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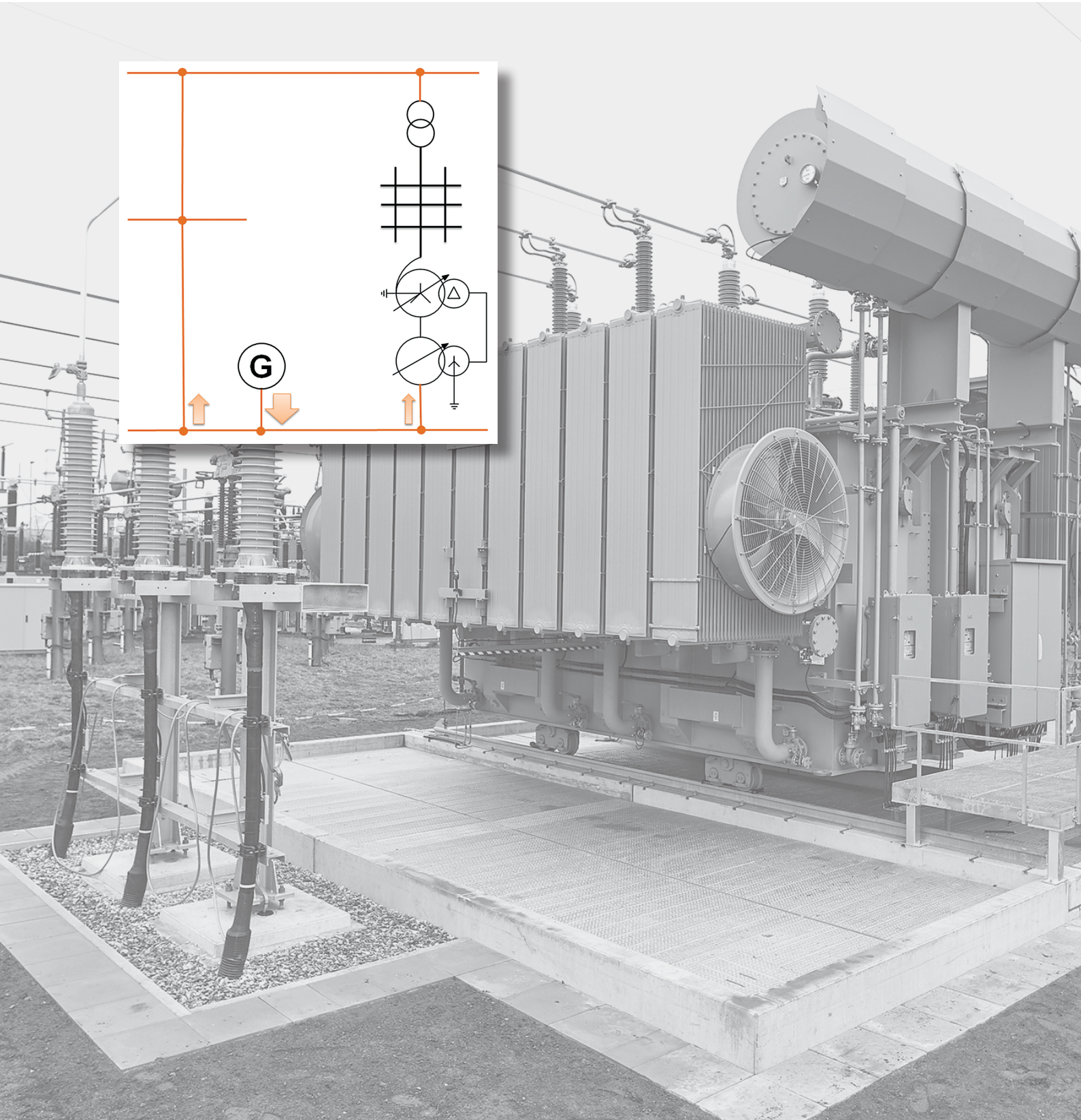
APPLICATIONS

Controlling the Power Flow.

Voltage Control System REGSys™ employed for Phase Shifting Transformers

REGSys™

Flexible controlling with REGSys™



Phase Shifting Transformers

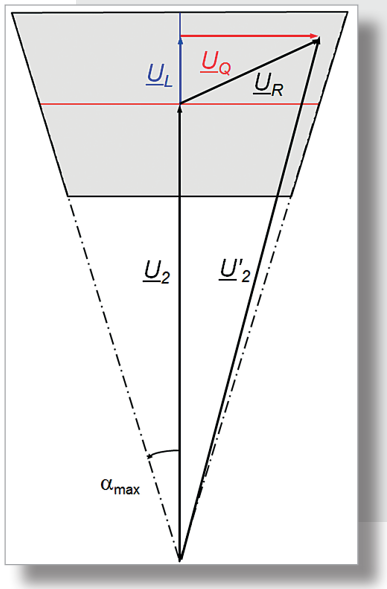
Phase shifting transformers, also named quadrature boosters, are special power transformers which enable the control of the active power flow in three-phase power grids.

