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Properties and Design of Single Element Meander Line Antenna

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Abstract: This paper describe properties and design of single element meander line antenna. Meander line antenna (MLA) is electrically small antenna.The meander line antenna is slow wave circuit which consists vertical and horizontal lines uniformly space and connected each other. MLA are widely used in applications where less space require. The proposed antenna is designed for USB application. The antenna performance parameters are optimized to achieve wide impedance bandwidth, high gain, VSWR<2 and an omni directional radiation pattern. Moreover, the current distribution and radiation pattern of MLA discussed in this paper.

Keywords: Meander Line; USB; VSWR

I. INTRODUCTION

Now a day's due to rapid changes in wireless communication technologies, there is tremendous increase in data rate and at same time reduction in antenna size and weight is demanded. There are varieties of techniques to reduce the size of micro strip antennas: use of high permittivity substrates [1], shorting pins [2], and meander line. For wireless communications applications such as Wireless Universal serial bus Dongle [3] radio frequency identification tags, Bluetooth headset, Mobile phone Mean dear line antenna is convincing solution. Meander lines find application as slow wave elements in low noise amplifiers such as traveling wave masers, as linear delay lines, or as dispersive delay lines in pulse compression filters [4]. WUSB technology has been developed and adopted in many multimedia devices based on easy plug- and play function. Design point view WUSB should be providing high speed data rate and compact size.

Inserting suitable slots in radiating patch is also a common technique in reducing the dimensions of patch antenna. The slots introduce parasitic capacitances which tend to reduce the resonant frequency of the antenna. Meander line antenna (MLA) is one type of the micro strip antennas. The meander line antenna was proposed by Rashed and Tai for reduce the resonant length [5]. Meandering the patch increases the path over which the surface current flows and that eventually results in lowering of the resonant frequency than the straight wire antenna of same dimensions. The electrical small antenna (ESA) defines as the largest dimension of the antenna is no more than one-tenth of a wavelength [6]. ESA is one step ahead to reduce of size of monopole antenna. Meander antenna is electrically small antenna. Printed MLAs can function as small radiators.

This paper presents properties, parameter consideration and design printed single element meander antennas in the .4GHz-2.7GHz band by providing a good initial geometrical configuration of the antenna. This article has been divided into eight sections. Section II describes in detail properties of meander line. Section III describes meander line antenna design. The structure of proposed antenna discuss in section IV. The results obtained from our proposed antenna are listed in Section V and discussed in section VI. Finally concluding remarks are presented in Section VII.

II. PROPERTIES OF AN MLA

Figure 1.Meander Line Structure

The design of meander line antenna is a set of horizontal and vertical lines. Meander line antenna is one type of the micro strip antennas. Combination of horizontal and vertical lines forms turns. Meander line technology allows designing antennas with a small size and provides wideband performance. In meander line antenna the size of the dipole at given frequency is reduced by a factor that is proportional to the number of turns. The adjacent horizontal segments of the meander line antenna have opposite phase. Number of turns increases efficiency increases. The Resonant frequency of meander line antenna as a function of meander separation and meander spacing. Meander spacing increase resonant frequency decrease. In case of meander line if meander spacing is increase resonant frequency decreases. At the same meander separation increase resonant frequency decreases [7].

A meander antenna is an extension of the basic folded antenna and frequencies much lower than resonances of a single element antenna of equal length. Radiation efficiency of meander line antenna is good as compare to conventional half and quarter wavelength antennas. Antenna size reduction factor

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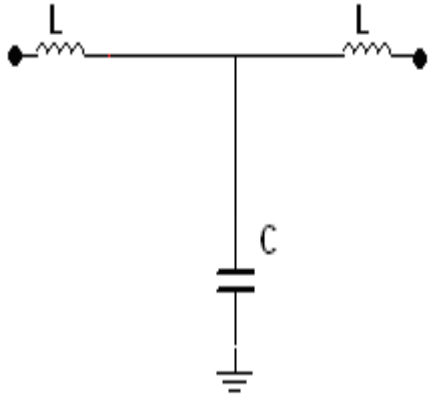
β depends primarily on number of meander elements per wavelength and spacing of element widths of the rectangular loops [8].

