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Coupling Transformer Operation of a Dynamic Voltage Restorer Under Electrical Grid Conditions

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Abstract—To improve electrical grids power quality, a dynamic voltage restorer with a magnetic voltage source converter protection scheme integrated in the coupling transformer is developed. Finite element analyses with an electrical-magnetic coupling modeling are performed to study the behavior of the coupling transformer in extreme electrical grid conditions.

Index Terms—Power system modeling, short-circuit currents, transformer cores, voltage fluctuations.

I. COUPLING TRANSFORMER WITH A MAGNETIC PROTECTION SCHEME OF A DYNAMIC VOLTAGE RESTORER

Dynamic Voltage Restorers (DVR) increase power quality by acting on grid voltage fluctuations. They are composed of a coupling transformer with the primary winding inserted between a supply and critical loads and the secondary winding connected to a Voltage Source Converter (VSC), an energy storage unit and a VSC grid fault protection scheme which is usually an electromechanical bypass [1]. To reduce the time response of the latter, a magnetic bypass is integrated in the coupling transformer through a return leakage leg (Fig. 1) [2]. It is based on the Virtual Air Gap (VAG) principle, i.e., the monitored local saturation of the return leakage leg by a DC current, which protects the VSC by modifying the magnetic flux circulation in the coupling transformer.

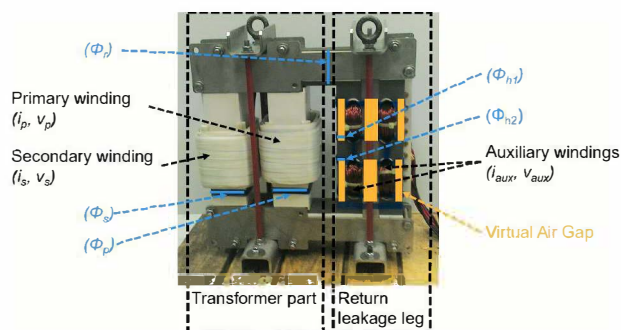


Fig. 1. Experimental device of the coupling transformer

II. MODELING OF THE COUPLING TRANSFORMER

To study the operation of the coupling transformer with a VAG which combines both DC and AC magnetic flux according to the electrical grid characteristics and especially during harsh grid fault conditions without making any unsafe experiment, a 2D-modeling of the coupling transformer has

been performed with Finite Element (FE) analyses by using the softwares Gmsh and GetDP. The non-linearity of the magnetic steel is taken into account by using first magnetization B(H) curves. The windings are excited by using electrical circuit equations coupled to the FE formulations. For the two operation modes: Normal operation (NOp) and Fault operation (FOp), a sinusoidal voltage is imposed at the terminals of the primary and the secondary windings and a DC current density is imposed in the auxiliary windings.

The modeling allows analyzing the magnetic flux distribution, the current and the voltage of the windings and the sources of the coupling transformer. Fig. 2 describes, for instance, the behavior of the coupling transformer with a constant DC current at the apparition of a sudden high grid fault current. The latter increases the desaturation of the return leakage leg, the overvoltage at the auxiliary windings terminals and the current in the VSC which is nevertheless still limited. Note that the limitation of this current can be improved by acting on the DC source and by short-circuiting the secondary winding during grid faults.

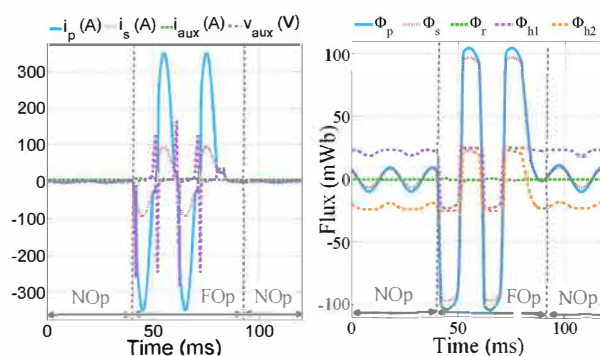


Fig. 2. Behavior of the coupling transformer during a high grid fault current

In the extended paper, the operation of the coupling transformer of the DVR will be studied by FE analyses as regards the electrical grid behavior: for a rated operation and for different grid fault conditions.

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