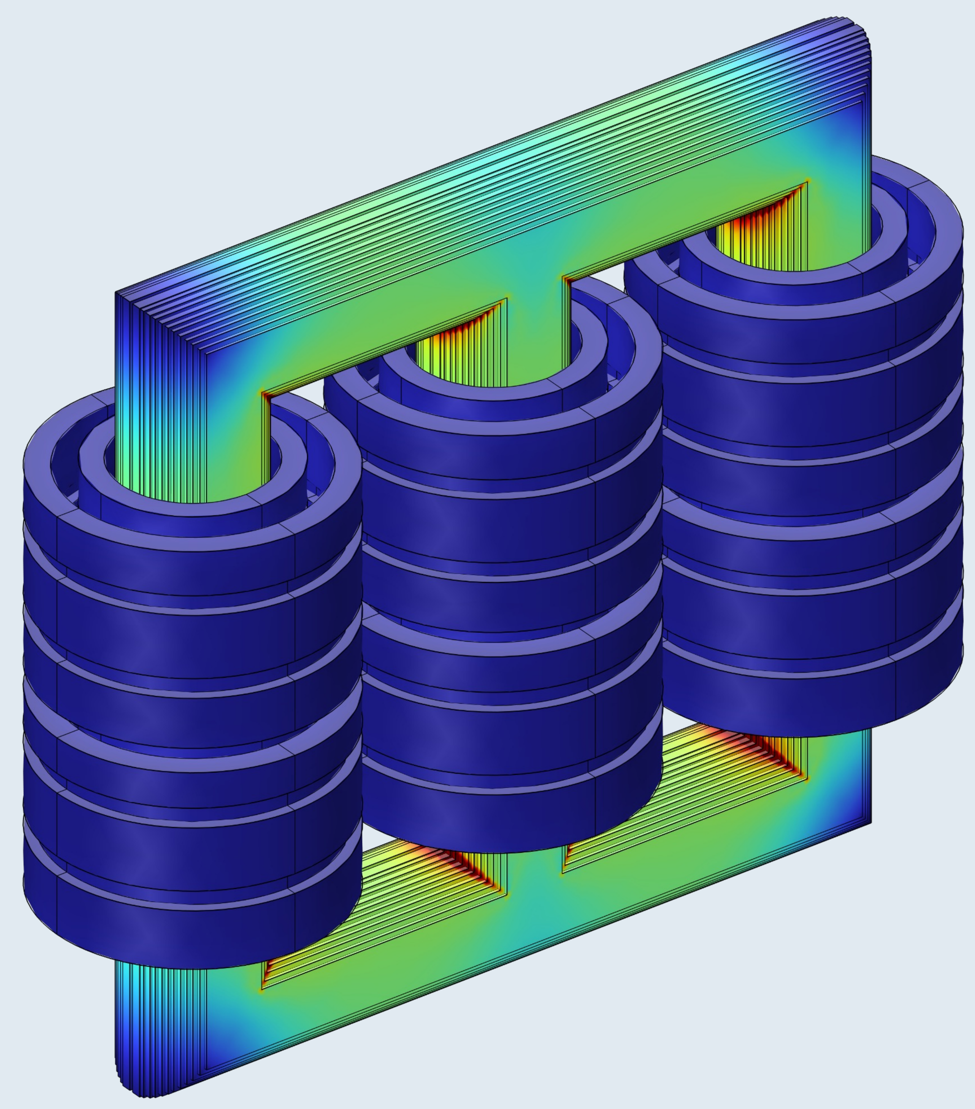

Short Circuit Forces Assessment for 12-Pulse Converter Transformer

The external short-circuit event can be considered as one of the most demanding load conditions, where high forces are generated in the transformer windings. This work evaluates the peak forces generated by these events.

