PCB Inductor with Shielded Windings to Contain Electric Field and Reduce EMI

The continued adoption of wide bandgap power devices is enabling power converters to run at increased switching frequencies without sacrificing power density. However, these factors may also strengthen parasitic capacitive and inductive couplings between different areas of the power converter. If not properly addressed, these near-field couplings can increase the converter's conducted electromagnetic interference (EMI).

Common mode (CM) noise is generated by the switching voltage of the converter coupling to ground through distributed parasitic capacitance and returning through the power lines. Therefore, EMI filters are used to attenuate the CM noise through the power lines. However, due to their close proximity, the switching voltage of the power stage can capacitively couple to the filter and effectively bypass its attenuation.

The inductors and transformers of the power stage are often the dominant cause of CM noise due to their outsized effect on the capacitive couplings. This is due to the application of the switching voltage across the windings, combined with the fact that high-frequency core materials typically have very large permittivity.

In this work, the concept of the shielded-windings PCB inductor is introduced. By inserting shield layers into the PCB, the inductor's electric field can be contained in order to minimize the parasitic capacitive couplings, and thereby reduce the CM noise. Based on the CM noise model developed in prior work, this paper outlines the design of the shielded-windings inductor, which is evaluated and optimized using FEA simulation tools. The tradeoff between shielding performance and eddy loss is described, as well as other important considerations for the inductor's electrical performance within the converter.

Fig.1. PCB inductors: original inductor (left), shielded-windings inductor (right)

This work proposes a novel PCB inductor with integrated shield traces to contain the noisy electric fields of the inductor windings. By careful design of the shielding layers, the proposed inductor has almost no increase in copper loss compared to the original unshielded PCB inductor. At the same time, the proposed shielded-windings inductor is shown to effectively reduce the EMI of the converter under test, with up to 25 dBV reduction in the CM noise.

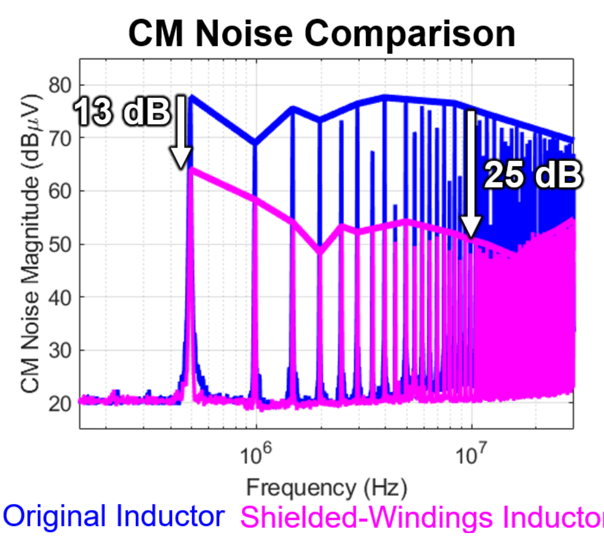

Fig. 2. Comparison of CM noise for both inductor designs