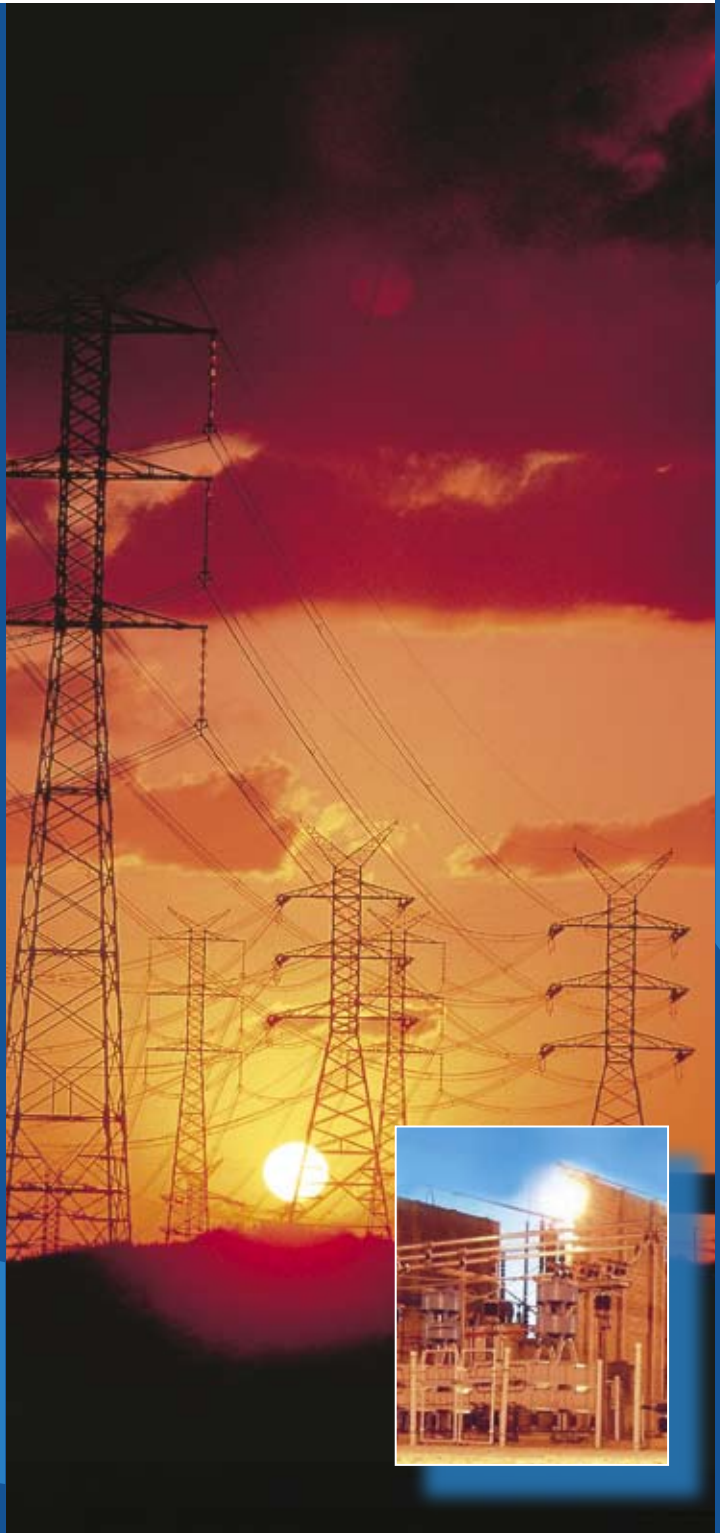


# Utility Static Var Compensator (SVC)



## Dear Customer,

### ***Customised and customer driven***

Nokian Capacitors' moderate size, overall flexibility and an ability to listen to customers are natural benefits of the company over giant multinational corporations. We focus our resources and technology on power quality and compensation, which makes our company a major player in this field of expertise without our having to compromise our customer-driven approach.

### ***Environmental benefits and improved economy***

In reactive power compensation, reliability and good return has been a traditional trigger for investment. Today, environmental benefits often drive investments in the form of reduced energy losses, low noise emissions and efficient use of existing overhead lines. Apart from financial gains, a positive environmental impact is an added value for customers.

### ***Market, trends and reality***

The blackouts that occurred in several countries in 2003 reflect a reality, in which investments in transmission infrastructure have failed to follow the growth of electricity consumption and in which the advancing age of assets is a problem in many countries. Energy market liberalization further emphasises a need to focus on efficiency and transparency; a trend which favours solutions offered by Nokian Capacitors. The market outlook is positive for energy saving solutions regardless of the turbulences of world economy, politics and other factors effecting the short-term market demand.

