BACK

MAJOR TRENDS

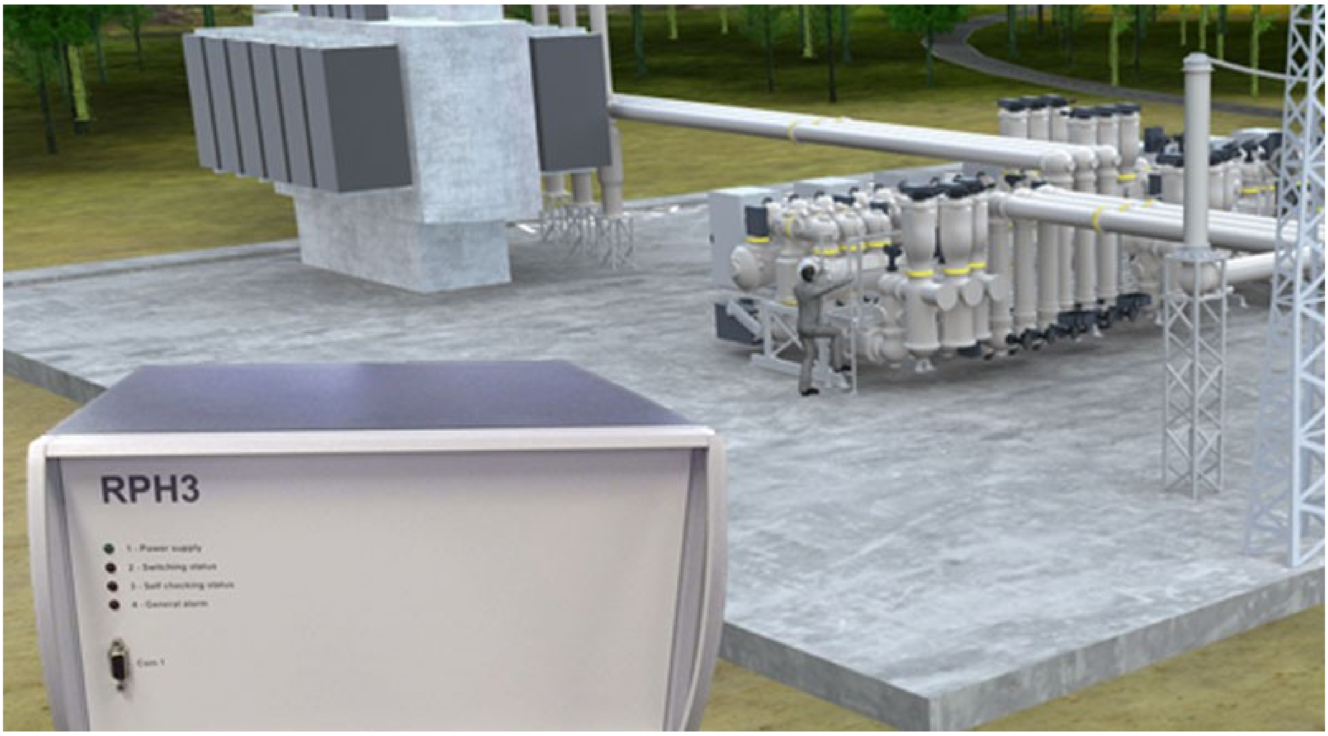
RPH3, the ultimate solution for the controlled switching of power transformers

01/12/2016 - 5.50 pm

POWER QUALITY POWER TRANSFORMERS

The ability to mitigate switching transients is becoming a key issue for today's grids as the generated stresses lead to power quality problems and accelerated ageing. The RPH3 digital synchronous switching relay has been applied to power transformers, resulting in reductions in overvoltages, inrush current—and costs..

5 comments



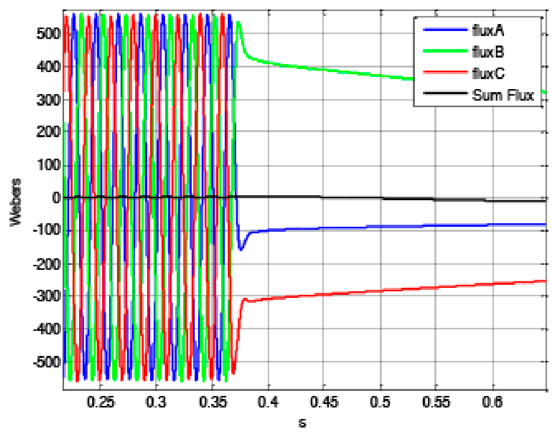
The increase in electrical power demand, energy market deregulation, the introduction of new operators and producers, and the variety and intermittency of new power sources (wind farms, solar farms, etc.) require high-voltage transmission grids to withstand an ever-growing number of switching operations. The transients resulting from these operations generate stresses on all substation and network equipment, leading to potential power quality problems and accelerated ageing, incorrect protection relay tripping (and, in the worst case, even flashovers). “To mitigate such stresses and improve power quality, controlled switching is a sound and cost-effective alternative to adding circuit-breaker closing resistors, over-rating electrical equipment, and installing additional protective devices,” says Farid Aït-Abdelmalek, Senior Software Build & Release Engineer at Grid Solutions in Aix-les-Bains, France.

