

SVC

static var compensator



Historical milestones for Nokian Capacitors

- 1957 □ Founding of Nokian Capacitors
- 1964 □ Optical signal transmission for series capacitors
- 1975 □ First series capacitor in the world with non-linear resistor
- 1977 □ SVC for Electric Arc Furnace (EAF) flicker compensation
- 1978 □ Among the first to use the 735 kv double tuned filter for utility SVC

Utility SVC for support of the 330 kv grid
- 1994 □ Digital Protection & Control System (NDP)

New design of free-standing thyristor valves for SVC application
- 1997 □ Laser powered measuring system for platform electronics (series capacitor bank)
- 2001 □ Furnas Brazil, 345kV Utility SVC with new digital control system
- 2002 □ Tennet Netherlands 1500Mvar HV-filter banks compensation turnkey project
- 2002 □ BCHydro Canada 500 kV series capacitor bank turnkey delivery (incl. civil works, installation and commissioning)
- 2002 □ North China Power Group four 500 kV series capacitor banks
- 2003 □ RautaRuukki Raahе Finland SVC turnkey delivery

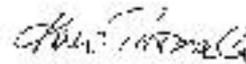
Dear customer,

Today's world is marked by speed, efficiency, the will to win and the concurrent concern about the environment. These challenging modern demands make it a pleasure to design and produce products that streamline production and increase growth of business, at the same time enhancing the protection of the environment.

In addition to increased awareness of environmental values the liberalization of the energy market, the quality requirements of power utilities and the need for cost efficiency are all drivers for different industrial plants to consider investing in a Static Var Compensator (SVC) system. The growing demand for SVCs is reflected in our product development and in our focus on our customers' needs. What does this mean in practice for your company? In short, it signifies successful and quality SVC deliveries, and an investment that pays itself back in one to two years.

Nokian Capacitors has been awarded quality and environmental certificates, which in their part, also guarantee the high eminence of our business. The control- and protection systems of the SVC are the results of our long-standing experience and product development. We also have top of the world expertise in components – we produce the main components used in the SVC systems under the strict qualitative scrutiny.

Please, get acquainted with this brochure, let yourself be convinced of the necessity of an SVC for your company, contact us and let us take care of the rest.



Kari Tuomala Managing Director



Tailored electricity

Nowadays the quality of electricity supply is becoming more important due to the use of sophisticated computer controlled systems. This has been recognised by the electrical utilities, which penalise disturbing users.

The Static Var Compensator is designed to decrease disturbances caused by changes in reactive power and voltage fluctuations in the normal operation of transmission lines and industry distribution systems. Disturbance may be caused by line switching, line faults, non-linear components such as thyristor controls and rapidly varying active or reactive loads. A typical source for these kind of disturbances are electric arc furnaces and rolling mills.

These disturbances result in harmonics that load the supply network, and cause voltage fluctuations. Varying loads can also create disturbances in the form of phase unbalance and voltage flicker phenomenon as well as create a need for additional reactive power.

The benefits of an SVC can be seen within a steel plant as stable power factor despite of varying loads of the plant, and externally when the disturbances don't affect the supplying grid. In short, the SVC affects the following:

- flicker reduction
- voltage stabilisation
- reactive power compensation; improved power factor
- increased voltage on the load bus
- reduction of harmonics

