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Pattern Reconfigurable Printed Yagi-Uda Antenna

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***Abstract* – This paper presents a pattern reconfigurable antenna which is based on Yagi-Uda dipole antenna. The antenna can operate at ISM band of 2.45 GHz. It consists of microstrip-to-coplanar stripline (CPS) transition, driven elements and parasitic elements. The switch of driven element can be controlled by using PIN diodes while parasitic element function can be either reflector or director with different PIN diode states. The maximum of radiation patterns are in azimuth plane with four directions around the antenna to the directions of ∅ = 40°, 120°, 220° and 320°.**

***Index Terms* — pattern reconfigurable antenna, microstrip-to-CPS transition, beam switching, Yagi-Uda antenna.**

I. Introduction

Reconfigurable antennas have played a vital role in improving performance of wireless communications [1]. For the pattern reconfigurable antennas, Yagi-Uda antenna is one of the solutions suitable especially for horizontal polarization [2], [3] with two-beam patterns. A four-beam Yagi-Uda antenna was presented [4] for UHF TV signal reception. The design was based on wire antenna fed by a coaxial transmission line. At high frequency, the design based on a printed antenna is suitable for mass production. This paper presents a four-beam pattern reconfigurable printed Yagi-Uda antenna. It is fed with microstrip-to-CPS transition. With this asymmetrical configuration, the dimension of parasitic elements are not identical as in the case in [4]. Hence they must properly adjusted. This antenna is suitable for being used as elements of MIMO and array antennas.

II. Principle and Design

The antenna design is similar to the one presented in [4] but the feed is through the microstrip-to-CPS transition. When one pair of a dipole is switched to operate, the parasitic elements corresponding to it are used by shorting the RF switches to behave as a reflector. On the other hand, at the other element the RF switches are opened. This element behaves as a director. The other two elements perpendicular to the dipoles are shorted by RF switches. With this operation, the antenna possesses two-beam patterns in forth and back directions. The other two-beam patterns can be obtained when the other pair of dipole is switched and the parasitic elements operate as a reflector and director. Hence, the antenna possesses four beams with main beams are in regions 1, 2, 3, and 4. It should be noted that RF switches are realized by PIN diodes.

To illustrate the operation of the antenna, an FR-4 printed circuit board was used to design at the frequency band of 2.4-2.5GHz. Fig.1 (a) shows the geometry of the printed pattern reconfigurable Yagi–Uda antenna. The length of each parasitic elements are not same i.e., L_2 and L_3. The spacing between the parasitic elements and the driven element are identical in order to reduce the design complexity. For the microstrip-to-CPS transition [5], the structure is shown in Fig.1 (b).

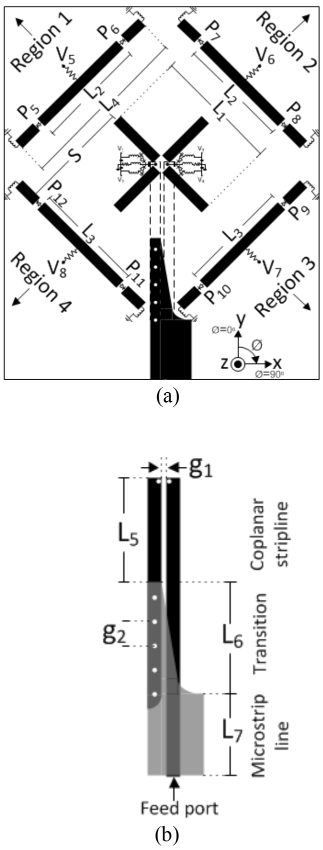


Fig. 1. Geometry of the proposed antenna
(a) Pattern reconfigurable Yagi-Uda antenna.
(b) Microstrip-to-CPS transition.

