



## Siemens Transformers – Case Study

# Low-Noise Transformers with DC Compensation

## Elimination of DC Effects

### The challenge

Nobody wants noisy transformers, especially not in urban surroundings. When ordering transformers, many utilities and grid operators are therefore especially conscious of noises produced by the units in subsequent operation. But what happens when a quiet transformer in the system manifests higher noise levels? Or if a transformer that has already been installed for years suddenly becomes so loud that neighbors feel disturbed?

The DC component in the grid is growing with the increasing electric power generation from wind and solar energy sources. But only a few hundred milliamperes can already result in a significant increase in noise level.

Austrian trans-regional grid operator APG was confronted with such a situation. Investigations of the cause were conducted following the first complaints from neighbors. It proved that the units had not simply become louder overnight without cause: A DC load had resulted in the otherwise perfectly functioning transformers becoming a source of noise pollution.



A look inside the DC compensation system

### The solution

Experts at Siemens Transformers have long studied the topic of "DC in the supply grid and its effects on transformers".

There are three different conventional strategies for circumventing this problem, but none of them is perfect:

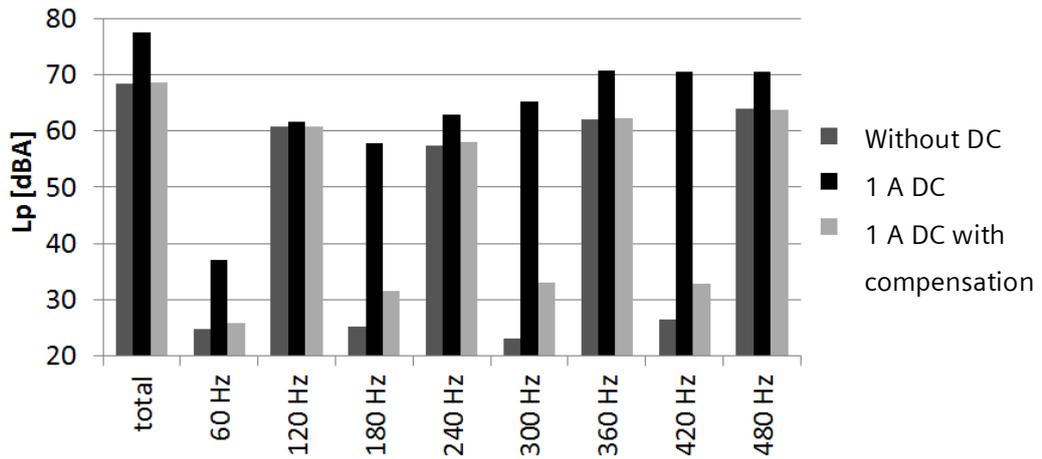
- Transformer replacement – doesn't solve the problem
- Installation of external noise protection walls – highly expensive / not always possible
- Implementation of DC blockers – ineffective for asymmetric loading

The approach developed by Siemens Transformers is not based on eliminating the DC load, but rather on eliminating its effects on the transformer. Since the DC current is not blocked, no other transformers in the grid are subjected to DC loads.

Siemens solutions for DC compensation for single-phase and three-phase units with three-leg cores were already available. With a few adaptations, a satisfactory solution was also achieved for the 5-leg core transformers implemented at APG.

### The Austrian Power Grid (APG)

Austrian Power Grid AG is the independent transmission grid operator of Austria and is responsible for the transmission grid at the highest voltage level. The APG-grid has a length of approx. 3,500km, which is operated and maintained by the company's team of 450 experts who adapt it to the rising needs of the industry and the population. Only an efficient grid allows for the integration of power from renewable sources into the European and the domestic power grid and thus realizing the energy revolution.



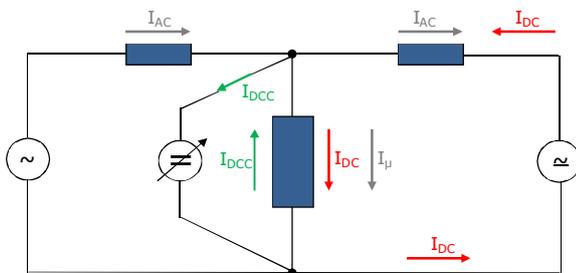
Noise level from a transformer with DC load without (black) and with compensation (light gray).

### Special technical aspects

#### 1. DC effects on transformers

Due to the magnetic conductivity of transformer cores, even a small DC component can have major effects, including an increased reactive power current requirement and associated greater losses. In a test, a single-phase transformer produced 30% greater losses with a DC load of 1.0 A.

DC loading of the core also results in increased noise production. Measurements at Siemens have demonstrated that loading with an asymmetric DC current of 0.14 A can already cause a 17 dB(A) increase in noise level. The objective was therefore to develop a method to render the transformer insensitive to DC loads.



Equivalent transformer circuit showing the operating principle of DC compensation: The effect of the existing DC current  $I_{Dc}$  on the transformer core is canceled out by the compensation current  $I_{DCC}$ .

#### 2. Noise reduction with DC compensation

The concept of DC compensation in Siemens transformers is not based on preventing the flow of DC current through the transformer, but rather on generating a magnetic field in the core to counteract the field produced by the existing DC current.

This magnetic field is generated by an additional winding, the compensation winding. The required DC current is determined and fed to the compensation winding by the control unit. The magnetic field generated by the DC current on the grid side and that generated in the compensation winding cancel each other out in the core. This results in the AC field present in the transformer core during normal operation.

As can be seen in comparison measurements, the DC effects on transformer noise level can be nearly completely eliminated with DC compensation activated.

#### Noise reduction and improved efficiency in a single solution

The DC component in modern power transmission grids is increasing. This is due to both regenerative power generation as well as static reactive power compensation and DC-powered trains. Active DC compensation is the solution of choice for continued low-loss and low-noise transformer operation.

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