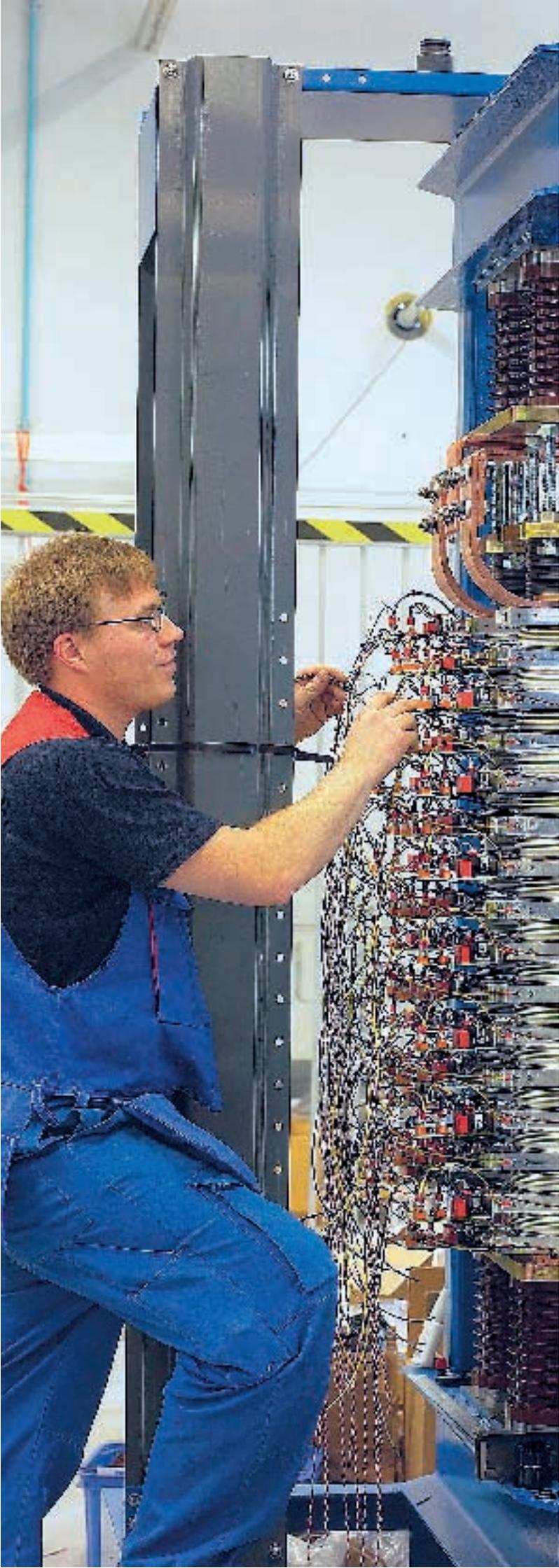
The achieved benefits of the SVC will improve production and the quality of steel of the factory.

Nokian Capacitors guards the high quality of the Static Var Compensator by inhouse manufacturing the main components of the SVC equipment, such as capacitors, reactors, thyristor valves, and the digital control and protection system.

Experts at your service

The services of Nokian Capacitors range from analysis and design, delivery of the SVC to after-sales services. We also carry out tests and reactive power / distortion measurements to ensure that the performance levels of the SVC are met as determined in the beginning of the project. Our global sales network contributes to projects with knowledge of the local environment and customs.





Functional benefits of the Static Var Compensator

The Static Var Compensator increases the quality of power in many respects. The benefits of reactive power compensation, more constant voltage levels and reduced distortion levels are transferred to the end user as production increases, total power losses are reduced, and reactive power penalties are avoided. The pay back time of the SVC investment ranges typically between one to two years.

Flicker reduction

Very rapidly varying reactive power causes voltage fluctuations at the point of common coupling of a steel plant. The human eye perceives the frequency of voltage fluctuations as flickering lights.

Voltage stabilisation

Electrical arc furnace operation can be strongly unbalanced especially in the beginning of the melting process. The three-phase induction motors suffer due the unbalanced supply voltage. The unbalanced voltage causes reduced efficiency, overheating, noise, torque pulses and speed pulses to motor operations.

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

Reactive power compensation

Transmission of reactive power leads to significant voltage drops and current increases in the networks, which limits the transmission capacity of active power. Public utilities maximise their transmission line capacities by advising their customers to utilise local reactive power compensation. The Static Var Compensator maintains the demand of reactive power within the limits set by utilities, thus avoiding penalties.

Reduction of harmonics

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

The filter circuit of the SVC system is designed to absorb harmonics generated by loads as well as by thyristor-controlled reactors. The total harmonic distortion and individual harmonic voltages are limited below specified levels.

Economical benefits

Energy savings

Compensation and improving the quality of power increase the capacity of active power transmission and reduces energy consumption. Thus, the unnecessary overload of the power network can be avoided. Both your company and the environment benefit from the more efficient use of electricity, saving in the consumption of energy.