### ***Customer confidence in infrastructure projects***

Our customers' confidence, as shown in major infrastructure projects, and good performance in operation prove Nokian Capacitors ability to offer complete technically and commercially competitive solutions for large utility applications worldwide.



*Kari Tuomala  
Managing Director*





# Historical milestones for Nokian Capacitors

**1957**

- Founding of Nokian Capacitors

**1964**

- Installed first light-optic signal transmission
- Installed first complete solid state electronics

**1971**

- Fast reinsertion system for the world's biggest Series Capacitor

**1975**

- First Series Capacitor in the world with non-linear resistor

**1977**

- SVC for Electric Arc Furnace (EAF) with flicker compensation

**1978**

- The first to use the 735 kV double tuned filter for Utility SVC
- Utility SVC for support of a 330 kV grid

**1988**

- Provided capacitors for the biggest Series Capacitor 1056 Mvar in the world

**1989**

- Forced triggered Spark Gap & Metal Oxide Varistor

**1994**

- Digital Protection & Control System (NDP)
- New design of free standing Thyristor Valves for SVC application

**1995**

- Manufactured capacitor unit sizes up to 1000 kvar

**1997**

- Started using laser powered measuring system for platform electronics (Series Capacitor bank)

**2001**

- Built a 345 kV Utility SVC with new Digital Control System
- New NDP+ Protection & Control system with Field Bus System

**2002**

- 1500 Mvar HV filter banks compensation turnkey project
- 400-500 kV Series Capacitor bank turnkey deliveries (incl. civil works, installation and commissioning)

**2003**

- Full scale seismic test available for SC
- Forced triggered Spark Gap for 450 kV crest Ulim

**2005**

- Launched remote service concept

**2006**

- Provided many service contracts for Series Capacitor
- The world's biggest 400 kV Series Capacitor bank, 1008 Mvar, turnkey delivery to India



# Solutions for better power quality by using a Utility SVC

Nowadays the quality of electricity is becoming more and more important due to the increasing usage of electricity in our everyday life. Our electrical equipment, such as computers, are becoming more sophisticated and at the same time more vulnerable to disturbances.

Less energy is produced by the use of fossil fuels and more renewable energy sources are being taken into use around the world, for example wind farm usage is increasing especially rapidly.

Disturbances in the normal operation of transmission lines and industrial distribution systems may be caused by line switching, line faults and non-linear components, such as thyristor controls, rapidly varying active or reactive loads, unbalanced phase voltages, of the network or loads.

## The problems solved with SVC :

- Harmonics
- The need for additional reactive power
- Voltage fluctuation
- Flicker phenomena
- Unbalanced loads
- Rapid changes in reactive power
- Power oscillation

Electricity makes our everyday life much easier and we want the best out of our electricity. The disadvantages mentioned above can be reduced by the use of a Utility SVC.



# Functional benefits of the Utility SVC

The Static Var Compensator for utilities increases the quality of power in many respects. The benefits of stabilised voltage levels and reactive power compensation improves the system stability and increases the power transfer capability of a transmission line.

## Reduction of harmonics

Non-linear loads generate harmonic currents. The harmonic currents load the network and lead to voltage distortions. Distorted voltage may cause malfunctions in sensitive computerised devices and other process control equipment.

The filter circuit of the Utility SVC system is designed to absorb harmonics generated by loads as well as by Thyristor Controlled Reactors (TCR). The total harmonic distortion (THD) and individual harmonic voltages are limited to below specified levels.

## Power transfer capacity increases

Transmission of reactive power leads to significant voltage drops and current increases in the network, which limits the transmission capacity of active power. Utilities can maximise their transmission line capacities by compensating reactive power. The Static Var Compensator maintains the demand of reactive power within the limits set by utilities.