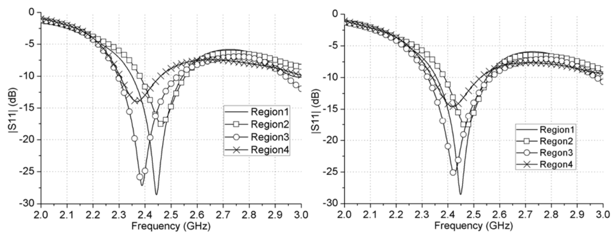
With the above geometry, the dimensions of the antenna and the microstrip-to-CPS transition are varied to obtain four-beam patterns with gain in excess of 4.5 dBi. The length of parasitic elements and separation between driven element and director/reflector were varied to obtain the highest directivity. It was obtained when the length of director and separation between elements are $0.28\lambda_0$ and $0.27\ \lambda_0$, respectively.

TABLE I
DIMENSIONS OF PATTERN RECONFIGURABLE PRINTED YAGI-UDA ANTENNA

Symbol	value (mm) before adjusting dimensions	Value (mm) after adjusting dimensions
Length of driven element (L_1)	37	37
Length of director in region 1 and 2 (L_2)	34.28	34.28
Length of director in region 3 and 4 (L_3)	34.28	25.7
Length of reflector (L_4)	50	50
Length of CPS (L_5)	22.02	22.02
Transition length (L_6)	23.66	23.66
Microstrip line length (L_7)	17.19	17.19
Gap between strips (g_1)	1	1
Distance between metallic PIN on transition (g_2)	5.1	5.1
Separation between parasitic elements and driven element (S)	33	33

III. SIMULATION RESULTS

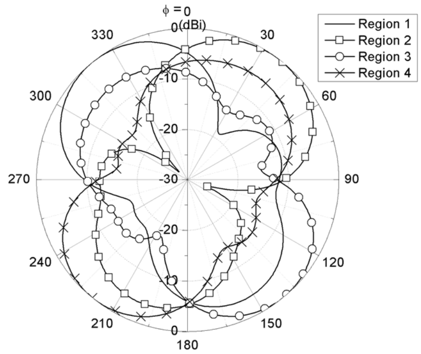
By using the same dimensions of all parasitic elements, the impedance response is at different frequencies because of the effect of microstrip-to-CPS transition. Fig. 2(a) shows the |S11| versus frequency for the different regions. It is obvious that each beam resonances at the different frequency and the antenna cannot respond satisfactorily in the frequency range of 2.4-2.5 GHz. To solve this problem, the length of parasitic elements were varied. The |S11| response of the antenna in each region is depicted in Fig. 2(b). It is relevant that the antenna can cover the specified frequency band with |S11|<-10 dB. The dimensions are listed in Table 1.



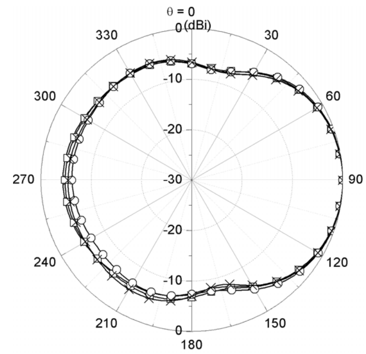
(a) (b)

Fig.2. |S11| versus frequency for different regions.
(a) Before adjusting dimensions
(b) After adjusting dimensions

The azimuth and elevation radiation patterns are shown in Fig.3 (a) and (b), respectively. The four-beam patterns are obtained with half-power beamwidth on 60°. The front-to-back ratio is 5 dB, see Fig.3 (a). The elevation patterns have beamwidth of 90°. The feeding structure affects the radiation patterns as noted in Fig.3 (b). The gain in regions 1, 2, 3, and 4 are 4.57, 4.52, 5.18, and 5 dBi, respectively. The peak of these patterns are in the directions of 320°, 40°, 140°, and 220°, respectively.



(a)



(b)

Fig 3. Simulated radiation patterns at 2.45 GHz.
(a) Azimuth patterns (b) Elevation patterns

IV. CONCLUSION

The pattern reconfigurable Yagi-Uda antenna with four beams has been proposed. The radiation pattern can be reconfigured with PIN diodes. The proposed antenna can operate at the designed frequency. Simulation results illustrate that the antenna possesses gain in excess of 4.5 dBi with reconfigurable pattern. This antenna can be applied as elements of MIMO and array antennas

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