Capability
of Wind Power to Access Power Grids

Project Overview

A new era in grid optimization

NR STATCOMs were put into service with wind turbine in Longyuan Mulilo De Aar Wind Power on Nov. 17, 2017, and renewable power was successfully transmitted to the grid, with installed STATCOMs to fulfill its reactive power requirement in full range and dynamic way.

This wind farm project with installation capacity of 244.5MW, located in Northern Cape Province of South Africa, comprises of

- Phase I of 100.5 MW
- Phase II of 144.0 MW, in total amount of 163 units of 1.5 MW wind generator.

Each UP' s converter is 1.5 MW wind turbine generator is connected via 0.69/33 kV step-up transformers to a 33 kV overhead line network.



A 132kV transmission line was constructed to transmit the wind power to Eskom transmission power grid via the Hydra Substation.

The generated power is required at its maximum capacity to flow into the South African national grid. This demand also needs sufficient amount of reactive power to strengthen transmission channel and to maximize active power output. NR solution provided STATCOM (Static Synchronous Compensator).

After the project is implemented, it can send 644.0 million kilowatt-hours of clean electricity every year, which is equivalent to 215.8 thousand tons of standard coal and 619.9 thousand tons of carbon dioxide emission, meeting the electricity demand of 85,000 households.

The Challenge

One step ahead of the game

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 issues 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.

The traditional grid code always includes power factor and Low Voltage Ride Through requirements, now has been expanded to specify High Voltage Ride Through requirements, speed of response requirements and step voltage change requirements.

Integration – the key challenge

Even if advance wind turbine generators has some variable reactive power capabilities, wind farms cannot provide enough dynamic reactive power to satisfy all of their interconnection grid code requirements. NR' s STATCOM, is an ideal solution to provide additional necessary reactive power to help a wind farm reconcile these requirements.

“STATCOM is VSC-based in topology, compact in footprint, the latest member of FACTS, and has prominent performance in helping renewable energy access power grids for more and more strict grid code.”

Dr. Jacky Zhao
Senior Product Manager
NR Electric

The Solution

Milestones

STATCOM is the trendy member of NR' s FACTs family of products, an IGBT-based VSC (Voltage Source Converter) installed to assist power grids handle a variety of challenges.

Four independent STATCOM systems, one at each collector bus, are installed in these wind farms, with 14 Mvar, 18 Mvar, 21 Mvar and 24 Mvar, respectively in capacity at 33 kV level.



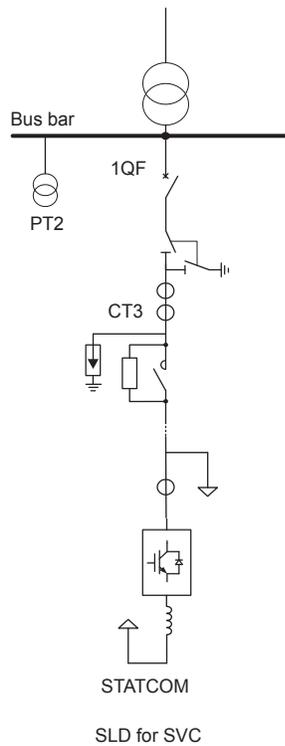
Longyuan Mulilo De Aar Substation

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.

The STATCOM, installed in wind farms, comprises step-down transformer, phase reactor, delta-connected IGBT converters, water/air cooling system, controller and protection units, operation work station as well as other necessary accessories.

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.

For most time, the wind turbine generators manage their LVRT requirements themselves, sometimes along with STATCOM' s operation. While STATCOM, in HVRT period, is required to bring the voltage down very quickly to a level where the wind turbine generator could withstand and ride through (not trip off-line) the required high voltage event.



Excellent Feedback

STATCOM installed in this project have been playing unique functions to do strong voltage support, correct power factor, and improve power quality at the point of common coupling to ESKOM power grid. Preferred solution of STATCOM system, particularly for renewable energy access to power grid. It takes small footprint, less & easy maintenance and has been becoming leading-technology solution for reactive power and voltage support.