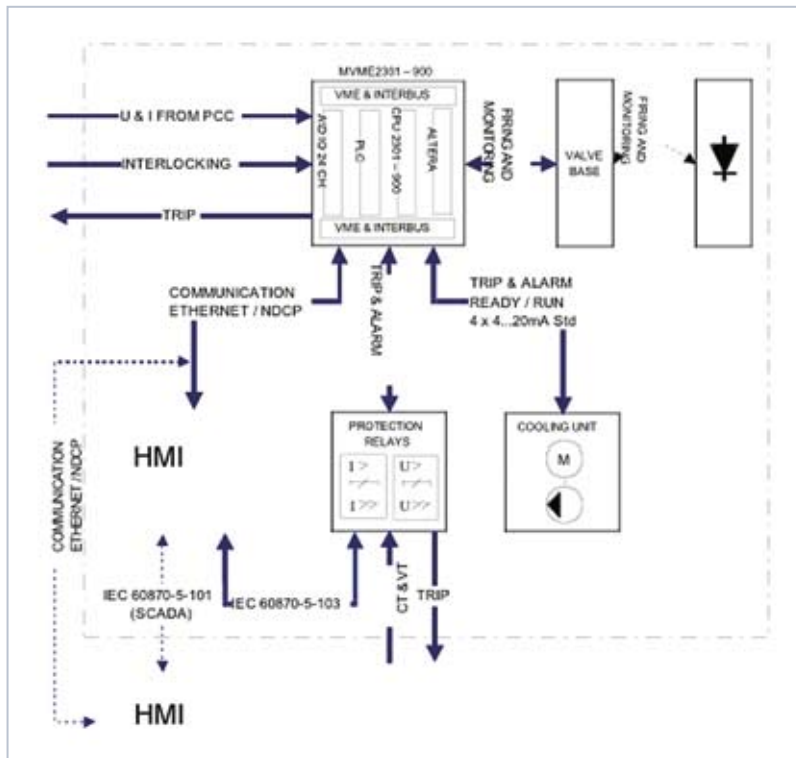
## Voltage stabilisation, unbalance loads

Loaded non-transposed lines will create voltage unbalance. The unbalanced voltage causes reduced efficiency, overheating, noise, torque pulses and speed pulses to motor operations.

The Utility SVC operates in single-phase control mode, thus balancing the voltage.

## Flicker reduction

Rapidly varying reactive power causes voltage fluctuations at the point of the common coupling. The human eye perceives this frequency of voltage fluctuations as flickering lights. The SVC will reduce flicker.



Control block diagram



## Tailored and flexible project delivery

No two SVC installations are the same. The scope of the SVC installation depends on the technical and economic needs of each customer.

The location of the SVC, once installed, can be fixed or relocatable. While outdoor equipment is usually built as fixed structures, indoor equipment is often located within a container that is easily relocatable. It is possible to use a modular design of the SVC. This makes transportation, installation and commissioning at the site fast and easy.

### Power Utility data determine the tailor-made design of the Utility SVC

A successful delivery begins with an accurate assessment of the requirements for an SVC. Nokian Capacitors can provide consultative help even in determining the scope of supply.

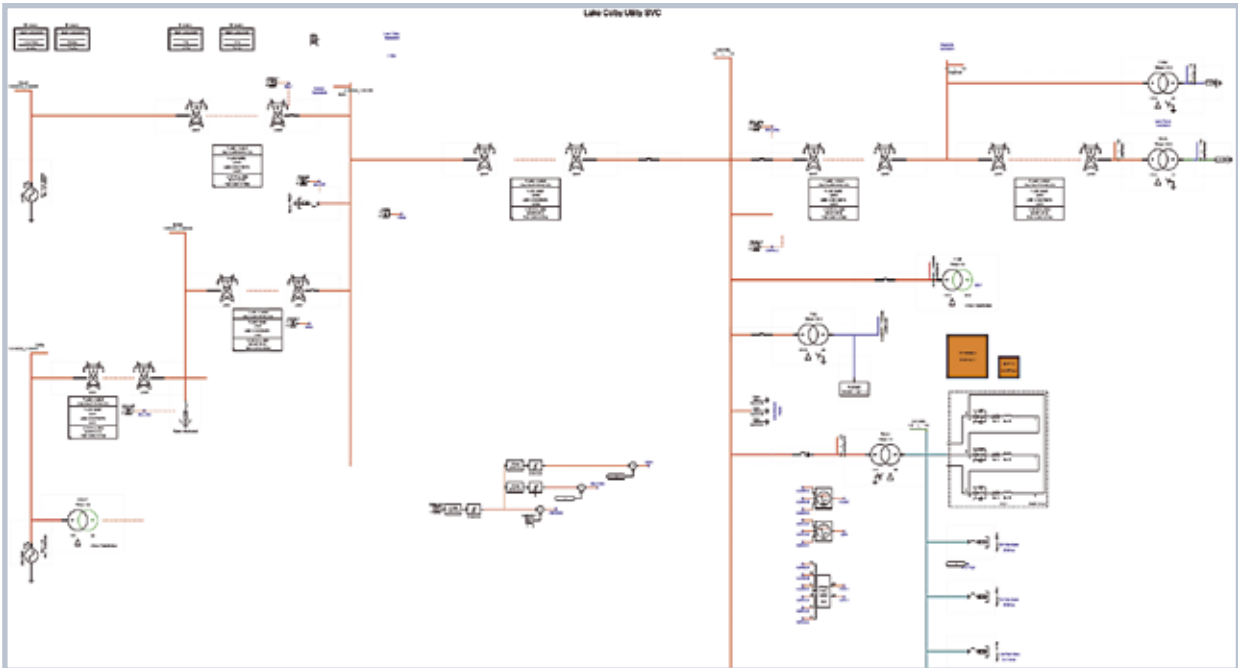
Each network has its own quality requirements for power, thus, the Utility SVC must always be tailor-made. The design of the Utility SVC depends on the fault level and load parameters. In case of a high fault level, the main parameter of the Utility SVC design might be reactive power compensation, while flicker and harmonic reduction are major concerns for a low fault level.

