Direct current in electric power grids affects the grid's components (for example, transformers) in a negative way. Direct current comes from a variety of sources, including:

- power electronics (static var compensation)
- HVDC transmission
- neutral offset by DC drives

Transformer cores have very high magnetic conductivity, so even small current can excite the transformer. In this way small direct current can have large effects. Even a minor DC bias leads to a significant increase in noise as well as to a change in the frequency spectrum of no-load noise. In addition, the excitation current is increased and distorted, the transformer’s reactive power consumption rises sharply, and no-load losses in the core increase. In case of strong direct current, the higher harmonic stray flux causes additional losses in metallic parts that can harm the transformer. Moreover, reactive power consumption can reach a level that is critical for the power grid.

While three-limb transformers are relatively insensitive to symmetrical direct current in all phases (the direct flux cannot close in the core), they react quickly to minor asymmetries. Five-limb transformers or single-phase transformers are also extremely sensitive to direct current in the neutral point, distributing (almost) symmetrically to the phases.

Compensation of direct current
Large effects of small DC

Measurements in several power transformers have shown the extreme consequences of small direct current:

In a single-phase transformer, a direct current of 0.2 A on the HV side increased the noise level by 10 dB(A).

This increase in noise level is especially drastic for transformers with a low basic noise level: In a three-limb transformer, an asymmetric direct current of 0.14 A was sufficient to increase noise by 17 dB(A), and 0.5 A increased noise by 25 dB(A)!

In addition to the noise increase, no-load loss is augmented as well: With a 0.2-A direct current, a single-phase transformer’s core loss increased by 11 percent, and with 1.0 A by 30 percent.

Major direct current that occur when HVDC is operated in ground-return can increase losses to a level that can harm the transformer.

Our solution for DC-safe transformers

All of the aforementioned negative effects can be eliminated through our innovative approach that makes transformers insensitive to direct current. In general, the solution applies the same direct flux of opposite sign to the core.

A direct current of less than 1.0 A cannot be measured accurately with transformer load currents of 100 or even 1,000 A. To address that issue, Siemens has developed a sophisticated procedure for accurately and reliably measuring the direct flux in the core.

The remedy for DC problems

With the Siemens DC compensation system, transformers are insensitive to direct current. DC flux offsets in the core caused by inrush currents and switching operations in the grid are similarly compensated.

Independent of the direct current, noise, and core losses in the transformer are always kept at the original baseline with no direct flux.