A microprocessor-based synchronizing relay

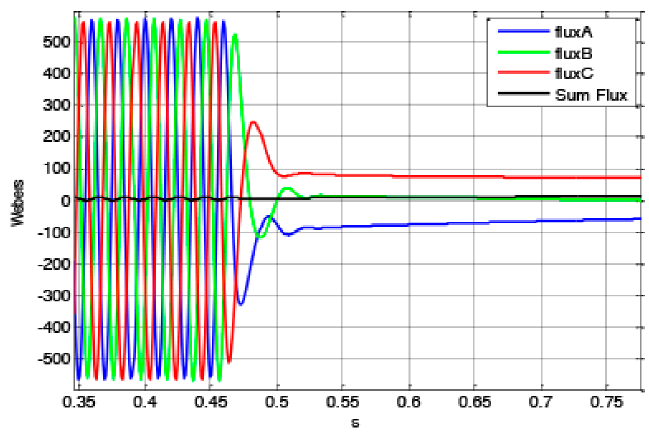
Energizing of power transformers deserves particular interest not only because of electromechanical constraints generated by strong inrush currents, but also because it has a direct influence on power quality and overall electrical transmission system reliability. A thorough investigation program focusing on energizing strategies and power quality, supported by field and lab tests, led to the optimized programming of RPH3—an advanced microprocessor-based synchronizing relay already used as point-of-wave switching of shunt reactors—and capacitor banks. RPH3 is suitable for the controlled switching of power transformers, which is able to reduce overvoltages, inrush currents and, ultimately, costs.

Switching sequence: a compromise

The ideal switching sequence of most power transformers with phase coupling corresponds to a closing operation at the time of flux matching, where the prospective flux equals the magnetic core residual flux for the first winding to close. For the remaining windings to close, the prospective flux should be equal to the dynamic flux imposed by the winding already closed. “You might think that taking into account the transformer magnetic core residual flux for each energizing sequence is the best solution to control the level of inrush current and its consequences,” explains Alain Fanget, Senior Expert at Grid Solutions. “However, due to flux sharing, the above sequence is a compromise: to reduce the maximum flux error for all three phases, the winding with the highest level of flux is commonly energized first, which could impose a compromise for the two remaining ones. The straightforward situation would be to reach zero residual flux condition.”



Inductive voltage transformer signal integration (random opening)



Inductive voltage transformer signal integration (controlled opening) : transformer almost demagnetized

Energizing strategies

Therefore, when performing power transformer controlled energizing operations, the main methods usually considered are:

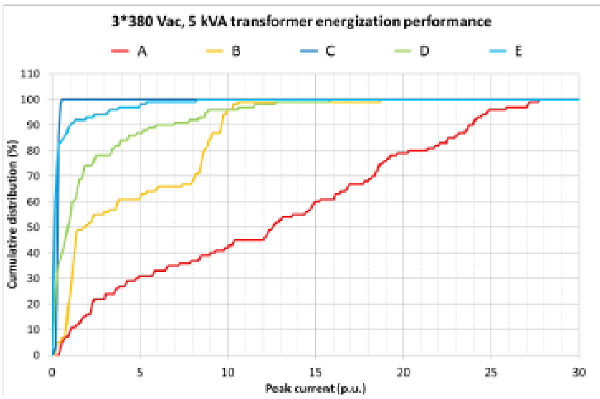
- energizing at fixed switching angles without considering the residual flux level, usually with assumption of zero residual flux, in order to avoid worst case (closing at maximum flux difference)
- energizing at fixed switching angles under consideration of a known residual flux level fixed by previous controlled de-energizing or by external conditions (loaded opening, presence of external impedances leading to self-demagnetization, etc.)
- energizing at variable switching angles taking into consideration the residual flux level computed with the aid of a controlled switching device such as the RPH3, regardless of the previous de-energizing condition

TRANSFORMER ENERGIZING SCENARII

Sequence	Description	
	Transformer energizing	*Transformer de-energizing*
A	Random	Random
B	Fixed angles	Random
C	Fixed angles	Fixed angles
D	Variable angles taking into account residual flux estimation	Random
E	Variable angles taking into account residual flux estimation	Fixed angles

PEAK INRUSH CURRENT INDICATORS

Energizing strategy	A	B	C	D	E
$I_{98\%}$ [p.u.]	27.4	10.4	0.5	11.5	5.0
$P_{(I=1p.u.)}$	0.1	0.25	1	0.55	0.9



A combined approach

An experimental study has been performed to compare and identify the best energizing conditions for a power transformer (see tables and figure). Statistically, it appears that the most suitable strategy to energize a power transformer is to control the previous opening conditions, given that this is possible. If it is not possible (as in the case of a protection operation where the opening timing cannot be controlled), the best solution is to compute and use the residual flux level. Hence the two most probable scenarios: “controlled opening-controlled closing,” and “random opening-controlled closing with residual flux.”

Aït-Abdelmalek says: “The RPH3 controlled switching device has been programmed to be able to make the distinction—it both calculates the flux and controls the opening and thus the residual flux level in the power transformer—and to adapt the closing switching angles for the circuit breaker.” This innovative approach (patent pending), which automatically shifts from one strategy to the other, stands out as the ultimate compromise for mitigating transient phenomena.

To know more, read the conference paper or contact our expert, Farid Aït-Abdelmalek.

RATE THIS ARTICLE

COMMENTS

5 comments

SIGN UP FOR OUR NEWSLETTER

LEARN MORE

EXPERTS

Alain Fanget

Grid Solutions - Lead Engineer

Farid Ait-Abdelmalek

Grid Solutions – Senior Software Build & Release Engineer

SEND A MESSAGE TO OUR EXPERTS