“IEEE-1031-2000-Guide for the functional specification of transmission static var compensators” gives more detailed description of the data required.

*-25...+25 Mvar, 115/12,5 kV, 60 Hz,  
Tri-State Generation & Transmission, Clapham, USA*



# Simulation of the network

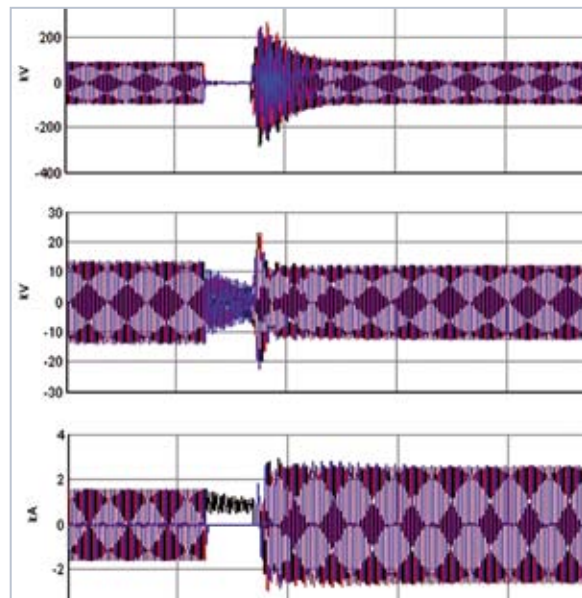


## Real Time Digital Simulator (RTDS)<sup>®</sup>

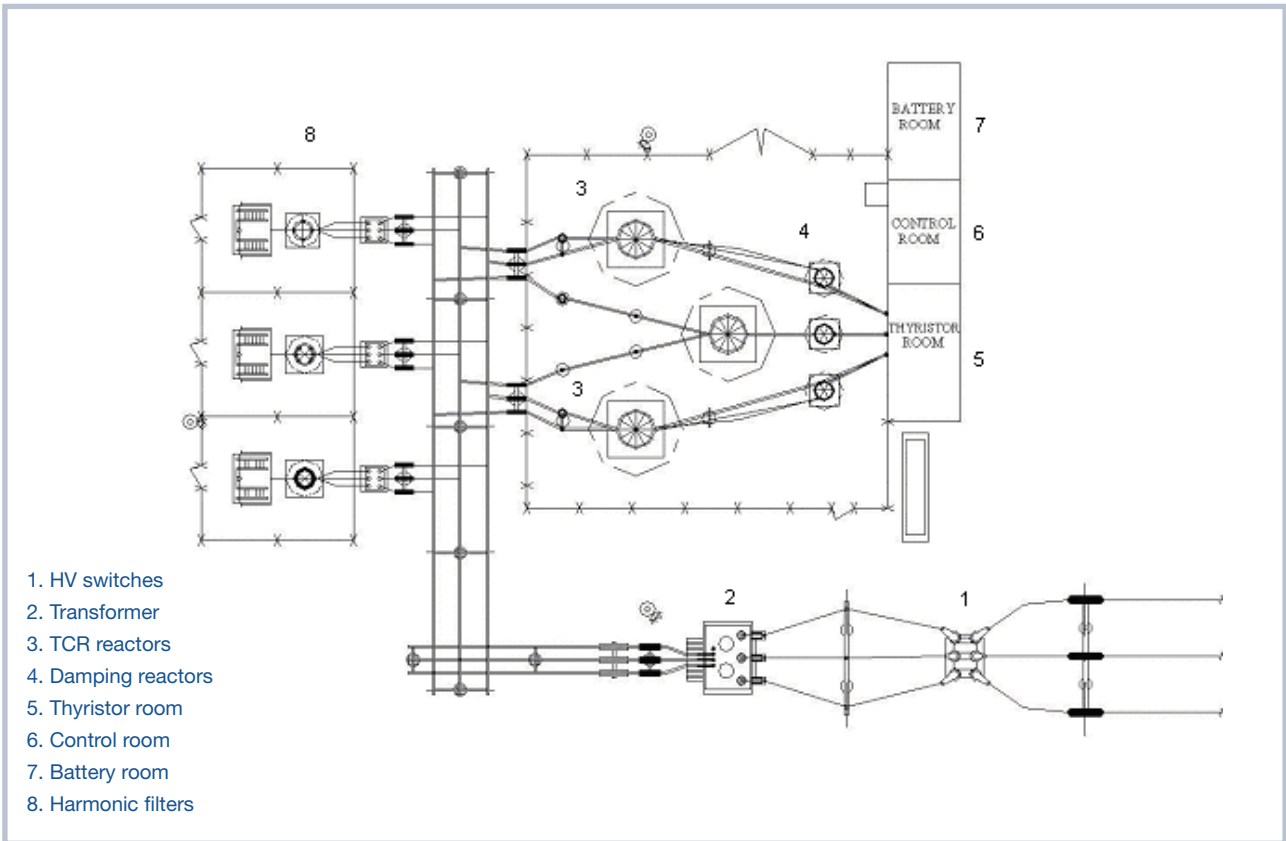
The Real Time Digital Simulator (RTDS)<sup>®</sup> is a tool for the design and simulation of electric networks. The simulation was made so that two SVC control systems were connected to the simulator in order to simulate the interaction between them. Nokia Capacitors has two RTDS<sup>®</sup> simulation racks, which handle and design 100 network nodes.