Increase in productivity

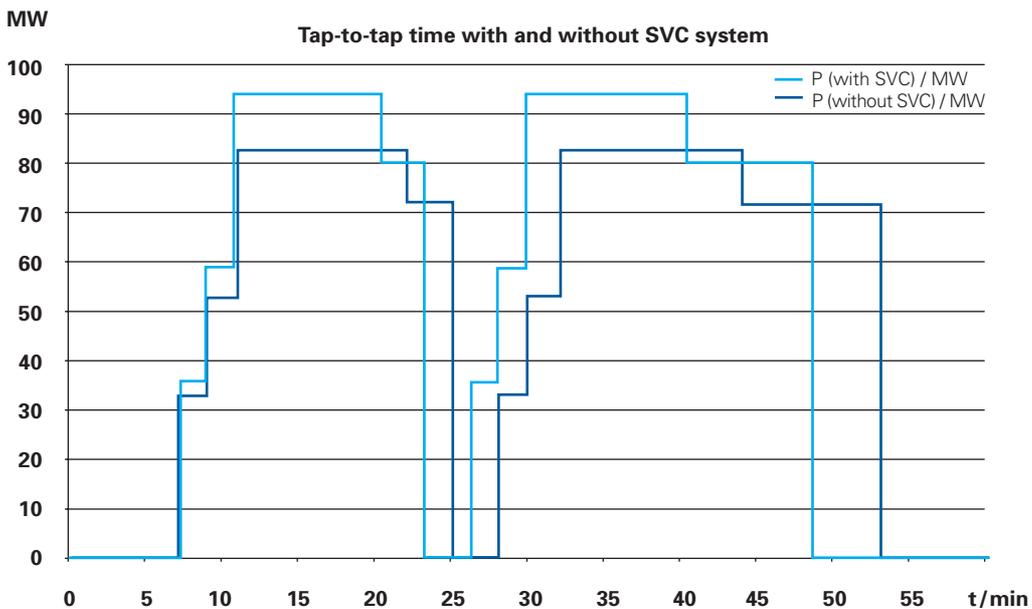
The SVC system can keep steel plant bus voltage practically at a constant level. This decreases the steel processing time and thus increases productivity. The SVC system also reduces production breaks and expensive restart procedures.

The arc furnace stabilized by the SVC also has a considerable effect on the consumption of electrodes, heat losses, and the lifetime of furnace inside lining.

As the improved quality of power from the network reduces the stress on equipment, its lifespan increases, thus lowering the maintenance and replacement costs.

Benefits of the SVC:

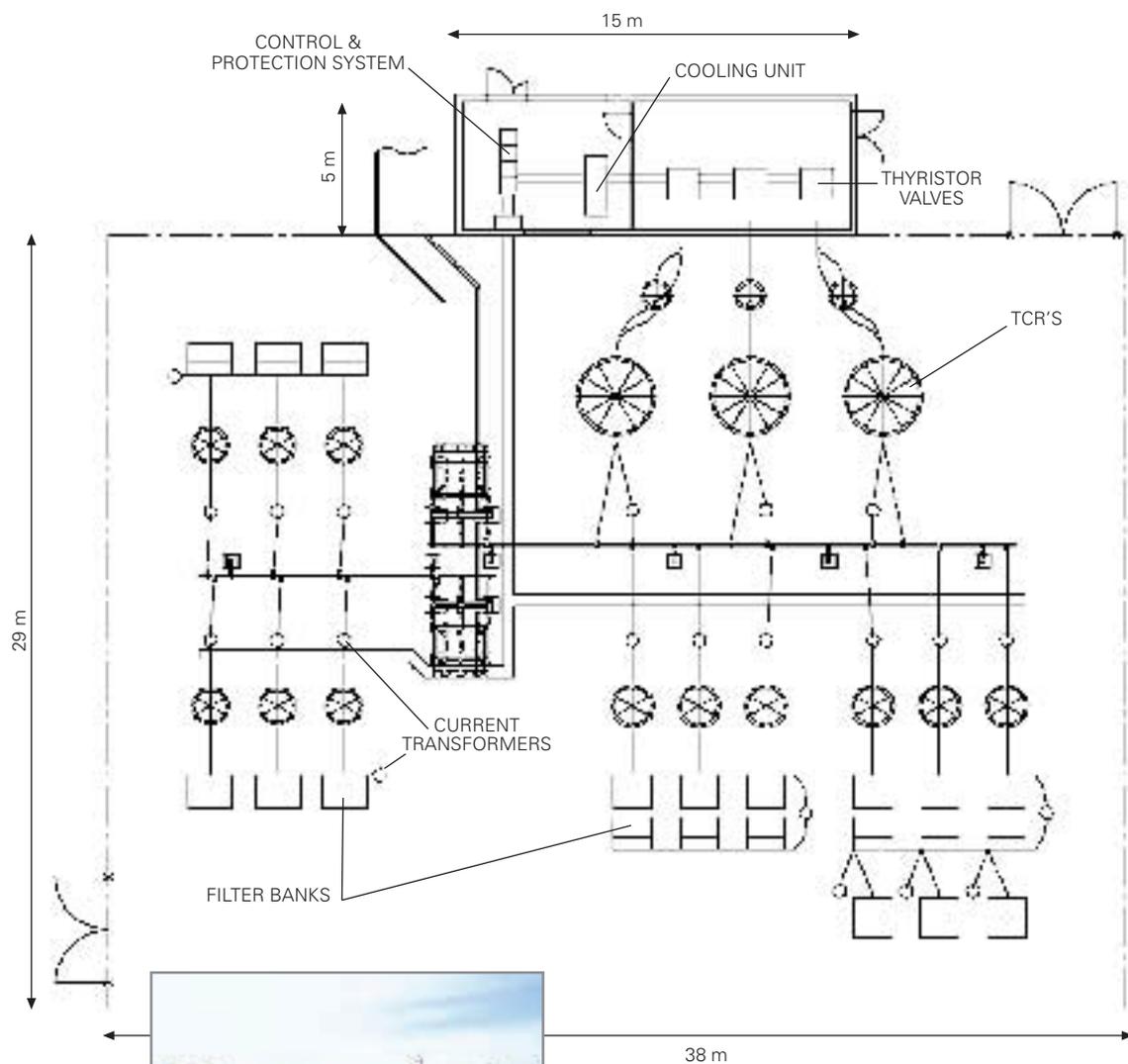
- Increase in productivity
- Energy savings
- Reduction in consumption of electrodes
- Reduction of heat losses
- Increase lifetime of furnace inside lining



