SVC for voltage support of pipeline drives

Golden Valley Electric Association (GVEA), located in Fairbanks, Alaska, is operating a Static Var Compensator (SVC) in their 138 kV grid, supplied by ABB in 2005 as a turnkey project. The SVC, located at Jarvis Creek in the Delta Junction region of Central Alaska, is rated at 8 Mvar (inductive) to 36 Mvar (capacitive) at 138 kV. In addition, it has a rated two-minute boosted capacitive output of 45 Mvar. The SVC was erected and commissioned on a turnkey basis in less than 12 months.

Also included in the ABB undertaking were two 5 Mvar Mechanically Switched Capacitors (MSC) connected to the 138 kV system in the Jarvis Creek substation. The MSCs are used during annual maintenance, when the SVC is offline, or in the event of an unexpected trip of the SVC.

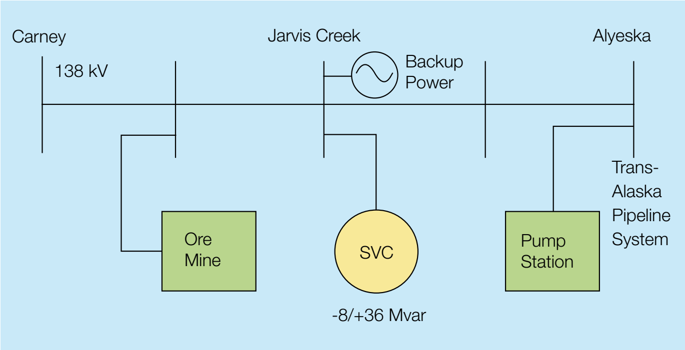
With the geographical conditions of the installation, large ambient temperature variations have to be accommodated. Thus, the equipment has been designed to operate over a temperature range of -52 to +35 degrees C.

Dynamic voltage control

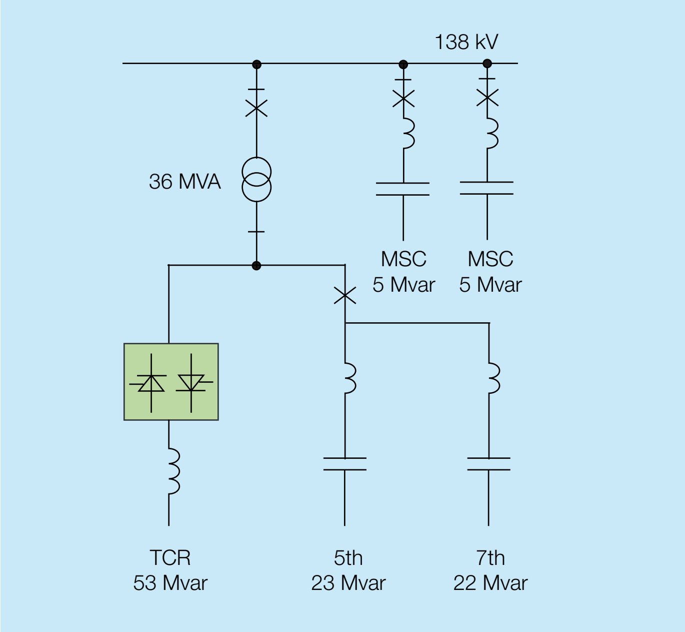
The SVC is necessary for the operation of a recently electrically converted pump station in the Trans-Alaska Pipeline System, which transports oil from Prudhoe Bay to the south Alaskan coast. The purpose of the SVC is to yield dynamic control of the system voltage for various load conditions from steady state to load rejection situations in this remote part of the long radial, weak grid, and thereby to assure an uninterrupted flow of oil via the pipeline. The pump station comprises three pumps, each powered by a 6.6 kV, 5.4 MW VFD (Variable Frequency Drive). Also of importance is dynamic voltage support to a nearby ore processing plant.

The purpose of the rated two-minute boosted capacitive output (45 Mvar) is to allow the SVC to respond to dynamic fluctuations in the power system during and/or after a fault and after a large load rejection.

The alternative to the SVC would have been to build a second, 145 km long, 138 kV line from the North Pole substation near Fairbanks to Jarvis Creek, an investment which would have amounted to some 75 million USD. The SVC cost only a fraction of this.



