ESTIMATION OF THE PARAMETERS OF A MATCHING TRANSFORMER FOR A BIDIRECTIONAL TWO-STAGE DC/DC CONVERTER WITH SEPARATED COMMUTATION FOR THE POWER SUPPLY SYSTEM OF THE DC RAILWAY WITH BATTERY ENERGY STORAGE SYSTEM

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In modern power supply systems that use direct current lines, for example, railway (RW), various Microgrid variants, etc., is desirable the presence of battery energy storage system (BESS). It is imperative that the system contains a bidirectional matching converter (BMC). BMC provides the exchange of energy between the input voltage source – BESS and the output voltage source – contact RW network. Matching transformer (MT) provides voltage levels matching and galvanic isolation. Proposed BMC circuit [1] with an input voltage of U_{in}=600 V and an output voltage U_{out} of 2–4 kV (nominal voltage U_{outN}=3.3 kV).

The BMC’ primary low-voltage stage is a Voltage-Fed Inverter (VFI) with IGBT's Zero-Voltage-Switching. Nominal voltage of these IGBTs is 1200 V. The secondary high voltage stage is a Current-Fed Inverter (CFI) with an additional serial four-quadrant switch (FQS) with IGBT's Zero-Current-Switching. Nominal voltage of these IGBTs is 6500 V. The transformer's leakage inductance L_s perform the role of the nondissipative turn-on snubber. The frequency conversion is set to f=1 kHz.

The amplitude of the current of w_2 winding is assumed to be 200 A (transistors FZ250R65KE3), turns ratio $K_t=w_2/w_1$ accepted 6.67. The use in the VFI a standard IGBT FZ1800R12HE4_B9 with a nominal current of 1800 A in conjunction with capacitive snubbers provides a small value of turn-off losses (about 7% of the IGBT static losses). Then we have an estimation for a reasonable value of L_s: 150 μH $\leq L_s \leq$500 μH.

The estimation for the leakage inductance referred to the secondary winding is about 500 μH. To reliably reduce the leakage inductance to an acceptable level, it is proposed to split the secondary winding and place primary winding between the halves of the secondary. Then L_s decreases by 5/8 times to 300 μH. The results of transformer' loss, overheating and leakage inductance estimates were verified by modeling in Maxwell and SolidWorks/Flow Simulation packages, relative error of estimation does not exceed 8 and 14 percents, respectively.

References:

[1] V. Ivakhno, V. Zamaruiev, B. Styslo, R. Kosenko, A. Blinov, “Bidirectional Isolated ZVS DC-DC Converter with Auxiliary Active Switch for High-Power Energy Storage Applications” in *IEEE 2017 First Ukraine Conference on Electrical and Computer Engineering (UKRCON),* 2017, pp. 589- 592.