The measured data or simulated model is run on the RTDS<sup>®</sup>. The simulation model and control system parameters are altered to give maximum performance. Simulations may be used to optimize installation cards, losses and performance. In some cases the SVC power is reduced to minimize losses and at the same time increasing the performance. RTDS<sup>®</sup> is also a powerful tool in line fault situations.

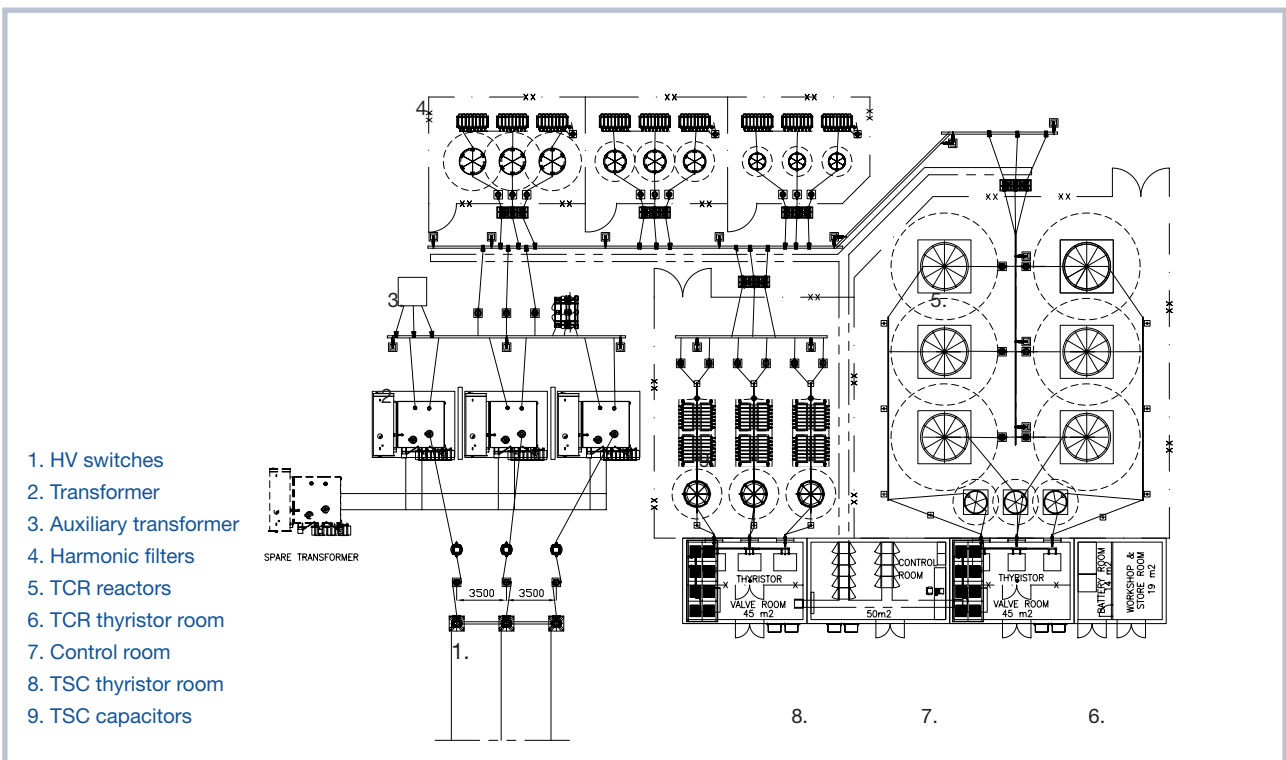
The below picture, design tool for electric networks, shows an RTDS simulated network in which Nokia Capacitors delivered two Utility SVCs to the same network.



