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STUDY OF THE PARASITIC CAPACITANCE VALUES IN A PLANAR STRUCTURE WHEN THE HIGH FREQUENCY LOSS INCREASE METHODS ARE APPLIED

BY

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Abstract. The present study continues the researches regarding planar structures, namely electromagnetic interference (EMI) filters. It is known that in order to improve their behaviour, the high frequency losses must be increased and the parasitic capacitance values must be decreased. There are different methods to be applied in order to eliminate the two problems above mentioned. The aim of this research is to determine the influence of the methods used to increase HF losses on the values of the parasitic capacitances.

Key words: influence of parameters; HF losses; parasitic capacitances; planar structures.

1. Introduction

Having many advantages compared to classic wire wound technology, planar magnetic components are largely used in the last few years. Electromagnetic interference (EMI) filters are one of many structures created in planar technology due to its numerous advantages, but, like all the other planar structures, must be improved considering their limitations. For EMI filters the

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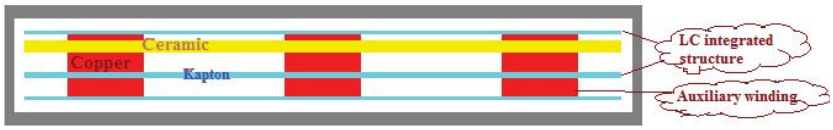
improvement can be achieved by decreasing the parasitic capacitance and increasing high frequency losses (Răcăşan *et al.*, 2007). The construction of such a filter is based on a so-called original structure presented in Fig. 1 in 2-D and 3-D, which can be found in special literature (Răcăşan *et al.*, 2012).



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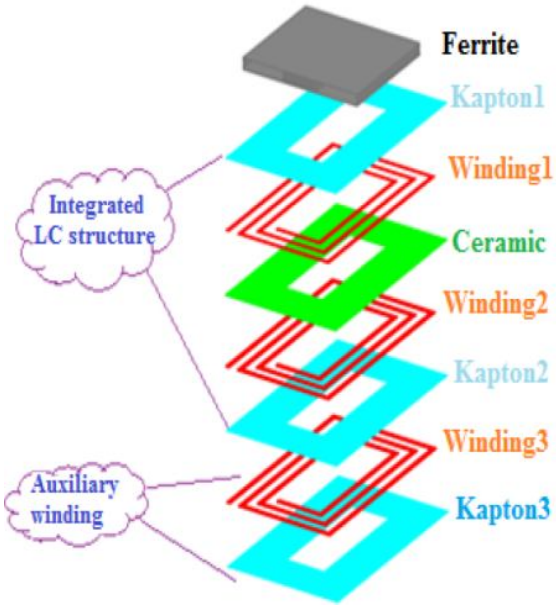


b

Fig. 1 –The original structure on which the study is based: *a* – 2-D view; *b* – 3-D view.

The starting point of this study are the results obtained regarding the increase of HF losses. In a previous work it was determined that nickel plating the copper windings is increasing the HF losses (Răcăşan *et al.*, 2010). Starting from here, it was observed that the main parameters which influence the losses are: using different materials of high conductivity in order to plate the windings, the kapton2 thickness, the thickness of the platting on the windings, the material parameters (Hebedean *et al.*, 2012).

This paper will present a parallel approach of the methods used in this structure in order to increase the HF losses and the influence of the same methods applied from the parasitic capacitance point of view (Hebedean *et al.*, 2012).

2. Methods and Materials

There were two main cases studied (Fig 2).

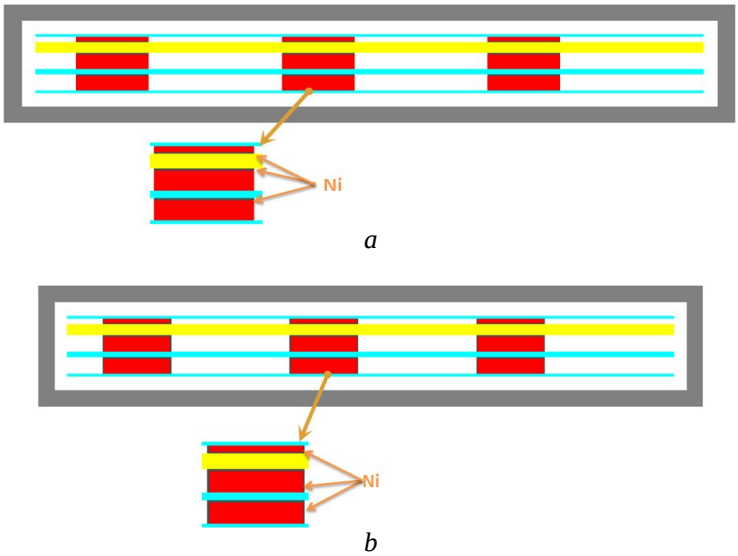


Fig. 2 – Nickel coating of the copper windings: *a* – structure with nickel coating on the exterior winding surfaces; *b* – structure with nickel coating on the exterior and lateral winding surfaces

For the study of the HF losses, only the second case, represented in Fig. 2 *b*, was considered because the platting of the exterior and lateral surfaces of the windings determined the higher losses. Considering eight different materials of high conductivity (Micu *et al*., 2002), for which the characteristics are presented in Table 1, it was determined that in the frequency range of 100 kHz…10 MHz nickel is the best material for the windings platting and its relative permeability which can vary between 110 and 600 doesn't influence the HF losses. Also, when the nickel coating thickness increases, the HF losses increase to. (Hebedean *et al*., 2012).

