Multi-level PWM core loss tester employing switched-mode power amplifiers

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A soft magnetic core loss tester enabling multi-level PWM excitation is presented. The experimental setup is based on NI LabVIEW and compactRIO employed as an arbitrary waveform generator feeding signal to a switched-mode power amplifier, which, due to a significantly higher slew-rate compared to linear amplifiers, allows to perform core loss measurements ranging from sinusoidal to multi-level PWM excitation.

Keywords: Multi-level PWM; core loss measurements; stator cores.

1. Introduction

When dealing with Pulse-Width Modulation (PWM) core loss measurements in soft magnetics materials, two main experimental approaches can be identified in the literature: DC-bias and measurements employing power electronics converters. While the former superposes a small AC ripple to a DC excitation waveform to characterize the asymmetrical minor loops due to PWM excitation [1], the latter employs full-bridge converters to represent the full hysteretic loop. However, both methodologies come with drawbacks: DC-bias measurements are usually limited to relatively small specimens due to power [2] and slew-rate limitations of the power amplifier, and systems employing power electronics converters cannot be easily reconfigured for PWM switching schemes different than the intended use; a hybrid solution is presented in [2], where the authors perform DC-bias measurements with a one phase-inverter. With the advent of switched-mode power amplifiers having slew-rates typically ten times larger than their linear counterpart, the limitations concerning core loss measurements under PWM excitation for soft magnetic materials can be overcome. In this work, a 20 kVA switched-mode amplifier is integrated with a NI cRIO operated as an arbitrary waveform generator allowing to excite stator cores both with sinusoidal and multi-level PWM voltages thus enabling for a direct assessment of the influence of the latter on core losses.

2. Results and discussion

Figure 1 shows the hysteresis loops obtained by carrier-wave PWM modulating the excitation voltage associated to a reference sinusoidal magnetic flux BH loop at 1 T and 200 Hz on the back iron of a stator core. In particular, PWM switching schemes with respectively 2, 3 and 5 level were adopted to perform such an experiment. Moreover, in the bottom row of Fig. 1 the voltage and current waveform of the excitation winding are reported. The core losses increased by 19, 4.3 and 2.1% respectively for the 2, 3 and 5 level switching cases when compared to the sinusoidal flux measurement test.

In the final version of this work a broader range of magnetic flux density amplitudes and excitation frequencies will be considered along with different amplitude modulation ratio and switching frequencies. In addition, practical implications related to the slew-rate and the capability of the switched-mode power amplifier employed in this study will be presented.

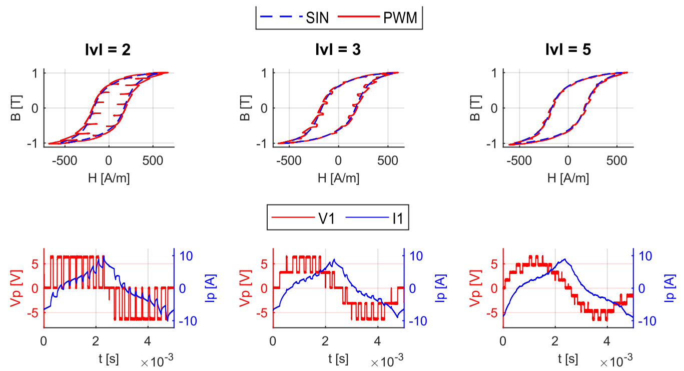

Figure 1 - BH loops and excitation voltage and current waveform for PWM switching schemes with 2, 3 and 5 levels. The reference sinusoidal flux is 1 T at 200 Hz and it is PWM-discretized with an amplitude ratio of 0.8 and a switching frequency of 4 kHz.

References

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