Overload control of a 220 kV transmission line by means of an OLC

TWENTIES is an R&D project funded by the 7th Framework Programme of the European Commission with the objective of increasing the wind power penetration in the European grid. A specific task force deals with the flexibility enhancement of the European transmission grid by installing new equipment that enables more efficient power flow control to optimize network capacity and allow increasing wind integration. Increasing wind power penetration in current networks will contribute to the objectives of the European Union known as “20/20/20”, i.e. 20% reduction of CO_2 emissions, 20% improvement of energy efficiency and 20% energy consumption from renewable sources.

ABB has installed and commissioned an OLC, Overload Line Controller, based on a system of discrete series reactors that enable efficient control of the power transmission conditions, limiting system overload and controlling the compensated line loading conditions with a response time of fractions of a second.

The OLC is a simple and effective FACTS (Flexible AC Transmission Systems) solution to provide power flow control, power flow limitation and overload mitigation, particularly in such cases where the transmission lines are part of power networks with high penetration of wind energy sources.

The OLC is integrated in series in one of the main 220 kV corridors in Spain in the Aragón-Navarra region, forming part of the national Spanish power grid owned and operated by REE (Red Eléctrica de España). Under certain conditions, the selected region has limitations in its transmission capacity due to overload of the corridor. By integrating the OLC, this problem can be diminished, or even eliminated, consequently increasing the renewable generation that can be transmitted. The OLC is located at the Magallón substation of the 24 km Magallón-Entrerrios 220 kV line.

The general purpose of the OLC is to provide the line with power flow control and operation closer to its natural limits, thereby increasing the transmission capability of renewable energy.

Objectives of the OLC

The specific objectives of the OLC are the following:

- Maintain the power flow through the line below overload conditions by inserting the inductive series compensation required.
- Maintain the power flow through the line inside an operating band by connecting and disconnecting the inductive steps required.
- Provide the line with inductive series compensation equal to the reactance set point chosen by the system operator.
- In case of emergency (hazardous overload), provide the line with back-up overload protection by inserting the required amount of inductive series compensation.

Main system design

The OLC is based on inductive series compensation by means of three discrete, mechanically switched air core reactors, rated at 12 Mvar (2.6 Ω/phase), 24.5 Mvar (5.2 Ω/phase), and 48 Mvar (10.3 Ω/phase), controlled to achieve a desired total level of compensation. The reactor system comprises several compensation steps allowing for eight different settings following a digital control philosophy, covering the rated compensation range.

The device incorporates a high-speed response control system, capable to respond to external reference signals (sent by the control system or the grid operator) and to measurements and/or alarms from the system (overloadings).

The OLC is controlled by a micro-processor based control system. The control system is based on the ABB MACH 2 concept, built around an industrial PC with add-in circuit boards and I/O racks connected via standard type field buses. Dedicated voltage and current transformers provide the control system with network variables employed in the OLC control.

The control system provides facilities for OLC control either from an Operator Work Station (OWS) in the OLC control room or remotely via a GWS in communication with the SCADA system of REE.

Two control modes are available:

- Closed-loop control, where an active power limit, P-lim, or a fixed power value, P-set, are set by the grid operator, whereupon the required level of compensation is determined by the control system.
- Open-loop control, where the compensation steps are set manually by the grid operator (Impedance setting, Z-set, or Maximum compensation mode, Z-max).

In addition, there is Emergency Control (P-emerg) to provide the line with back-up overload protection.

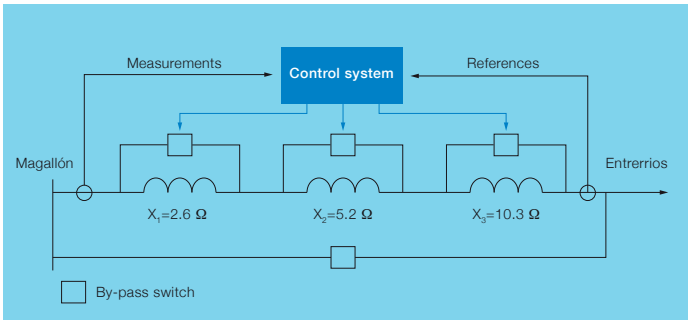
An impedance controller integrates all of the above control modes inside MACH 2.

Field tests

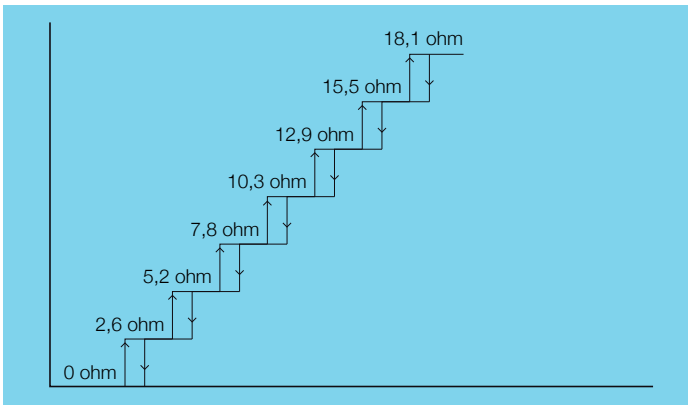
The functionality of the OLC has been successfully tested and verified in field tests in the 220 kV grid.

Reference

RTDS Studies for the TWENTIES OLC, International Conference on Power Systems Transients (IPST 2013), Vancouver, Canada, July 18-20, 2013.



Single-line diagram, OLC



OLC stepwise compensation scheme

Main technical data, OLC

System voltage	220 kV		
Nominal line current	1250 A		
Total rated impedance	18.1 Ω		
Series reactors:	L_1	L_2	L_3
Reactor power	12 Mvar	24.5 Mvar	48 Mvar
Reactor impedance	2.6 Ω	5.2 Ω	10.3 Ω

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