The transmission line current neither contributes much to the radiated power nor produce losses. The gain of piano line was larger than that of meander antenna. Planar meander line antenna with added quarter sfera parasitic element at the both side of the meander can produce double beam radiation pattern at frequencies much lower than resonances of a single-element antenna of equal length. Meander Line antenna is composed of crank shaped conductor [9].Equivalent model of meander line antenna is shown in Fig 2. The meander line element consists of vertical and horizontal line so it formed a series of sets of right angled bends. The polarization of antenna depends on radiations from the bend. The spacing between two bends is very vital, where if the bends are too close to each other, then cross coupling will be more, which affects the polarization purity of the resultant radiation pattern. In other case the spacing is limited due to the available array grid space and also the polarization of the radiated field will vary with the spacing between the bends, and the spacing between the micro strip lines [10].

Multilayered meander line polarizers are widely used due to their broadband, low insertion loss, and ease of manufacturing. By loading a meander line structure on to a half wave dipole, the resonant frequency can be decreased. In other words, by incorporating meander lines, the dipole antenna can be designed to have a reasonably small size at a desirable frequency [11].

III. SINGLE ELEMENT MLA DESIGN



Figire.2 Lumped equivalent model of meander antenna

The meander line antenna acts as a resonant LC circuit. The vertical elements act as the inductor, horizontal elements act as capacitor. The horizontal lines lie in the short length of the PCB while the vertical lines are placed along the long length of the PCB. The meander line configuration of the monopole allows reducing the occupied space of the antenna element to less than $0.1\lambda_0$ in each dimension.

IV. STRCUTURE OF AN ANTENNA

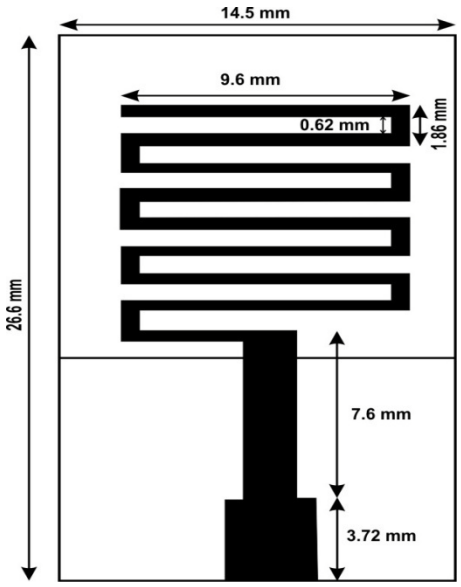


Figure 3. Prposed antenna structure

There is no generally applicable analytic design methodology for meander line antenna. So there is need of computational methods for design optimization.

The MLA is created using meander line and shaped ground as shown in Figure 3; on rectangular FR4 substrate. Height of the substrate is 1.59 mm with relative permittivity 4.4 and ground of size 13.33 mm x 10.04 mm. The total USB dongle PCB area is typically about 14.5mm×26.6 mm where the antenna area. MLA is electrically small antenna so total length of antenna is $\lambda/10$ .Quarter Wave Transformer is used for impedance matching purpose impedance of antenna is 50 ohm. There are total eight turns are present in proposed meander line antenna structure. Ground is back side of the antenna and dimension should be $\lambda/4$ or $\lambda/2$.

The lumped inductance and capacitance are calculated as follows:

Lumped inductance

$$L_A = \frac{Ll}{2}$$

Lumped capacitance

$$C_B = Cl$$

Where L inductance per unit length is, C is capacitance per unit length and l is length of line segment

Total length of antenna is given by

$$N \times S = \lambda/10$$

Where N number of turns, S is spacing between two meander lines. Where d is the monopole wire diameter.