# Utility SVC layout example



# Utility SVC with Thyristor Switched Capacitors layout example





# Case study

## Steady power supply to Northeastern, New Mexico

Tri-State is the power supplier to a 44 member system in Colorado, Nebraska, New Mexico and Wyoming, serving nearly 1.2 million people in the region.

In order to keep up with voltage levels along distribution lines, many electric utilities are starting to make the change from manually switched capacitor banks to volt ampere reactive (VAR) management systems. Tri-State Generation and Transmission is employing the unique technology to its transmission infrastructure with the commissioning of a new static VAR system at its Clapham Substation in northeast New Mexico.

Nokian Capacitors Ltd., built the new Static Var Compensation System at the Clapham Substation, which employs microcomputers and the latest thyristor technology. Nokian Capacitors' system handles a bigger capacity, faster and more efficiently.

The benefit of using the latest technology is the ability to easily monitor the system. In addition, the NC remote service enables the SVC to be monitored 24/7. The Original static VAR system at Clapham Substation has stabilized power delivery to northeastern New Mexico for more than 20 years. Now with the pairing of a new, technologically advanced system and a reliable workhorse, Tri-State will continue to deliver dependable power to its member system.

### Tri-State Generation and Transmission, Clapham

Country	USA
Description	Utility Application
Rated voltage (kV):	115/12,5 kV
SVC rated power (Mvar):	-25...+25 Mvar
Year of installation:	2005



# Nokian Capacitors' Utility Static Var Compensator to stabilize voltage at Campos substation near Rio de Janeiro

Nokian Capacitors has delivered a Static Var Compensator (SVC) to Furnas Centrais Elétricas, the biggest Brazilian utility. The turnkey project included the design and delivery of:

- Thyristor controlled reactors
- Four filter banks
- Step down transformers
- Control & protection and monitoring system
- Civil construction
- Installation
- Testing and commissioning of the SVC
- RTDS<sup>®</sup> simulation of the system.

Furnas Centrais Elétricas SA supplies power to Rio de Janeiro, Sao Paulo and their surroundings - the most heavily populated area of the country. After competitive bidding in 2000, Furnas Centrais Elétricas ordered the SVC from Nokian Capacitors Ltd. The SVC was installed at the 345 kV Campos substation, 300 km north of Rio de Janeiro, to stabilize the voltage level at peak loads and in fault situations. The project incorporated the latest technical solutions and digital control. The thyristor valves, cooling unit and control & protection system are mounted in containers, which can easily be relocated if needed.

The Campos SVC was commissioned in 2001 and the customer reports that everything works reliably and smoothly.

For the Brazilian project, we introduced our newly acquired RTDS (Real Time Digital Simulator)<sup>®</sup> to test the correct behavior of the control & protection system. Tests for this project were made in the RTDS laboratory in Winnipeg, Canada and at Nokian Capacitors' factory.

## Technical data

Rated voltage	345 kV
Rated power	-60...+100 Mvar
Rated frequency	60 Hz
Step down transformers	3*33 MVA / 15 kV
Thyristor Controlled Reactor	2*80 Mvar
Filter banks	5th 20.5 Mvar 7th 35.2 Mvar 11th 13.6 Mvar 13th 21.0 Mvar

Logic for switching 16 MSRE  
(Mechanically Switched Reactive Elements).  
Response time 50 ms.

Maintenance monitoring system.

The RTDS<sup>®</sup> models the network with various operating conditions in real time. By connecting an actual control & protection system to the simulator, it is possible to test system faults, which for safety reasons would be dangerous or impossible to test in field conditions.

Our cooperation with Furnas Centrais Elétricas SA began in 1998. Good partnership and many successful projects have given rise to a number of new initiatives.



# Mechanical Switched Reactive Elements logic

The MSRE-switching system is part of the larger utility control system called SVS (Static Var System) which consists of the -60...+100 MVar SVC and 16 mechanically switched external elements. Basically the SVC controls the voltage at dynamic basis and the MSRE elements provide reactive power support at steady state condition.

## The operation range of the SVC was divided in three areas:

- Transient condition: reactive elements shall be switched as fast as possible.
- Intermediate condition: the reactive elements are switched according to inverse time curve with faster behaviour as the instantaneous operation point of SVC is far from 0 MVar.
- Normal condition: reactive elements are switched in long term to a pre-defined operation condition.

The reactive elements are divided in three groups according to its power (MVar) and voltage level (345, 138 and 13,8kV).

