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Asymmetric Coplanar Strip Fed Pattern Reconfigurable Antenna

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ABSTRACT

Asymmetric coplanar strip fed pattern reconfigurable antenna is presented. An asymmetric coplanar strip feed line is introduced for the first time to design a simple pattern reconfigurable antenna. The antenna consists of two arms placed orthogonally on an asymmetric coplanar strip feed line. Omni directional reconfigurable pattern is attained by alternately switching the radiating arms. A prototype of the antenna is developed and tested, the simulated and experimental results are compared and are found to be in good agreement. The antenna is suitable for different wireless applications in the 2.4GHz band.

Key words: Antenna, Asymmetric coplanar strip, pattern reconfigurable antenna, WLAN

INTRODUCTION

Reconfigurable antennas are receiving much attention, because of its ability to tune the characteristics like resonant frequency, pattern, and polarization according to requirement. Recently considerable amount of research have been undertaken to the design of pattern reconfigurable antennas. The pattern should be reconfigurable on the same frequency of operation without adding much complexity in structure. A pattern reconfigurable antenna has the potential to reduce the interference by altering the null positions, to save energy by directing the signal toward intended users, and to provide larger coverage by steering the main beam [1-7]. The possibility to guide the radiation beam's directions electronically using tuneable switching devices adds more flexibility to the antenna [2].

Various designs have been proposed to achieve radiation pattern reconfiguration in literature. Liu et al proposed a square-ring radiating patch and four shorting walls in which antenna can radiate two complementary patterns by controlling the states of PIN diodes [3]. A reconfigurable antenna based on a folded dipole and reflector uses four switches to steer the beam in the desired direction [4]. A parasitic planar patch antenna capable of multi-directional pattern reconfiguration is presented by Jusoh et al [5]. The main driven circular patch is surrounded by several parasitic circular patches, and four pin diode switches are used to short/open the parasitic patches to ground. A reconfigurable microstrip antenna with pattern and polarization selectivity is obtained by using a four-way power divider to feed different radiating elements [6]. A microstrip-fed truncated monopole arranged side by side with a common ground plane achieved the required pattern reconfiguration by alternately activating the monopoles [7]. All the above pattern-reconfigurable antennas are highly complicated with more switching devices. An asymmetric coplanar strip line is used in [8-9] to design compact antennas. Compact size is achieved by virtue of single lateral ground strip instead of twin lateral ground strips in the CPW feed.

In this work, a simple pattern reconfigurable antenna using an asymmetric coplanar strip (ACS) feed is presented for the first time. The antenna consists of two radiating arms which are placed orthogonally on an asymmetric coplanar strip feed line. The proposed antenna operates at 2.4 GHz covering WLAN band. The performances of the antenna such as reflection characteristics, radiation characteristics and gain are also presented.

ANTENNA DESIGN

The geometry of the proposed pattern reconfigurable antenna is shown in Fig. 1. The antenna is printed on a FR4 substrate of relative dielectric constant 4.4 and height h =1.6 mm. A vertically oriented inverted L shaped arm with length L_3+L_4 and a horizontally oriented arm with length L_2 forms the radiating part. Width of arm W_d and ground

W_g are optimized so as to get improved matching. The antenna is excited by an asymmetric coplanar strip [9]. The width W_f and gap G are derived using standard design equation for 50Ω impedance. The two radiating arms are placed orthogonally on the feeding strip. The antenna can be made to radiate at two orthogonal polarizations by exciting either of the radiating arms. Thus the radiation pattern can be switched between *y-z* and *x-z* planes. The optimized parameters are L_1=21 mm, L_2=21 mm, L_3=20 mm, L_4=12 mm, L_g=8 mm, L_x=12.5mm, W_g=6.5mm, W_d =3 mm, W_f=3 mm, G = 0.5mm, h=1.6mm, ε_r= 4.4

