Impacts of Magnetizing Inductance on EET-DCX

A scalable electronic-embedded transformer (EET) DCX was recently proposed to address leakage inductance deviation, simplify the design of high-frequency and high-power transformers, and provide good current-sharing characteristics when paralleling transformers. Previous literature assumed the existence of an infinitely large magnetizing inductance in EET-DCX to achieve perfect current sharing, which contradicts real-world situations. However, the presence of magnetizing inductance introduces a current mismatch between parallel transformers, posing challenges for thermal management in high current, high operating frequency applications.

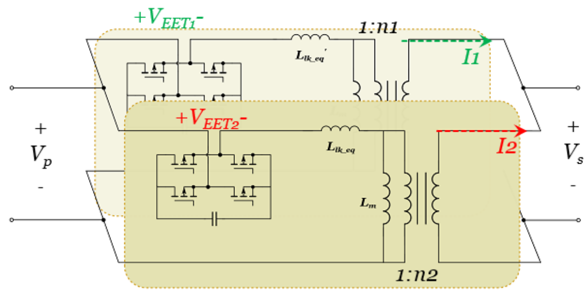

Fig. 1. EET converter

Fig. 1 shows the structure of an EET converter with 2 EET modules in parallel, with an unavoidable deviation on leakage inductance. With the transformer model, a model like Fig. 1 can be obtained so that the secondary side leakage inductance is reflected on primary side leakage inductance, magnetizing inductance and turns ratio value. Due to the absence of magnetizing inductance, the secondary side leakage inductance cannot be perfectly reflected to the primary side. With the deviation on secondary side leakage inductance, a variation on turns ratio can be expected, which causes the difference between n1 and n2.

In order to maintain the same secondary side voltage despite the different turns ratio between the 2 EET modules, the current on EET would be different according to equation (1).

$$V_s = (V_p - I_1{}'Z_1)\cdot n_1 = (V_p - I_1{}'R_{eq})\cdot n_1$$
$$= (V_p - I_2{}'Z_2)\cdot n_2 = (V_p - I_2{}'R_{eq})\cdot n_2 \qquad (1)$$

As per the equation, the current mismatch situation can be obtained as in Fig. 2, which shows the current on I1 and I2 in p.u. under different tolerant deviation on leakage inductance. With larger tolerance, larger current deviation should be expected. With a 30% tolerance on leakage inductance, the current mismatch would reach as high as 0.223 p.u., e.g. 22.3%.

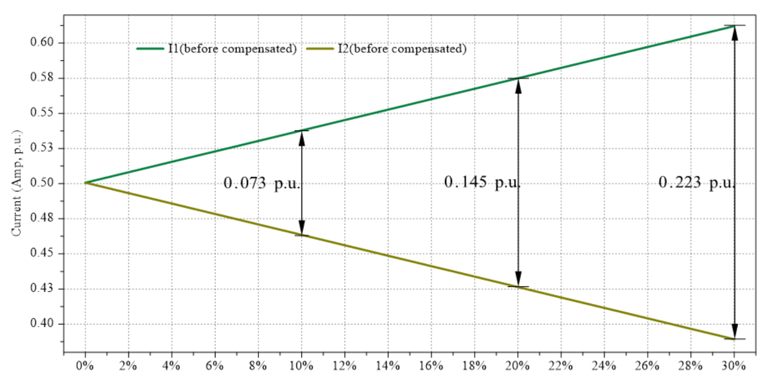

Fig. 2. Current mismatch situation on EET

This paper shows the impact of magnetizing inductance in an EET converter, which is supposed to have a perfect current balance nature. The undesired equivalent turns ratio difference causes a current mismatch between EET modules.