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An Overview of Magneto-Electric Dipole Antenna Feed Design

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Abstract— *In this paper , an overview of various feed design techniques of Magneto- Electric dipole antenna has been analyzed and stated. Also it has been observed that with change in feeding design , the impedance bandwidth also varies. Different feeding pattern can change the impedance bandwidth from 25.5% to 114%, with stable gain and radiation pattern.*

Keywords—Equal E and H plane, impedance bandwidth, feeding structure, magneto-electric dipole radiation pattern

I. INTRODUCTION

With the introduction of portable phones, mobile technologies have been reached to a new era, where antenna design is a crucial parameter to visualize the overall system performance. Now, the researches have been more inclined towards designing of wideband antennas with stable radiation pattern and beamwidth, reconfigurable frequency range and low cost of fabrication for millimeter waves. Dipole antennas have the advantage of having a simple structure but suffer from poor radiation pattern. On the other side patch antennas have low profile but they exhibit narrow bandwidth. Various technique been proposed to increase the bandwidth but radiation pattern and gain vary in undesirable manner over the desired frequency range.

Recently a new wideband "Magneto Electric Dipole Antenna" has been proposed by Prof. K.M.Luk, which is actually originated from the researches made in the designing of complimentary antenna. In basic form this antenna consists of a planar electric dipole and a shorted quarter wave patch antenna and having many desirable features like wide impedance bandwidth , low cross polarization, low back radiation, almost identical radiation pattern in E and H planes and constant gain within the operating frequency range. Beside this, the antenna can have linear, circular or dual polarization. There are primarily 6 active area of research in Magneto Electric Dipole Antenna, which include

a) Feeding structure
b) Wideband Dual polarization
c) Low profile and compactness
d) Unidirectional
e) Circular polarization

The purpose of this paper is to provide an insight into the recent developments that have been made in the theory and design of feeding design of magneto electric dipole antenna.

II. RESEARCH ON FEEDING LINE STRUCTURES

The concept of exciting electric and magnetic dipole simultaneously to produce equal E and H plane radiation pattern was first introduced by Clavin [11] in 1954 and since then many researches have been proposed on said complimentary antenna. A wideband complimentary antenna has been redesignated as Magneto Electric Dipole antenna by K.M.Luk in 2006. This section will give a brief overview of the some of the feed line structures that have been used for the design and development of magneto electric dipole antenna.

2.1 Ґ Shaped Feed

A simple feed line structure was proposed by Bi Qun Wu and K.M.Luk[1] for a dual polarized magneto electric dipole antenna which was excited by two Ґ shaped strips at the operational frequency of 2.45 GHz. As shown in Fig.1 the square shaped upper part of the antenna was acting like an electric dipole and connected to vertically oriented shorted patch antenna. Each Ґ shaped strip feed was having two portions- a transmission line and a coupled line. The transmission line was a linear tapered microstrip line and was located closed to bent vertical wall. The L shaped coupling strip was use for impedance matching. The feeding strip entered into triangular hole of second dipole arm without touching the metal. The SMA connector located under the ground plane was connected to the end of linear tapered line. To enhance the isolation between two ports, two orthogonal Ґ shaped strip feeds were connected at different heights to reduce the coupling effect. The antenna provided more than 36dB isolation and 67% impedance bandwidth with stable radiation pattern.