This figure shows the influence of the shortened tap-to-tap time as increased steel production. The melting time of the changes decreased from 53 minutes to 48 minutes once the SVC was installed. This is a 9.4% reduction of one heat time – the total increase of the productivity can be transferred to the steel tons via saved time for each heat.

Tailored SVC installation

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



Typical layout and space requirements of an SVC installation.

A130 Mvar / 21kV-50Hz SVC installation at the Outokumpu Polarit steel plant in Tornio, Finland. The filter banks and thyristor reactor are located in the outdoor switchyard, while the thyristor valves, control and protection system and switchgear are located inside the pre-assembled building in the back.



Pre-processed scrap is loaded to scrap baskets and charged to the Electric Arc Furnace at the plant of AvestaPolarit Stainless Oy, in Tornio, Finland.

System parameters determine the design of the SVC

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

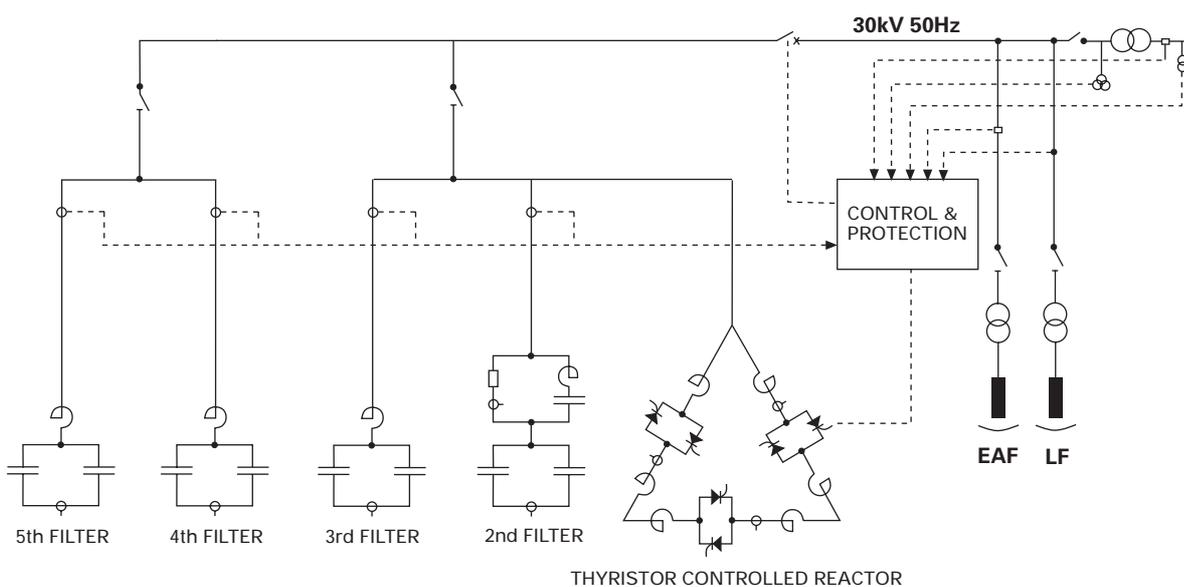
The location of the SVC once installed can be fixed, or re-locatable. Outdoor equipment is usually built as fixed structures. Indoor equipment is often located within a container that is easily re-locatable. It is possible to use modular design of the SVC. This makes transport, installation, and commissioning at the site fast and easy.

