Ohmic losses in transformer clamping plates

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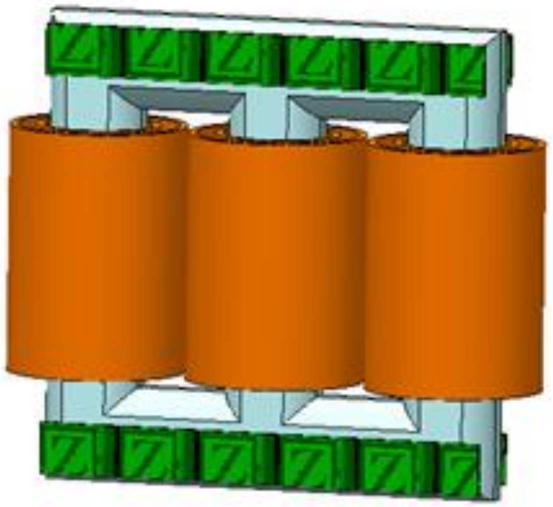
Calculating stray losses in power transformer tanks and clamps is an important design characteristic to consider. However the standard approach requires modeling skin effects in 3D which requires a very fine mesh. This can significantly increase the solution time making the simulation impractical to perform at times.



Using the proprietary formulation of the non-linear Surface Impedance boundary condition (SIBC) that is unique to Simcenter MAGNET, very accurate non-linear loss predictions can be achieved in time-harmonic context without the cost of using fine 3D meshes.

Simcenter MAGNET's SIBC reconciles both the low and high saturation regimes, applies to a wide range of materials, and covers both the B- and H-sinusoidal cases, which other proposed empirical models fail to do.

This page first presents an example of how the SIBC can be applied to transformer clamping plates. The formulation used by Simcenter MAGNET is then validated more rigorously using a benchmark model.

TRANSFORMER CASE STUDY

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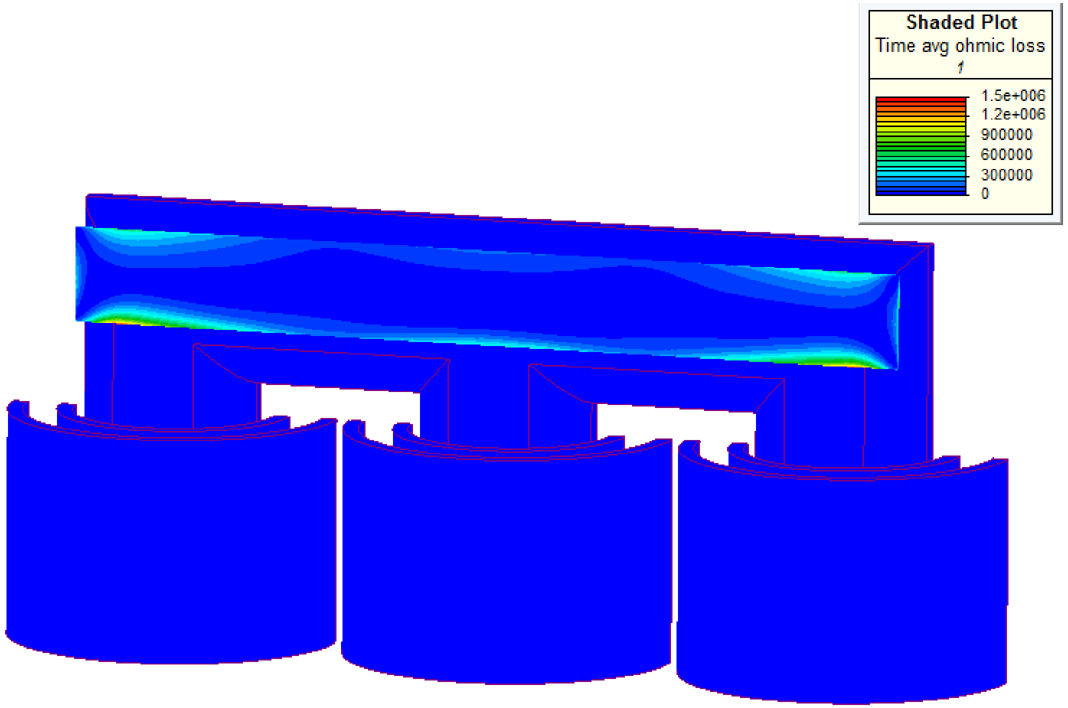
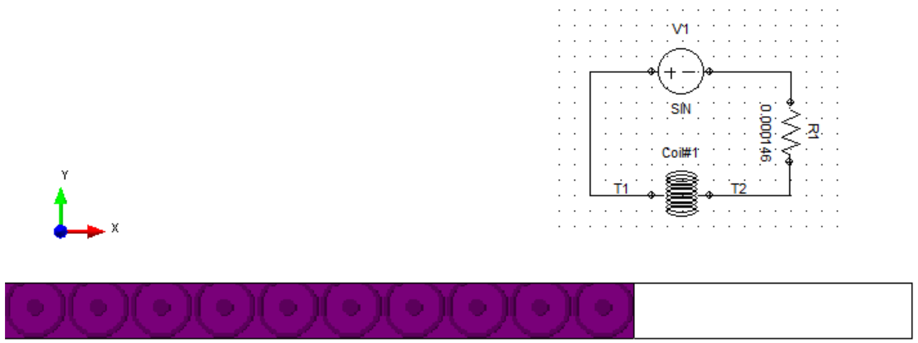
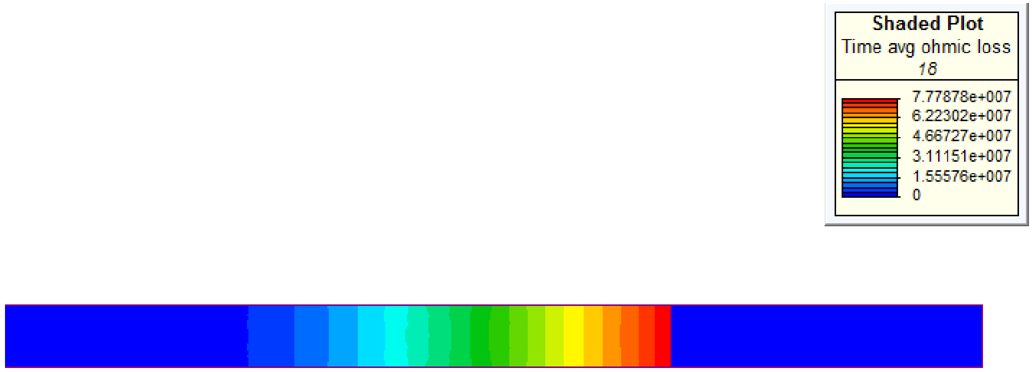