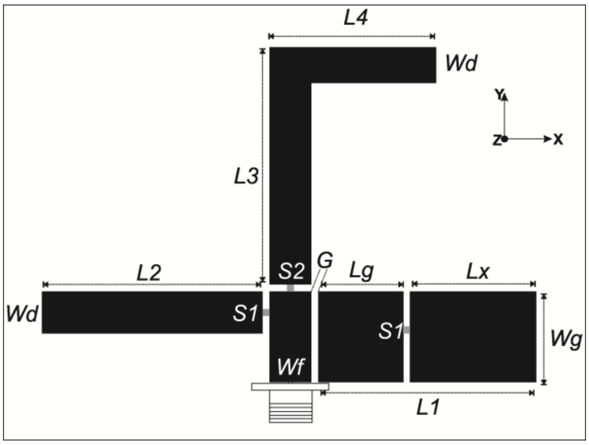


Fig. 1 Geometry of the proposed reconfigurable antenna

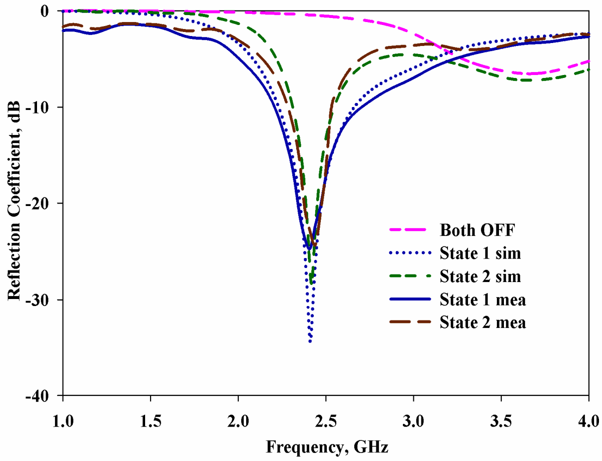


Fig. 2 Simulated and Measured reflection characteristics

The radiation pattern is electronically controlled by using two switches S_1 and S_2 (At present Copper link is used for proof of concept). There are two S1 switches simultaneously operated in order to get the required resonating length for x-polarization. The resonant length L_g+ L_3+L_4 and L_1+L_2 are designed to yield resonance at 2.4 GHz. The optimized dimensions of the proposed pattern reconfigurable antenna are L_1 = 21 mm, L_2 = 21 mm, L_g = 8 mm, L_3=20 mm, L_4= 12 mm.

When the switch S_1 is ON and S_2 is OFF the condition is defined as State 1, and when S_1 is OFF and S_2 is ON the condition is defined as State 2. The simulation studies of the antenna are carried out using Ansoft HFSS [10] and are experimentally validated using Rohde & Schwarz ZVB20 Network Analyzer [11].

RESULTS AND DISCUSSION

A prototype of the designed antenna is fabricated and tested. Fig. 2 shows the simulated and measured reflection coefficients of the antenna in different states. The antenna shows almost similar impedance bandwidth and resonances during state 1 and state 2. The antenna exhibits a 2:1 VSWR bandwidth of 18.5% and 10.5% centred at 2.41 GHz during state 1 and state 2 respectively. This is wide enough to cover the 2.4 GHz IEEE 802.11 WLAN band. It is observed that both simulated and measured reflection characteristics match well.
The surface current distribution and 3-D radiation pattern of the proposed antenna during state 1 and state 2 are shown in Fig. 3 and Fig. 4 respectively. When the antenna is in state 1 a large surface current distribution is observed along the horizontal arm, L_1+L_2 which corresponds to 0.55λg at 2.41 GHz. It is equivalent to a dipole and X axis directed pattern is obtained, which provides equal power along *y-z* plane and a null along *x* axis.

During the state 2 the current dominates along vertical arm and half wave variation can be observed along the length L_g+L_3+L_4. The inverted L resonates like a dipole. The X directed current along the ground plane L_g and the strip L_4 are in opposite direction and are expected to cancel each other in the far field. Thus the current along L_3 dominates and radiates with polarization along Y direction. So state 2 produces a *y*-axis directed pattern, in which the *x-z* plane displays equal power and a null along *y*- axis.

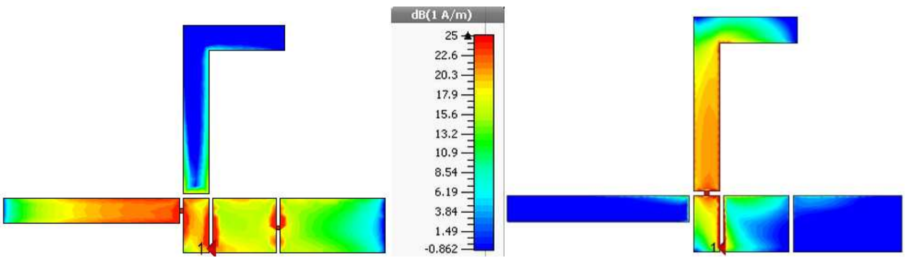
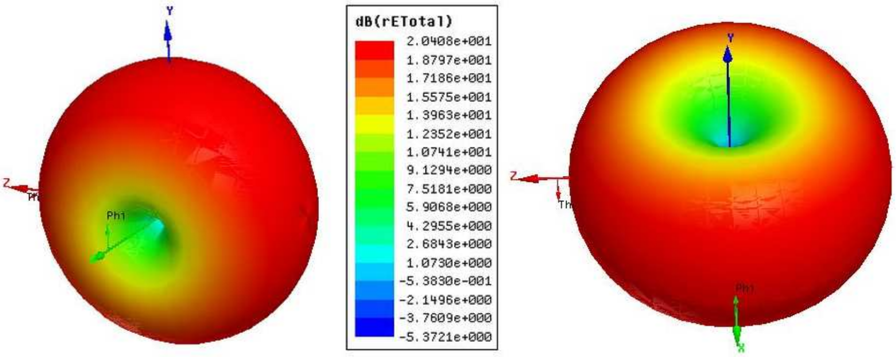