Tailored and flexible project delivery

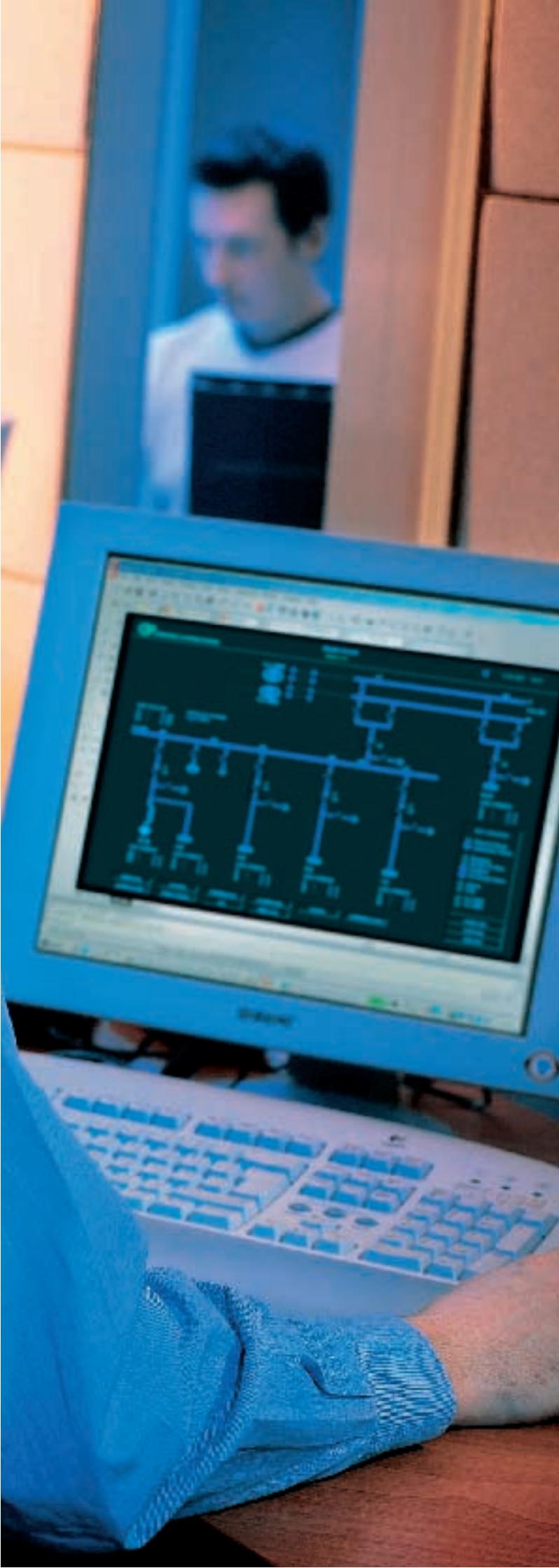
A successful delivery begins with an accurate assessment of the requirements for an SVC. Nokian Capacitors can provide consultative help already when determining the scope of supply.

Once the project begins, a competent team of experts will be in charge of the project, on site, for as long as needed. In the beginning of a project Nokian Capacitors analyses the network, its load and the physical space in which the SVC is to be installed. Changes in the reactive and active power are measured as a function of time, as well as distortions caused by harmonic currents. The fault level of the network is also checked, in case it is not already known. Based on the measurements, the size of the SVC is calculated, the parameters for the filters are assessed, as well as the flicker reduction.

Since Nokian Capacitors manufactures the main components of the SVC, it has full control of its delivery times. In fact Nokian Capacitors is recognized for having exceptionally fast delivery times, without compromising the flexibility and individual service provided for its customers. Individual needs are also taken into consideration by Nokian Capacitor's international sales network. It provides high quality documentation (such as installation, operation and maintenance manuals) and operation training in the customer's language according to their requirements.



This figure shows the single line diagram of a SVC installation. The number of filter banks and switchgear configuration depends on specific project requirements.