The characteristic impedance of each meander section given as:

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$$Z_o = 276\log\left(\frac{2S}{d}\right)$$

V. RESULT

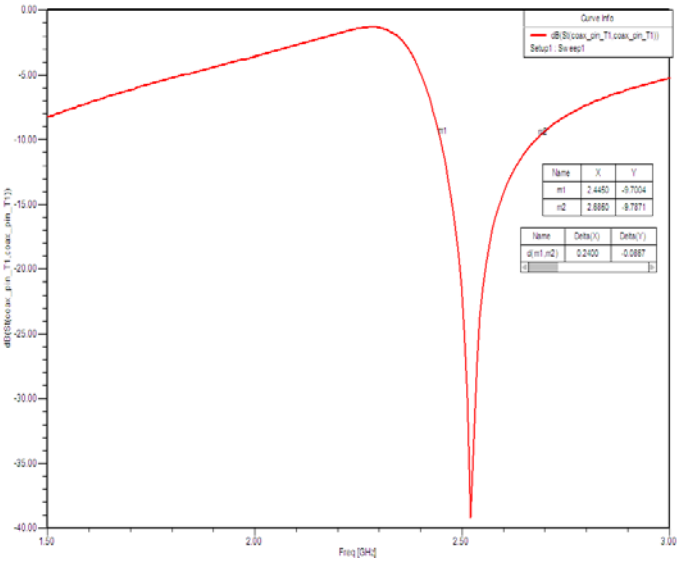


Figure 4. Simulated return loss for proposed MLA antenna

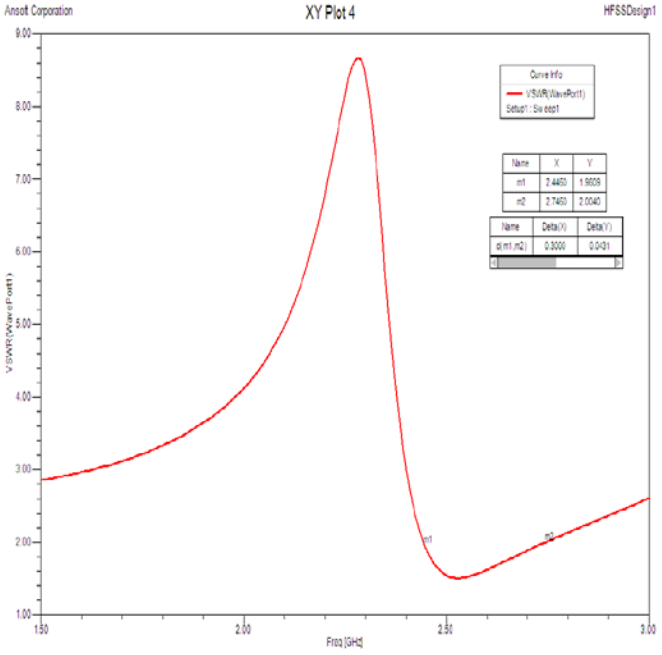


Figure.5 Simulated VSWR for proposed MLA antenna

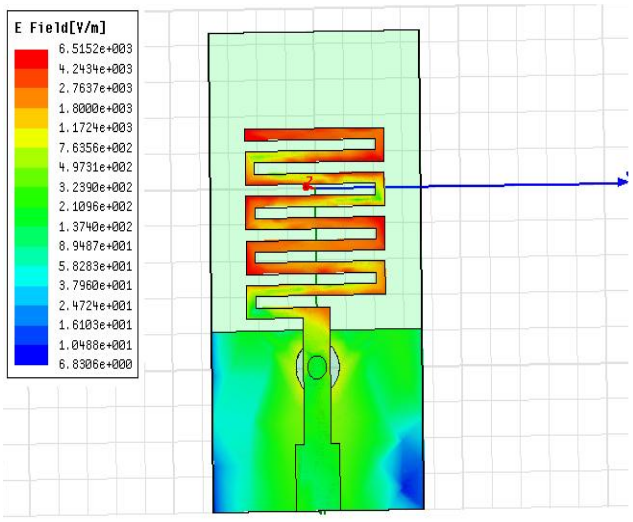
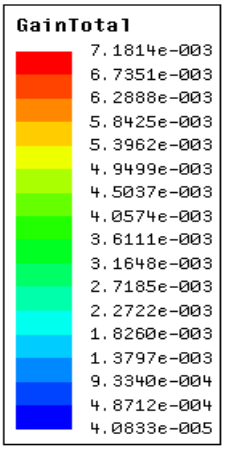
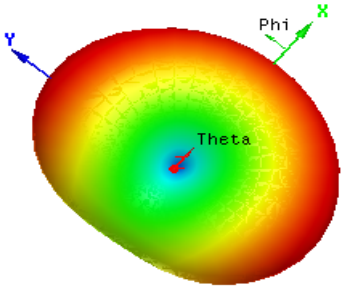
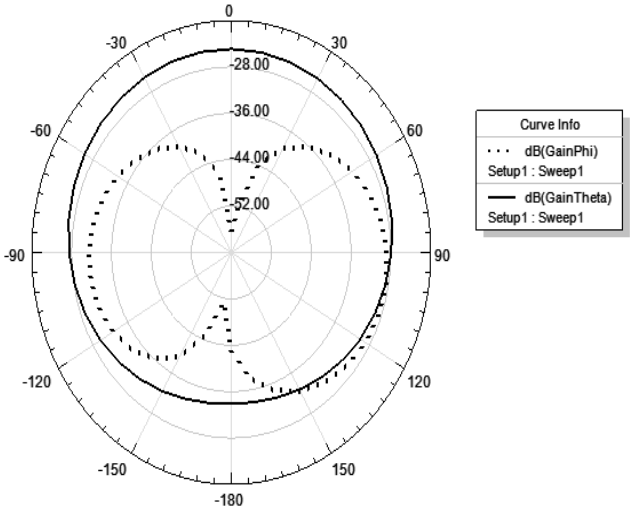


Figure.6 Surface current distribution on MLA at 2.5 GHz





7. (a)



7.(b)

Figure.7(a) and 7(b) Radiation Pattern of Proposed antenna

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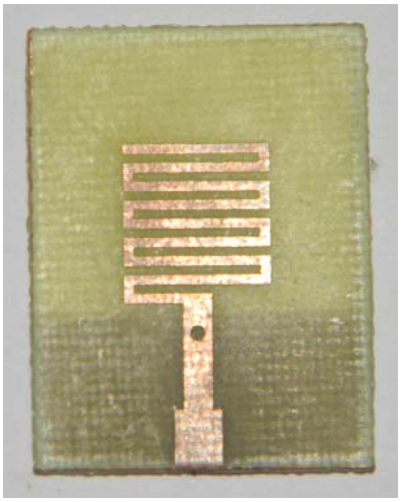

Figure.8 Photo of the fabricated antenna without connector

VI. DISCUSSION

This section discusses the simulated results of MLA. HFSS has been used to simulate the antenna for several performance parameters such as impedance bandwidth, radiation patterns and VSWR. The parametric study of the antennas reveals the band behavior. The antenna is designed to operate on 2.5 GHz. Fig.4 illustrates the S11 of MLA; where it shows a return loss of -39.1 dB for the operation on 2.5 GHz. The impedance bandwidth calculated at -10 dB scale for this band is 240 MHz.Fig.5 illustrates the VSWR of MLA which is less than 2.

The simulated current distribution on the Surface of MLA is presented in Fig.6. In small antennas, the ground plane plays a major part in radiation. A connector position at middle place so that maximum current distribution observed. The current distribution on the ground plane and its effect on the resonant frequencies were also observed during simulation. Omni directional pattern observed in Fig.7 (b)

VII. CONCLUSION

In this work, design of a compact single element planar antenna system was presented. Due to size reduction proposed antenna useful for wireless communication. The antenna system operates in the 2.44GHz - 2.68GHz frequency band with a bandwidth is 240 MHz .Return loss is – 39.1 dB is obtained. The proposed research work is suitable for USB application

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