Reconfigurable Meander Antenna for wireless applications

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Abstract: This paper presents a meander line reconfigurable antenna for dual-band operations. The design is based on the classic meander line principle with a coupled line to accomplish two different radiation modes for Wireless Local Area Network, Direct-to-home-Satellite (DTH) and modern radar system. Essential configuration of these antennas can be achieved by distributing antenna current via electrical switches such as p-i-n diodes and varactors through coupled meander lines. The antenna is printed on FR-epoxy substrate with dielectric constant 4.4 and thickness 1.6 mm. The proposed antenna achieves a better impedance matching in 2-5 GHz frequency bands with bandwidth of 150 MHz.

Keywords: **Varactor-diodes, Substrate, Microstrip Patch Antenna.**

I. Introduction

Microstrip Antennas (MSAs) are broadly utilized in various applications of frequency identification like defense and health checks system [1], thanks to their low profile structure, low-weight and multi-functionality. However the electrical performances of the MSAs experience a variety of drawbacks like low gain and insufficient bandwidth so as to extend bandwidth, various techniques are proposed in [2-4] like defected ground structure, superstrate loading and use of array structure etc. The bandwidth of the antenna is additionally improved by increasing the width of the substrate and reducing the dielectric constant, but these trends are limited by an inductive impedance offset that increase with thickness, the bottom plane and radiating patch in microstrip antenna furthermore assist to extend the bandwidth of antenna. To realize the wideband operation of antenna, it's necessary to scale back the antenna volume. The antenna miniaturization are often done by various effective techniques like shorting pins and meander lines for wideband operations [5]. The meander line has gained significant interest and is preferred over other techniques, thanks to its simplicity, light-weight and low profile integration [6]. Meander Line Antenna (MLA) with reconfigurability is employed to perform the various functions simultaneously. For a transceiver, to hold out the various operations simultaneously, it's found difficult to perform multiple functions within confined volume, the utilization of multiple antennas for various purposes increases the system volume and price . When these antennas are utilized in arrays then spacing are often limited. To resolve this problem, reconfigurability concept is introduced with meander lines which reduces the complexity of multiple antennas by employing a single reconfigurable antenna, and provides same throughput as multiple antennas. The reconfiguration is achieved by altering frequency, polarization and radiation structure. The alteration in electromagnetic field and redistribution of antenna current is achieved by means of the many techniques like p-i-n diodes, varactors and frequency micro-electromechanical system (RF-MEMS) [7]. A frequency reconfigurable antenna with two printed dipole for multi input and multi output by using p-i-n diode has been discussed in [8]. This antenna has facility to vary its characteristics like frequency, polarization and radiation power without extending its hardware structure and it's highly adaptive in multipath environment [9-10]. The efficiency of MLA depends upon the amount of turns of meander line and gap between meander lines [11]. MLA reduces the quantity of radiating component in cable antennas like monopole, folded dipole and dipole type antennas [12]. The resonant length of antenna is reduced by folding wire. MLA with or without conductor are explained in [13] which provides better performance for Bluetooth application with number of meander line turns. A dual-polarization log-periodic MLA for radar system is optimized in [14]. Dual polarization helps to extend the facility of communication system and also minimize the multipath fading of received signal [15]. Microstrip feed is one among the simplest methods to fabricate and modeled [16]. In this paper, a coupled meander line reconfigurable antenna is proposed for dual-band operations in the frequency bands of 2-5 GHz. The reconfigurability of antenna is attained by changing the status of two electrical switches. A truncated patch is used to distribute the current through meander lines. The proposed antenna is numerically analyzed for performance investigation to measure the return loss, radiation pattern and voltage standing wave ratio (VSWR) of the MLA for better impedance matching.

II. Coupled Meander Line Antenna

Meander Line Antenna

The MLA is subset of MSA that attains the reduction in antenna dimensions by implanting the wire composition on non-conducting substrate [17]. The meander line is created by a collection of sequence of right angular bends shown in Figures 1(a) and 1(b) that are useful to decrease the resonant length of the antenna, separation in angled susceptance for resistivity matching is additionally reduced by the angle bends. The fundamental characteristics of antenna are formed by range of right angled bends and therefore the radiation usually happens from the vertical line of the array. The spacing between meander lines permits the antenna to radiate in numerous frequency ranges likewise as provides more coupling that affects the antenna radiation characteristics. After half wavelength or four half wavelength, the direction of current is altered. The scale of meander line produces the specified polarization, when antenna radiate through bends. In different case, the presence of array grid limits the spacing and therefore the polarization of the antenna. As MLA encompasses a disadvantage of low radiation power. The amount of horizontal and vertical lines assists to extend the efficiency and bandwidth of the antenna. Classic meander line, shown in Figure 1(a), is simply ready to perform at single frequency band, and low radiation power. To boost the capability of communication system for various applications and to beat the interferences, coupled meander line concept is projected shown in Figure 1(b) that exhibits dual-band operation with improved bandwidth and effective efficiency for space and DTH applications [18-19]. The operation principle of coupled meander line is same as classic meander line, only distinction in coupled meander lines is that the two lines are coupled along to produce the double band operation with higher performances of communication system.

