A Compact Circular Polarized Slot Antenna for Broadband Applications

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Abstract

A compact simple broadband circular V-shaped slot antenna microstrip antenna is proposed for circular polarization (CP). The Circular polarized patch consist Z type feed line on top of substrate and two right angle V shaped slotted cut on ground plane which is shown in backside of substrate. The multi response is achieved by using stub element in feed line Using stub element The broad CP and impedance bandwidths overlap by the symmetrically etched right angled V-shaped closed slot along the center line and the Z shaped feed line placed in a proper position. The proposed wideband CP antenna exhibits a much wider impedance bandwidth (1.61-4.85 GHz) of about 135.5% (S11 < −10 dB). The broadband CP antenna offers good gain over the entire frequency band of operation for Wireless applications. The proposed antenna possesses a high gain of 5.4 dB with the overall size is 44mm*50*1.6mm2.Proposed CP Broadband antenna covering UMTS, PCS, 2G,3G, WLAN, LTE, and WiMAX band applications.

Keywords: *Slot Antenna, microstrip stub, Broadband, WLAN and Defected ground Structure (DGS).*

I. INTRODUCTION

The circularly polarized (CP) antennas have received much attention since they require no strict orientation between the transmitting and receiving antennas and can mitigate the Faraday rotation effect as well as the multipath interference. The CP antennas can be applied in many wireless systems like RFID, WLAN, WIMAX and GPS [1-2]. The wide bandwidth antenna is very popular for high data rate wireless communication. CP antennas require wide overlapped bandwidth of VSWR/axial ratio (AR) while keeping a compact size. The slot antenna has the advantages of light weight, simple structure, low profile, broad bandwidth, easy impedance matching, and good radiation efficiency. Broad circularly polarized (CP) bandwidth can be achieved by using square slot antenna [3-6]. In [4], the corners of the slot antenna are connected to achieve 35.7% CP bandwidth with a compact size. Owing to the performance and compactness, the open-slot (or monopole slot) antenna attracts much attention. The length of conventional closed-slot antenna is usually half wavelength, however the length of the open-slot antenna is usually about a quarter-wavelength [7-8]. Many works for the CP open-slot antenna have been proposed [9-12]. In [9], an L-shaped open-slot antenna with CP has been first presented to operate at the GPS band of 1.57 GHz. In [11], the L-shaped open-slot achieves a wide CP bandwidth of 64% by introducing two rotated parasitic patches. In [10], a microstrip-fed open-slot antenna with a bent feeding structure and three slots achieves dual-band circularly polarization. A stair-shaped dielectric resonator and an open-ended slot ground are introduced for -10 dB return loss and 3-dB AR bandwidths of 71.7% (3.84-8.15 GHz) and 46% (4.15-6.63 GHz), respectively [11].
In this paper, a compact broadband CP microstrip patch antenna is designed, optimized and simulated. The proposed CP antenna covers frequency bands of 1.61-4.85GHz. Proposed CP Broadband antenna covering PCS, UTMS, 2G, 3G, LTE, WLAN and WiMAX band applications.

2. Circular Polarized Antennas

Circular polarization (CP) is usually a result of orthogonally fed signal input. When two signals of equal amplitude but 90 deg phase shifted the resulting wave is circularly polarized. Circular polarization can result in Left hand circularly polarized (LHCP) where the wave is rotating anticlockwise, or Right hand circularly polarized (RHCP) which denotes a clockwise rotation. The main advantage of using CP is that regardless of receiver orientation, it will always receive a component of the signal. This is due to the resulting wave having an angular variation.

3. Authors' Contributions

3.1 Design and Structure of Antenna Systems

The proposed circular polarized antenna structure is shown in Fig. 1. The proposed antenna has been design on FR4 substrate with size 40mmx50x1.6 mm3, relative permittivity of 4.4 and loss tangent 0.002. The design has been using high frequency structure simulator (HFSS), and the optimized geometry dimensions are in Table I. The proposed broadband CP antenna is composed of a Z-shaped feed line with a stub and a patch symmetrically etched two right-angled V- shaped slots (an open slot and a closed slot) along the center line. The Z-shaped feeding line is located at a proper position of the archived for CP excitation.

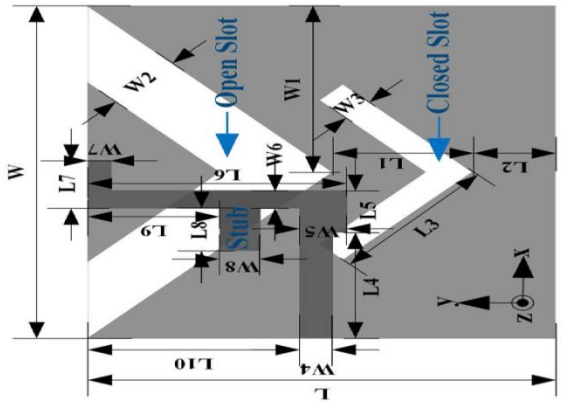
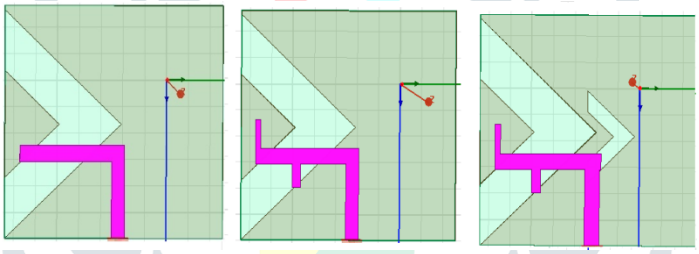


