

# Series Capacitors for increased power transmission between regions in Saudi Arabia

Since 2005, Saudi Electricity Company - Eastern Region Branch (SEC-ERB) has been operating four Series Capacitors in the 380 kV power transmission corridor interconnecting the Eastern Region with the Central Region of the national grid. The Series Capacitors, supplied by ABB as a turnkey commitment, have the task of increasing the power transmission capability over the interconnector, in order to meet the growing demand for electric power in the Central Region.

The power corridor is about 300 km long and consists of two parallel, double circuit 380 kV lines, Shedgum-Riyadh and Faras-Al Kharj. Each of the totally four lines is series compensated at the midpoint.

Series Capacitor ratings:

- Shedgum-Riyadh 2 x 503 Mvar, 380 kV
- Faras-Al Kharj 2 x 424 Mvar, 380 kV.

With the series Capacitors in place, the stability limit of the 380 kV circuits reaches about 2600 MW under double contingency criteria. Installation of series compensation was found to be the optimum solution to increase the power flow from the East to the Central region by about 500 MW <sup>1)</sup>.

Modification of existing relay protection systems in the line end substations was also part of the ABB undertaking. Likewise, 60 km of 34.5 kV overhead line plus access road were supplied to provide auxiliary power to the Series Capacitors.

In addition, ABB supplied altogether three Mechanically Switched Shunt Capacitors at Khurais, each rated at 230 kV, 63 Mvar.

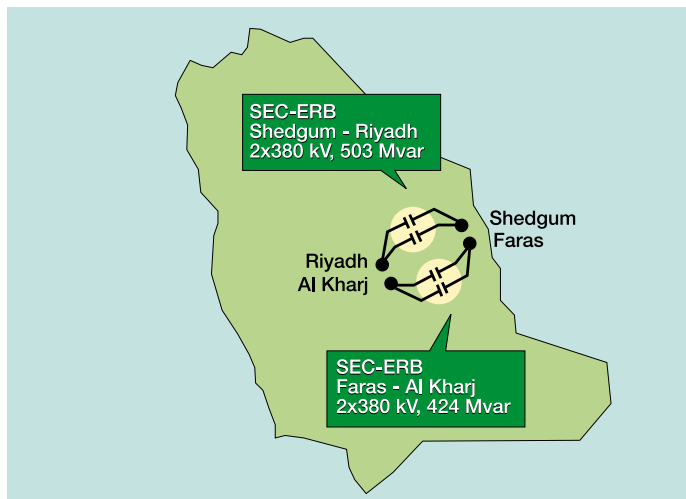
Also part of the picture, there are several TCRs (Thyristor Controlled Shunt Reactors) in operation in the system, supplied by ABB on previous occasions:

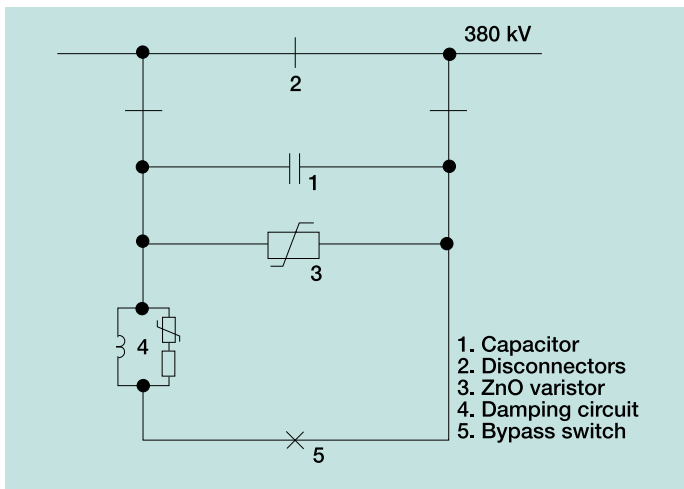
- Riyadh 380 kV, 2 x (0-150) Mvar
- Shedgum 380 kV, 0-200 Mvar
- Faras 380 kV, 0-200 Mvar.



## Main circuit design

The single-line diagram is identical for all four Series Capacitors, with a capacitor protective scheme consisting of a Metal Oxide Varistor (MOV), Current Limiting Damping Equipment (CLDE), and a Bypass Switch. The CLDE consists of a current limiting reactor, plus a resistor and a varistor in parallel with the reactor. The purpose of the resistor is to add damping to the capacitor discharge current, and thus quickly reduce the voltage across the capacitor after a bypass operation. The purpose of the varistor is to avoid fundamental frequency losses in the damping resistor during steady state operation.





Single-line diagram

### Control and protection 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.

The Series Capacitors can be controlled from two different locations. Locally in the Series Capacitor control room there is an Operator Work Station (OWS) based on a personal computer and a Mimic back-up panel. The Series Capacitors can also be controlled via a Remote Terminal Unit (RTU) interface from a remote control center.

The following are some of the available protective functions for each Series Capacitor:

- Capacitor unbalance protection
- Capacitor overload protection
- Flash-over to platform protection
- MOV overload protection
- MOV failure protection
- By-pass switch failure protection
- Subharmonic protection.

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### Platform to ground communication

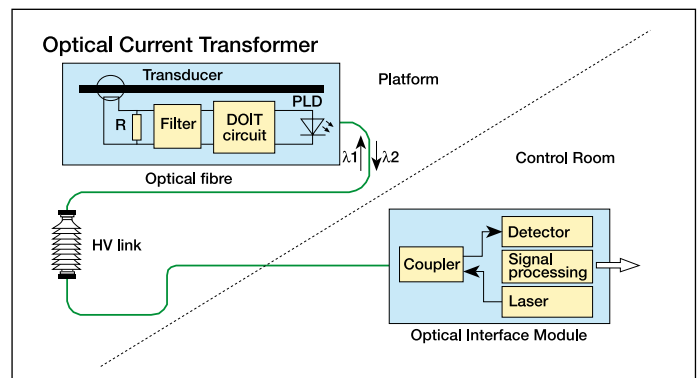
Current measurements for control and protection functions are achieved by means of Optical Current Transformers (OCT). The OCT consists of a current transducer in the high voltage bus bar on platform level and an optical interface module in the control room. Signal transmission between the transducer and the interface is by an optical fibre system including platform links, high voltage signal columns and fibre optic cables.

In the OCT transducer, the current is sampled and converted to a digital value. This value, coded as light pulses, is transmitted in the fibre system to the interface. The converter circuit in the transducer is optically powered by light sent from the interface to the transducer in the same fibre that transmits the measured value.

### Minimising line circuit breaker stress

To minimise transient recovery voltage (TRV) stress on line circuit breakers in conjunction with faults on the lines, the series capacitors are bypassed before the actual opening of the line circuit breakers. This is enabled by means of active communication between line protections and the Series Capacitors.

1) Cigré Case Studies, 2006



### Main technical data

	Shedgum-Riyadh (For each series capacitor)	Faras-Al Kharj (For each series capacitor)
Rated system voltage:	380 kV	380 kV
Rated reactive power:	503 Mvar	424 Mvar
Rated current per phase:	1850 A	1850 A
Overload current, 30 min:	2775 A	2775 A
Rated phase reactance:	49 $\Omega$	41.3 $\Omega$
Degree of compensation:	50%	50%
Rated MOV energy:	164 MJ/3-ph	304 MJ/3-ph