The digital control and protection at the heart of performance

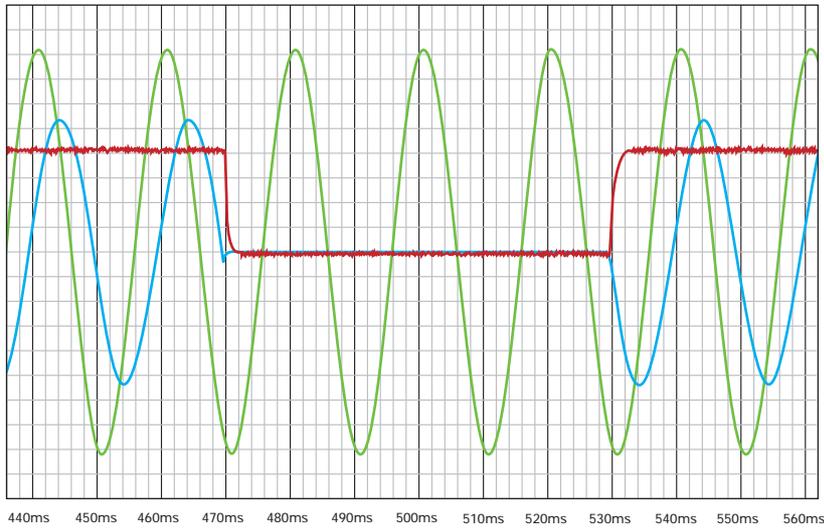
The digital control system measures changes in the reactive power consumption and initiates corrections to either generate or consume reactive power. The software and hardware of the control system are designed by Nokian Capacitors. They are based on commercial circuit boards. The control system communicates easily with the other systems operated by the steel plant.

The SVC control system is based on three Motorola CPU powered PC boards in a VME rack. The units are the Master board, which calculates the output of the SVC; and the Slave board that takes care of Programmable Logic Control operations. The Communication Interface transfers data between the VME rack and the Man-Machine Interface (MMI) computer. The operations of the SVC are controlled through a user interface screen.

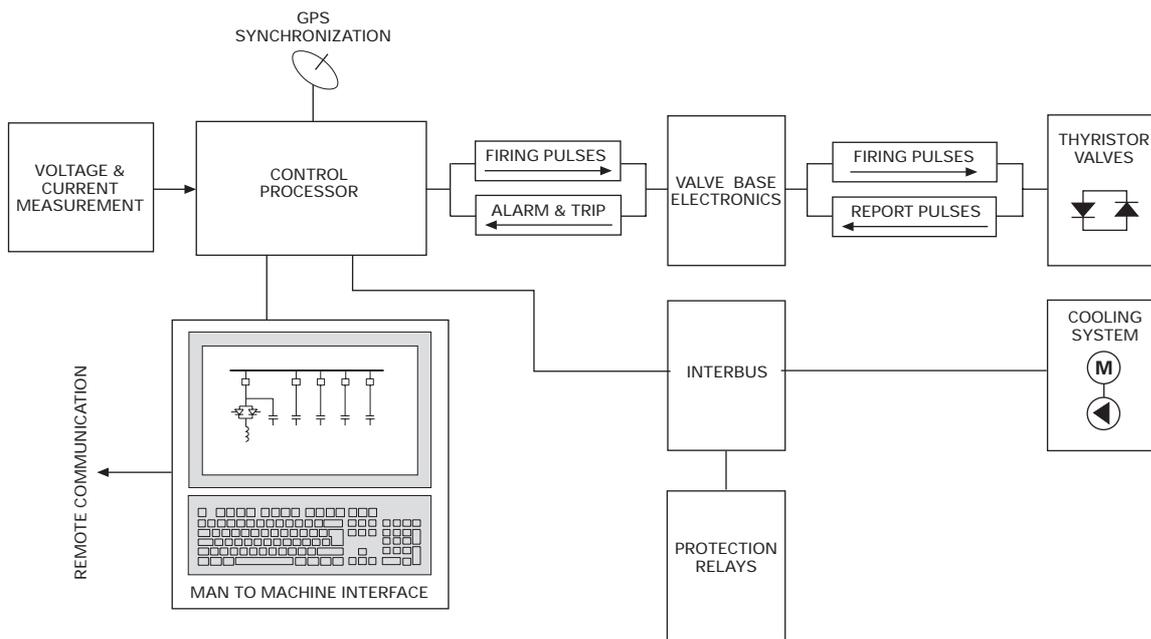
The control system and local MMI computer is connected to the remote MMI normally located in the control and operation centre via Ethernet links. The remote MMI controls all the local operations and surveillance functions in the same manner as the local MMI computer.

The performance of the control system is essential for flicker reduction. The main parameter is the response time of the SVC control system, which varies between one to three ms depending on the degree of load current. Thus the maximum response time of the complete SVC installation is 10 ms in a 50 Hz network due to the point on wave firing of the thyristor valves.