For this purpose, a change of the tap position results in a modification of the load voltage angle instead of a modification of the voltage magnitude. The control of active power load flow is used to prevent overloading of certain power supply units by reversing the load flow.

This process is based on the principle that the active power distribution on several parallel lines depends on the angular difference of the voltage at the beginning and end of the line. A change of the angle on one of the line affects the load flow in each line.

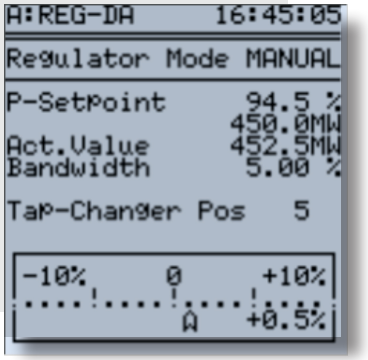
Furthermore, the transmission losses can be minimized. Many quadrature boosters are not designed to only change the phase angle, but they also have the possibility to change the magnitude of voltage and thereby adapt the voltage and the reactive power. Therefore these transformers are also equipped with separated on-load tap-changers for voltage control and for phase shifting.

Additionally to the independent control of voltage and phase shifting there are also transformer models that modify the voltage and the active power flow at the same time. To compensate voltage alterations during active power adjustments, many of these transformers have an additional longitudinal controller, with a separated on-load tap-changer.



Vector diagram of voltage control (blue) and phase shifting (red)

Controlling of Phase Shifting Transformers



REGSys™ controller basic display when performing active power control

Since phase shifting transformers have to control the active power, the usual voltage set point is replaced by an active power set point. For this purpose the software feature PQCtrl of the REGSys™ product family is used.

This software module is a component of REG-D™ and REG-DA firmware and forms the basis for active or reactive power control. The active power itself is also used as a set point variable, which the controller calculates by voltage and current measurements.

Usually, two voltage regulators REG-D™ or REG-DA are used to control a phase shifting transformer with active power and voltage control abilities. This offers the possibility of a clear and adaptable operation, since the assignment for operation and visualization is always given.

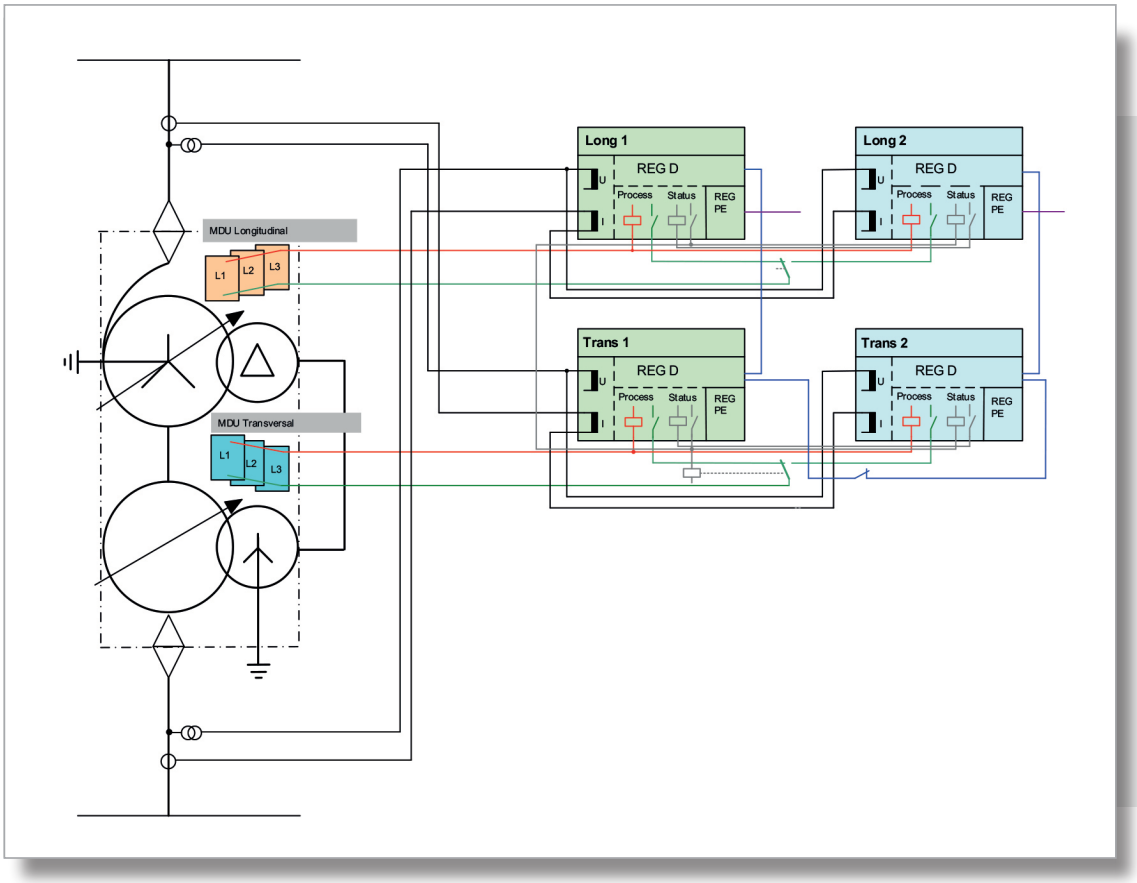
The regulator for the phase shifter is in the active power mode, whereas the longitudinal controller is in the reactive power or voltage control mode. Thus the operating mode for the longitudinal controller can also be changed.

