FACTS

Increased power transmission capacity in a 500 kV grid by installation and refurbishing of series capacitors

In British Columbia, an ABB series capacitor has been commissioned in the McLeese substation in the 500 kV network of BC Hydro. The series capacitor, rated 605 Mvar, was installed in a new line segment running in parallell with two previously existing 500 kV lines having the purpose of bringing hydro power from the G.M. Shrum and Peace Canyon hydro power stations in the north of the country down to the Vancouver area, a distance of more than 900 km.

The task of the series capacitor is to secure a balanced power flow over the parallel lines, and to increase the system transient stability, so that a total transfer capability of 3.300 MW can be maintained even at loss of one of the three lines.

The series capacitor is protected by a gapless ZnO scheme, designed to withstand the stresses of faults external to the compensated line without bypassing of the series capacitor.

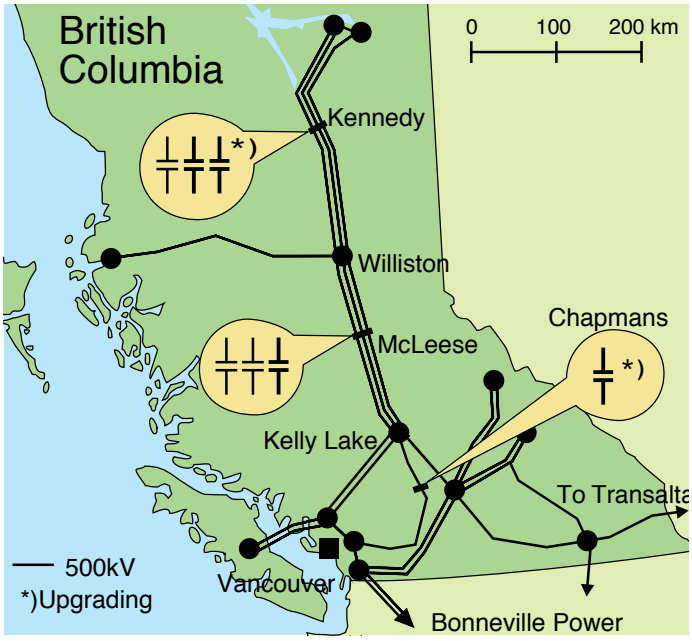

Fig 1. BC Hydro 500 kV series capacitors.

With the series capacitor installation at McLeese, all three 500 kV lines passing through this substation are series compensated (Fig.1). The installation was part of an upgrading process which also included the refurbishing of existing series capacitors at Kennedy and Chapmans substations, likewise entrusted to ABB.

State of the art technology

The McLeese substation is located nearly at mid-line between Williston and Kelly Lake. The mid-line location brings with it a natural limitation of fault currents which in its turn enables the utilization of a gap-less MOV protection scheme (Fig 2). Compactness is enhanced by the use throughout of high power capacitor units, with ratings close to 1 Mvar per unit.

The MOV has been rated to withstand a duty cycle as follows:
- A worst case 3-phase internal fault followed by reinsertion followed by a second worst case fault followed by sustained bypass for MOV cooling.
- Three worst case 3-phase external faults and remain in service followed by a worst case internal fault after which sustained bypass for MOV cooling is permitted.

The protection and control system is microprocessor based and uses optical current transducers for current measurements on the series capacitor platforms. The measured signals are brought to the control panels in the control room via optical fibres where all the protection and control actions are performed.

Major advantages of the system are:
- No control or protection equipment located on the platforms.
- No auxiliary power required on the platforms.
- No multiplexing of measured quantities.

Optical current transformers

Current measurements are performed by the use of optical current transformers consisting of a Current transducer in the high voltage busbar and an Optical interface module in the control room. Signal transmission between the transducer and the interface is by an optical fibre system including high voltage links and fibre optic cables (Fig 3).

Each Optical interface module handles six separate current channels. It includes laser diodes to power the transducers and detector circuits to receive and decode light pulses from the transducers. In the modules there are also circuits for automatic self-supervising of signal levels, timing and parity of received messages.

