

**Neetu Marwah**

# Step by Step Guide to Design a Magneto-Electric Dipole Antenna

**Technical Report**

# YOUR KNOWLEDGE HAS VALUE



- We will publish your bachelor's and master's thesis, essays and papers
- Your own eBook and book - sold worldwide in all relevant shops
- Earn money with each sale

Upload your text at [www.GRIN.com](http://www.GRIN.com)  
and publish for free



**Bibliographic information published by the German National Library:**

The German National Library lists this publication in the National Bibliography; detailed bibliographic data are available on the Internet at <http://dnb.dnb.de> .

This book is copyright material and must not be copied, reproduced, transferred, distributed, leased, licensed or publicly performed or used in any way except as specifically permitted in writing by the publishers, as allowed under the terms and conditions under which it was purchased or as strictly permitted by applicable copyright law. Any unauthorized distribution or use of this text may be a direct infringement of the author s and publisher s rights and those responsible may be liable in law accordingly.

**Imprint:**

Copyright © 2021 GRIN Verlag  
ISBN: 9783346572660

**This book at GRIN:**

<https://www.grin.com/document/1165005>

**Neetu Marwah**

# **Step by Step Guide to Design a Magneto-Electric Dipole Antenna**

## **GRIN - Your knowledge has value**

Since its foundation in 1998, GRIN has specialized in publishing academic texts by students, college teachers and other academics as e-book and printed book. The website [www.grin.com](http://www.grin.com) is an ideal platform for presenting term papers, final papers, scientific essays, dissertations and specialist books.

### **Visit us on the internet:**

<http://www.grin.com/>

<http://www.facebook.com/grincom>

[http://www.twitter.com/grin\\_com](http://www.twitter.com/grin_com)

## **Table of Content**

### **Chapter 1 Introductory Chapter**

- 1.1 Introduction
- 1.2 Review of Previous Research
  - 1.2.1 Wideband unidirectional patch antenna
  - 1.2.2 Bandwidth Enhancement Techniques for Conventional unidirectional Microstrip Patch Antenna
    - 1.2.2.1 U-slot Technique
    - 1.2.2.2 L-shaped Probe Technique
- 1.2.3 The Dipole Antenna
  - 1.2.3.1 Bandwidth Enhancement Techniques for Dipole Antenna
- 1.2.4 Complementary Antenna
  - 1.2.4.1 Complementary Antenna Composed of Slot Antenna and Parasitic Wires
  - 1.2.4.2 Complementary Antenna Composed of Slot Antenna and a Monopole
- 1.2.5 Magneto-Electric Dipole Antenna
  - 1.2.5.1 Magneto-Electric Dipole Antenna with Modified Ground Plane
  - 1.2.5.2 Magneto-Electric Dipole Antenna with Differential Feed
  - 1.2.5.3 Circularly Polarized Magneto-Electric Dipole Antenna
  - 1.2.5.4 Planar Printed Magneto-Electric Dipole Antenna
  - 1.2.5.5 Reconfigurable Magneto-Electric Dipole Antenna
  - 1.2.5.6 Millimeter Waves Magneto-Electric Dipole Antenna
- 1.3 Objectives
- 1.4 Structure of the Book

### **Chapter 2 Design of an End-Fire Magneto-Electric Dipole Antenna**

- 2.1 Introduction
- 2.2 Antenna Description and Design Geometry
- 2.3 Current Distribution in the Magneto-Electric Dipole Antenna
- 2.4 Simulation and Measured Results
- 2.5 Parametric Study
  - 2.5.1 Effect of Variation in length of Capacitive Arm
- 2.6 Conclusion

### **Chapter 3 Design of a Differentially-fed Magneto-Electric Dipole Antenna**

- 3.1 Introduction
- 3.2 Electrical Parameters of Differentially fed Antenna
- 3.3 Antenna Description and Design Geometry
- 3.4 Simulation and Measured Results
- 3.5 Conclusion

