

Simulation Studies of Nonspiral Planar Microcoils of Square Geometry

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Abstract- Planar microcoils are integrated components in micro sensors and actuators with the recent advancements in MEMS technology. Spiral planar microcoils are reported mostly in literature. Non-spiral planar coils provide an easier option to using lesser number of metal levels. They can be used effectively for generation and detection of magnetic fields. In this paper, a non-spiral planar square microcoil is proposed and its finite element model is developed. Simulation results are presented highlighting the unique features of the coil.

Keywords—non-spiral planar coil; microsensor; metal level; analytical model

I. INTRODUCTION

Use of planar microcoils in magnetic sensors and actuators is an efficient way of miniaturisation of device size dimensions. System sensitivity will also be improved as the radius of the coil is inversely related to its sensitivity[1]. Planar microcoil is an essential component in microsystems utilising magnetic actuation as it can provide long range and high-density energy[2]. It has wide acceptance in biomedical systems such as in drug distribution system, micro analysis system and lab-on-chip systems for actuation purposes [3]. Magnetic actuation is safe for biomedical applications since low frequency magnetic field isn't harmful for biological tissues[4]. Planar microcoils also find use in magnetic sensors as current applied to the coil produces a magnetic field surrounding it.

For small coil diameters(d) such as $d < 100 \mu\text{m}$, planar fabrication methods are followed for coil manufacturing [1]. Microcoils fabricated on substrates such as glass, Gallium Arsenide, PCB etc are reported in literature. Coils with high aspect ratio can be fabricated using SU-8 photolithography and electroplating [5-8].

Planar coils can be categorised as spiral and non-spiral (coplanar). In spiral coils, innermost turn is contacted to the contact pad outside using a via connection whereas in non-spiral coplanar type both coil ends can be directly taken out to contact pads. Therefore, spiral planar coils' fabrication requires atleast two levels of metal interconnection whereas a single layer of metal interconnection is sufficient for non-spiral coil fabrication[9]. Design of a planar coil requires various coil geometric parameters such as turnwidth and thickness of the coil turns, turn radius, the number of turns, and spacing between them. In fig. 1, a spiral microcoil fabricated on PCB is shown with geometrical parameters given by width w , thickness h , spacing between turns s and diameter of innermost turn d_1 .

In this work, design of a non-spiral square planar microcoil is proposed and its merits are discussed compared to other existing planar microcoil structures.

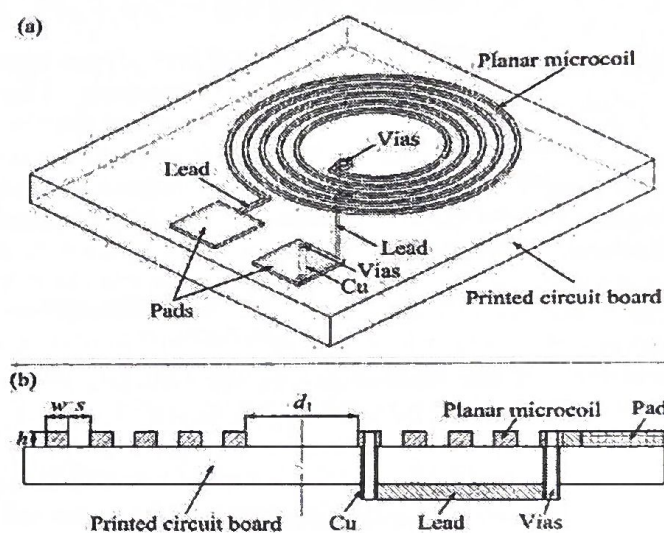


Fig.1. Planar spiral microcoil on PCB (a) Isometric diagram (b) Schematic of its transverse section [10]

An analytical simulation using COMSOL Multiphysics 5.2a is performed to find out impact of geometry of a square microcoil on magnetic flux density.

II. DESIGN OF NON-SPIRAL PLANAR MICROCOIL

A non-spiral planar microcoil of 5 turns is shown in Fig.2. Diameter of innermost and outermost turns from the centre are represented as ' d_1 ' and ' d_5 ' respectively.

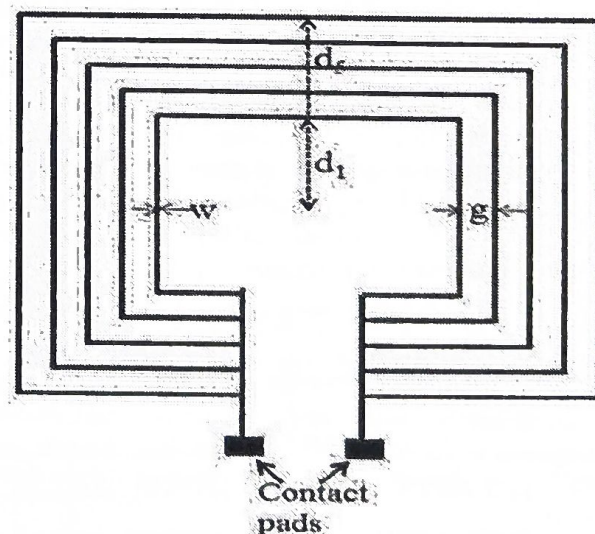


Fig.2. Schematic of non-spiral square planar microcoil

' w ' is width of a turn and ' g ' is spacing between adjacent coil turns. The distance ' d_i ' of the i^{th} turn can be calculated as shown in equation (1).