

ABB STATCOM For flexibility in power systems



ABB Power Systems



Static Synchronous Compensator: an additional tool for improved utilisation of power systems

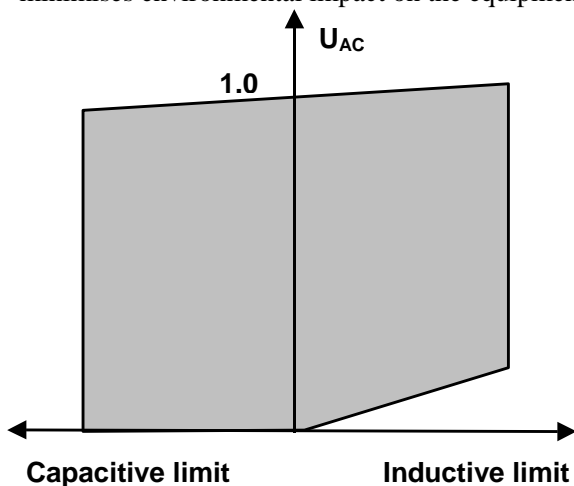
With the commercial breakthrough of high power gate turn-off devices, the road is paved for an additional step forward in flexibility of AC transmission and distribution systems: STATCOM, or the Static Synchronous Compensator. The name is an indication that STATCOM has a characteristic similar to the synchronous condenser, but as an electronic device it has no inertia and is superior to the synchronous condenser in several ways, such as better dynamics, a lower investment cost and lower operating and maintenance costs.

With the advent of STATCOM, still better performance can be reached in areas such as:

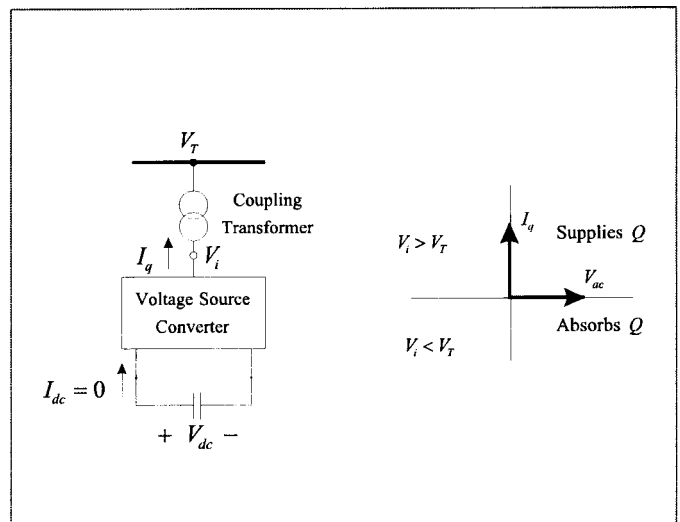
- Dynamic voltage control in transmission and distribution systems;
- Power oscillation damping in power transmission systems;
- Transient stability improvement;
- Ability to control not only reactive power but, if needed, also active power (with a DC energy source available).

STATCOM also brings further benefits like:

- A small footprint, due to the replacing of passive banks by compact electronic converters;
- Modular, factory built equipment, reducing site works and commissioning time;
- Use of encapsulated electronic converters, which minimises environmental impact on the equipment.



Schematic current- voltage characteristic of STATCOM



STATCOM Principal Diagram

State of the art power system control

A STATCOM can be seen as a voltage source behind a reactance. It provides reactive power generation as well as absorption purely by means of electronic processing of voltage and current waveforms in a Voltage Source Converter (VSC). This means that capacitor banks and shunt reactors are not needed for generation and absorption of reactive power, giving a compact design, a small footprint, as well as low noise and low magnetic impact.

The VSC has the same rated current capability when operating with capacitive or inductive reactive current. Therefore a VSC having a certain MVA rating gives STATCOM twice the dynamic range in MVar. This also contributes to a compact design.

A DC capacitor bank is utilised to support (stabilise) the controlled DC voltage needed for the operation of the VSC. The VSC technology has been exploited in industrial and traction applications for more than a decade. Its use in high-power applications requiring tens and hundreds of MVA however has been hampered by previous difficulties in series connecting gate turn-off devices (GTOs). These problems have been overcome by ABB, enabling the full utilisation of STATCOM for utility purposes.

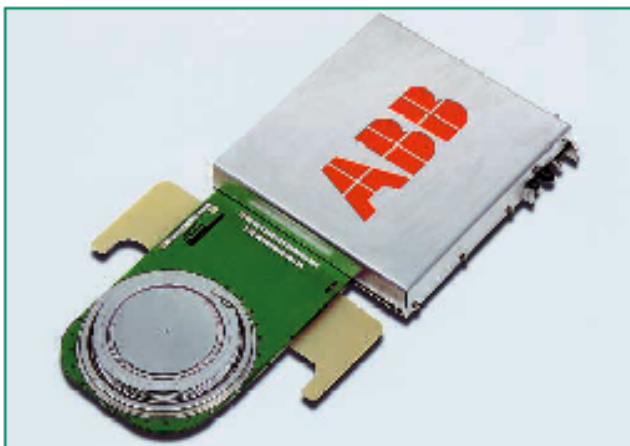
Characteristics of STATCOM

The technology used by ABB is the so-called Hard Drive, briefly described below. By means of this technology, ABB has eliminated the need of costly and cumbersome paralleling of converters.