## **Chapter 4 Design of Magneto-Electric Dipole Antenna with Modified Ground Plane**

- 4.1 Introduction
- 4.2 Principle of Operation
- 4.3 Design of E-Shaped Antenna without Cavity
- 4.4 Performance of E-Shaped Antenna without Cavity
- 4.5 E-Shaped Antenna with Rectangular Cavity Reflector
  - 4.5.1 Effect of Height of Rectangular Cavity
  - 4.5.2 Effect of Width of Rectangular Cavity
- 4.6 Simulation and Measurement Results
- 4.7 Conclusion

## **Chapter 5 Design of a Planar Circularly Polarized Magneto-Electric Dipole Antenna**

- 5.1 Introduction
- 5.2 Antenna Geometry and Design
- 5.3 Current Distribution
- 5.4 Simulations and Measurements
- 5.5 Parametric Study
  - 5.5.1 Effect of Length of ground Plane
  - 5.5.2 Effect of Width of ground Plane
  - 5.5.3 Effect of Width of Feed Line
- 5.6 Conclusion

## **Chapter 6 Design of a Magneto-Electric Monopole Antenna**

- 6.1 Introduction
- 6.2 Antenna Design and Geometry
- 6.3 Current Distribution
- 6.4 Analysis of Magneto-Electric Monopole Antenna
- 6.5 Simulation and Measurement Results Analysis
- 6.6 Parametric Study
  - 6.6.1 Effect of Height of Monopole Antenna
  - 6.6.2 Effect of length of Feed of Monopole Antenna
  - 6.6.3 Effect of Width of Ground Plane
  - 6.6.4 Effect of Length of Ground Plane
- 6.10 Conclusion

## **Chapter 7 Concluding Remarks**

## **References**

## List of Figures

### Figure

- Figure 1.1 Geometry of U-slot microstrip patch antenna
- Figure 1.2 Geometry of L-probe patch antenna
- Figure 1.3 Geometry of half wavelength dipole element
- Figure 1.4 Radiation pattern of dipole antenna
- Figure 1.5 Wide-band and UWB dipole shapes
- Figure 1.6 Basic design of a complementary antenna consisting of electric dipole and magnetic dipole
- Figure 1.7 A complementary antenna combined with a slot and inverted-L wires
- Figure 1.8 A design of monopole-slot complementary antenna
- Figure 1.9 Current distribution of magneto-electric dipole antenna using L-shaped feed
- Figure 1.10 Dielectric loaded ME dipole antenna
- Figure 1.11 ME dipole antenna with stair cased shaped feed design
- Figure 1.12 ME dipole antenna with modified ground plane
- Figure 1.13 Differential-fed ME dipole antenna
- Figure 1.14 Circularly polarized ME dipole antenna
- Figure 1.15 Planar printed ME dipole antenna
- Figure 1.16 A reconfigurable M.E dipole antenna
- Figure 1.17 Feed network of ME dipole antenna
- Figure 1.18 Geometry of the Substrate Integrated Waveguide (SIW) fed CP aperture-coupled ME dipole antenna
- 
- Figure 3.1a Prototype of proposed antenna with side view of feed
- Figure 3.1b 3-D view of proposed feed design
- Figure 3.2a Side view of the proposed antenna
- Figure 3.2b Top view of the proposed antenna
- Figure 3.3 The simulated and measured differential return loss,  $S_{dd11}$
- Figure 3.4 The simulated and measured gain of proposed antenna