The purpose of the MSRE Logic is to measure the SVC' susceptance and identify what element should be switched on or off according to the operation areas and size of available MSRE element. Other aspects as discharge time of capacitors, operation rotation of MSRE elements inside one group, maintenance of one MSRE element, breaker operation cycle, logic's freezing during short circuit in power system are considered as well.

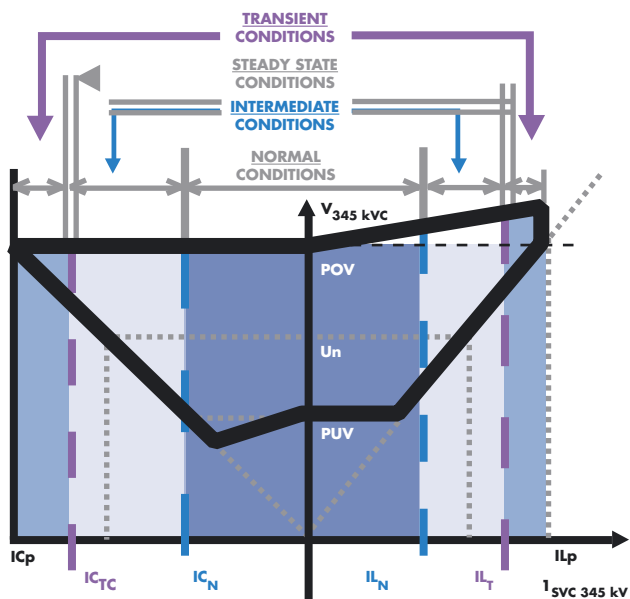


Figure 1: SVC Operation Ranges

The MSRE Logic was extensively tested in RTDS environment together with Furnas Operation Team in order to verify the power system behaviour and set all parameters of the logic aiming the best performance according to Campos area operation practice.

## An example can be seen for the Inductive Transitory Procedure

1. Switch on a G1 reactor.
2. If there is not any G1 reactor available, switch on two G2 reactors.
3. If both G1 and G2 reactors are not available, switch off a G1 capacitor.
4. If there is not any G1 capacitor available to switch off, switch off a G3 capacitor.
5. If there is not any G3 capacitor available to switch off, switch off all G2 capacitors.
6. If none of the above possibilities are available, alarm to operator.

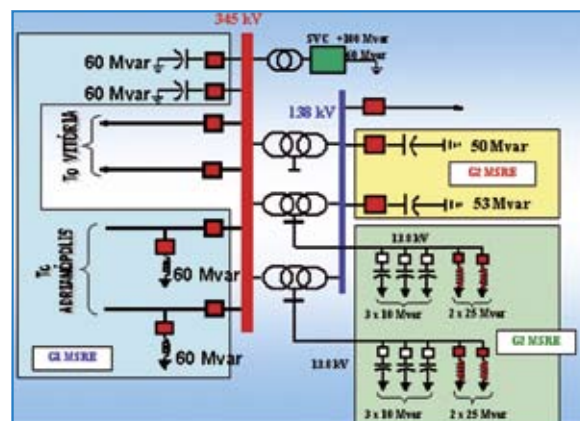


Figure 2: Campos MSRE elements



# Static Var Compensator for utility applications - Photogallery

## Pictures of installation



*-25...+25 Mvar, 115/12,5 kV, 60 Hz, Tri-State Generation & Transmission, Clapham, USA*

## Working SVC:s



*-60...+100 Mvar, 345/15 kV, 60 Hz, Campos, Furnas Centrais Elétricas SA, Brazil*

# Quality System

Nokian Capacitors' Quality System fulfils the requirements of the ISO 9001:2000 standard. The ISO 9001 certificate was received in 1993 and updated to ISO 9001:2000.

Environmental aspects have always been taken into account during the design, manufacturing and delivery of Nokian Capacitors' products. In 2000 Nokian Capacitors received the certificate conforming to the environmental standard, ISO 14001. In 2004, Nokian Capacitors received the IQNet 2004 certificate and in 2005 the OHSAS 18001 certificate.

**We participate in IEC, CIGRE and IEEE actions.**





# Highlights of NC Service Concept

## A Series Capacitors delivery includes:

- Series capacitor equipment
- Installation
- Commissioning
- Civil works (in turnkey projects)
- Spare parts
- Training

## NC Service also has these services that the customer can take advantage of:

### 1.

NC Remote Service guarantees expert operational support worldwide and aims at uninterrupted transmission. Nokia Capacitors has a hotline service for phone and e-mail support.

