A BEAM SHAPING RECONFIGURABLE RADIAL LINE SLOT ARRAY (RLSA) ANTENNA

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ABSTRACT

A reconfigurable beam shape radiation pattern microstrip antenna is initiated in this paper. The antenna's radiating surface is designed using a radial line slot array (RLSA) arrangement, which is fed from an aperture coupled structure. This novel feeding structure for an RLSA antenna incorporates PIN diode switches which are integrated with the feed line structure to enable the variety outcomes of the radiation patterns. The circular arrangement of slots at the radiating surface, contributes to the reduction in size of the proposed antenna compared to conventional microstrip antenna that can yield the same antenna gain. The proposed antenna design operates at 2.3 GHz frequency band, and has a maximum gain of 13.8 dB. The proposed antenna has an enormous potential for point-to-point and point-to-multipoint communication and WiMAX application.

Keywords: Reconfigurable Antenna, Radial Line Slot Array Antenna, Beam Shaped Radiation Pattern

1. INTRODUCTION

A lot of efforts have been allocated to enhance the gain of the conventional microstrip antenna [2-3, 5, 9]. For high gain purpose, a radial line slot array (RLSA) antenna design is more beneficial [5]. An RLSA antenna has as much as 50% higher gain than the conventional microstrip antenna [6]. Conventionally, the RLSA antenna has no reconfigurable ability due to its feeding structure which is via coaxial-to-waveguide transition probe. However, it is made realizable by using feed line, PIN diodes and an aperture coupled feeding structure [7-8, 10-12].

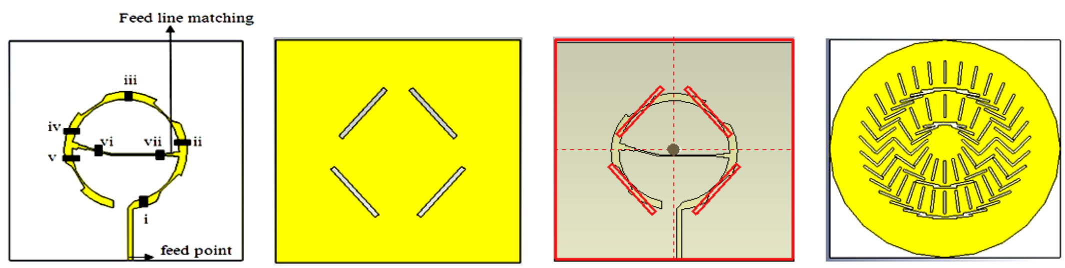
As the proposed antenna is etched from FR4 substrate, it is inexpensive in terms of fabrication. Dimension wise, the proposed antenna length and width are 150 mm and 150 mm respectively, which is smaller than conventional microstrip antenna that could achieve the same function and performance [10]. In [3, 8, 9-13], switching mechanisms are utilized to alter the radiation pattern efficiently. The antenna, proposed in this paper, can be used in a beam shaping for point-to-point and point-to-multipoint communication.

2. ANTENNA STRUCTURE

The proposed antenna structure, as shown in Figure 1, has the ability to exhibit the beam shape radiation pattern. The ‘circular’ and a ‘bridge’ feed line are interconnected by switches, which consists of end-fire beam-shaped reconfigurable switches (EBRS). The EBRS are referring to the first up to the fifth switches as shown in Figure 1(a).

Four aperture slots are used to couple the feeding line to the radiating surface as shown in Figure 1(b). Inaccuracy of alignment between the layer of feed line and aperture slots to the radiating surface can significantly deteriorate the antenna’s performance especially on the gain characteristic.