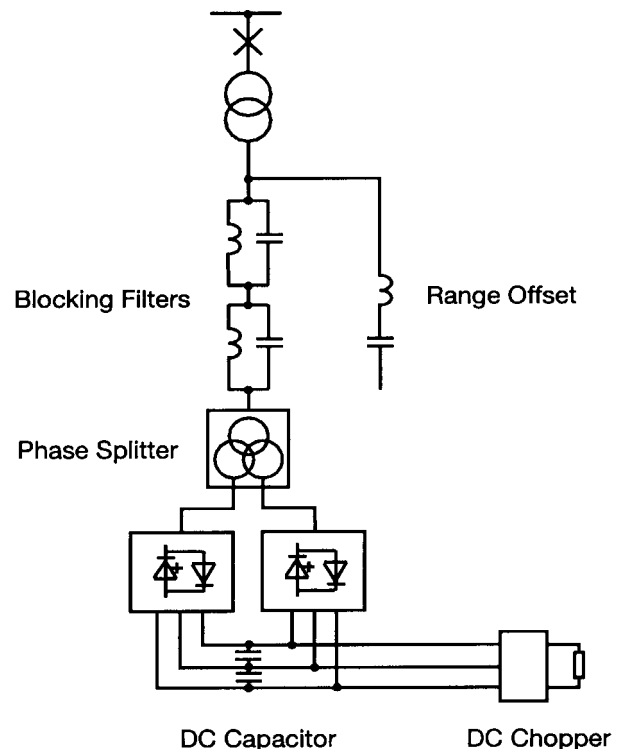
The characteristic of STATCOM reveals another strong point of this technology: it is capable of yielding full output of capacitive generation almost independently of the system voltage (constant current output at lower voltages). This is particularly useful in situations where the STATCOM is needed to support the system voltage during and after faults where voltage collapse would otherwise be a limiting factor.

Voltage Source Converter

The reactive power of STATCOM is produced by means of power electronic equipment of Voltage Source Converter type. The VSC may be of 2-level or 3-level type depending of the required output power and voltage. Each VSC module uses three phase-legs, each comprising two or four strings of series connected GTOs. Normally one redundant GTO is provided in each string. A number of VSCs are combined together in multi-pulse connection to form the STATCOM. In steady-state the VSCs operate with fundamental frequency switching in order to minimise converter losses. During transient conditions caused by line faults, however, a PWM mode is utilised in order to limit the fault current entering the VSCs. In this way, STATCOM is able to ride through transients on the AC side without blocking.



GTO with gate unit



STATCOM Single Line Diagram

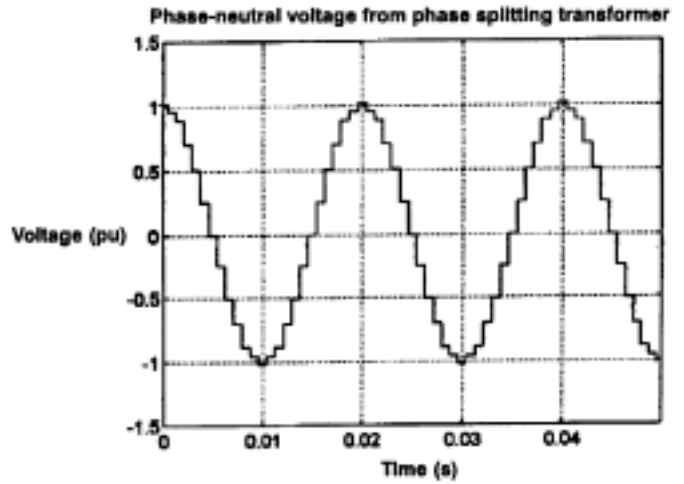
Hard Drive technology

A major factor to be addressed when series connecting GTOs is voltage sharing. This is coupled to the so-called storage time, a parameter which shows a relatively large variation between individual GTOs as well as for varying device temperature. Unless remedied, the variation in storage time would cause unequal voltage sharing between GTOs.

The most straightforward way to eliminate the voltage-sharing problem is to reduce the storage time in the GTO dramatically. By reducing the inductance in the gate circuit a high rate of change of the gate current can be achieved, which cuts the storage time by one order of magnitude! This is referred to as the Hard Drive or Gate-Commutated Thyristor (GCT) concept. With this technology the voltage-sharing problem has been practically eliminated under all operating conditions. Consequently, there is no need for expensive special selection and matching of components for the GTO strings. Also, one single type of spare devices is enough, greatly facilitating the handling of spare parts.

Intermediate phase splitting transformers

The VSC modules are combined into a multi-phase STATCOM using intermediate phase splitting transformers. An example of the resulting wave-shape of the combined VSC modules is shown in the figure (four 2-level converters combined into a 24-pulse converter).



VSC 24-pulse output voltage

Control system

The ABB STATCOM control system is based on the same platform as other equipment in the reactive power compensation family, i.e. VarMACH. This offers compact, modular design utilising microprocessors and digital signal processors connected by high performance industry standard buses and fibre optic communication links. Due to extensive self-supervision, the need for periodic maintenance of the control system has been reduced to a minimum.

A Station Control and Monitoring system (SCM), PC based, provides the operator interface to the installation.

Harmonic Filters

A combination of blocking filters and shunt filters are provided to suppress the residual harmonic voltages from the converter.

DC chopper

A resistive DC chopper is normally used to limit the DC side voltage during transients. It is designed for short time operation only.

Small footprint

A typical, compact layout for an ABB STATCOM is shown below.