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Abstract

The aim of this work is to compute the mechanical forces in a 12-pulse converter transformer winding in different short-circuit modes. A 12-pulse converter transformer is a three-phase transformer with two secondary windings whose tension have 30° phase displacement and one primary winding. The secondary windings feed a doble 6-pulse rectifier diode bridge, typical circuit configuration is shown in figure 1. In case one diode of the input rectifier is faulted and becomes short-circuited, the converter transformer can be subjected to a dynamic short circuit stress being higher than that due to a fault occurring on the DC-link (equivalent to a three-phase short circuit on both secondary windings). The Magnetic Fields interface of the AC/DC Module was used to compute magnetic field and induced current distributions in and around the windings, in this way is possible to obtain the exact Lorentz forces distribution (radial and axial).

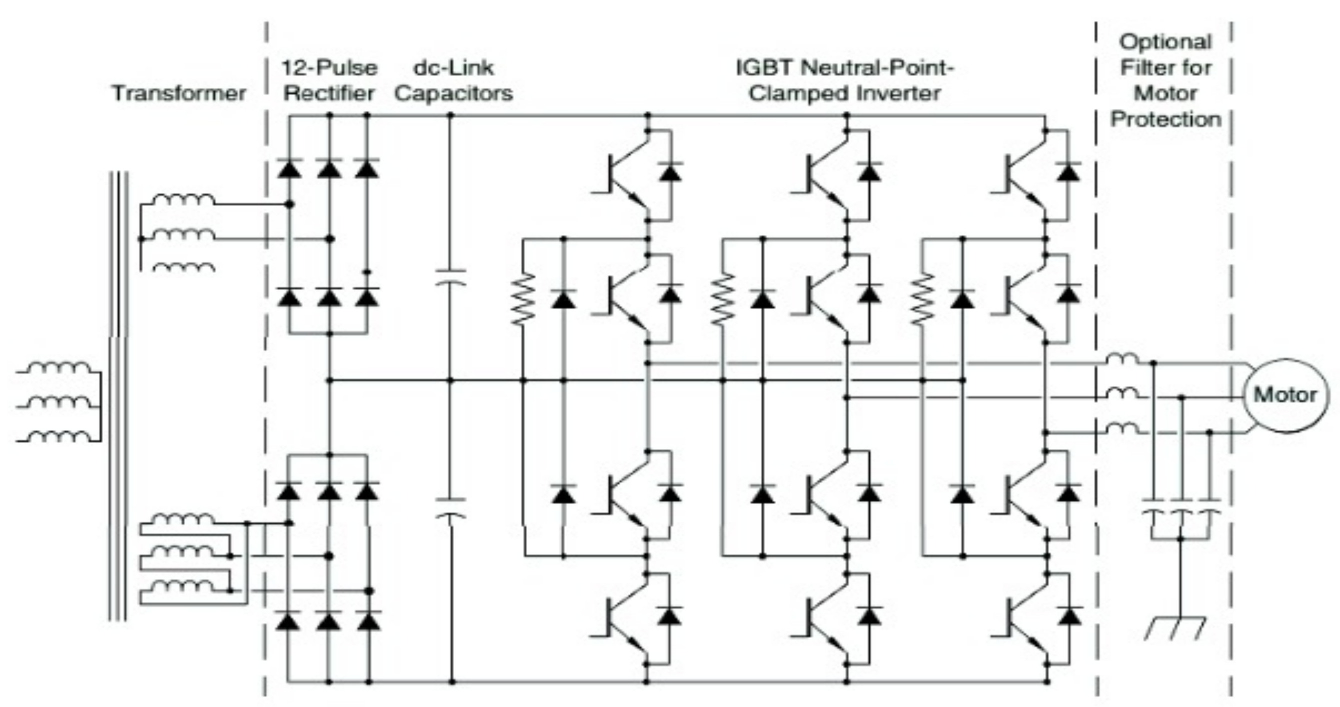

FIGURE 1. 12-pulse circuit configuration

Methodology

A time dependent analysis was performed in 2D axisymmetric model to compute the Lorentz forces, in particular the Magnetic Field interface of AC/DC Module was used. The windings are modeled using Ampère's law:

$$\sigma \frac{\delta \boldsymbol{A}}{\delta t} + \nabla \times \left(\frac{1}{\mu_0 \mu_r} \nabla \times \boldsymbol{A} \right) = \boldsymbol{J}_e$$