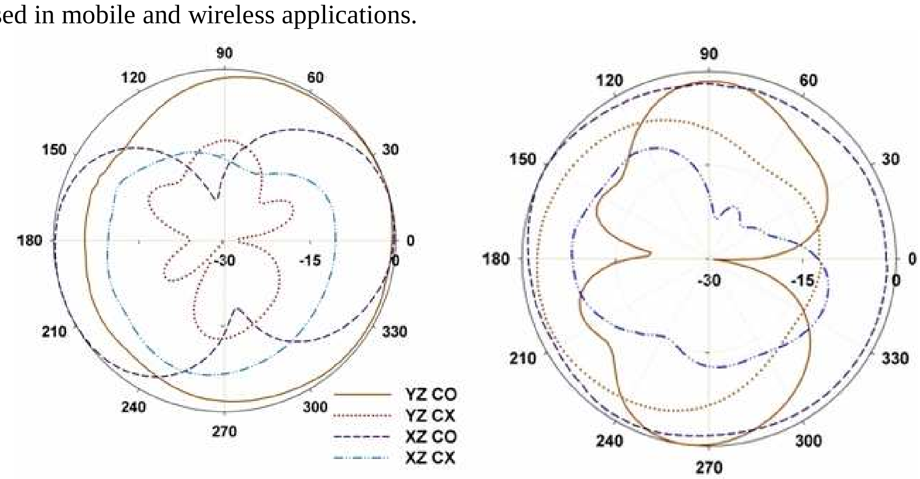
Fig. 3 Surface current distribution a) state 1 b) state 2



a ***b***

Fig. 4 3D radiation pattern a) state 1 b) state 2

The measured radiation pattern and gain of the proposed antenna is given in Fig. 5 and Fig. 6 respectively. Both *x* directed and *y* directed pattern have omni directional pattern. Higher cross polar level in radiation pattern is due to feeble current variation along the L_3 and L_x during state 1 and state 2 respectively. The measured average gain of the antenna obtained in the 2.4 GHz band is 1.6dBi. The discrepancy in measured results can be mostly attributed to the measured environment and the tolerances in the manufacturing process. The proposed pattern reconfigurable antenna can be used in mobile and wireless applications.



a) **b)**

Fig. 5 Measured radiation pattern during a) state 1 b) state 2

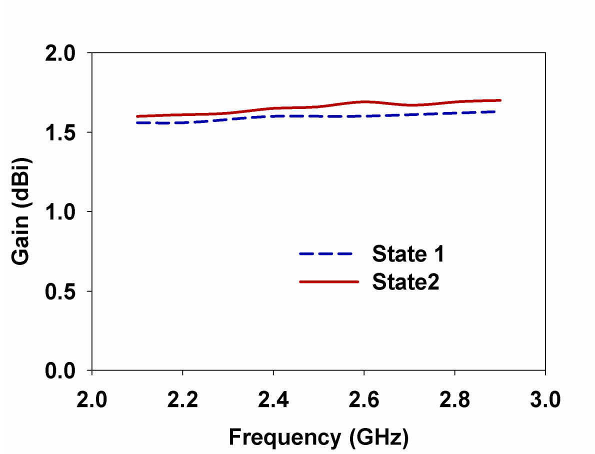


Fig. 6 Measured gain during a) state 1 b) state 2

CONCLUSION

An asymmetric coplanar strip fed pattern reconfigurable antenna is presented. The possibility of ACS feed line for the design of compact uniplanar reconfigurable antenna is explored for the first time. The antenna has two radiating arms which are placed orthogonally on the feeding strip. The radiation pattern is electronically controlled by using two switches S1 and S2. The antenna has simple structure compared to complex geometries in literatures. A prototype of the antenna operating at 2.4GHz is fabricated and analyzed the characteristics at different states. The antenna exhibits good radiation characteristics in the bands of operation suitable for 2.4-GHz band applications.

Acknowledgements
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