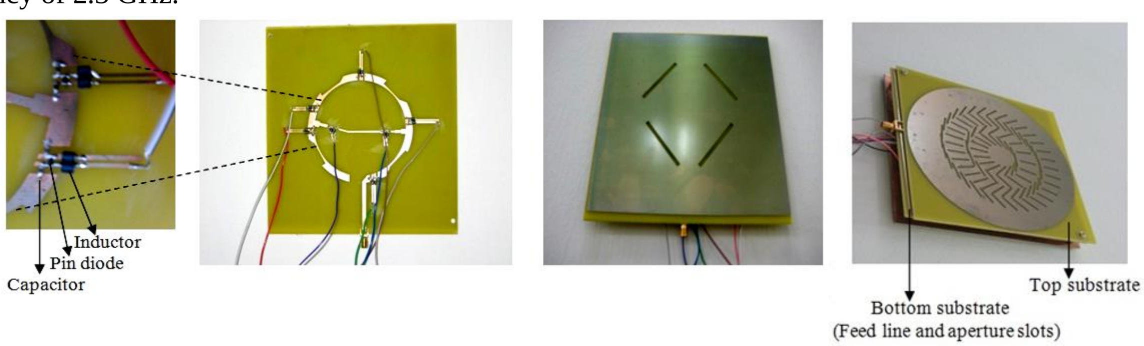
The RLSA pattern that is used as the radiating surface in the proposed antenna has the arrangement as shown in Figure 1(d) in order to provide a linear polarization along the beam direction. There are 96 slots, with 16 slots in the inner-most ring, and 32 slots in the outer-most ring. The width and length of the RLSA slots are 1.5 mm and 15 mm respectively. The gaps between the slots are mostly 8 mm. The diameter of the circular radiating surface is 150 mm.



(a) (b) (c) (d)

Figure 1: Simulation structure of the proposed antenna (a) feed line (b) Aperture slots (c) Alignment of aperture slots and feed line (d) RLSA radiating surface

Figure 2 shows the photographs of the proposed antenna. Each of the PIN diodes is surrounded by two inductors and two capacitors forming the switching circuit as shown in Figure 2(a). The inductors intend to choke off the alternating current (AC) and radio frequency (RF) signals from flowing into the feeding line while the capacitors allow the flow of the AC and block the direct current (DC) simultaneously. The proposed antenna is developed using an aperture coupled configuration where the upper and bottom substrate are made of FR4 dielectric substrates (relative permittivity = 4.7, loss tangent = 0.019). The sizes of the substrates are 150 mm x 150 mm. The proposed antenna is operating at frequency of 2.3 GHz.

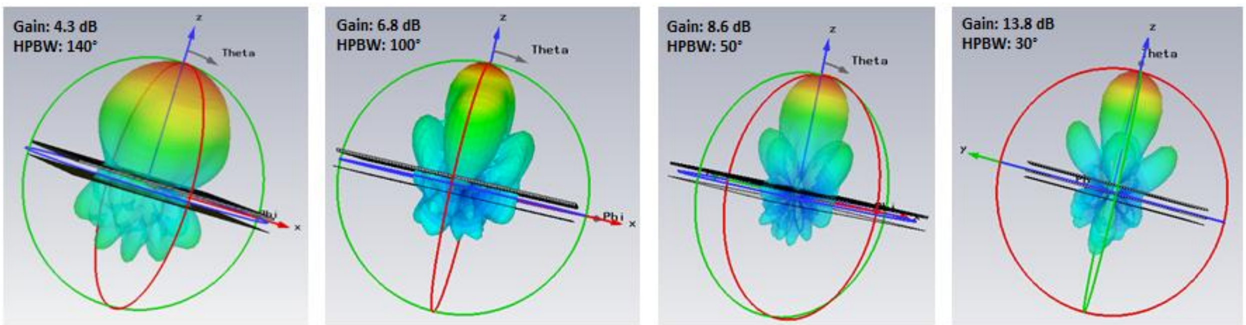


(a) (b) (c)

Figure 2: Photograph of the proposed antenna (a) Feed line with PIN diodes switches (b) Aperture slots (c) Layout view

