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UWB d-Shaped Antenna With Minimized Dimension For Communications

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Abstract: In this article, implementing an ultra wide band (UWB) d-formed antenna with minimized dimension has been proposed. The proposed antenna is fabricated at a height of 0.8mm from the ground with 1.6GHz bandwidth in measurement, which corresponding to 57.14% practical bandwidth. With designing the d-shaped structures by applying the standard printed planar manufacturing methods, implement the structure with proper number of the unit cells and employing the spiral inductors that perform role of the shunt inductances, the structure size is reduced and as well as the antenna bandwidth, effective aperture, gains and efficiencies have been increased. The antenna size is 15 5 0.8 mm^3 and at the resonance frequency f_r=2.8GHz the measured radiation gain and efficiency are 1.9dBi and 63%, respectively.

Keywords: Ultra wide band (UWB) d-shaped antenna, minimized dimension, transmission lines (TL-s).

1. INTRODUCTION

A printed patch antenna [1-2] is a low-profile antenna consisting of a metal layer over a dielectric substrate and ground plane. Typically, a printed patch antenna is fed by input signal, but other feed lines such as coaxial and microstrip transmission line can be used. The advantages of printed patch antennas are that they radiate with moderately high gain in a direction perpendicular to the substrate and can be fabricated in a low cost printed circuit board (PCB). This paper presents a new concept of designing the printed UWB antenna with minimized dimension.

2. PRESENTING THE DESIRED ANTENNA STRUCTURE

This paper introducing a new and distinct printed d-formed antenna structure based on metamaterialtransmission lines (MTM-TLs). The MTM structuresmay be implemented in different technologies [planar hybrid or MMIC, LTCC, hollow waveguide], in different waveguide or transmission line (TL) configurations [microstrip, coplanar waveguide (CPW), coplanar strip-line (CPS), coaxial, waveguide, etc.], and usingdifferent *LC* elements [printed or chip form; interdigital (ID) or metal-insulator-metal (MIM) capacitors; straight, spiral, meander inductors]. Some typical implementations are shown in Fig.1 [3-4-5].

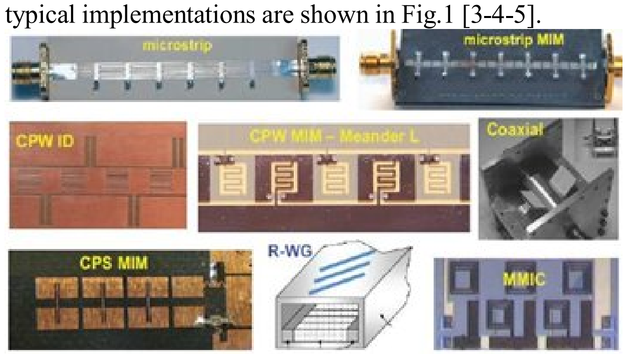
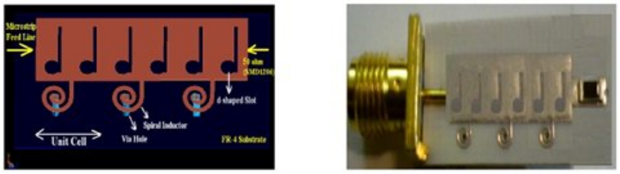


Fig.1. Typical metamaterial structures implementation [5].

The desired antenna is constructed of three d-shaped unit cells based on metamaterial-TLs. Any of unit cellsconsist of a d-formed slot that is printed directly on the patch by standard printed planar fabrication techniquesand act like series capacitance (C_L), spiral inductor that through metallic via hole is connected to the groundplane and perform the role of the shunt inductor (L_L). Two waveguide ports were defined at the left and right ofthe x-axis in order to feeding the structure and calculate the S_{11} parameter. Port 1 is excited by microstrip feed line and port 2 is matched to 50Ω SMD1206 load impedance with size of 4.2mm, which is connected to ground plane through a via hole. This antenna is fabricated on FR-4

(Lossy) substrate with Tanδ=0.001, dielectricconstant =4.6 and height h=0.8mm. The configuration of the proposed antenna is shown in Fig.2



Simulated Prototype Fabricated Prototype.

