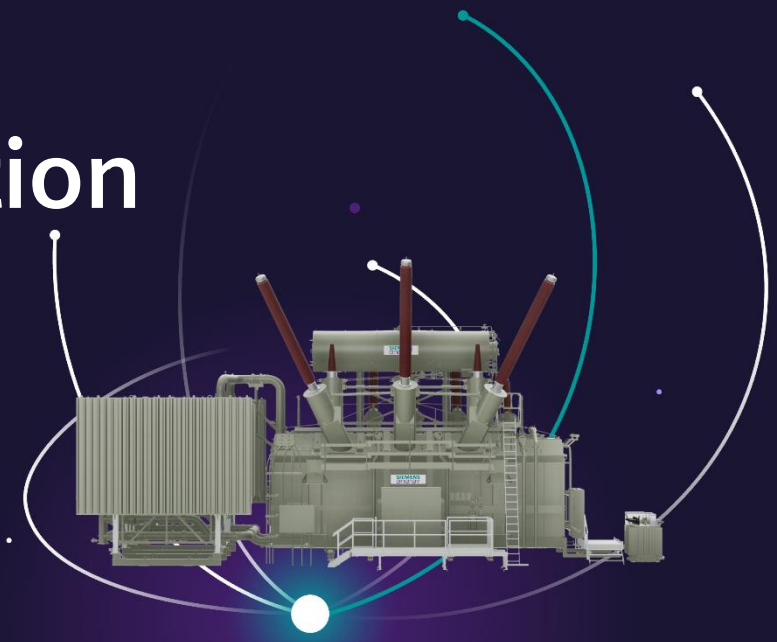
DC compensation

Noise reduction and improved efficiency in a single solution



The challenge

Balancing efficiency and silence

The evolving landscape of power transmission and distribution, reshaped by the surge of renewable energy sources, brings about a set of complex operational challenges for transformers. At the forefront is the dual imperative of diminishing noise pollution and bolstering operational efficiency — crucial for the sustainable growth of urban environments and the resilience of power networks.

The increased incorporation of direct current (DC) bias in our electrical grids is not without its concerns. It poses significant issues related to the acoustic impact and energy efficiency of transformers — factors that are becoming increasingly critical in our densely populated cities. Our cutting-edge DC compensation technology directly addresses these issues. It is the culmination of our commitment to innovation, ensuring that transformers function with remarkable silence and peak efficiency. By significantly reducing energy losses, we're not just meeting the existing benchmarks but setting new ones for a future-ready grid.

The DC compensation system neutralizes the effects of unwanted DC bias without semiconductor components.

Our solution

Advancing transformer resilience

The pursuit of excellence in transformer technology has led to an extensive investigation into the effects of direct current (DC) in the power supply grid and its impact on transformers. The quest for a viable solution has unearthed several traditional methods, each with its inherent drawbacks. Simply replacing transformers does not tackle the core issue, while constructing external noise protection walls is often a financially and spatially impractical endeavor. Moreover, the implementation of DC blockers has proven insufficient, especially when faced with the complexity of asymmetric loading conditions.

In response to these conventional shortcomings, a forward-thinking approach has been developed that shifts the focus from blocking the DC load to mitigating its effects on transformer performance.

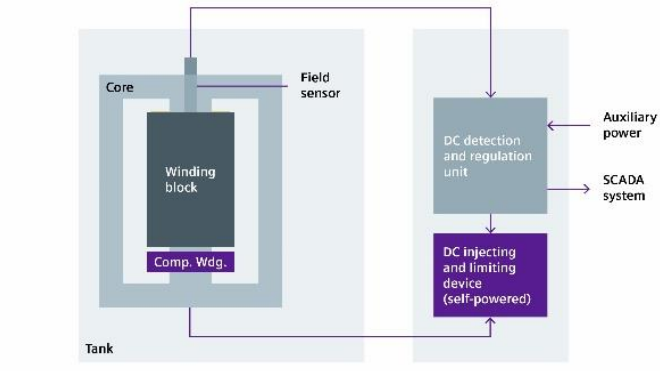


Figure 1 DC ready transformer (left) and upgrade package to a full DC compensation on the right.

By allowing the DC current to pass through unobstructed, there is no additional burden placed on neighboring transformers in the grid.

Refinement of this approach has led to the development of advanced solutions tailored to various transformer configurations. Initially designed for single-phase and three-phase units with three-leg cores, the technology has been adeptly modified to accommodate a wider range of core structures. This expansion of technology demonstrates a commitment to versatility and addresses the diverse challenges presented by DC currents in modern power systems.

Main benefits

- **Restore Noise and Loss Levels:** Achieve nominal operational values for noise and power efficiency, enhancing the quality of life and system performance.
- **Ensure Regulatory Adherence:** Seamlessly comply with stringent local noise regulations, avoiding penalties and fostering community goodwill.
- **Cut Operational Costs**: Siginficantly reduce the expenses linked to no-load losses, contributing to a more economical operation and increased savings over time.
- **Eliminate Noise Enclosure Costs:** Save on the investment and maintenance of additional noise enclosures with our inherently quiet technology.