- Figure 3.5 The simulated and measured differential input impedance of proposed antenna
- Figure 3.6 Simulated antenna efficiency and radiation efficiency of proposed antenna
- Figure 3.7 Simulated and measured E-plane and H-Plane radiation patterns at:  
a-1GHz, b-1.5GHz, c-2GHz and d-2.5GHz
- Figure 4.1 Prototype of proposed antenna
- Figure 4.2 Schematic of Proposed Antenna (a) side view and (b) Top view
- Figure 4.3 Current distribution of E-shaped antenna at 2.6 GHz
- Figure 4.4 The simulated and measured return loss of E-shaped antenna
- Figure 4.5 The simulated and measured gain of E-shaped antenna
- Figure 4.6 Variation of return loss with frequency for different cavity heights
- Figure 4.7 Variation of gain with frequency at different cavity heights
- Figure 4.8 (a) Co-polar and (b) cross polar radiation patterns in E-plane for different cavity height at 2.4GHz
- Figure 4.9 Variation of return loss with frequency for different cavity lengths
- Figure 4.10 Variation of gain with frequency for different cavity length
- Figure 4.11 Simulated (a) co and (b) cross polarization radiation patterns in E-plane for different cavity length at 2.4 GHz
- Figure 4.12 Simulated and measured return loss vs frequency of proposed antenna
- Figure 4.13 Simulated and measured gain with frequency of proposed antenna
- Figure 4.14 Simulated antenna efficiency and radiation efficiency vs frequency of proposed antenna
- Figure 4.15 Simulated and measured E-plane and H-plane radiation patterns at:  
(a) 2.4GHz, (b) 2.8GHz and (c) 3.2GHz
- Figure 4.16 Simulated and measured co-polarization and cross polarization radiation patterns in E-plane at: a- 2.4GHz, b-2.8GHz, c- 3.2GHz
- Figure 5.1a Top view of the proposed antenna
- Figure 5.1b Side view of the proposed antenna
- Figure 5.1c 3D view of the proposed antenna
- Figure 5.2a Front side of the proposed antenna
- Figure 5.2b Back side of the proposed antenna
- Figure 5.3 Measured and simulated return loss of the proposed antenna
- Figure 5.4 Measured and simulated 3-dB axial ratio of the proposed antenna

- Figure 5.5 Measured and simulated gain of the proposed antenna
- Figure 5.6 Current distribution indicating right-handed circular polarization at 10.5GHz
- Figure 5.7 Measured and simulated E-plane and H-plane radiation patterns at:  
(a) 9.5GHz (b) 10GHz and (c) 10.5GHz
- Figure 5.8 Variation of return loss with frequency for different length of ground plane
- Figure 5.9 Variation of gain with frequency for different length of ground plane
- Figure 5.10 Variation of axial ratio with frequency for different length of ground plane
- Figure 5.11 Variation of return loss with frequency for different width of ground plane
- Figure 5.12 Variation of gain with frequency for different width of ground plane
- Figure 5.13 Variation of axial ratio with frequency for different width of ground plane
- Figure 5.14 Variation of return loss with frequency for different width of feed
- Figure 5.15 Variation of gain with frequency for different width of feed
- Figure 5.16 Variation of axial ratio with frequency for different width of feed
- 
- Figure 6.1a Side view of the proposed antenna
- Figure 6.1b Top view of proposed antenna
- Figure 6.1c 3-D view of proposed antenna
- Figure 6.2 Prototype of proposed antenna
- Figure 6.3 Current distribution of proposed antenna at 4.7GHz
- Figure 6.4a Schematic of proposed magneto-electric monopole antenna
- Figure 6.4b Equivalent circuit of magneto-electric monopole antenna
- Figure 6.5 Real and imaginary parts of input impedance of proposed magneto-electric monopole antenna
- Figure 6.6 Measured, simulated and formula based return loss of proposed antenna
- Figure 6.7 Measured and simulated gain of proposed antenna
- Figure 6.8 Measured and simulated E-plane and H-plane radiation patterns at:  
(a) 5GHz (b) 6GHz (c) 7GHz (d) 8GHz
- Figure 6.9 Measured and simulated co-polarization and cross polarization radiation patterns in E-Plane at: ( a) 5GHz (b) 6GHz (c) 7GHz (d) 8GHz
- Figure 6.10 Simulated return loss of proposed antenna at different height
- Figure 6.11 Simulated gain of proposed antenna at different height
- Figure 6.12 Simulated return loss of proposed antenna for different length of feed
- Figure 6.13 Simulated gain of proposed antenna for different length of feed

- Figure 6.14 Simulated return loss of proposed antenna for different width of ground plane
- Figure 6.15 Simulated gain of proposed antenna for different width of ground plane
- Figure 6.16 Simulated return loss of proposed antenna for different length of ground plane
- Figure 6.17 Simulated gain of proposed antenna for different length of ground plane

# CHAPTER 1

## INTRODUCTION

---

### 1.1 Background

With the rapid and extensive usage of mobile phones, wireless communication systems and technologies have entered into many important domains of our daily lives, which include social media, business development, medical and healthcare applications, agriculture, scientific applications and many more. The antenna plays a pivotal role in all the wireless communication applications to determine the overall system performance and the various novel applications have urged strong demands for new high performance antenna systems.