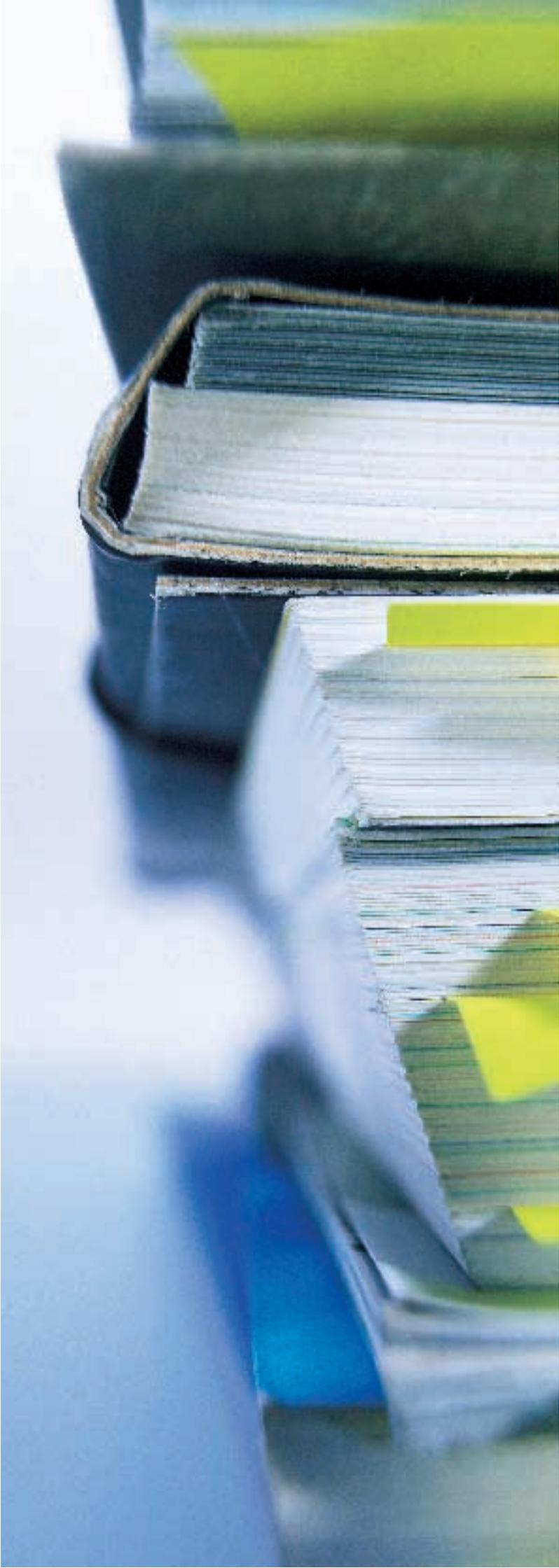
The control system meets all EMC (Electro Magnetic Compatibility) requirements. Nokian Capacitors runs a simulation in a RTDS (real time digital simulation) environment when developing the digital control system of each plant.



Step responses of the control system. This figure shows the measured step response of the control system. The green curve is the phase voltage. To the left of the curve, the 60 deg lagging current (red curve) is stepwise interrupted. To the right there is a stepwise switching on the load current. The blue curve is the measured reactive power signal used to control the thyristor valves. The thyristor valve causes an additional delay depending on the point of wave switching requirement. This may be between 0 to 10 ms.



Block diagram of the control system.