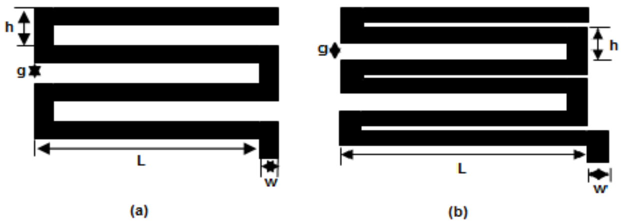

Figure1: (a) Classic meander line, 1(b) Coupled meander line

III. Geometry of Proposed Antenna

The recently introduced antenna design is a continuation of the classic meandering technique. The combined path is recommended for dual band frequency applications. The basic operation of a coupled meander line reconfigurable antenna (CMLRA) is similar to that of a truncated monopole microstrip patch antenna. Implemented in such a way that the overall volume of the antenna remains the same with improved performance. The dimensions shown on this antenna are 0.25 λg × 0.25 λg, where λg is the 76 mm guide wavelength of the antenna. placed at the beginning of both meanders, as shown in Figure 2 (b), at points S1 and S2, allowing the antenna currents to flow through the meanders. Antenna reconfiguration is performed using two switches to change antenna settings.

The antenna is printed on a FR epoxy substrate with a dielectric constant of 4.4 and a thickness of 1.6 mm. The design includes a truncated pole patch and a ground plate printed on the back of the microstrip supply substrate. Equipped with a group of 50 Ohm ports at the edge of the substrate to provide excitation of the antenna. Optimized square wave spacing 0.5 mm to 1 mm. The CMLRA size is given by the following equations:

$$L = 0.1\lambda g$$

$$h = 0.2\ \lambda g$$

$$w = 0.01\ \lambda g$$

where λ_g is the wavelength of meander antenna, L is the length of meander line, h is the length of bend and w is the width of meander line. The substrate height and patch dimensions are found by [19]. The dielectric constant lies between 2.2 to 12. The structure of reference antenna and CMLRA is shown in Figures 2(a) and 2(b) respectively. The geometry of reference antenna and CMLRA are classified in Table 1 and Table 2.

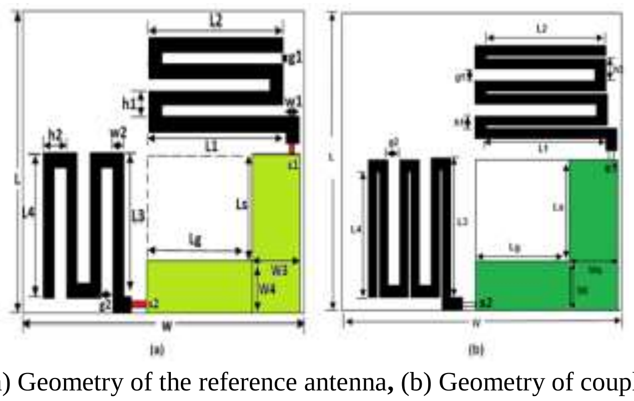

Figure 2: (a) Geometry of the reference antenna, (b) Geometry of coupled MLRA.

Table 1. Geometry of reference antenna [19].

Parameters	Dimensions (mm)
Substrate (L, W)	19
Length of truncated patch (Lg, Ls)	6.75
Width of truncated patch (W3, W4)	3
Length of Meander line (L1, L2, L3, L4)	9
Width of Meander line (W1,W2)	0.8
Gap between Meander line (g1, g2)	1
Height of Meander line (h1, h2)	1.8

Table 2. Geometry of CMLRA.

Parameters	Dimensions (mm)
Substrate (L, W)	19
Length of truncated patch (Lg, Ls)	7
Width of truncated patch (Wl, Ws)	3
Length of Meander line (L1, L3, L2, L4)	8.9, 8.2
Width of Meander line (W1)	0.8
Gap between Meander line (g1, g2)	1
Height of Meander line (h1, h2)	0.7, 1.5

IV. Geometry of Proposed Antenna Results and Discussion

4.1. Reference antenna

In the reference antenna [19], the antenna operates in the 2.42GHz band for Bluetooth and WLAN applications, as shown in Fig. 3, and has a bandwidth of 95 MHz. Antennas operating in the same band with different polarizations in xz and yz can reach a plane and VSWR equal to 2.