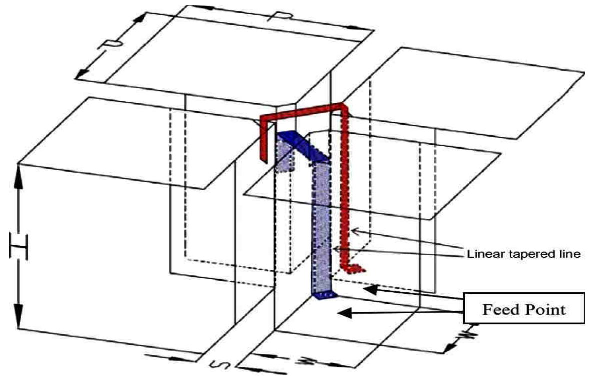

Fig.1. *Geometry of Γ shaped feed*

Z.Y. Zhang et al [2] also proposed a Γ shaped feed and concluded that Γ shaped feed can enhance the impedance bandwidth. The antenna was having two triangular shorted patches, vertically oriented shorted patch, Γ shaped strip, ground plane and SMA connector. The feed structure is same as proposed by Luk et al[1] . The antenna achieved impedance bandwidth of 84% within the operating range of 2.05 GHz -5.05GHz with stable radiation pattern.

2.2 Twin L Shaped differential feed

Luk [3] again introduced the concept of differential feed antenna, which was excited by two out of phase but equal amplitude signals.This differential feed antenna revealed a major advantage in the form of common mode current ellimination and completely elliminated the need of balun. The antenna consisted of magneto electric dipole antenna, a rectangular cavity and differential feed network. Twin L shaped differential feeding structure were built on 5870 substrate having thickness of 0.79mm and relative permittivity 2.33 and the stabilization structure has 1.5mm thickness and relative permittivity 2.65, as shown in Fig.2. The SMA connectors were placed under the ground plane to feed the antenna. The feed line with 50 ohms input impedance transmitted the electrical signal from coaxial launcher to magneto electric dipole and the series high impedance stub on the top side worked as series inductor for impedance matching.The antenna provided an impedance bandwidth of 111.4% and stable radiation pattern.

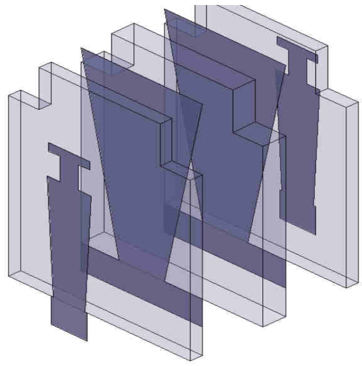

Fig.2 *Geometry of differential feed*

Mingjian Li and Luk [4] achieved impedance bandwidth of 114% for operating range of 2.95 GHz -10.73 GHz with stable radiation pattern using differential feed. The structure of feed was same as proposed above with a rectangular hole penetrated in the middle of upper substrate of the 3 layer feeding structure, as shown in Fig.3.

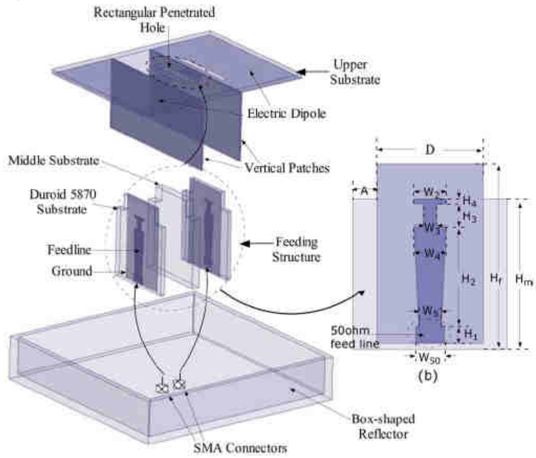

Fig.3. *Geometry of hole penetrated differential feed*

2.3 Stair Shaped Feed

Lei Ge and Luk [5] found that if a stair shaped probe feed was used, the additional need of balun could be elliminated. This stair type feed was having two portions- a transmission line and a coupling line, as indicated by Fig.4. The transmission line was formed by folding a linear metallic strip and acted like an air microstrip line.It was placed normal to ground plane having one end connected to SMA connector beneath the ground plane. L shaped coupling strip was formed by folding a uniform metallic strip. Its horizontal part was responsible for coupling electrical energy to antenna and vertical portion introduced capacitance to compensate the inductance caused by horizontal part. This feeding structure provided an impedance bandwidth of 95.2% and nearly identical E and H plane

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pattern with low cross polarization as well low back radiation.