The output from the Optical interface modules to the protection system is a fully digital serial protocol, controlled by a DSP (Digital Signal Processor), allowing flexibility to implement protocols with high noise immunity.

VarMACH protection and control system

All protection and control functions are built using the VarMACH system developed by ABB (Fig 4). With this, all protective functions needed in the series capacitor can be implemented in one rack. For proper redundancy, a primary as well as a standby system are provided. The protective functions include:
- MOV overload
- MOV overcurrent
- MOV failure
- Capacitor overload
- Capacitor unbalance
- Flash-over to platform

Control functions included are discharge automatics and insertion automatics.

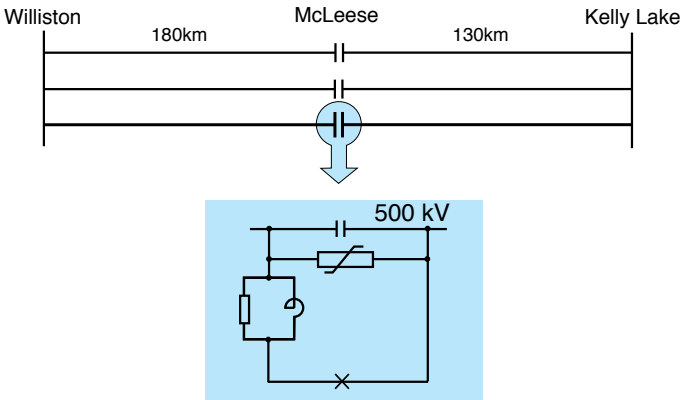

Fig 2. Installed 500 kV series capacitor at McLeese.

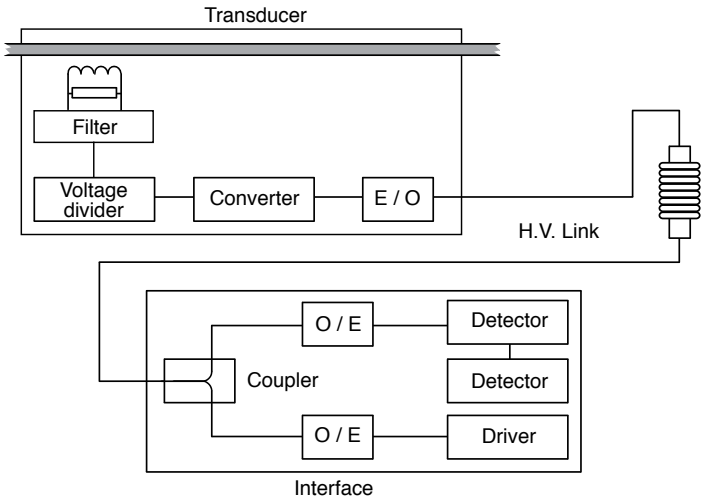

Fig 3. Digital optic current transformer.

Station Control and Monitoring

The operator interface to the protection and control functions is provided by the SCM (Station Control and Monitoring) system. This system is built from standard computers (PCs) and interfaces directly to the protection and control racks without the need for any remote terminal units (RTUs).

The main functions of the SCM system are:

- Full graphic status display of the series capacitor
- Touch screen operation
- Display and control of protection settings
- Sequence of events recording
- Transient fault recording

Remote access

Due to the modular design and open systems approach of the SCM it is also possible to call into the SCM system from remote sites by means of a modem and some additional software to gain access to online data or recorded SER or TFR files.

Various levels of passwords and a call back arrangement can be applied for security.

Series capacitor refurbishing

In addition to the series capacitor installation at McLeese, ABB has also provided refurbishing of existing series capacitors in the BC Hydro 500 kV transmission system, two at Kennedy and one at Chapmans substations. In these, state of the art control and protection equipment as well as bypass switches have been introduced, thereby improving the function of the series capacitors as well as the availability of the power transmission system as a whole.