3. Influence of the HF Losses Increase Methods on the Parasitic Capacitance Values

The study regarding the structures with different coatings of the winding was resumed, this time from the parasitic capacitances values point of view. It was observed that the value of all the capacitances from the structures remains the same, regardless from the material used.

The relative permeability of the nickel doesn't influence either, the

values of the parasitic capacitance remaining constant with the variation of the relative permeability.

Table 1
Materials Considered for the Study

Material	Relative permittivity, ε_r	Relative permeability, μ_r	Conductivity, σ S/m
Ni	1	600	1.45E+07
Zn	1	1	1.67E+07
Cr	1	1	7.60E+06
Pb	1	0.99998	5.00E+06
W	1	1	1.82E+07
Ag	1	0.99998	6.10E+07
Cu	1	0.99991	5.80E+07
Fe	1	4,000	1.03E+07

The values of the useful and parasitic capacitances of the structure decrease with the increase of the kapton thickness, the highest decrease of all being considered for C22 (useful capacitance for winding 2) and the parasitic capacitance (C33) (Răcăşan *et al.*, 2012)

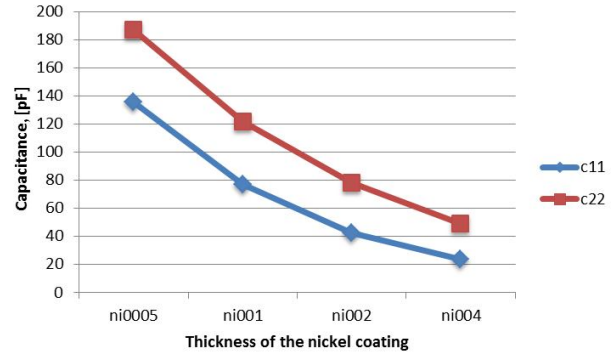
In order to determine the influence of the nickel coating thickness, three cases were considered: a) the nickel coating for the study above was placed so that the distance between the kapton layers would not be increased, so the thickness of the copper windings was decreased with the increase of the nickel coating, b) the geometry of the copper windings will remain the same and the thickness of the nickel coating will vary, leading to the thickness increase of the whole structure and the copper windings will remain the same and c) the thickness of the nickel coating will vary and in order to maintain the same dimensions for the structure, the kapton and ceramic layer were considered to be thinner.

2.1. Influence of the Nickel Thickness for the Three Configurations Studied

In previous researches regarding the HF losses increase, the dimensions of the nickel coating covering the copper windings were varied between 0.005 mm and 0.4 mm.

Considering the same structures and analysing them from the parasitic capacitance point of view, it was discovered that all the capacitances of the structures decrease with the increase of the nickel coating. For this study, four thickness values of the nickel coating were considered. The useful capacitances C11 and C22 will decrease as it can be seen in Fig. 3 *a*, as for the parasitic capacitance which is considered to be C33, the values vary as in Fig. 3 *b*. The useful capacitances values are decreasing with a higher percentage than the

parasitic capacitances, so in order to obtain an optimum from the capacitances point of view, a thinner nickel coating must be used.



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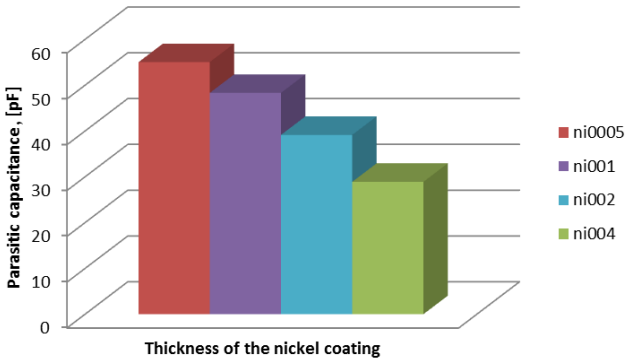


b

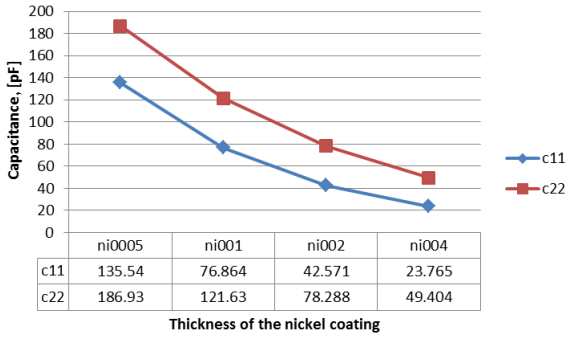
Fig. 3 – Variation of the parasitic capacitance and useful capacitances with the thickness of the nickel coating – case 1.