Fig.2. Configuration of the proposed d-shaped antenna constructed of three unit cells.

As is evident from Fig.2, to designing desired miniature antenna is used of the standard printed planar fabrication technique. This technique is based on implementation the d-shaped slots with small dimensions that are printed directly on a printed circuit board (PCB), so that these printed slots play the role of the seriescapacitors (C_L) and as a result a foot print area reduction of the antenna structure is obtained. As well as, byimplement the spiral inductors with their regulated dimensions, which these inductors have performed the roleof the left handed inductors (L_L) the good performance parameters such as wide bandwidth and suitable radiation properties are provided. The length, width and height of proposed antenna are 15mm, 5mm and 0.8mm and its physical size is 0.1 0.03 0.005 , where is free space wavelength at 2GHz. This antenna covers 1.6GHz bandwidth from 2GHz to 3.6GHz in measurement, which corresponds to 57.14% practical bandwidth. The reflection coefficients (S_{11}<-10dB) of the proposed antenna are exhibited in Fig.3.

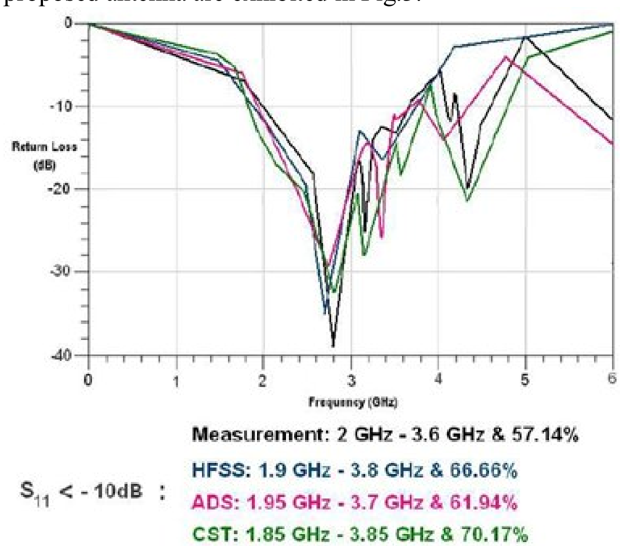


Fig.3. The simulated and measured return losses (S_{11}<-10dB) ofthe proposed d-shaped antenna. It should be emphasized that, the simulation return losses were obtained from High Frequency Structure Simulator (HFSS), Advance Design System (ADS), and CST Microwave Studio softwares.

Moreover antenna dimension and bandwidth, its radiation performances are other important issue in the design process. Therefore, proper radiation characteristics are required properties of the antenna systems. In this structure for reach to this objective, with choice of three composite right/left handed (CRLH) unit cells with optimized dimension, each of which have physical dimension of 0.024 0.03 with length and width of 3.6mm and 5mm, respectively, the effective aperture of the structure has been developed, that leads to increase the radiation properties like radiation gains and efficiencies. The measured radiation gains and efficiencies of the proposed antenna at the frequencies of 2, 2.8 and 3.6 GHz are 0.8dBi and 34%, 1.9dBi and 63%, and 1.5dBi and 55%, respectively. The E-plane and H-plane radiation patterns of the antenna are plotted in Fig.4. As can be concluded from Fig.4, the antenna radiation patterns have unidirectional characteristics.