Precisely, the development of numerous wireless communication systems and applications have triggered the all-time high demand for wideband, low profile and unidirectional antennas that can accommodate various wireless communication applications while exhibiting good electrical characteristics, including stable gain, wide impedance bandwidth, low cross-polarization and low back lobe radiations across the entire range of frequency operation. Many designs have been proposed in the literature to accommodate various wireless communication applications with enhanced antenna parameters. The standard L-shaped probe feed patch antenna are able to achieve an impedance bandwidth of 35% with an average gain of 7.5dBi [1]. With slot antenna an impedance bandwidth of 17% - 40% can be achieved [2-3]. But each of these unidirectional antennas exhibits an asymmetric E-plane and H-plane radiation pattern and unable to provide stable gain bandwidth product in the range of frequency of operation. Recently, a novel wideband antenna, known as the ME dipole antenna, is proposed by Luk *et. al.* [4-5], which has been derived from the complementary antenna. The basic structure of ME dipole antenna consists of a vertically oriented quarter wave shorted patch and a horizontal planar dipole, equivalent to a combination of a magnetic dipole and an electric dipole. This antenna has demonstrated good electrical characteristics like identical E-plane and H-plane radiation pattern, low cross polarization, low back lobe radiations and stable gain in the range of operating frequency.

The large size of this antenna, owing to the presence of magnetic dipole, is a matter of concern but it is also observed that the size of the ME dipole can be further reduced [6], and two ME dipole antenna elements can be integrated to form a wideband dual-polarized antenna with excellent electrical characteristics [7].

In the last few years, there have been tremendous increase in the demand for multifunctional antennas and many novel shaped antennas have been proposed in the literature to achieve high level of performance. These diversified antenna systems approaches have received much desired attention in wireless communication sectors. Broadly these diversified antennas have raised the platform for demand and supply in terms of capabilities of wireless communication system [8]. Different categories of diversity antennas include, the spatial diversity antenna, the frequency diversity antenna [9], the polarization diversity antenna [8, 10] and the pattern diversity antenna [11-12]. The pattern diversity antenna and polarization diversity antenna are most commonly used to analyze and compute the effects of multi-path fading and providing compatible solutions in the complex environment [9]. As compared to classical unidirectional antenna systems, the pattern diversity antennas are used to radiate and receive signals through different radiation modes and hence they are capable of providing high effective gain and maintaining the same installation space [11]. Various antenna structures that are offering pattern and polarization diversities for different applications have been proposed in the literature [11-12]. But the major drawback of these available pattern and polarization diversity antennas is that they suffer from narrow overlapped impedance bandwidth of the excitation ports [11] and incomplete pattern diversity modes [12], and hence, their implementation for various applications is limited.

In this thesis, several new classes of ME dipole antennas for various wireless communication applications are proposed, which include- end-fire radiation pattern ME dipole antenna for airborne radar application, an improved UWB ME dipole element with differential feeding structure for Monolithic Microwave Integrated Circuits (MMIC) and Radio Frequency Integrated Circuits (RFIC) applications, an UWB ME dipole antenna with modified ground structure for high gain applications, a novel planar circularly polarized ME dipole antenna for satellite communication and a novel design of ME monopole antenna for UWB applications. All these proposed antennas are based on a structure that is composed of a planar electric dipole antenna and a shorted magnetic dipole antenna, which are excited simultaneously to obtain almost symmetrical E-plane and H-plane radiation patterns, wide