In order to increase the efficiency of the manufacturing process, the case where the geometry of the copper windings will remain the same and the thickness of the nickel coating will vary will be analysed and discussed. For this case, the assembled structure will occupy more space in the devices where it will be used. Considering the new geometry of the structure, the results regarding useful and parasitic capacitances are presented in Fig. 4.

Another case considered to be analysed is the one where the geometry of the copper windings has the initial geometrical parameters, the nickel coating varies in thickness and the kapton and ceramic layer thicknesses will vary in

order to maintain the same distance of the layers from the ferrite core. The conclusions are the same as in the first two cases.

There was also considered to determine the influence of nickel platting the windings only on the exterior surfaces, but the results remain approximately the same.



	ni0005	ni001	ni002	ni004
c11	135.54	76.864	42.571	23.765
c22	186.93	121.63	78.288	49.404

a

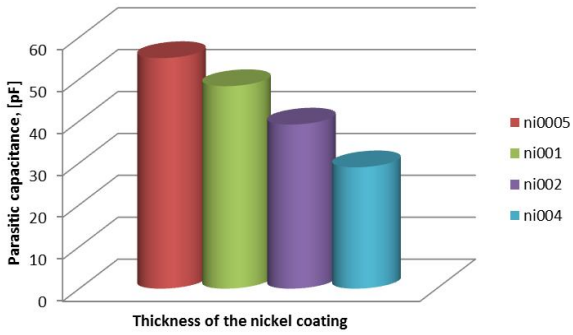


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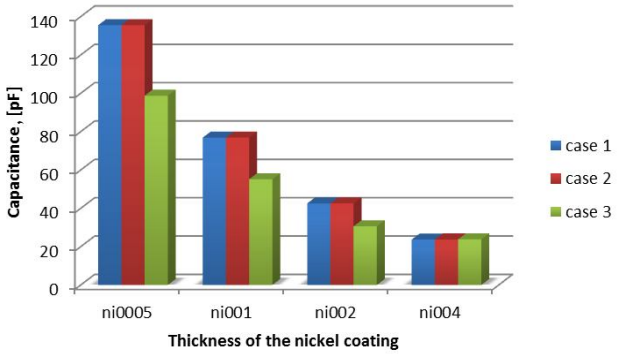
Fig. 4 – Variation of the parasitic capacitance and useful capacitances with the thickness of the nickel coating – case 2.

2.2. Influence of the Nickel Thickness for the Three Configurations Studied

Even though the results are similar for the studied cases, at a close look, it can be observed that in the third case, the values for the useful capacitances decrease the most, as for the parasitic capacitances, they are not as reduced as in the first two cases (Fig. 5). It can be stated that the first two cases can be considered as better solutions for this problem.



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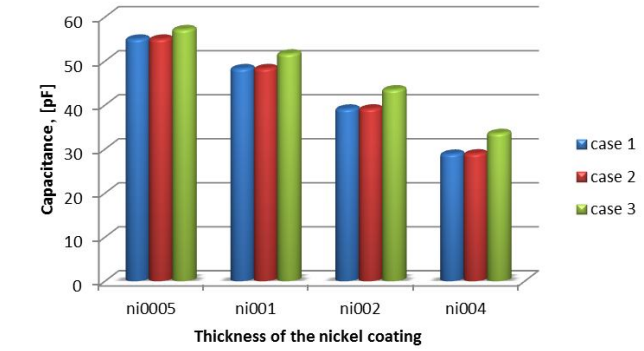

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Fig. 5 – Comparison between the capacitances values in the three studied cases.

4. Conclusions

Because of the large costs for the construction of the planar structure, determining the optimum characteristics by modeling the structures is very important. It was demonstrated that the values of the capacitances remain constant, not depending on the material used for the coating of the windings if we refer to the highly conductive materials. Also, the values of the useful and parasitic capacitances of the structure decrease with the increase of the kapton thickness.

The study of the influence of nickel thickness was conducted on three cases mentioned above and it was observed that all the capacitances of the structures decrease with the increase of the nickel coating. After comparing the results it can be stated that the first two cases can be considered as better solutions for this problem.

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STUDIUL VALORILOR CAPACITĂŢILOR PARAZITE ÎNTR-O STRUCTURĂ PLANARĂ ATUNCI CÂND ASUPRA ACESTEIA SUNT APLICATE METODE DE CREŞTERE A PIERDERILOR ÎN ÎNALTĂ FRECVENŢĂ

(Rezumat)

Studiul de faţă continuă cercetările cu privire la structurile planare, mai exact a filtrelor cu interfaţă electromagnetică. Se cunoaşte faptul că pentru a îmbunătăţi comportamentul acestor filtre, se doreşte ca pierderile în înaltă frecvenţă să fie mărite iar valorile capacităţilor parazite trebuie micşorate. Pentru a elimina cele două probleme menţionate, există metode diferite pentru fiecare dintre ele. Scopul acestui studiu este de a determina influenţa pe care o au metodele de creştere a pierderilor HF asupra valorilor capacităţilor parazite.