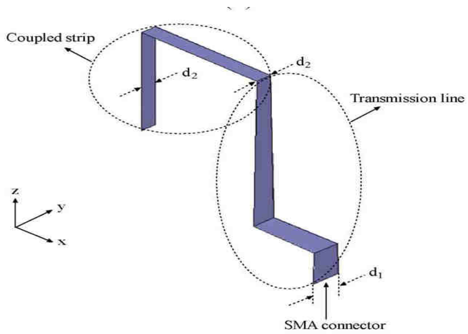

Fig.4. *Geometry of stair shaped feed*

2.4 F Shaped Feed

AN Wen-Xing et al [6] proposed a F shaped feeding strip to provide an impedance bandwidth of 25.5% and 39.5% in the lower and upper bands at both input ports ranged from 0.75 GHz -0.97 GHz and 1.73 GHz -2.59 GHz respectively, as shown in Fig.5. This F shaped strip was placed between the vertically oriented shorted patches of same polarization and it was the combination of two Γ shaped strip at different heights. The transmission portion was placed along the vertically oriented patch with a gap of 1mm and two L shaped stripline was connected to the transmission portion at different heights. The horizontal portion of feed was kept normal to vertically oriented patch and vertical portion was along vertically oriented shorted patch. The length of two portions was so selected that the inductive reactance of first portion was cancelled by capacitive reactance of the second portion.

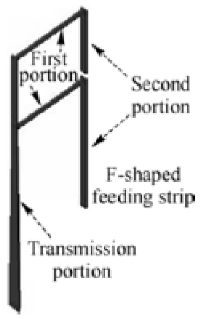

Fig.5. *Geometry of F shaped feed*

2.5 Vertical Parallel Plates and Cross Shaped Horizontal Plate Feed

Shao- Wei Liao et al [7] proposed a much simpler design for differential feed to achieve impedance bandwidth of 92% in 0.80GHz – 2.16GHz frequency range. The feed consisted of two vertical parallel plates and a horizontal plate, as shown in Fig.6.. The vertical parallel plates acted like balanced transmission line to transmit differential signal from coaxial launcher to horizontal portion of feeding structure. The horizontal plate was used to couple the differential signal to radiation structure.

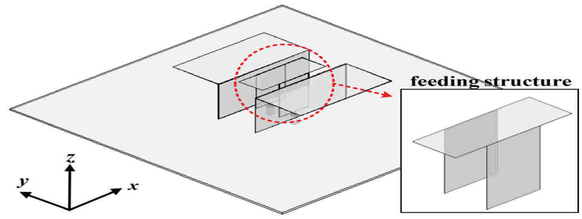

Fig.6. *Geometry of vertical parallel plate and crossed horizontal plate*

Quan Xue et al [8] concluded that if magneto electric dipole antenna is ideally symmetrical, differential port to port isolation will be theoretical infinite and due to differential driven feed, its cross polarization level could be very low. The differential feed consisted of two pair of vertical parallel plated and cross shaped horizontal plate, as shown in Fig.7. Each pair of vertical parallel plates acted like balanced transmission line and cross shaped horizontal plate coupled differential signal to radiation structure. With this feed structure 68% impedance bandwidth had been achieved within the frequency range of 0.95 GHz -1.92 GHz.

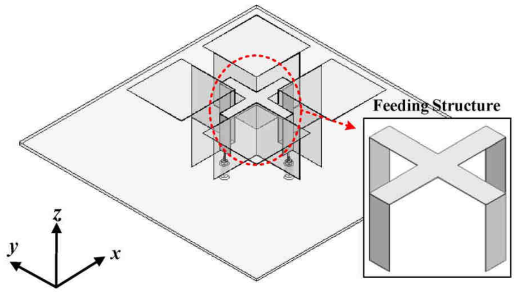

Fig.7 *Geometry of two pair vertical parallel plates and cross shaped horizontal plates*