The non-linear SIBC was used on the clamping plates of a 100 MVA, 230/132 kV power transformer. The table at the bottom of the page shows that the non-linear SIBC allows solving the model about 50 times faster than a conventional mesh with an error of less than 1%.



The test case is a semi-infinite non-linear conductor facing the x direction excited by a voltage source such that current flows along the surface. Using symmetry, only a thin slab needs to be modeled. By adding a resistor in series with the source, the problem can actually be continuously tuned from B-sinusoidal when the resistance is set to zero to H-sinusoidal when the resistance is large enough that it essentially fixes the current in the circuit.

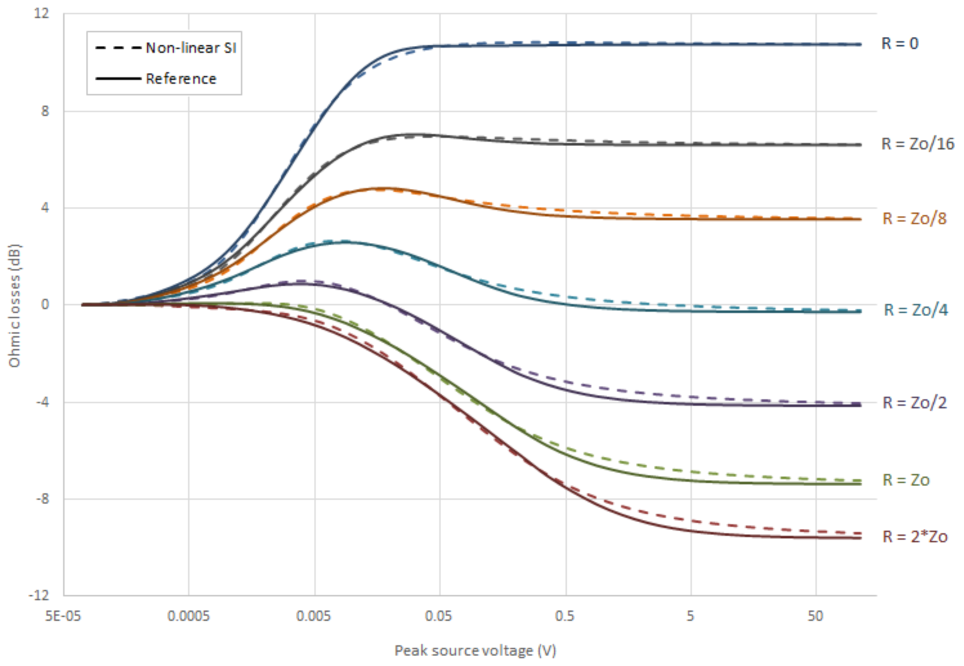
REFERENCE LOSSES



The real ohmic losses illustrated here can be computed without any approximation in a reasonable amount of time by using a fine mesh in the skin depth region and the Transient solver which takes into account nonlinearities in a rigorous fashion.

NON-LINEAR SURFACE IMPEDANCE APPROXIMATION

This graph compares the losses obtained with the Time-Harmonic solver and the non-linear SIBC to the exact losses calculated using the Transient solver for different values of external resistance. As can be seen, the non-linear SIBC yields an excellent fit all the way from low saturation to high saturation no matter the resistance. Note that the losses are expressed in dB relative to the losses obtained with a linear solution such that all the curves.



SUMMARY OF RESULTS

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The table below summarizes the results obtained with and without the Surface Impedance boundary condition. The losses obtained when solving the model in linear mode are also reported for comparison. As can be seen, the non-linear Surface Impedance approximation allows solving the model about 50 times faster with an error of less than 1%.

Boundary Condition	Losses	Solving time
None	333 W	2 hours
Surface Impedance	336 W	Under 3 minutes