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*Ingenuity for life*

# Silence is easy

## Ready for DC in the grid with Siemens DC Compensation and DC ready transformers

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# The challenge

Power grid operators are required to constantly maintain and improve efficiency of their grid and power equipment. At the same time, growing public awareness and urbanization demands to minimize noise pollution to the surrounding environment and neighborhood. As a consequence, power grid operators are continuously specifying lower values of noise pressure and loss values for power transformers.

While these values are properly tested during the factory acceptance tests in a controlled environment, the actual situation in the grid may vary due to impacts of Direct Current (DC). DC occurs from power electronics in the grid, HVDC interconnections, renewable power generation or small direct currents caused by geo magnetically effects.

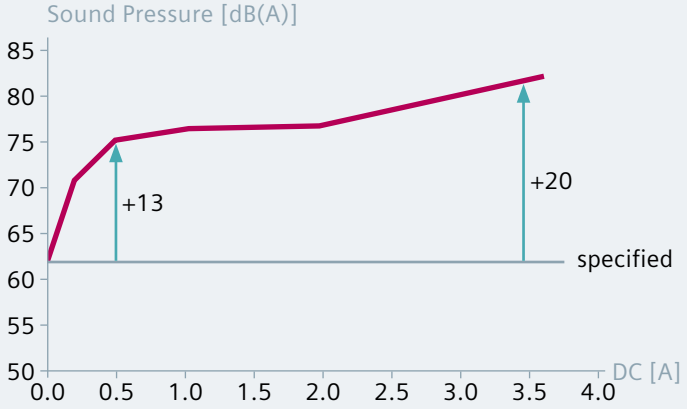


**Figure 1:**
Change in sound pressure by increasing DC in HV (example B=1.6 T).

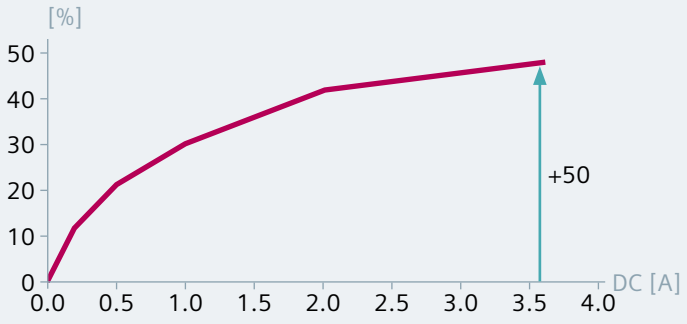


**Figure 2:**
Relative change of no-load losses over DC load in HV (example B=1.6 T).

These impacts are significantly increasing noise and loss levels. For instance, only a few hundred milliamperes of DC can already result in a significant increase of noise and no-load losses (figure 1). A DC of 500 mA may cause an increase of 13 dB(A) compared to reference measurement in the test field without DC. For a human being an increase of 10 dB is perceived as double the noise. Furthermore DC load causes an up to 50 percent increase in no load losses.

Due to the magnetic conductivity of transformer cores, even a small DC impact can have major effects, including an increased reactive power current requirement and associated greater losses. (See highly increasing line already at some 100 mA in figure 1 & 2.)

Given a lifetime of minimum 25 years, power equipment needs to be prepared already today to cope with challenges by DC impacts in the future. With exponentially increasing renewable power generation, hence a changing grid topology, the objective was therefore to develop a method to render the transformer insensitive to DC loads. Siemens is capable to introduce DCC preparation in a new transformer, which we call “DC ready”. This enables quick retrofitting to a full DCC system at a later stage.