In addition to the standard functionality of the control system for active or reactive power, several options can be implemented upon request:

- Active power control on demand and schedule and/or characteristic curve
- Adaptation of permissible control deviation by recording the real change in the active power per tap change
- Automatic determination of actual power set point by communication with other controllers or measuring devices and an adjustable offset value
- Redundant design of the control systems
- Interlocking and prioritizing the voltage or the phase shifting controller
- Cos (φ) set point for longitudinal control

All important information can be logged and if necessary adjusted or even controlled by means of SCADA. The monitoring functions of the REGSys™ for the voltage, the current, the on-load tap-changer and the transformer are fully preserved in the case of power control.

Application Example I



Single line diagram of the phase shifting transformer with redundantly control systems

Phase Shifting Transformers as Transformer Bank with redundantly designed Control Systems

The phase shifting transformer used in this project is a transformer bank consisting of six transformer poles with a power of 800 MVA.

Due to the importance of the transformer, the control was designed redundant. On that note, there is a second equivalent and independent device for the phase shifter and the voltage controller. In case of a problem of the primary controller, the reserve system is automatically switched over. If required, it can also be changed into the secondary system manually (for example via IEC 61850).

In addition to the regulation of active power and reactive power voltage the REGSys™ also takes care for the control and supervision of the transformer pols including the act of step supervision.

Furthermore the regulation systems provide local and remote (IEC 61850) control for the transformer bank and the individual poles.

Application Example 2

Phase Angle and Longitudinal Controller with Automatic Determination for Active Power Set Points

The special feature employed in this project is the automatic determination of the active power set point value for phase angle controller. For this purpose, there is communication between the control system of the phase shifting transformer and two additional voltage regulators, which manage the voltage in the distribution network.

The set point value of the phase shifter results from the sum of the active power of the two distribution network transformers. For adaptation to additional loads which are not fed-in via the two transformers, an additional active power (active power offset) can be defined. The amount of the active power will be added to the automatically determined sum.

As an alternative to the automatic determination of the actual power set point, this can also be set in real time via SCADA technology. The regulation of the longitudinal control is based on reactive power, in which the set point value is set via $\cos(\varphi)$.

The simultaneous process of the on-load tap-changing for reactive power and phase angle control is not permitted on the used transformer.

Therefore the control system is locked, so that always only one on-load tap-changer can be triggered. For this purpose the active power control precedes other types of control methods. Since the phase shifting transformer is a transformer that changes reactive and active power at same time, there is a supervision function for the reactive power implemented.

If the reactive power exceeds the set bandwidth, the active power control is stopped and an adaptation of the reactive power (voltage) is carried out.

After this adjustment, the active power control is released again.

Application Example 3

Phase Shifting Transformers with Adaptive Permissible Control Deviation (Bandwidth)

In this application, a modification of the active power ΔP per on-load tap-change depends on the network configuration and is therefore not a constant. As a result, the permissible control deviation used for the control, must be adapted to the network conditions. Therefore, the expected on-load tap-change ΔP is calculated from the average of the effective changes of the last N tap operations.

If less than N tap-changes are available yet, a default ΔP value is assumed which can be parameterized. The number of N used for averaging the taps is also adjustable. In this project a voltage regulator REG-D™ with characteristic S2 is used.

Due to four 64-channel recorders, this version enables the recording of all relevant measurements and computational values, such as voltage, current, tap position, active power and adaptive permissible control deviation (bandwidth).

In case of a fault, it also allows a simple analysis as well it provides a proof of the calculated setting values.

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