“NR’s STATCOM provides strong voltage and reactive support for this windfarm to access the grid. Compensators also has good cooperation with wind turbine through power plant controller to reach complete ride-through capability.”

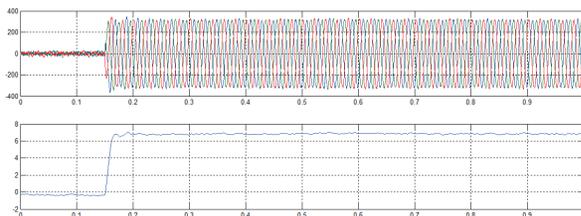
Jian Ge
R&D Engineer
NR Electric

For transient events, the wind turbine converters and the STATCOM work independently to achieve the transient targets. The turbines provide the bulk of the reactive current responding based on their terminal voltage. While the STATCOM monitors the point of the connection parameters and ensure that the wind farm requirements are fulfilled within allowable margins.

3 regulation modes included voltage control, power factor regulation and constant reactive power control, are configured in the STATCOM to satisfy the South African operating requirements.

In voltage control mode, the wind farm must control the voltage at the high side of the wind farm power transformer on a defined droop curve which spans the maximum and minimum reactive power target for the wind farm. In power factor control mode, the wind farm must control the power factor to a defined power factor set point at the high side of the wind farm power transformers.

In reactive power control mode, the wind farm must control the reactive power flow at the high side of the wind farm power transformers to a reactive power set point. Field -test waveforms demonstrate the installed STATCOM is able to spend no more than 30 milliseconds finalizing a step change of reactive power as its important inherent feature.



STATCOM step response of reactive power

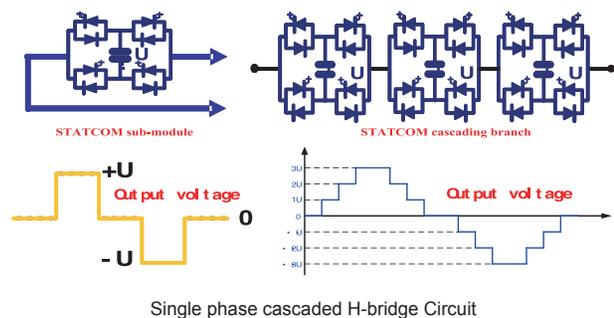
Most transmission service operators require, after the wind farm comes on-line, detailed field tests to demonstrate that the wind farm has the capability to meet all of the grid code requirements. STATCOM' s fast response is capable of boosting the overall reactive power regulate as quick as possible.

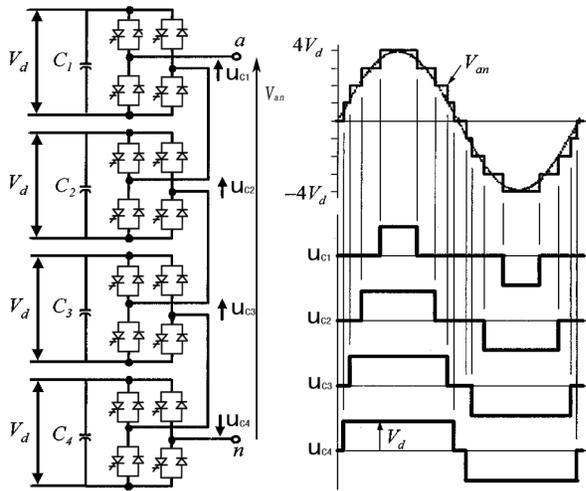
NR’s Statcom Features

NR’ s STATCOM has a simply topology and high degree of prefabrication and in-factory testing, as well as a small footprint to perfectly enable customized solution.