FIG. 1 - Geometry of Proposed CP Antenna

3.2 Performance Evaluation of Antenna Systems



(a) Antenna-1 (b) Antenna-2 (c) Antenna-3(proposed)

FIG.2- Antenna evolution from Antenna-1 (a) to Antenna-3 (c).

The Antenna Evolution of improving the developed antenna are in Fig. 2 from Antenna-1 to Antenna-3. Antenna-1: Patch etched a right- angled V-shaped open slot + Z-shaped feeding line. Antenna-2: Patch with etched a right-angled V-shaped open slot + (Z- shaped + stub) feeding line. Antenna-3: Patch etched right- angled V-shaped slots (Z-shaped + stub) feeding line.

3.3 Result and Discussion

The proposed Circular polarized (CP) slotted antenna has simulated and optimized using HFSS software

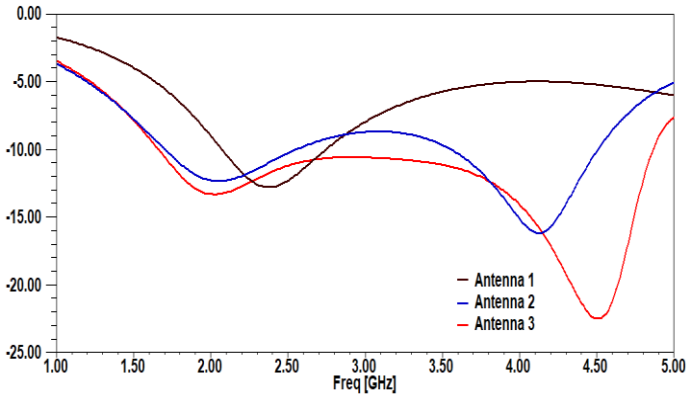


FIG.3- Simulated return loss for Antenna-1, 2, and 3.

The simulated return loss for Antenna-1, 2 and 3 are shown in Fig. 3. For Antenna-1: The total length of the open slot is 26 mm about half wavelength of 2.4 GHz, only one resonance at 2.45 GHz is excited. For Antenna-2: After the stub is introduced, two impedance bands at 2.2 GHz and 4.1 GHz are formed, as can be seen in Fig. 3 a. For Antenna-3: A symmetrical right-angled V-shaped closed slot is introduced, and the length is about 33 mm about half wavelength of 2.3GHz. Then broadband impedance bandwidth from 1.6 to 4.8 GHz is obtained. The etched closed slot introduces a perturbation for the orthogonal electric fields along the diagonals of the patch. The length of closed slot L3 is swept to achieve a 90 degree difference between the orthogonal electric fields. Finally, CP radiation is excited in whole band.

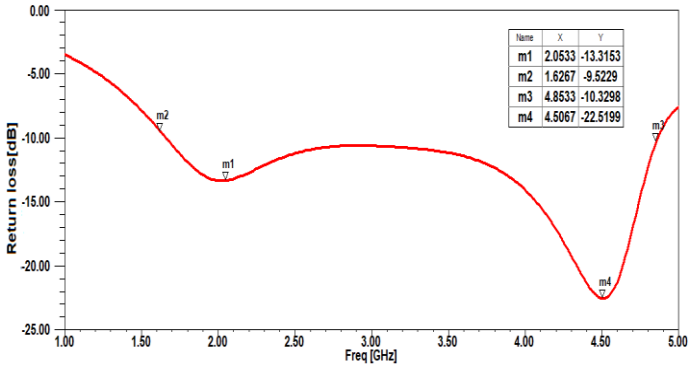


FIG. 4 – Return loss of the Proposed CP antenna

As shown in fig 4 the value of Return loss of proposed antenna is -13.31dB at 2.0GHz. The proposed antenna exhibits a wide impedance bandwidth about 3240MHz with 131.3%.

