Providing grid stability and flexibility

Use case: Phase-shifting transformers for California, U.S.A.

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The challenge

Connecting grids across countries always poses challenges for the utilities on both sides. The power flow needs to be controlled so that the energy produced in one country can be consumed there. However, in the event of overproduction, the utility needs to provide the option for sending the excess power to the neighboring country.

To transmit the power produced in California (U.S.A.) to its own customers instead of the neighbors in Mexico, the local utility needed a viable solution – which is either a B2B DC backbone or phase-shifting transformers (PST).

The solution

The local utility opted for two PSTs as the go-to solution for optimizing the grid. They control the power flow in the transmission network on a 230kV transmission in an optimal way that allows them to push more power onto their 500kV transmission lines instead of having uncontrolled power transmission. This is especially crucial for the customer when one of the 500 kV transmission lines is out of service.

Due to local grid requirements, the phase shifters needed to provide an extremely large and asymmetrical phase angle. However, the physical size still needed to be as compact as possible for ease of transportation. The customer also specified tank-mounted ONAF cooling and no sound-damping measures.

Technical features

1. Phase angle

Due to local grid requirements in both countries, the phase shifters needed to provide an extremely large asymmetrical phase angle from -80.1° to 31.3°. This phase angle range implied that the units would be extremely large. However, for ease of transportation and reduced footprint, the customer asked for the most compact dimensions possible. Ultimately, the series and exciter transformer shipping dimensions were 468.5 x 149.6 x 181.1 inches (11,9 x 3,8 x 4,6 m) and the shipped weight was 582,000 lbs. (264 tons) and 623,900 lbs. (283 tons) respectively.

2. Two-tank design

Due to the large phase-angle requirement, it was not possible to design the phase shifter as a single-tank unit. Therefore, the PSTs were designed as a classical two-core/two-tank unit.

Economic success through reducing losses and protecting existing equipment with PST technology

3. Regulation
The regulation of the PSTs in the existing grid was a very important issue for this project. Therefore, three off-single-phase on-load tap changers and one off-ARS-type switch were incorporated in the PSTs. A special winding concept was developed that enabled the use of a standard R-type tap changer. This resulted in the PSTs being equipped with seven offthroat connections instead of the usual four offthroat connections:

4. Cooling
The PSTs are equipped with ONAF (oil natural-air forced) tank-mounted radiator cooling with fans but with no pumps. The cooling fans were selected to meet the required low noise level.

6. Seismic withstand
Because California is in a region that has a high incidence of earthquakes, it was important to design and manufacture the PSTs to be qualified according to the requirements of IEEE 693-2005 and meet the requirements of the high qualification level. In order to meet this requirement, a third party was employed to: 1) develop a finite-element mathematical model that could be used to perform the seismic analysis of the PSTs and 2) prepare a seismic analysis qualification report.

Other applications for PSTs
PSTs are crucial components in the ongoing effort to improve grid reliability and stability. They offer many advantages in various applications:

Increased transmission capacity and optimized utilization of transmission equipment
by balancing line-loading of parallel lines/network segments

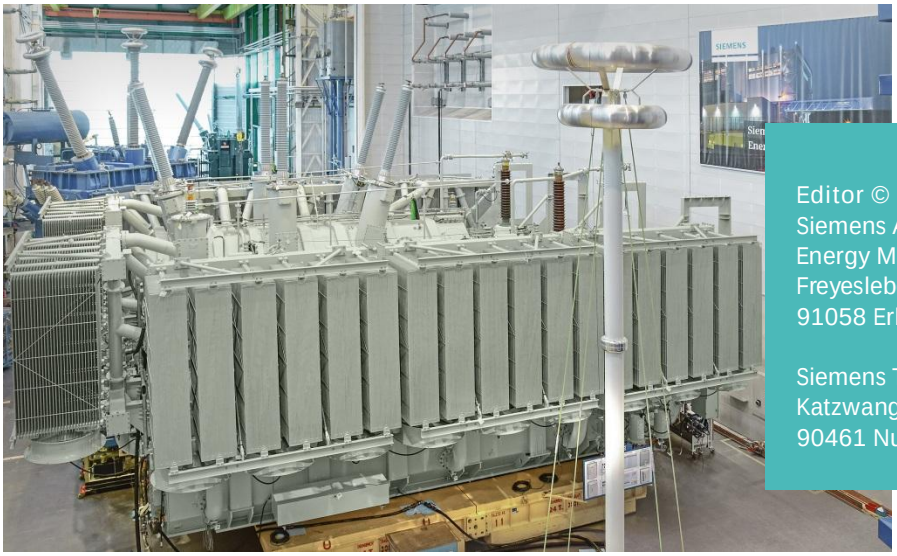
Improved grid stability
by preventing unwanted loading and loop flows

Direct power sourcing of cheap electricity from nearby power plants
by enforcing power flow through the utility's separate line and avoiding public grid fees

Improved commercial cross-networking trading

Fast (re-)connection of networks with large differences in phase angle
by temporarily reducing the phase shift

Do you experience grid instability or bottlenecks in your transmission system, or do you want to avoid public grid fees on your lines? Think about a PST, and contact us!



Editor © 2017:
Siemens AG
Energy Management Division
Freyeslebenstrasse 1
91058 Erlangen, Germany

Siemens Transformers
Katzwangerstrasse 150
90461 Nuremberg, Germany