Optimization of Planar Structures by Means of Shifted Winding

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Summary. Planar structures are often used recently due to their many advantages. Transformers, power inductors and EMI filters are only a few components that are constructed using this technique. In order to increase their efficiency, parasitic capacitance (EPC) must be decreases and HF losses must be appropriate to their utilisation. In previous studies it was discovered that a shifted winding of the planar structures decreases EPC.This paper represents a study which aims at finding an optimum shifting of the windings, wich will decrease EPC and increase HF losses.

1 Introduction in planar structures

Planar technology has many advantages such as improving high frequency (HF) characteristics, reducing size, lowering profile, achieving structural and functional integration, lowering manufacturing time and cost [1].

A planar integrated structure is composed of alternating layers of conductors, dielectrics, insulation and ferrite materials [2].

The difference between conventional and planar magnetic components is in terms of orientation of winding layers. Windings in a planar magnetic component have flat, wide and rectangular cross sections, and the core of a planar structure has a lower profile than that of a conventional structure. A comparation between planar and conventional structures is shown in Fig. 1.

Planar structures also have disadvantaged like large footprint area, increased parasitic capacitance and low window utilization factor. Depending on the analyzed structure and its mode of operation, different parameters must be optimized.

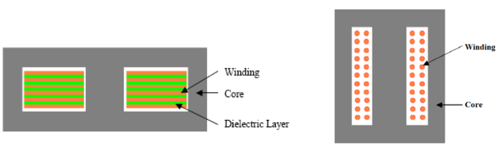

Fig. 1. Comparison between planar and conventional structure

EMI filters can also be constructed as planar structures. In order to optimize their behavior, equivalent parasitic capacitance (EPC) and equivalent series inductance (ESL) must be reduced and because the role of EMI filters is to attenuate unwanted noise, a higher loss factor at high frequency is needed.

Because the aim of this study is to improve planar structures with the same parameters and role as EMI filters, the EPC needs to be decreased and the HF losses of the planar structure increased.

2 Presentation and validation of the technique used to increase HF losses

In previous studies, the shifting of the winding was demonstrated to be the best method to decrease EPC [4] , but it was not considered to be a factor that influences the HF losses. The authors considered this as an alternative to the nickel plating of the copper conductors, which is also a method to increase HF losses, and researched the way that shifted windings affect the loss values.

The original structure from Fig. 2 was the object of this study. In previous researches, the conductors of winding3 were placed so as to decrease EPC. A study of the loss variations depending on the shifted windings was conducted. Winding3 was shifted to eight different positions and the losses were calculated with the help of a 2D numerical modeling program of the electromagnetic field.

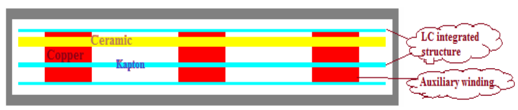

Fig. 2. Model to be studied [3].

The notation SO from Fig. 3 represents the original structure and the other notations are referring to structures with different shifting of winding3, for example bd1.1 represents a structure with winding3 shifted to the right with 1.1mm from its original position.

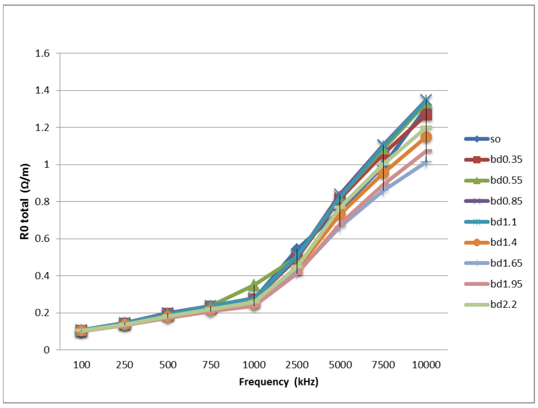

Fig.3. Structure losses depending on winding3 shifting for the original structure

The conclusions of this study are that the shifted winding affects the high frequency losses. From further investigations, the results show that for the structures with pure copper conductors, the optimum or maximum value of the losses is present for the structure with winding3 shifted with 1.1 mm as shown in Fig. 4.

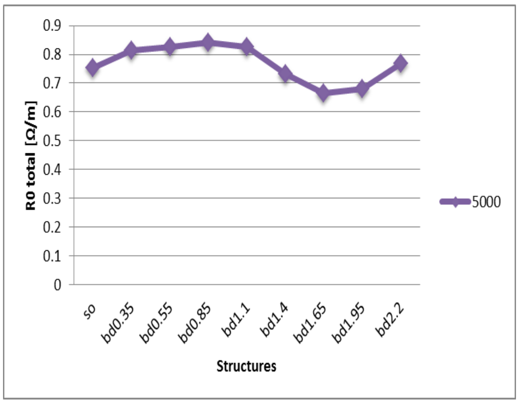

Fig. 4. Variation of losses with the shifting of winding3 for the original structure

3 Study of the optimal positioning of the conductors

In this chapter, the optimum structure from the HF losses point of view is presented. As for the EMI filters, the value for the losses must be increased at HF. The results were obtained using an software program previously tested.

The problem of determining the optimal location of the conductors is considered to be a magnetostatic problem, so for the numerical analysis module of the field the boundary element method (BEM) was chosen. BEM is a semi-analytical method, which leads to accurate results using a small number of mesh elements and is fast in terms of computing time.

Because the number of "mobile" elements is relatively small, the algorithm of optimal design is based on conjugate gradient method (CG) with an optimum step in the search direction.

The paper presents the optimum structure starting from simple structures with one or two mobile conductors, reaching more complex ones. The results are compared with the optimal results for the EPC reduction.

Finally, is attempted to be obtained an optimum result considering the losses and also the parasitic capacitance.

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