Electromagnetic Vulnerability of Wires with Arbitrary Shape

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Abstract**—** Practical wiring systems typically exhibit non-straight complicated shapes based on their environment. Therefore, the effect of wire shapes needs to be quantified to accurately assess the field-to-wire coupling and crosstalk in practical wiring systems. In this work, a hybrid modeling and experimental approach is employed to quantify the coupling and crosstalk to wires with a wide variety of shapes. Comparisons to straight wires are drawn and best/worst case shapes for coupling and crosstalk are identified.

Keywords-Wires, Electromagnetic coupling, characteristic mode analysis, shape

I. INTRODUCTION

In practical applications, wires possess a wide variety of complicated shapes based on their environment. Therefore, in this work, we experimentally study the field-to-wire coupling and crosstalk between wires with complex shapes. We validate these experimental measurements using full-wave simulations and we quantify the results using the characteristic mode analysis (CMA) which decomposes the total response of the wires in terms of their fundamental modes.

II. EXPERIMENTAL SETUP

Figure 1 shows the experimental setup used to test the far end coupling in a two-wire system above a metallic ground plane. The parabolic wires use a rubber band at the center location to create the nonstraight shape. Due to the significant size difference between the width of the rubber band and the length of the wires, the rubber bands effect on the coupling is negligible.

Figure 2 outlines the results found for the far end coupling. It can be seen from Figure 2 that even a minor difference in shape can cause a significant difference in the coupling. Additional shapes of 2 or more wires were studied and the results will be presented in the conference.

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III. CHARACTERISTIC MODE ANALYSIS OF WIRES WITH ARBITRARY SHAPES

CMA decomposes the total current induced in a wire into a set of fundamental modes and quantifies the relative significance of each mode at a specific frequency. CMA of non-straight wires show that, as the average curvature of the wire increases, both the bandwidth and the resonance frequency of the wires change. These CMA analysis will be used to explain the experimental and computational results presented in Figure 2.

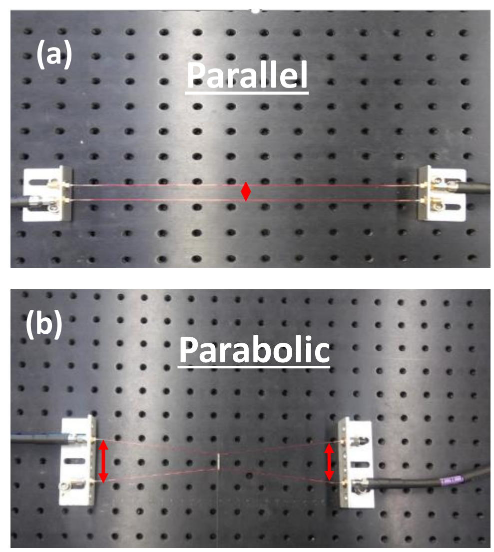
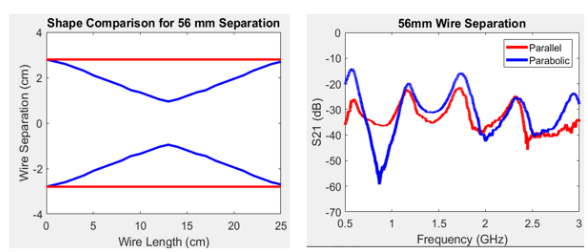


Fig. 1. Physical setup for testing far end electromagnetic coupling in a 2-wire system for **(a)** parallel wires and **(b)** wires arranged in a parabolic shape by using a rubber at the center of the wires.



(a) (b)

Fig. 2. (a) Straight versus parabaolic 2-wire configurations and (b) corresponding far-end coupling experimentally measured.