$$\boldsymbol{B} = \nabla \times \boldsymbol{A}$$

From which the resulting Lorentz force density can be calculated as:

$$\boldsymbol{F} = \boldsymbol{J} \times \boldsymbol{B}$$

Results

The Lorentz forces, due to the effects of the over current originated from an external short circuit on a single secondary winding are shown in figure 2. The asymmetric distribution of forces between the upper and lower windings shows how axial forces can have much higher values than radial forces. This work is a significant breakthrough in the prediction of a realistic forces distribution in transformer windings subject to any kind of short circuit, compared to the traditional analytic method.

	Upper winding	Lower winding
Radial Fr [N]	2635	-390630
Axial Fz [N]	68787	-617890

Table 1. Lorentz forces

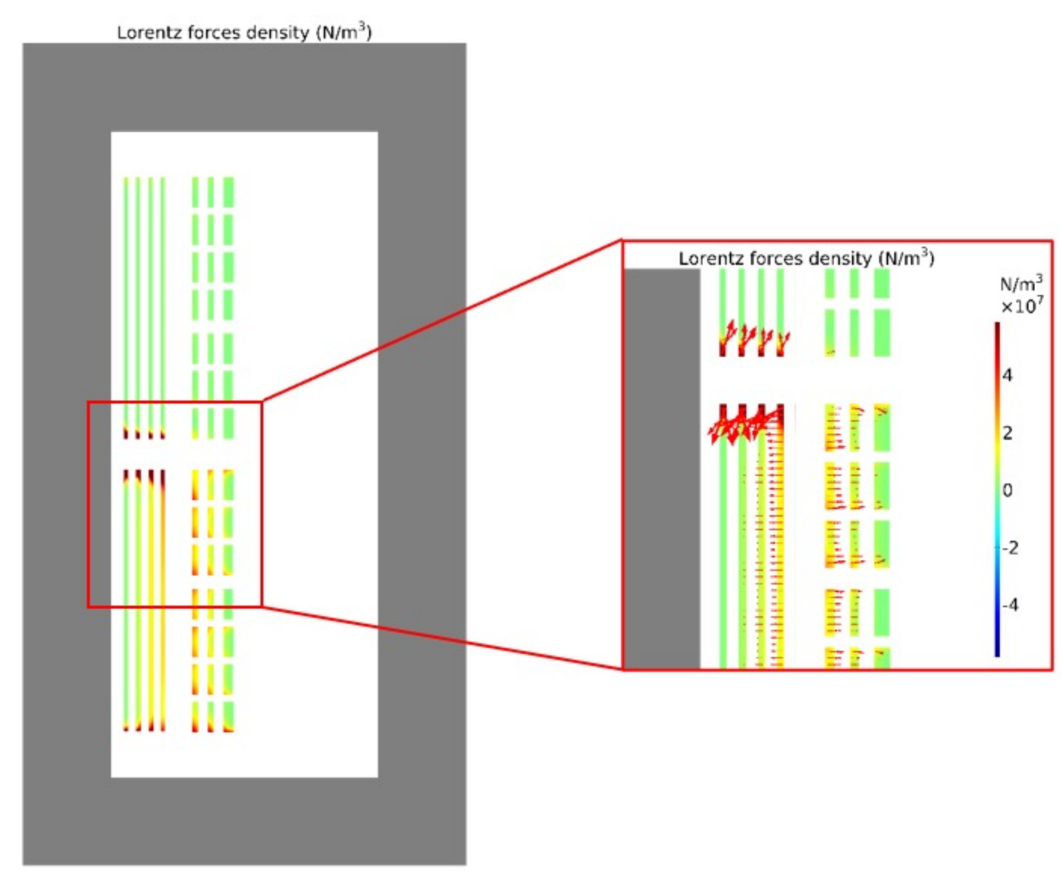

FIGURE 2. Left: Lorentz force density. Right: zoom on the winding area with higher force density and force vectors

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