H-Bridge Modular Converter

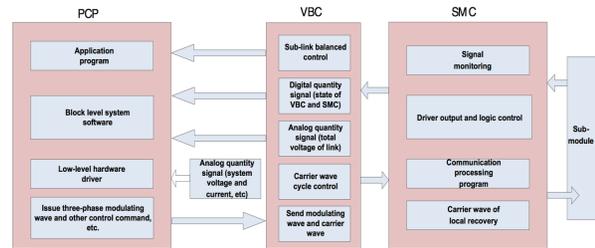
- Compact structure
- Convenient maintenance
- Chain-link multi-level topology
- Perfect sinusoidal output
- Low switching frequency
- Built-in redundant cells in series
- Leading technology in DC voltage balancing
- Well-proven drive and sub control board





Multi-level output of cascaded H-bridge Circuit

Fiber optical cables are employed to ensure safe control and feedback of the high-voltage bridges. UAPC also includes a whole family of I/O circuit boards for sampling and signal processing. An operator workstation is able to provide various kinds of communication protocol to exchange information and data with substation control system/remote dispatch center.



Control and Protection

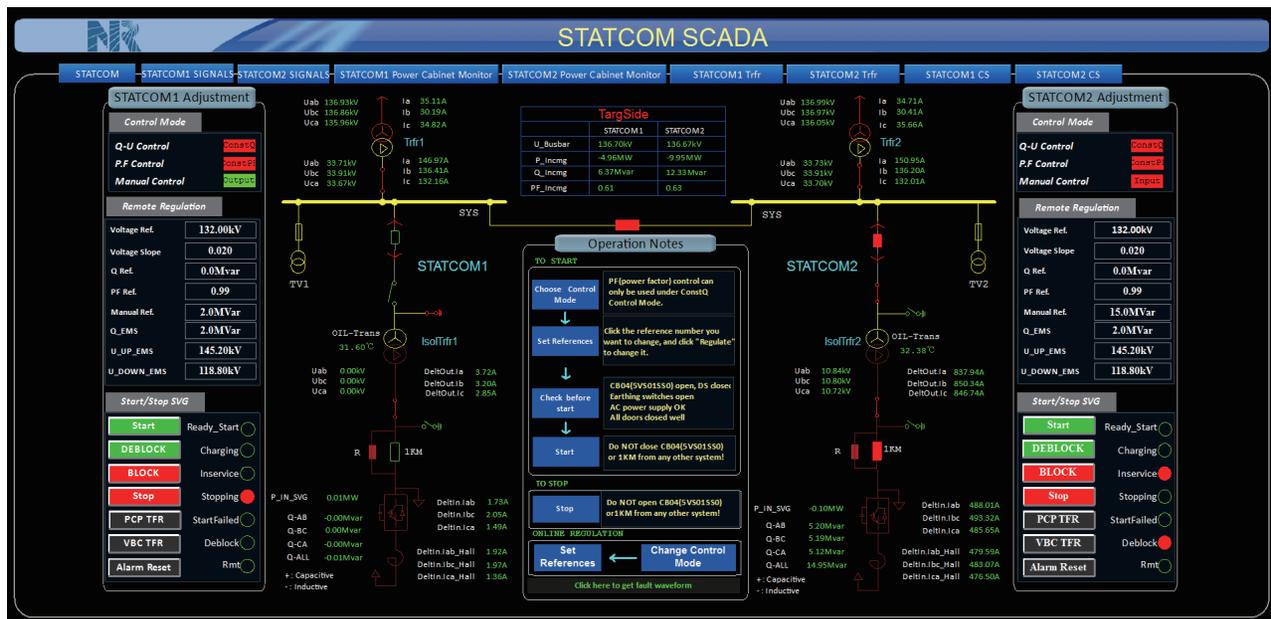
NR's UAPC is a committed hardware platform for control and protection, and field-proven in lots of power electronic product application for decades.

Hierarchical structure is adopted in control and protection system, which consists of primary control and protection system (PCP), valve-based control and protection system (VBC) and sub control and protection unit (SMC). Meanwhile, there are three levels - system level, unit level and device level, to control and protect STATCOM system.

Solution Benefits

Field adaptability

- Small footprint and compact
- Fast reactive power regulation
- Strong voltage ride-through capability
- Full reactive current output even at depressed system voltage
- Advanced integrated functions with high performance
- Robust control algorithm for voltage and reactive support
- High degree of prefabrication to reduce project lead-time
- Redundant cell design for easy maintenance



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