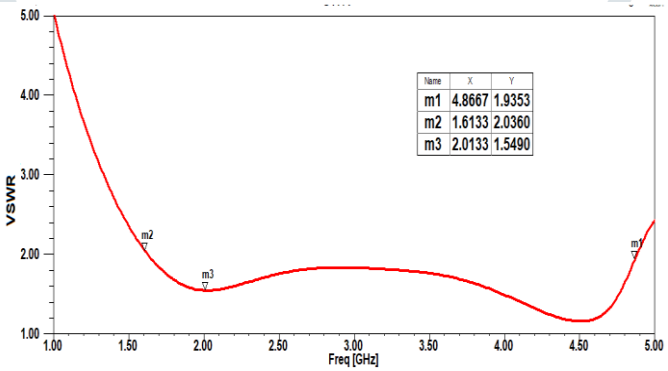


FIG. 5 – VSWR of the Proposed CP antenna

Fig.5 shows, VSWR vs. frequency plot, it is found that the VSWR is 1:2 at wide frequency band from 1.6-4.8GHz

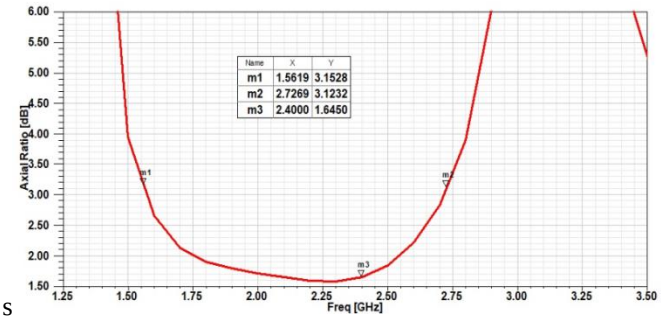


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FIG. 6 – Axial Ratio of the Proposed CP antenna

Fig.6 shows Axial Ratio bandwidth of proposed antenna ARBW of 45% (1.56 –2.72 GHz)

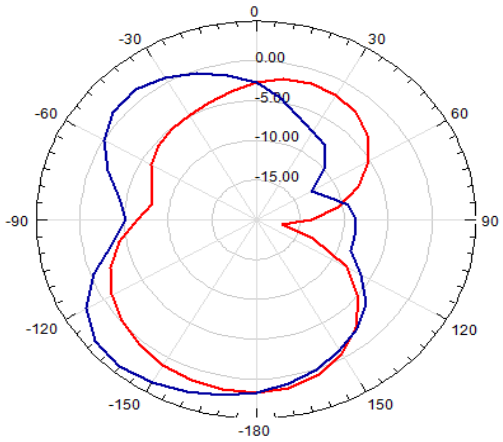

FIG 7- Radiation Pattern of the Proposed CP antenna

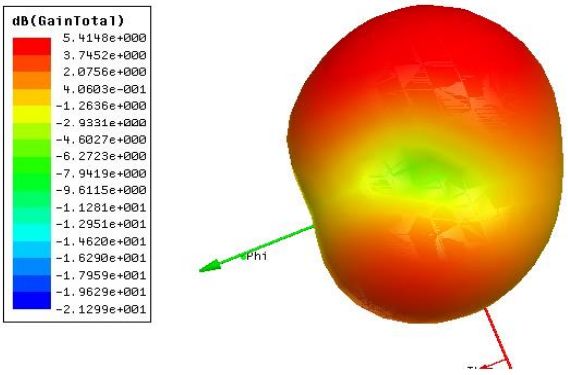

FIG 8- Axial Ratio of the Proposed CP antenna

The simulated gain of the antenna at 2.45 GHz is presented in Fig 8.The maximum gain is 5.4 dB at 2.45 GHz.

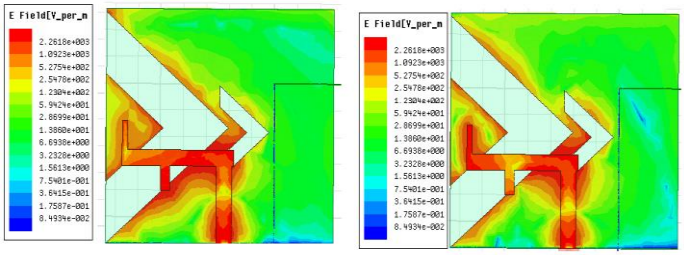

FIG.9- Surface current distributions at (a) 2.4GHz and (b) 3.5 GHz

The current distribution of the antenna at 2.4 GHz & 3.5GHz is presented in Fig 9. it has been seen that the magnetic current at the middle gap and the electric current on the stub section of the Z feed is crucial for resonance and Red colurs indicates maximum current along the edge of Z feed patch.

4. Conclusions and Perspectives

In this paper, broadband CP right-angled V-shaped slot antenna has been proposed. The proposed antenna is composed of a Z-shaped feedline with a stub, a patch and symmetrically etched two right-angled V-shaped slots (an open slot and a closed slot) along the center line. The conventional characteristics of antennas like impedance matching, radiation patterns and gain to evaluate their performance as well as specific characteristics like Axial Ratio, Impedance Bandwidth and gain have been presented. The designed antenna systems work efficiently in the band of 1.61-4.85 GHz. Furthermore, these are compact, planar and low-cost. These antenna systems can be employed in handheld wireless devices. Further applications could be medical imaging and localization.

Future work includes the development of prototypes of these systems and to justify the simulations with measurements. Also, more detailed study is required on the characterization of antennas in terms of capacity evaluation. A study on how to feed these systems is also remaining.

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