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Editorial: High quality and reliability of transformers

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Editorial on the Research Topic
High quality and reliability of transformers

The transformer is the key electromagnetic device for energy transmission and distribution in power systems. Facing the complex conditions of power grid operation, a transformer with high quality and reliability should be developed, which should feature characteristics such as a stable and effective output, high efficiency, good short-circuit ability, low noise and low vibration, reliable insulation, perfect protection measures, *etc.* The aim of the current Research Topic was to collect scientific contributions that enable high-performance transformers to be developed, covering areas such as topologies, analysis methods, control strategies, and applications. It is a pleasure to present five articles that exemplify this Research Topic in different ways. The articles have been evaluated by a program committee composed of international researchers, professors, and industry experts.

As to the high-voltage transformers, the magnetic field distribution inside the tank is extremely complex, resulting in the frequent occurrence of multi-point ground faults in the core. Ground current, which ascertains whether there is a ground fault in the iron core, has the characteristics of difficult calculation, low precision, and long time consumption, which makes the analysis of the ground current of the iron core difficult. Zhou et al. proposed a fast core grounding current calculation method considering the connection of converter transformer windings. By establishing the circuit model of the converter transformer and considering the influence of saturation characteristics, the analytical calculation of the core grounding current was realized. Compared with the finite element method and experimental results, the proposed analytical method could meet the requirements of engineering accuracy and provide a new method for fast and accurate calculation of grounding current.

In the long-term working process of the transformer, the coupling of electrical, magnetic, thermal, and stress physical fields leads to the deterioration of insulating oil and oil paper. To reduce the probability of insulation damage and improve the reliability of transformer insulation, it is necessary to study the electrical properties of insulation materials inside transformers. Zhang et al. investigated the growth mode of carbon traces on the surface of cardboard insulation throughout the failure process from pressurization to breakdown in pure insulating oil and in insulating oil containing carbon particles. The influence of different concentrations of carbon particles on the surface breakdown voltage of oil-paper insulation and the corresponding damage characteristics were studied, providing a theoretical basis for evaluating the state of oil-paper insulation of converter transformers.

With the surge in demand for electricity worldwide and the continuous improvement in the reliability requirements of power systems, effective fault diagnosis methods are needed to

diagnose potential transformer faults. Zhou et al. proposed a method based on a probabilistic neural network algorithm to predict DC bias voltage, short circuits between iron cores, and multi-point grounding faults of transformers. By modeling and simulating transformer multi-point grounding, DC bias, and short-circuit faults between silicon steel sheets, the vibration and noise distribution of transformers under different faults were obtained. Taking the vibration and noise of the transformer core as the characteristic parameters, various faults of the transformer were modeled and predicted based on the probabilistic neural network algorithm. Facing the most common winding fault problem of transformers, Liu et al. adopted a multi-layer perceptron (MLP) method based on digital twins (DT) to locate transformer winding faults. The problem of insufficient winding fault cases was solved by introducing DT technology, and the digital twin of transformer windings was established based on a double ladder network. Through the fault simulation of DT, the fault samples were obtained, the mathematical indicators of the frequency response data were extracted, and the MLP model was trained to locate the winding fault. The superiority and feasibility of MLP were proved by comparing it with support vector machine (SVM) and experimental verification.

The DC transformer is the key piece of equipment to realize voltage conversion and power distribution in a DC power grid, and its operational characteristics have a profound impact on the DC power grid. Wang et al.proposed a control method for dual active full bridge (DAB) DC/DC transformers based on neural network sliding mode control under the reduced-order modeling method. The RBF neural network was used to transform the SMC to complete the parameter approximation of the sliding mode controller and improve the voltage fluctuation of the sliding mode controller. Through experimental comparison with PI linear control and classic SMC control methods, it was verified that the proposed control method had a faster response and more stable output.

The abovementioned articles make an important contribution to current research efforts in terms of the design, analysis, and control of high-quality and high-reliability transformers. In the aspect of analysis, it is necessary to establish accurate mathematical models and simulation tools to study the electromagnetic characteristics, thermal characteristics, and loss characteristics of the transformer to ensure its stable operation and reliability. In the aspect of control, it is necessary to develop advanced regulation algorithms and control strategies to achieve accurate control and protection of the transformer. In the aspect of diagnosis, it is necessary to develop advanced fault detection algorithms and data analysis technology, combined with advanced technologies such as digital twinning and neural networks, to achieve effective health assessment and condition monitoring of the transformer in order to improve its reliability and operation efficiency. Finally, we thank the reviewers for their timely and insightful comments and the authors for constructive scientific discussions.

Author contributions

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