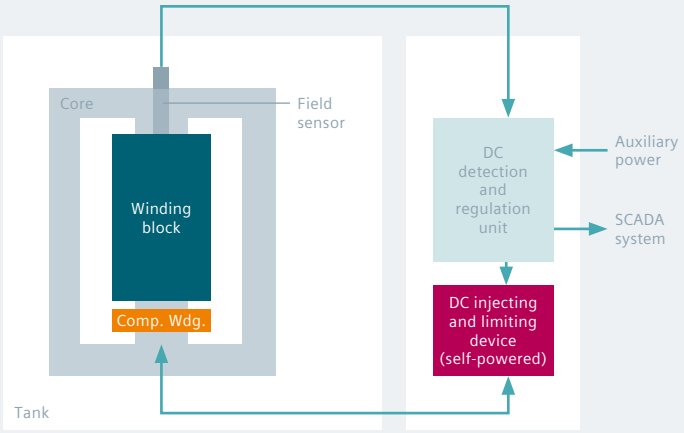


**Figure 3:**
DC ready transformer (left) and Upgrade Package to a full DC Compensation on the right (simplified)

# The solution

The approach developed by Siemens Transformers is not based on eliminating the DC load, but rather on eliminating its effects on the transformer. The DC is therefore able to flow at a certain location and will not be obstructed.

Siemens solutions for DC compensation for single-phase and three-phase units with three-leg cores as well as five-leg cores are available since 2011. Our reference projects can be found all over the world, including Europe, Northern America, Africa and Australia. In the future, we expect an increase of DC especially in Northern America, Europe and Asia-Pacific.

## 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 DC current.

This magnetic field is generated by an additional winding: the compensation winding. The required DC current is determined by sensors at the active part and controlled by a 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 an AC field that equals the one in the transformer core during normal operation.

The DC effects on transformer noise level can be nearly completely eliminated with DC compensation activated (see figure 4). The same is also applicable for no-load losses. Thus, noise and no-load losses decrease to almost original levels without DC present. Therefore, active DC compensation is the solution of choice for continued low-loss and low-noise transformer operation when DC is already in the grid.

## External solutions to cope with DC would be:

- Low Noise Transformer without DCC – does not solve the DC effect
- Installation of external noise protection walls – highly expensive/not always possible
- Implementation of DC Blockers – ineffective for DC asymmetric loading and depending on Neutral accessibility, not effective on Autotransformer – within Siemens portfolio for retrofitting

## DC ready configuration

In order to prepare for the future with changing grid topology and increasing renewable generation, power transformers should be ready for DC in the grid. Siemens transformers can be designed “DC ready”.

The active parts of these transformers are already equipped with all required components for DC compensation, like compensation winding, internal measurement sensors and connections. The control unit is not yet included for DC ready transformers and can easily be retrofitted later, based on the actual amount of DC in the grid.

DC ready transformers therefore have the advantages of

- Easy plug&play retrofit of the control unit for DC compensation, determined to the actual amount of DC without any major rework of transformer
- Capability to eliminate impacts of DC and set back loss and noise levels to factory condition – even under changing DC amounts in the future
- DC ready fleet, and one full version at stock for quick reaction on changing grid environment
- Capability to measure actual DC components during transformer operation with DC measuring instrument by Siemens
- No DC study and analysis upfront necessary

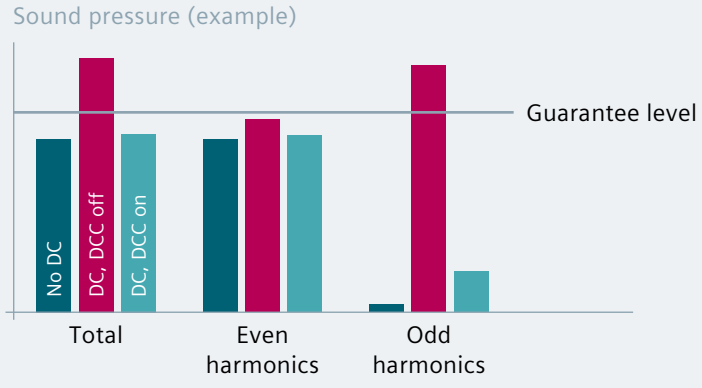


**Figure 4:**
Systematic view on noise level with different DC exposures

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Energy Management Division
Freyeslebenstrasse 1
91058 Erlangen, Germany

Siemens AG
Transformers
Katzwanger Strasse 150
90461 Nuremberg, Germany

For more information, please contact
our Customer Support Center.
Phone: +49 180 524 70 00
Fax: +49 180 524 24 71
(Charges depending on provider)
E-mail: support.energy@siemens.com

TH 101-170275 WS 0617