Magnetic and Circuital Modeling of a Low Harmonic Pollution Three Phase Transformer

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Abstract

Introduction: A three phase transformer with two secondary windings whose tensions have 30° phase difference is considered. These secondary windings feed a double 6-phase rectifier bridge, so that the resulting output consists in a 12 impulses signal with extremely low harmonic pollution. This configuration (Figure 1) is important as started to be extensively used in different applications among which power traction in rail transport system. The construction of a similar system can be done inside a single transformer without any external adsorption inductor, positioning the two secondary windings one above the other and splitting the primary in two parts, so that each one is correctly coupled with the corresponding secondary winding. This properly designed setup, despite being intriguing for the reduction in required components (and corresponding reduction in construction and maintenance cost) has the difficult requirement in its design for a correct calculation of magnetic dispersion reactance between the two secondary windings. Use of COMSOL Multiphysics and Results. The above described design technical evaluation turns out to be correctly exploited by a 2D-axisymmetric magnetic induction current model (Figure 1, right) given the chance to have proper circuital connection (in fact the system, given the description above, has, at least, 6 external input/output cables which internally might split even more, resulting in the need of being able to control properly this multi-port system). The authors used COMSOL to design these configurations whose experimental constructions turned out to act as expected, showing a very good comparison between model theoretical prediction and experimental measurements. Conclusion: The choice of the COMSOL to design a properly balanced transformer has been exploited. It has been verified that building a similar model in COMSOL it is easy as you can:

- build a parameterized geometrical model;
- exploit a magnetic FEM simulation in the frequency domain (skin and proximity effect are then fully considered) (Figure 2);
- couple freely the different winding to external circuit (this is technically done with the feature called "coil group domain" in connection with the "electrical circuit" interface).

An important side advantage of the choice of COMSOL is the fact that the magnetic calculations here presented is readily coupled to the thermal simulation via the computed electromagnetic losses, and similarly to the mechanical simulation through the electromagnetic forces.

Figures used in the abstract

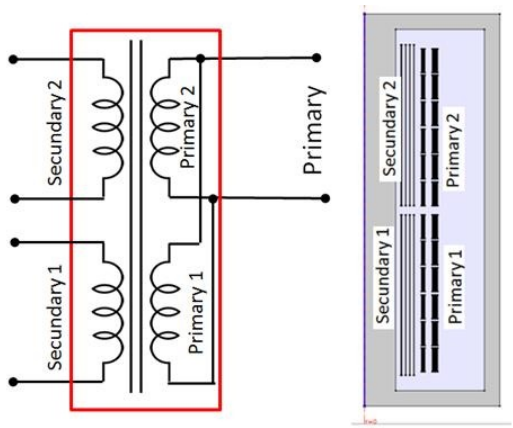

Figure 1: The considered configuration for the transformer where the primary is split into two parts which are feeding two secondary windings. On the left a circuital configuration. On the right the 2D-axisymmetric representation of one of the three columns of the transformer.

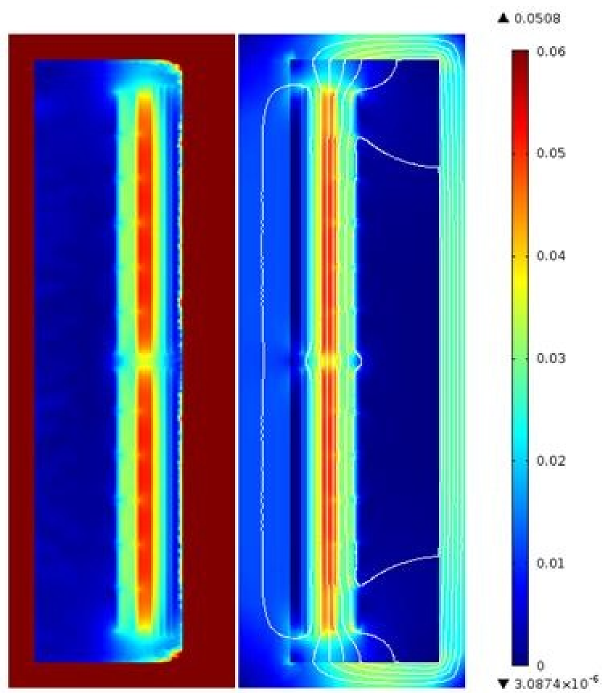

Figure 2: Magnetic flux density norm for one of the three columns of the transformer superimposed on the right with streamline of the magnetic flux at phase 0. The fringing effect visible in the middle is due to the presence of the gap between the two primary secondary windings which are one above the other. Image on the left (mirroring the system) is relative to a very small frequency (no induction) compared to the interesting 50 Hz case (right).