Eastern part, Central Alaska transmission system



Single-line diagram, SVC and MSC

Island operation

In case of failure of the radial 138 kV line from Carney to Jarvis Creek substation, a stand-by generator is available to provide partial back-up power at Jarvis Creek. In a situation like this, the SVC performs the task of keeping the system voltage stable for different load conditions of the pump station.

SVC main design

The SVC consists of a Thyristor Controlled Reactor (TCR) and two Harmonic Filters, tuned close to the 5th and 7th harmonics, and rated at 23 Mvar and 22 Mvar respectively. The TCR has a nominal rating of 53 Mvar. The control system controls the SVC so that the resulting reactive power can be controlled continuously over the entire range from maximum inductive to maximum capacitive.

Thyristor valve

The thyristor valve consists of single-phase assemblies. Each valve is equipped with bi-directional controlled thyristors (BCTs) which means that two anti-parallel high power thyristors are integrated onto one silicon wafer and are assembled in a single housing. Snubber circuits (series connection of resistors and capacitors) are mounted in parallel with the thyristors.

The thyristors are electrically triggered, and the energy for triggering is taken from the snubber capacitors. The order to trigger the thyristors is communicated via optical light guides from the valve control unit. This type of system is normally called “indirect light triggering”. The thyristor control units (TCUs, located in the valves) also incorporate important supervision and protection, such as thyristor overvoltage and recovery protection.

Heat sinks are located between the thyristors. The heat sinks are connected, each level in parallel, to a water piping system. The cooling medium is a water/glycol mixture with low conductivity.

Control system

The Control System is based on the ABB MACH 2 concept, which is a system of both hardware and software specifically developed for power applications. The MACH 2 concept is built around an industrial PC with add-in boards and I/O racks connected through standard type field busses such as CAN and TDM.

The main objective of the control system is to maintain the high voltage bus voltage close to a voltage set point. The voltage control system is a closed loop system. The automatic control can be switched off and the SVC operated manually. The control variable is compared with a set reference value. The network and SVC characteristics determine the operating point of the SVC. A set voltage reference and a slope setting give the SVC VI characteristic.

The SVC can be controlled from different locations. Locally in the SVC control room there is an Operator Work Station (OWS/SER) based on a personal computer and a mimic panel as a back-up possibility for operation. The SVC can also be controlled remotely from the RTU/SCADA via a Gateway Station (GWS).

MACH 2 main computer

Internal supervision
The control system includes an extensive system for supervision and self-diagnostics. All microprocessors, measurements and most controller functions are supervised. Descriptive alarms are displayed on the OWS screen with millisecond resolution to facilitate fault tracing. There is also a built-in Transient Fault Recorder (TFR) that records all measurements and a large number of internal signals.

Under-voltage strategy
Should the primary voltage drop, e.g. due to some fault in the high voltage system, the normal voltage control will control the SVC to its full capacitive output, i.e. the TCR is controlled to zero current.

If the voltage in one of the phases at the 138 kV bus drops below a pre-set level, an under-voltage strategy is activated to steer the SVC output to zero. The under-voltage strategy can also be externally activated by a digital signal, associated with the relay protection system.

Over-voltage strategy
The SVC is designed for five minutes' inductive operation at 1.15 p.u. primary voltage. Moreover, the SVC is designed to be controllable up to 1.3 p.u. primary voltage. If the primary voltage exceeds 1.3 p.u., the TCR is controlled to full conduction by means of continuous firing pulses. If the voltage still remains above 1.3 p.u. after one second, the SVC is tripped.

Connection redundancy
In case of unavailability of the SVC transformer, it can be replaced by a 20 MVA mobile substation. In this mode of operation, the SVC will have limited capacitive range. The control system parameters and functions are automatically adapted to the new configuration, and the SVC mechanical design allows easy connection of the mobile substation.

Main technical data

System voltage	138 kV
System fault level	84 MVA to 765 MVA
Ambient temperature range	-52 to +35 degrees C
SVC rating	8 Mvar inductive to 36 Mvar capacitive (continuously); 8 Mvar inductive to 45 Mvar capacitive (2 minutes).
Control system	Positive sequence voltage control by means of a closed loop regulator.
Thyristor valve	Water cooled, BCT type thyristors, indirect light firing.
MSC	138 kV, 2 x 5 Mvar

For more information please contact:

ABB AB
FACTS
SE-721 64 Västerås,
SWEDEN
Phone: +46 (0)21 32 50 00
Fax: +46 (0)21 32 48 10

www.abb.com/FACTS

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