Special technical aspects

DC effects on transformers

The inherent magnetic properties of transformer cores make them sensitive to the presence of direct current (DC), where even a minimal DC component can precipitate significant consequences. Among these are an elevated demand for reactive power current and the subsequent amplification of losses. Empirical evidence supports this; for instance, a single-phase transformer subjected to a DC load of merely 1.0 A was observed to incur a 30% increase in losses.

Furthermore, the imposition of DC loading can exacerbate acoustic emissions from transformers. Precision measurements conducted have revealed that an asymmetric DC current of just 0.14 A can result in a noise escalation of up to 17 dB(A), a substantial auditory impact. Confronted with these findings, the imperative was clear: to engineer a method that would enable transformers to operate with an immunity to DC loads, thus preserving their efficiency and acoustic integrity.

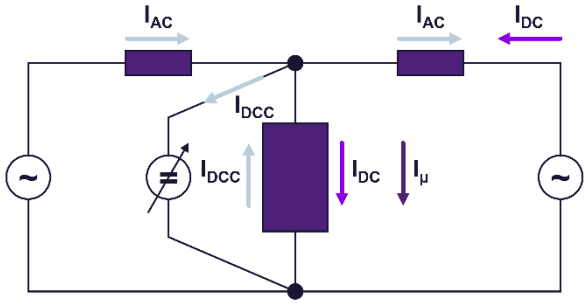


Figure 2: Equivalent transformer circuit showing the operating principle of DC compensation: The effect of the existing DC current IDC on the transformer core is canceled out by the compensation current IDCC.

Noise reduction with DC compensation

The essence of the DC compensation strategy employed within these transformers is to embrace rather than obstruct the flow of DC current. The technique involves the ingenious creation of a compensatory magnetic field within the transformer core, which is designed to neutralize the field generated by the prevalent DC current. This balancing act is achieved through the introduction of an additional winding within the transformer, aptly named the compensation winding.

The control unit plays a pivotal role in this process, meticulously calculating the requisite DC current to supply to the compensation winding. When this calculated current flows through the compensation winding, it produces a magnetic field that effectively counterbalances the field induced by the DC current on the grid side. The result is a harmonious cancellation within the core, restoring the transformer's core to its optimal AC field during typical operation.

Empirical measurements stand as a testament to the effectiveness of this method; they demonstrate that the implementation of DC compensation can substantially, if not entirely, mitigate the noise level increases typically associated with DC effects on transformers.

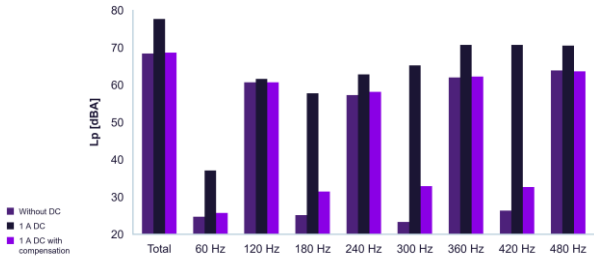
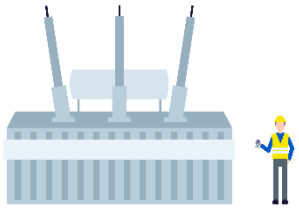


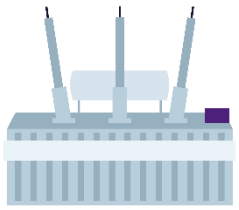
Figure 3 Noise level from a transformer with DC load without (black) and with compensation (purple).



DC detection and analysis

A two-step-approach creating transparency on DC bias

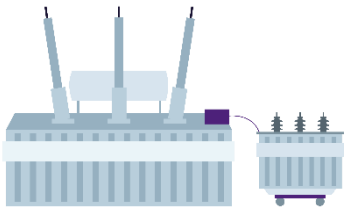
The free of charge DC detection app transforms any smartphone into a DC detection device and can be used by any person at site. The app records the transformer noise, processes the audio data, and indicates potential DC bias. In case DC is detected, a comprehensive sound spectrum analysis provided by transformer service experts creates full transparency on potential DC bias issues and gives recommendations. This enables informed decisions regarding service, retrofitting for DC-ready transformers, and investment or replacement options.



DC ready

Preparing transformers to be ready for DC compensation

The DC-ready design enables the subsequent DC measurement and DC compensation. The active parts of these transformers are already equipped with all required components, like compensation windings, internal measurement sensors, and connections. These compact components, not reliant on semiconductor or electronic sensors, are used for DC compensation (step 3), making minor modifications for DCC-Ready straightforward without impacting the transformer's longevity or operation, and enabling a smooth retrofit of DCC in the future.



DC compensation

Eliminated DC in the asset and reduction of no-load loss and noise impacts

The compensation device is connected to the DC ready system. It constantly analyses the DC effect on the transformer and generates necessary direct current needed for compensation. The compensation windings installed in the DC ready design are generating a magnetic field in the core to counteract the field produced by DC current. The required DC current is determined by sensors at the active part and controlled by a control unit. The DC effects on transformer noise and loss level can be nearly completely eliminated.

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