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Ferrite transformer inductance modeling and extraction based on S-parameter measurement.

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In this paper, a modeling and characterization of ferrite transformer using vector network analyzer (VNA) and specially developed PCB test fixture based on S-parameters measurement are presented. The main advantage of this kind of measurement is high accuracy, due to elimination of many layout- and setup-related problems, which arise in practical implementation of ferrite components. Since the components can exhibit significant difference in performance for different layouts, they should be characterized by independent network parameters, such as S-parameters.

A ferrite transformer is formed with an appropriate connection of ferrite component to the conductive traces on the PCB (Fig. 1). The chosen ferrite component, SM bead 48-057-38, is wired multi-hole bead for PCBs with 4 copper wires (diameter 0.6mm), size 10.86mm×10.86mm×6.35mm [1].

Two different PCB layouts for connection of 4-way bead as a 2 turns transformer are analyzed. A 3D view of the 2 turns ferrite transformer and its dimensions are presented in Fig. 2. A VNA E5071B, Agilent Technologies, is used together with the SUSS wafer probe station PM5, for the characterization of transformer in the frequency range from 300kHz to 1GHz. The procedure of parameter extraction of ferrite transformer is discussed with more details in [2]. Characterization of the same component as EMI suppressor up to 3GHz was presented in [3].

Besides the parameter extraction based on S-parameter measurement, the modeling of complex structure of ferrite component is presented in this paper. The structure is modeled using the partial inductance method [4]. The conductive path is divided into straight conductive segments. Some segments are within the ferrite material (vertical segments depicted with red color in Fig. 2). They are modeled like conductors in an infinite ferrite material.

The upper horizontal segments (i.e. yellow segments on the top of the component) are on the surface of magnetic material, and they are modeled using the method of current images. Since the permeability of ferrite material is high (μr=1000), and the thickness of ferrite material is 6.35mm, the enhancement effect of a thick magnetic substrate on the inductance of conductive segments is also calculated [5]. In the same manner, the inductances of the PCB conductive lines are calculated. The primary inductance is determined as a total sum of all partial self-inductances and all mutual inductances.

Comparison of modeled and extracted values of ferrite transformer inductances is presented in Fig. 3. As it can be seen, there is a good agreement between modeled and extracted values of transformer inductance for Structure 2.

Since the characterization of ferrite transformers is very important for modern circuits, the aim of this paper is to propose the equivalent model of ferrite transformer and to verify the modeling by comparing the calculated and extracted values of inductances for different structures of transformers.

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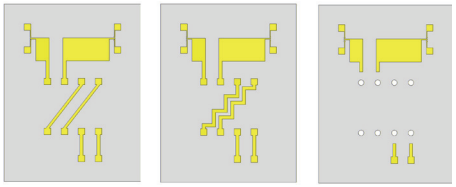

Fig.1. PCB layout for connection of SMD bead 48-057-38 as a 2-turns transformer: a) structure 1, b) structure 2 and c) de-embedding

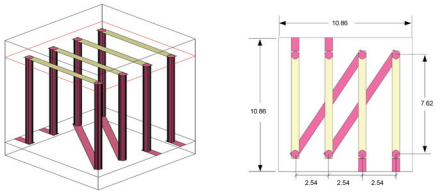

Fig. 2. A ferrite transformer is formed with an appropriate connection of ferrite component to the conductive traces on the PCB: a) 3D view and b) dimensions in mm.

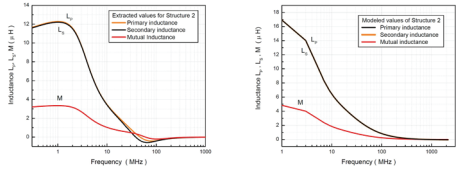

Fig. 3. Comparison of modeled and extracted inductance of ferrite 2 turns transformer (structure 2)