Technical data series capacitor at McLeese	
Number of banks	1
System voltage	500 kV
Rated current	1950 A
Rated reactance	53 Ω
Degree of compensation	50 %
Rated reactive power	605 Mvar
Protective system	Gapless MOV
Rated MOV energy	95 MJ
MOV design criteria	External faults

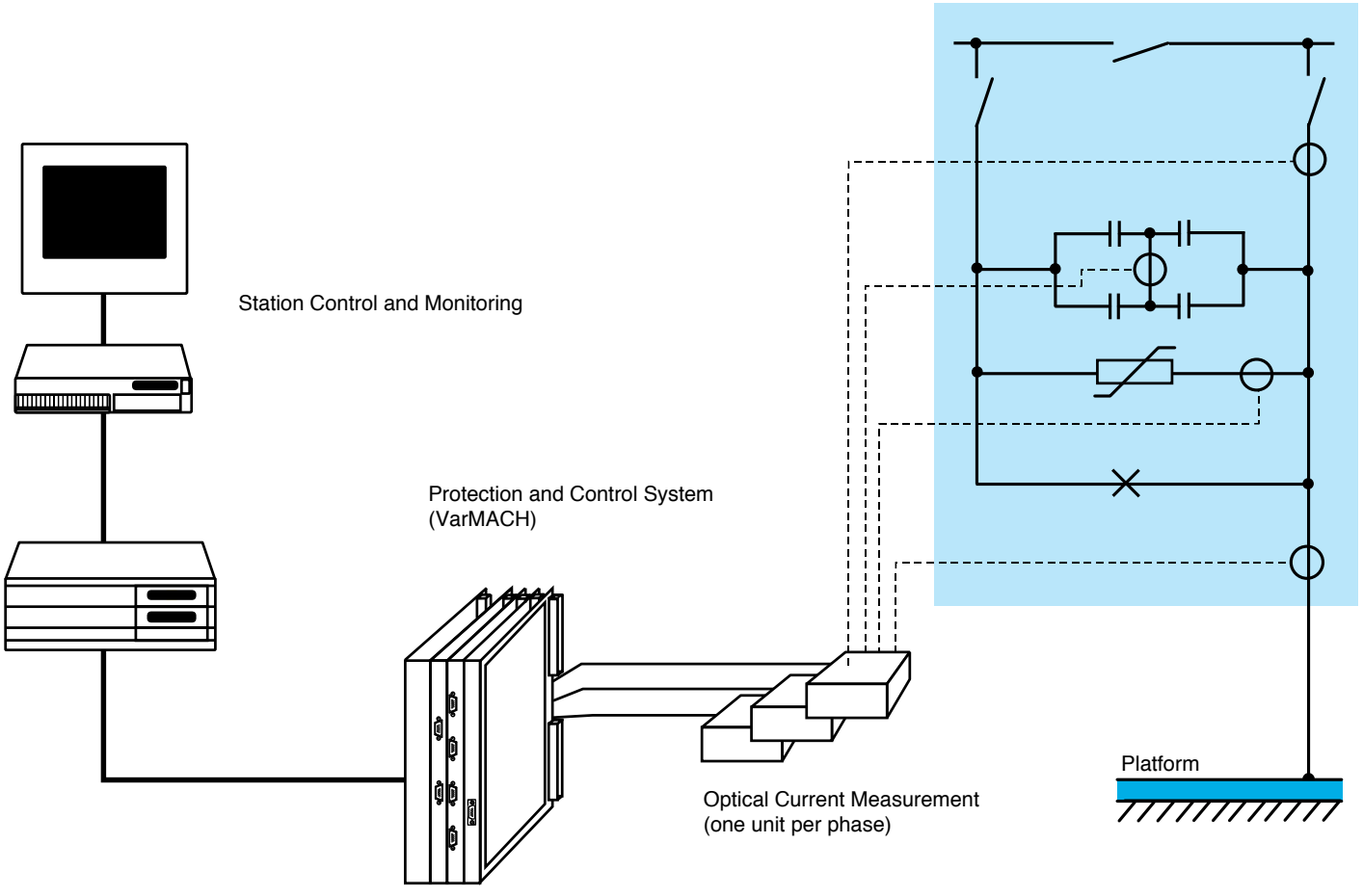

Fig 4. Series capacitor protection and control system.

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