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Analysis and design of dissipative frequency selective two-layer conductive structures

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Abstract

In the drive towards power electronic integration, planar structures are widely used. Applications for the use of these structures are varied. These have been shown to have potential advantages with regard to reduction in size and cost. Much work has been done with regard to integration, but generally from an intuitive perspective, and without a general approach.

An important part of power electronic integration is EMI filtering. One way in which this is achieved is through dissipative filtering. It is demonstrated that this can be done for planar structures through the use of multi-layered conductors. Planar conductors have a particularly distinct advantage in that they are low profile and can be miniaturised. The resulting focus of this dissertation is an investigation into the characterisation of two-layer conductors in terms of how the properties of the two layers contribute to the frequency dependent resistance of the conductor. This is done with a direct view towards dissipative filtering.

This investigation begins with a description of the method of characterisation of two-layered conductors, and the construction of a parametric study around this. A contribution of this dissertation is the demonstration that the parametric space can be reduced without loss of generality of the characterisation. The results of this characterisation are used to demonstrate the importance of the total conductivity and total permeability as concepts. This concept provides flexibility in the design of two-layer dissipative filters.

The concept of a single-layer approximation is presented and investigated. It is shown to even further simplify the model used for multi-layered conductors, and presents a good first level understanding of what the frequency dependent resistance of the structure will be. This concept is shown to be useful in the design of two-layered conductors, and may be generalisable to multiple layers. A second contribution of this work is the presentation of design equations based upon this approximation for five different scenarios. This contribution includes the limits to the dimensions of the two-layer structure, with the conclusion that some specifications do not have physically realisable forms.

The final, major contribution that this work presents is as follows. In terms of dissipative filtering, it is shown under differential-mode excitation that the desired properties of the inner layer of the conductor should be: less conductive than the outer layer, and more permeable than the outer layer. These conditions are shown to provide a steeper gradient of resistance increase with respect to frequency. This conclusion is verified experimentally, which provides confidence in the modelling technique this dissertation is based upon.