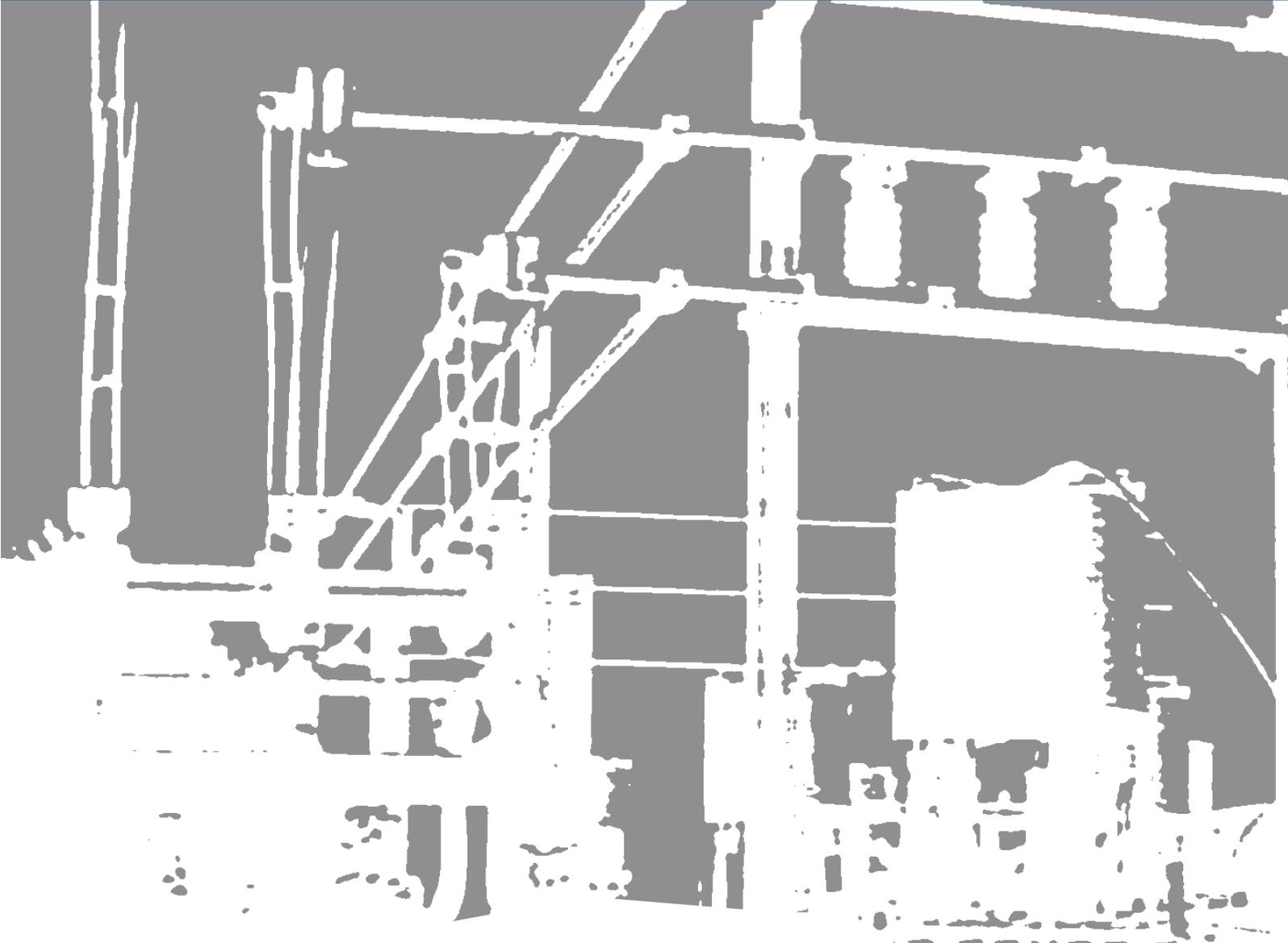


Data required for the design of a Static Var Compensator

Having read about the operational and economical benefits of the SVC, we now invite you to contact us to discuss the issues listed below.

Each SVC is designed individually, taking into consideration the special characteristics of the plant. The following list is an example of the required information for the design of an SVC for an arc furnace or rolling mill application. In case all information is not available the preliminary design of the SVC can be done using limited data.

- Schematic diagram of the system to which the SVC will be connected
- Data for the Point of Common Coupling (PCC):
 - rated voltage
 - frequency
 - maximum and minimum short circuit power
- Data for the Step-down transformer:
 - voltage (primary/secondary)
 - rated power
 - short circuit reactance
- Data for load (Arc-furnace)
 - type Electric Arc Furnace (EAF), Ladle Furnace (LF), AC or DC furnace
 - series reactor rated inductance
 - power of furnace transformer
 - primary and secondary current of furnace transformer
 - short circuit reactance
 - secondary circuit reactance
 - severity factor Kst
 - harmonics generated by the furnace (normally up to 23rd harmonic)
 - load cycle of the furnace
 - information about the used scrap
- Data for rolling mill
 - power (active, reactive)
 - load cycle
 - generated harmonics
- Power utility's requirement for the PCC
 - power factor or requested reactive power window
 - total voltage harmonic distortion THD
 - odd voltage harmonic distortion
 - even voltage harmonic distortion
 - flicker Pst
 - voltage fluctuation
 - voltage unbalance
 - current distortion (if specified)



Kaapelikatu 3
P.O. Box 4
FI-33331 Tampere
Finland

tel +358 3 388 311
fax +358 3 388 3360

www.nokiancapacitors.com