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Essay

A Study of Digital Measurement and Analysis Technology for Transformer Excitation Magnetizing Curve

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Abstract: Transformer excitation magnetizing curves (TEMC) reflect the dynamic operation characteristics of iron-core materials. Using numerical analysis and the waveform recording function of digital oscilloscopes, we developed a cost-effective method for determining the TEMC. This approach eliminates the need for conventional analog integrator circuits. To address the potential obstacles to the digital generation of TEMC—namely, curve offsets and curve transients—we proposed solutions involving Fourier filtering and determining the initial point of integration. The results indicate that the proposed approach yields results consistent with those of conventional analog integrator circuits and highlight its promise for applications in data processing.

Keywords: transformer excitation magnetizing curves (TEMC); hysteresis curve; integrator; Fourier transform

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1. Introduction

Transformer excitation magnetizing curves (TEMC) reflect dynamic responses, such as harmonics, inrush current, and losses, and hysteresis characteristics are typically measured using silicon steel sheets [1]. However, because of the potential formation of an extremely thin insulating layer between lamination steels and the formation of gaps between stacked and stamped lamination steels, whether the characteristics of a single material are retained after assembly remains unknown [2]. These factors may affect the characteristics of magnetic circuits. Generally, TEMC reflects the relationship between the magnetizing force (H) and magnetic flux density (B), also called the B–H curve. Because of magnetic saturation and magnetic hysteresis, this curve is a closed loop.

Epstein frames, composed of four symmetrical iron cores wound around two sets of coils, are used to assess hysteresis characteristics [3]. Another common method of evaluating hysteresis characteristics is to use a magnetic yoke with a Hall sensor and a pick-up coil [4–6]; before the B–H curve is calculated, the magnetic flux density is determined through the integration of the voltage signal of the induction coil. The conventional approach is to use an analog integrator that includes integrating circuits composed of capacitor and resistor components [1,7] and integrators composed of active components [8]. However, with the popularization of data-capturing cards, digital integrator circuits are expected to be used in the future [9–11].

To digitally integrate a voltage signal and accurately determine magnetic flux density, noise and DC components must be considered [12]. Pólik and Kuczmann [7] used the fast Fourier transform for noise filtering. Because commercial electric sources may have harmonic components, whether the source used in tests exhibits harmonics should be considered. Chatterjee et al. [8] analyzed the effects of several power supply harmonics and suggested that, with increased source harmonics, transformers can be operated below the rated voltage to reduce the winding current and prolong service life. Some studies have also proposed digital methods for deriving B–H curves and highlighted the lack of discussion regarding problems that may lead to incorrect B calculation [13–16]. Notice