Modeling and Analysis of the Performance Improvement Techniques for EMI Filters

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Summary Improving the characteristics of a filter presupposes two major directions of action: the first direction refers to the increase of attenuation (by means of the increase of losses) in high frequency, while the second direction refers to the suppression of the parasitic effects in the constitutive devices. Thus, in this light, the paper presents the authors' contribution to the two major directions of actions mentioned above; in the first part, techniques of loss increase are presented, while in the second part techniques of minimizing the parallel equivalent capacity are shown, techniques proposed by the authors. In part three of the paper these techniques are applied simultaneously to an EMI filter made by use of plenary magnetic technology in order to study its performance through 2D and 3D numerical modelling. The final conclusions will close the present paper.

1 Introduction

The main technological challenge for the integrated EMI filters, as it appears from the speciality literature, is that of improving its performance for high frequencies by reducing the equivalent parallel capacity (EPC) and the equivalent series inductance (ESL) of the integrated capacitor coils, by the increase of losses at high frequency, respectively [1], [2]. The fundamental element of any integrated magnetic planar device is represented by its LC integrated structure. For the construction of the EMI filters, an LC integrated structure with three coils per layer has been chosen, an attractive structure which is also often mentioned in the literature for the manufacturing of different plenary integrated magnetic devices; it is presented in Fig. 1.

2 Techniques for improving the performance of the integrated EMI filters

In order to achieve the integrated EMI filters big losses at high frequency are desired, that is small losses at low frequencies, respectively. Aiming at that, the authors propose the *technique of nickel coating conductors*, a technique to be described in detail in the final work.

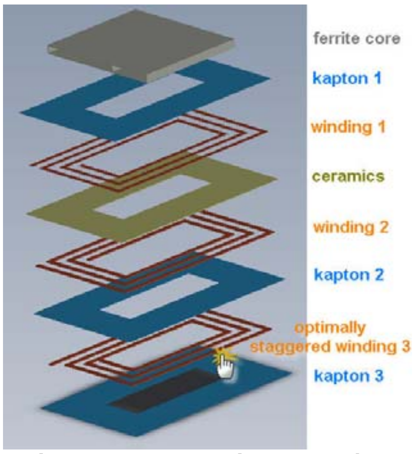


Fig. 1. Explanatory_ LC integrated structure with 3 coils –3D detailed image.

As far as the parallel equivalent capacity is concerned, since great geometrical complexity structures are involved, it cannot be defined by means of direct calculus relationships nor can it be localized in a certain device, since it is practically distributed within the space between the coil windings constituting the filter. A new technique for reducing the parallel equivalent capacity is proposed within the paper, that is applying a geometrical staggering among the coil windings. The structure of the optimum placing of the staggered coiling constitutes the subject of a study for optimal planning with specific numeric optimization algorithms created by the authors. These techniques of increasing loss at high frequency and of minimizing the EPC respectively are applied in the case of EMI integrated filters in order to improve their performance.
The equivalent principle scheme for an EMI filter achieved by means of planary magnetic technology is given in Fig. 2 [3].

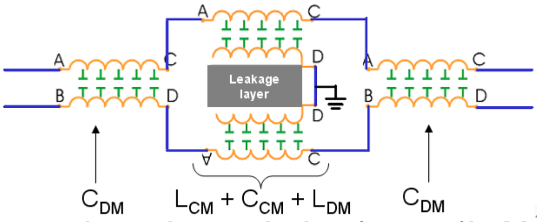
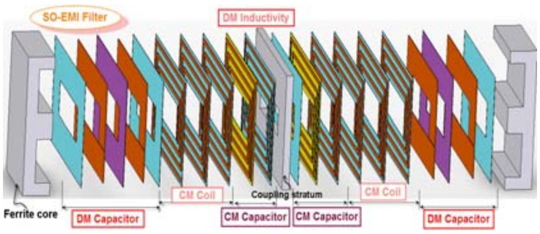
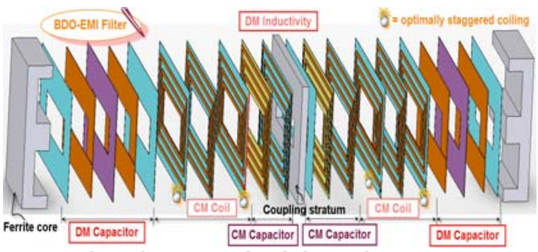


Fig. 2. The equivalent principle scheme for an EMI filter [3]

In order to highlight the performance introduced by means of applying the techniques proposed by the authors, a comparative study has been carried out, having as a starting point an initial structure achieved in the classical variant, the so called "original structure" and an "optimized structure" in the afore mentioned sense, respectively. The two structures are presented in Fig. 3, the constituting elements being mentioned alongside their functional role within the EMI filter.



a) The original structure

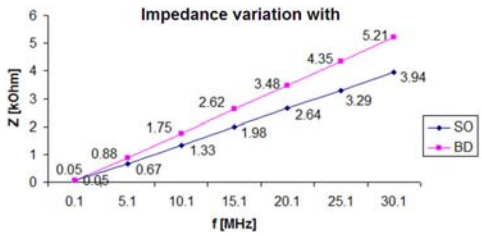


b) The optimized nickel coated structure

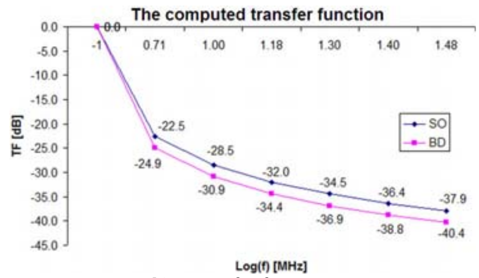
Fig. 3. Explanatory_ 3D EMI Filters – unfolded representations.

Comparing the capacity matrixes obtained following the numeric modeling of the two proposed filters, it can be noticed that the parasitic capacity corresponding to the CM_1 coil decreases from 219.4 pF, the value obtained in the matrix corresponding to the EMI filter based on the original structure, to 102.32 pF in the case of the EMI filter based on the coiling structure optimally staggered, the parasitic capacity corresponding to the CM_2 coil decreases from 219.16 pF to 101.61 pF respectively.

The impedance variation with frequency at the inlet of the closed filter for a 50 Ω charge in the case of the two proposed structures is shown in Fig. 4.



a) entrance impedance



b) transfer function

Fig. 4. The results of the comparative analysis of the variation with the frequency in case of EMI filters: SO – the original structure; BD – nickel plated, staggered coiling.

3 Conclusions

Following the analysis of the results obtained which have been detailed in the present paper, it can be stated that the techniques proposed by the authors for the improvement of the EMI filter performance prove to be efficient. Thus, the EMI filters which have applied these techniques have a parallel equivalent capacity reduced to approximately 47% of the initial value while the HF losses are increased with approximately 32% with respect to the initial value respectively.

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References

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