To evaluate the comparative performance of the CMLRA and the reference antenna, the developed antenna models were numerically analyzed using a high frequency structure simulator (HFSS) based on the finite element method (FEM) to work with electromagnetic fields in the solution domain. FEM creates a grid throughout the volume of the solution and permits the far electric field throughout that volume. The maximum number of passes is considered 20, and the fault tolerance is 2%. The mesh is adaptively improved with each pass and a complete solution is implemented that meets the convergence criteria.

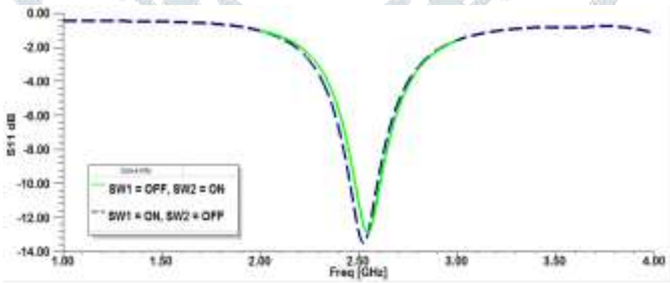

Figure 3: Simulated return loss of reference antenna

P-i-n diodes are used as switches for changing the state of polarization and radiation pattern. Without extending the dimensions, these switches allow the antenna to achieve the different antenna characteristics.

4.1.1. State1**:** In state1, switch S_1 is forward bias and S_2 is reverse bias, and then antenna resonates at frequency 2.52 GHz with return loss of -13 dB. In state1, the antenna changes its 3-D radiation pattern in terms of xz plane and polarization lies along the y-axis with bandwidth 95 MHz as discussed in [19].

4.1.2. State2**:** In state2, switch S_1 is reverse bias and S_2 is forward bias, and then antenna resonates at different frequencies such as 2.54 GHz with return loss of -12.8 dB. In state1, the antenna changes its 3-D radiation pattern in terms of yz plane and polarization lies along the x-axis with bandwidth 100 MHz as discussed in [19].

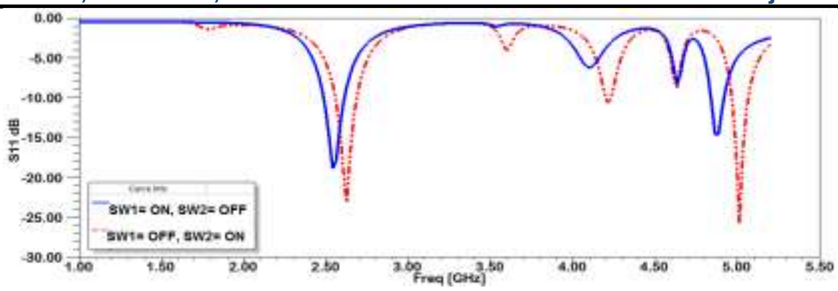

Figure 4: (a) Simulated return loss of coupled MLRA.

4.2.1. State1: In state1, switch S_1 is forward bias and S_2 is reverse bias and then the antenna resonates at two frequencies 2.5 GHz and 4.86 GHz with return loss of -19 dB and -15 dB respectively.

4.2.2. State2: In state 2, minor changes are observed in the resonant frequencies when the switch S_1 is reverse bias and S_2 is forward bias then it resonates at 2.6 GHz and 5 GHz. The antenna exhibits the omni directional radiation pattern in xz and yz plane shown in Figures 4(b) and 4(c) respectively. For both the states S1 and S2, the bandwidth of antenna is 150-100 MHz obtained with better VSWR which shows the better impedance matching of the antenna.

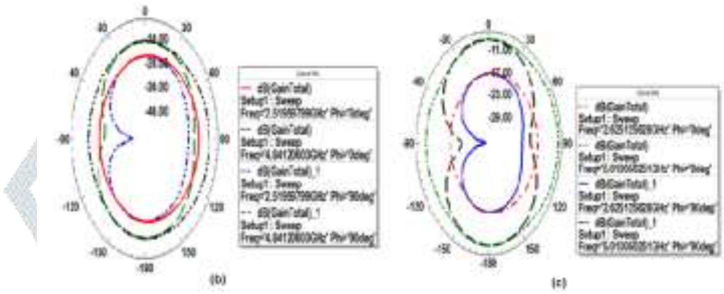

Figure 4: (b) Radiation pattern in xz and yz plane of CMLA in state 1, (c) Radiation pattern in xz and yz plane of CMLA in state2.

CONCLUSION

This paper presents a compact and reconfigurable dual-band antenna. The antenna is made on the basis of FR epoxy with dimensions 19 mm × 19 mm. A modified classical meander with meandering line concept is combined to create two resonances. By varying the distance between paired meanders, the reflection, VSWR and radiation characteristics of the antenna are improved. With a change in the gap between the paired meanders, the operating frequency of the antenna can also change. MLA is suitable for wireless devices such as mobile phones and other communication devices.

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