2.6 Polygon Shaped Feed

Kai He et al [9] proposed a feed, having two parts- a transmission line and a coupling strip which was composed of a horizontal polygonal part and a vertical part, as shown in Fig.8. The transmission line was realized by folding a metallic strip which acted like an air microstrip line with the vertically assembled folded patch as ground plane. One end of transmission line was connected to SMA connector while the other end was connected to coupling strip polygon part. It has been concluded that this novel polygonal structure had been working like inductive reactance to couple electrical energy to the antenna. The vertical part of the coupling strip formed an open circuited transmission line and worked as capacitance to compensate the inductance caused by polygonal structure. This feeding structure had been used to achieve wideband dual band with impedance bandwidth of 72% from 1.48 GH –3.15 GHz

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and 21% from 4.67 GHz – 5.78 GHz with stable and symmetric unidirectional radiation pattern.

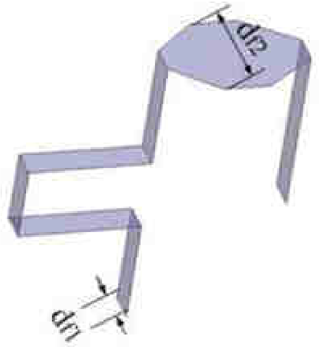

Fig.8. *Geometry of polygonal shaped feed*

2.7 U Shaped Tapered And Meandered T Shaped Feed

Botao Feng et al [10] proposed a composite feeding structure to reduce the size of antenna and to achieve good impedance matching. This feeding line was designed with inverted U shaped tapered and meandered T shaped line as show in Fig.9. This composite feed line helped in achieving better impedance matching along with minimal usage of space.

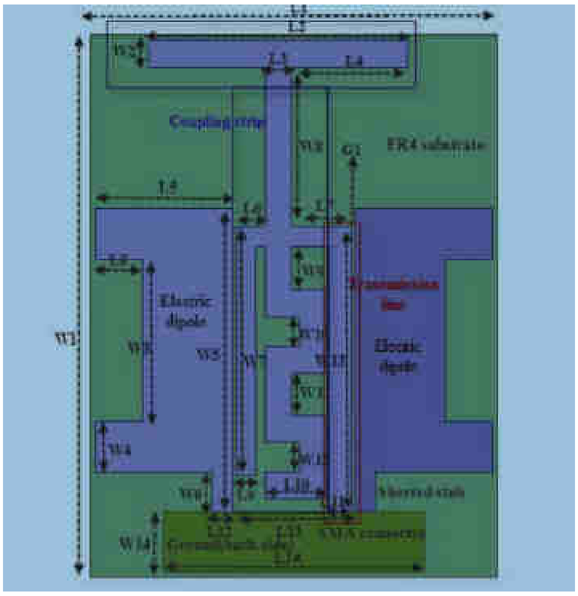

Fig.9. *Geometry of U shape tapered and T shaped meandered feed line*

The feeding structure consisted of two parts-transmission line and a coupling line. The rectangular transmission line was 1mm wider than coupling line and also separated 1mm away from one of the parallel electric dipole patches. This line was vertically placed on the ground plane and the bottom end had been connected to SMA connector underneath ground plane. The coupling strip consisted of inverted L shaped patch and meandering T shaped patch. The horizontal part of inverted L shaped patch had been used to couple electrical energy to antenna and T shaped patch worked together with one of the other vertical patch to compensate for the inductance caused by horizontal part. The antenna was able to achieve impedance bandwidth of 35.8% from 0.78 GHz-1.12 GHz for the lower band and a bandwidth of 50.5% from 1.66 GHz – 2.78 GHz for upper band.

III. CONCLUSION

In this paper, various feed design techniques for magneto-electric dipole antenna has been studied and an overview is presented. Through the various feeding design available in literature, it has been concluded that feed design is an essential criteria to modify the impedance bandwidth of magneto-electric dipole antenna. Moreover an appropriate feed design can lead to stable radiation pattern and stable gain over the operating frequency range. Appropriate design technique can provide high isolation in case of dual polarized antenna.

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