### 2.

Documentation

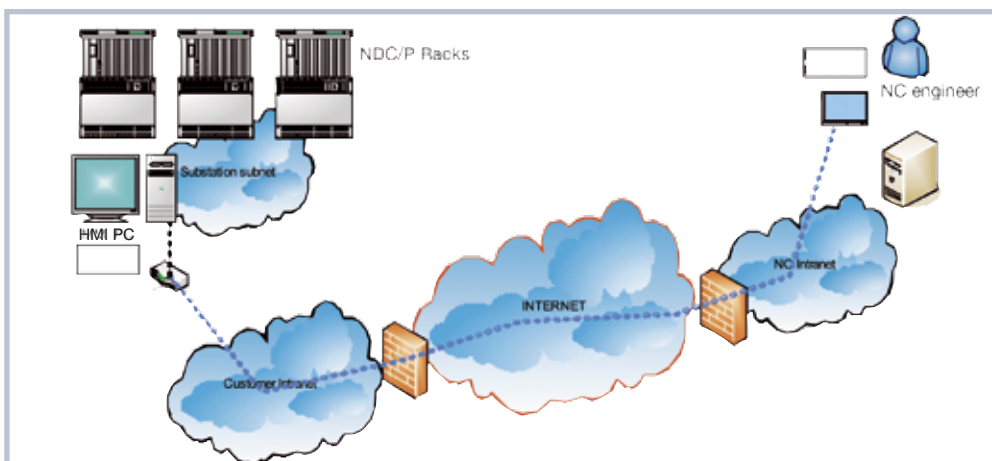
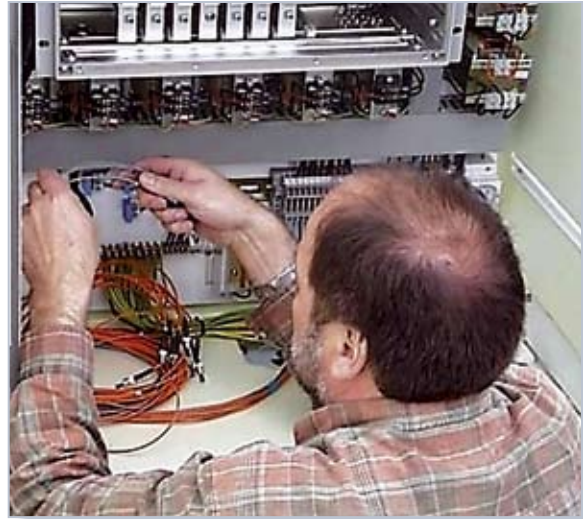
Each project has its own scope of delivered documents. It is possible to download the complete documentation from our Share Point web server. The documentation consists of the following:

- General Documents
- Studies
- Specifications
- Quality Documents
- Test reports
- Drawings
- Manuals

On our Share Point web server, the customers' own contract documentation can be easily found (with a user name and password).

Our aim is to fulfil our customers' needs.

Nokia Capacitors follows the security policy provided by SSL. That policy covers all documentation on our web server.



NC Remote Service



## Our Competence Portfolio

- Project Management
- System and Equipment Studies
- Electrical Engineering
- System Engineering
- Software Engineering
- Requirements Analysis and Management
- System Architecture Design
- Hardware Design
- Software Design, HW/SW Interaction
- UML (Design methodology)
- Software and Hardware Implementation
- C/C++ (Programming languages)
- Testing Methodologies
- Real-Time Operating Systems
- Protocols
  - IEC 60870-5-101
  - IEC 60870-5-103
  - IEC 60870-5-104
  - DNP 3.0
  - TCP/IP
  - MODBUS
  - PROFIBUS
  - IRIG-B
- Control and Protection Systems
  - Real-time measurement and modeling
  - I/O intensive real-time applications
  - Algorithms, PID-controllers, Laplacian transform, matrices and vector algebra



## Highlights

- Efficient method to maximize power transmission capability
- High availability with low maintenance costs
- High reliability with full redundancy
- Designed to endure severe conditions - from freezing to extreme heat
- Remote operability and service

Nokian Capacitors has 50 years of experience in reactive power compensation. Combining in-depth knowledge of modern digital technology, industrial control and our world-class high voltage products we are a unique combination of excellence. Don't miss the opportunity to work with an industry leader – contact us!



**Most high voltage equipment are made at Nokian Capacitors.**

## Other products

In addition to Utility SVCs, Nokian Capacitors is also a manufacturer of:

- Series Capacitors
- Industrial Static Var Compensator (SVC)
- SVC MaxSine
- MaxSine active filters
- Railway series capacitors
- Air core reactors
- Shunt capacitor banks
- Filter capacitor banks
- Enclosed medium voltage (MV) banks
- High voltage capacitor units
- Low voltage capacitor units
- Control & Protection System for capacitor banks
- Power factor controllers
- Unbalance relays
- Capacitance meters (clamp type)



In line with our policy of ongoing product development we reserve the right to alter specifications.



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