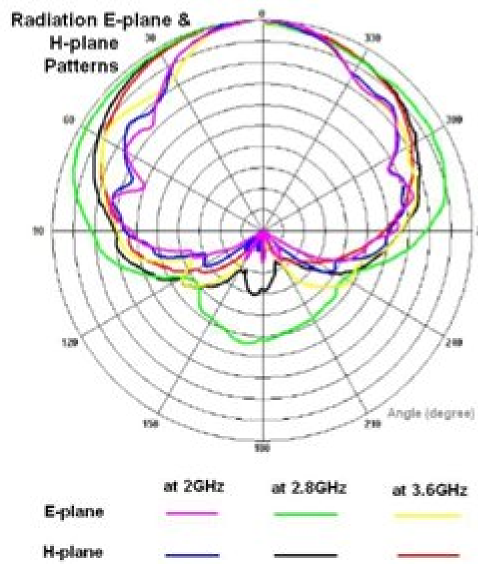


Fig.4. The measured E-plane and H-plane radiation patterns of the proposed antenna.

The equivalent circuit model of the proposed d-formed antenna is displayed in Fig.5.

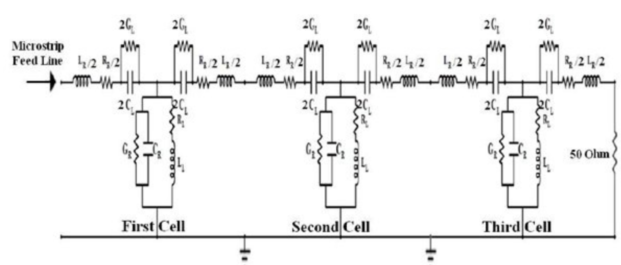


Fig.5. The equivalent circuit model of the d-formed antenna.

As the Fig.5 shows, the right-handed parasitic effects, i.e. unavoidably current flows on the patches and emptyspaces between patches and ground plane are modeled with the series inductance (L_R) and shunt capacitance(C_R). As well as, the resistive elements R and G in this figure represent in general the radiation resistance in the antenna, in addition to the conductor and dielectric losses, respectively. R_R and G_R are right-handed losses and R_L and G_L are left-handed losses. According to the results, the suggested antenna is include advantages of small size, to wit dimension of

15 5 0.8mm^3 or 0.1 0.03 0.005 , ultra wide band performance with 1.6GHz bandwidth from 2GHz to 3.6GHz in measurement, which corresponds to 57.14% practical bandwidth and good radiation properties with gains of 0.8dBi, 1.9dBi and 1.5dBi and radiation efficiencies of 34%, 63% and 55% in measurement, that occur at 2, 2.8 and 3.6 GHz, respectively.

It is noteworthy that, by selection of three CRLH unit cells to form d-shaped structures with minimized sizes, implementing the spiral inductors with regulated dimensions and applying the uniform excitation mechanism a tradeoff between antenna size, bandwidth, gain and efficiency is achieved. The structure unit cells are designed based on standard printed planar fabrication technique, which lead to downsizing, but also with employment of three unit cells the antenna effective aperture is extended. Therefore, with implement the mentioned ways can be realized the desired structure with desirable characteristics.

The results showing that, the proposed UWB d-shaped antenna with minimized dimension based on CRLH MTM-TLs can be used in the integrated systems.

3. CONCLUSIONS AND PROSPECTS

A d-shaped antenna structure with desirable characteristics has been proposed. With making the d-shaped structure by left-handed MTMs and spiral inductors, the antenna parameters such as dimension, gain, efficiency and bandwidth can be improved up to a desired limit, but also practical limitations should be taken care while fabricating the structure by construction standard techniques. The antenna has physical dimension, bandwidth, minimum gain and radiation efficiency of 0.1 $_0$ 0.03 $_0$ 0.005 $_0$,

where $_0$ is free space wavelength at 2GHz, 57.14% practical bandwidth, 0.8dBi and 34% that happen at 2GHz, respectively. The properties of the resultingantenna- including dimension, radiation patterns, gain, efficiency, bandwidth- depend not only on the selection of the number of CRLH unit cells, but also on the choice of the technology, configuration, and LC elements.

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