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Author(s)	Gupta, S; Jiang, L; Caloz, C
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Magneto-Electric Dipole Antenna based on Differentially-Excited Composite Right/Left-Handed (CRLH) Transmission Lines

S. Gupta and L. J. Jiang* C. Caloz†

Abstract — **A new magneto-electric (ME) dipole antenna array is proposed which provides a combined electric- and magnetic-dipole response in a planar configuration. The proposed structure is based on Composite Right/Left-Handed (CRLH) transmission lines, which is differentially fed and operated in the zeroth-order regime to provide maximal gain for the combined radiators. The basic principle of the proposed ME-dipole antenna is discussed and demonstrated with full-wave simulation results.**

1 INTRODUCTION

Magneto-electric (ME) dipole antennas consist of combined magnetic and electric dipole radiators, providing complementary radiation patterns within a single structure [1][2][3][4]. While several ME antennas have been proposed in the literature, these antennas have been mostly restricted to non-planar configurations, not suitable for integration with planar circuits. A planar ME antenna was proposed in [5] based on the zeroth order resonance of Composite Right/Left-Handed (CRLH) transmission lines [6], capable of providing both a magnetic and an electric dipolar response. However, this antenna requires two separate feeds to excite the magnetic and electric radiators. In addition, they have been restricted to resonant-type structures as opposed to travelling-wave antennas. In this paper, we propose a CRLH ME dipole antenna requiring only a single feed in a planar configuration capable of forming a travelling-wave antenna array.

2 Proposed ME-Antenna

Figure 1(a) shows a straight-forward but unpractical configuration of an ME antenna. Its consists of a current loop superimposed over an electric dipole, each with its own differential excitation. When excited together, both magnetic dipole and electric dipole radiation are achieved in the far-field of the structure. This antenna can be replaced by a combined structure of Fig. 1(b), where the rings are excited differentially and a part of the loop current is used to drive the electric dipole at the centre of the ring. This structure is more practical since it uses a *single differential excitation*. Moreover, if one places a second differential port at the other side of the loop, the structure converts from a *resonant-type* to a *travelling-wave* type antenna.

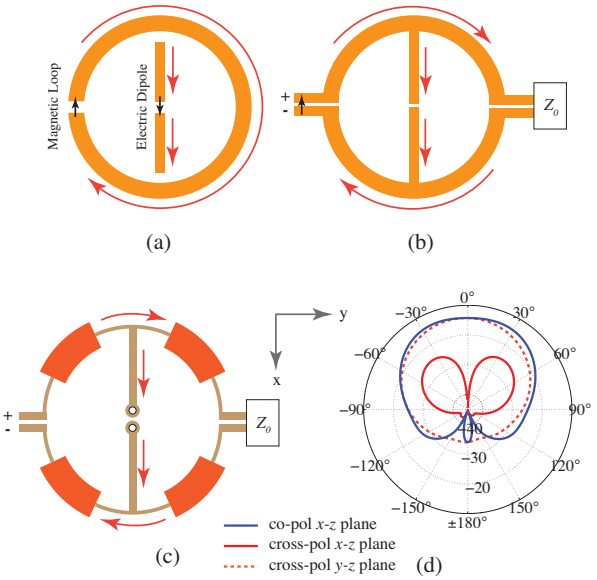

Figure 1: Proposed magneto-dielectric (ME) dipole antenna. The arrows indicate the currents. a) Straightforward but two feed configuration with separate electric and magnetic dipoles. b) Combined structure with differential feed. c) Corresponding antenna based on a single CRLH unit cell implemented in metal-insulator-metal technology. d) FEM-HFSS simulated radiation patterns at CRLH transition frequency.

It is well-known that the far-field gain of a current loop is small but can be improved by increasing the size of the loop while maintaining the current along the loop constant. This can be achieved by a CRLH structure operated in its infinite-wavelength regime [5]. In this regime, the size of the ring can be made very large without altering current direction providing to larger gain. This leads to the ME

*The Department of Electrical and Electronic Engineering, The University of Hong Kong, China (SAR); Email: shulabh@hku.hk

†Poly-Grames Research Center, École Polytechnique de Montréal, Canada.

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dipole antenna of Fig. 1(c), shown for a single unit cell, where the series elements (L_R and C_L) are used to form the current loop, and the shunt elements (L_L and C_R) are forming the electric dipole. The typical radiation patterns (in the presence of a ground plane) are shown in Fig. 1(d), where the magnetic dipole and electric dipole contributions are clearly seen. To further increase the gain, the size of the current loop can be increased as shown in Fig. 2, with a larger number of unit cells. The corresponding radiation patterns in the two-principal cuts exhibit the desired patterns, but with an enhanced gain compared to that of a single unit cell.

3 Features and Benefits

The proposed antenna offers several benefits compared to the conventional ME dipole antennas. First, it is compatible with integrated circuits. Second, it has a unique differential feed for both dipolar responses. Third, due to its differential nature, the proposed structure may benefit from co-design [7]. Finally, the proposed structure is naturally suited for an extension to array configurations due to its travelling-wave nature.

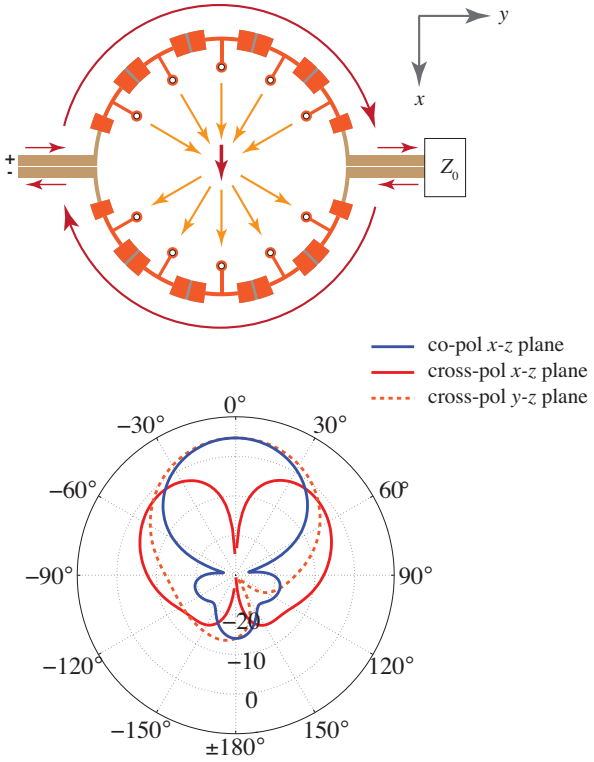

Figure 2: Proposed ME dipole antenna based on CRLH transmission lines operated in the infinite-wavelength regime, where the size of the ring can made arbitrarily large to enhance the gain.

4 Conclusion

A new travelling-wave configuration of a magneto-dielectric antenna based on Composite Right/Left-Handed (CRLH) transmission lines has been proposed and demonstrated with full-wave simulations results. The proposed structures provide a combined electric- and magnetic-dipole response in a planar configuration, and due to its inherent travelling-nature, is suitable for forming high-gain antenna arrays. The experimental prototypes are currently under-development and will be reported else-where.

Acknowledgments

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