3. RESULT AND DISCUSSION

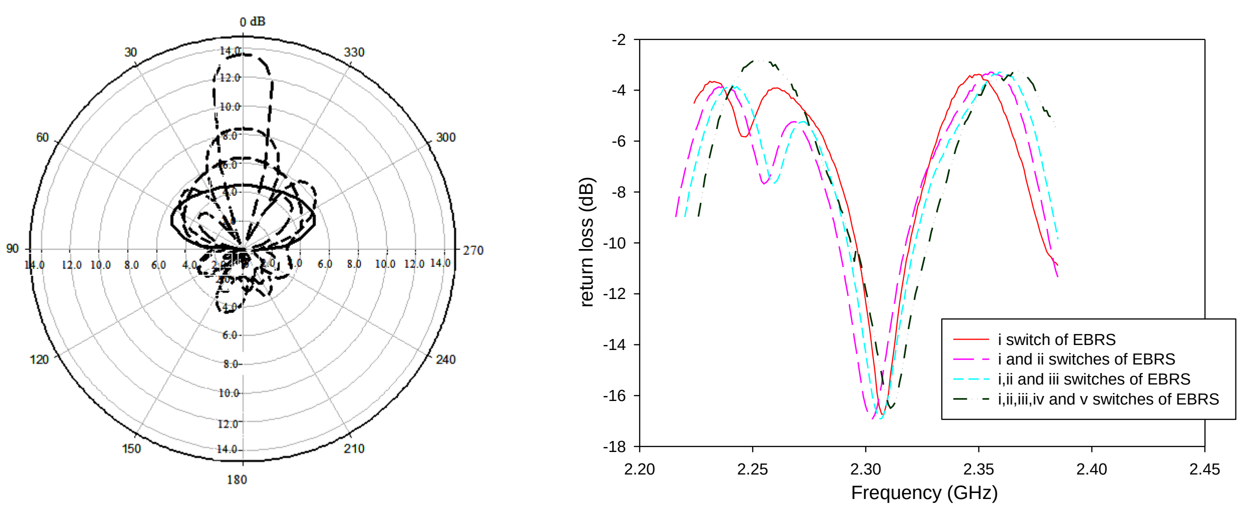
3-D representation of the far field radiation patterns are shown in Figure 3.Simulation shows that four different types of beam shape radiation pattern can be well reconfigured with the configuration of the EBRS. Different activation of EBRS will results in different gain and HPBW. By turning ON the first switch of the EBRS, gain and HPBW of 4.3 dB and -70° to 70° are obtained respectively, as shown in Figure 3(a). While in Figure 3(b), turning ON the first and second switches of the EBRS will narrow the HPBW from -50° to 50° with a gain of 6.8 dB. Figure 3(c) demonstrates the beam shape of the radiation pattern with the HPBW from -25° to 25° and a gain of 8.6 dB by turning ON the first, second and third switch of the EBRS simultaneously.



(a) (b) (c) (d)

Figure 3: 3D-polar plot of beam shape radiation patterns by turning ON the EBRS (a) switch i (b) switches i and ii (c) switches i, ii, and iii (d) switches i, ii, iii, iv and v

In figure 3(d), the HPBW of the radiation pattern is from -15° to 15° and antenna gain of 13.8 dB are obtained when the first until the fifth switches of the EBRS are turned ON. Computer Simulation Technology (CST) Studio Suite 2010 is used as a platform to design and simulate the radiation pattern of the proposed antenna. It is clearly shown that the radiation patterns have the behaviour of beam shaping characteristic where the higher the produced gain, the antenna's HPBW will becomes narrower as shown in Figure 4(a). All the radiation patterns of the proposed antenna are relatively at frequency 2.3 GHz as depicted by Figure 4(b).



(a) (b)

Figure 4: The complete performance of reconfigurable RLSA (a) Beam Shape radiation pattern (b) Return Loss

4. CONCLUSION

A novel reconfigurable radiation pattern microstrip antenna using RLSA is introduced in this paper. The research has taken advantages of the high performances of RLSA in terms of gain and less signals reflection, to make the proposed antenna becomes more efficient. This antenna is designed based on aperture coupled structure. The ability of the beam shape radiation pattern is attributed with the usage of PIN diode switches that integrated in the feed line of the proposed antenna. The capability of the proposed antenna would be greatly suitable for the application such as WiMAX and radar application in future.

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