A Circular Polarized V-Shaped Slot Antenna for Broadband Applications

Ms. Pooja Thorat
Department of Electronics and Telecommunication Engineering
Amrutvahini College of Engineering, Sangamner
Maharashtra, India

Mr. M. B. Kadu
Department of Electronics and Telecommunication Engineering
Amrutvahini College of Engineering, Sangamner
Maharashtra, India

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 gnd 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 Zshaped feedline 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 UTMS, PCS, 2G,3G, WLAN, LTE, and WiMAX band applications.

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

I. INTRODUCTION

When the cell phones were first introduced in the early days, they were large in size and had very limited service areas. Cell phones had very large antennas that have to be pulled out before making a phone call. Cell phone antenna may seem like a fairly harmless issue but it is not so. Only when the antennas are more efficient, less power is consumed by the devices. This is possible only when the size of the antenna is very small. The use of enabling technologies in recent years have brought a sporadic development to the wireless and satellite communications in the radar system, terrestrial cellular, and mobile satellite services.

Nowadays, the circularly polarized antennas have received much attention since they require no strict orientation between 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 such as GPS, RFID, WLAN and WIMAX [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 simple structure, low profile, light weight, easy impedance matching, broad bandwidth, and good radiation efficiency. Broad CP bandwidth can be achieved by utilizing 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 [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.

II. ANTENNA DESIGN

A. Antenna Configuration

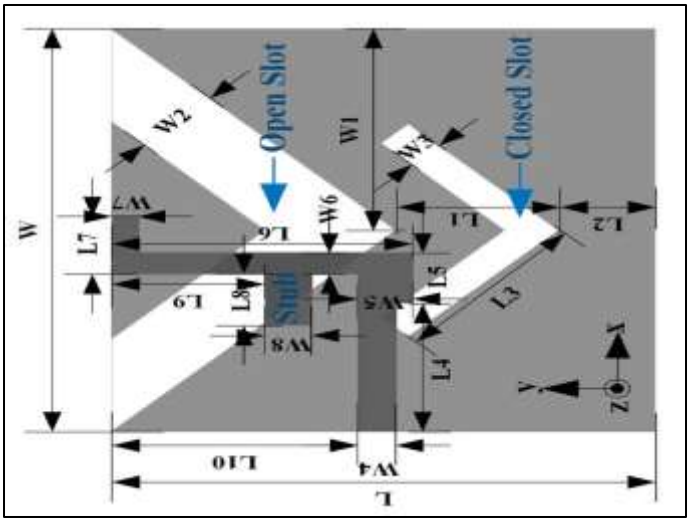


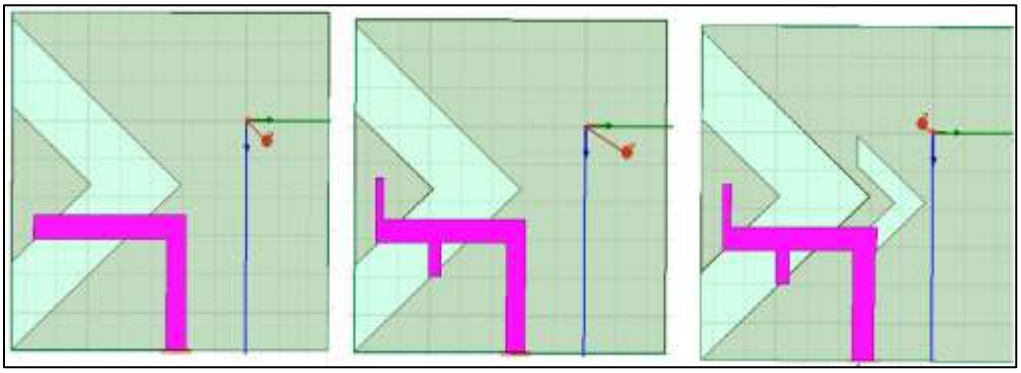
Fig. 1: Geometry of Proposed CP Antenna

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.

Table – 1
Optimized Antenna Parameter dimensions (mm)

L	*W*	*H*	*L1*	*L2*	*L3*	*L4*	*L5*
50	*44*	*1.6*	*7.8*	*14.2*	*10.8*	*16.0*	*0.4*
L6	*L7*	*L8*	*L9*	*L10*	*W1*	*W2*	*W3*
24.5	*8.5*	*8.5*	*12.0*	*24.2*	*26.5*	*7.2*	*2.5*
W4	*W5*	*W6*	*W7*	*W8*			
3.4	*3.8*	*3.0*	*1.2*	*2.0*			

B. Design Process



(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.

III. RESULTS AND DISCUSSIONS

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

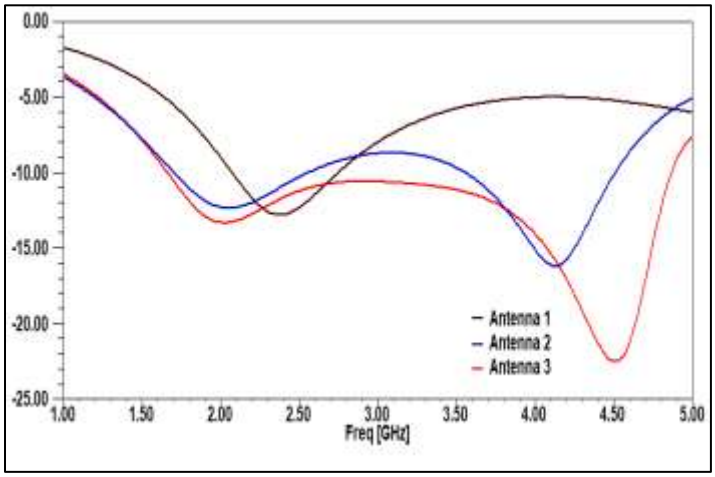


Fig. 3: Simulated return loss for Antenna-1, 2, and 3.

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 are 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.

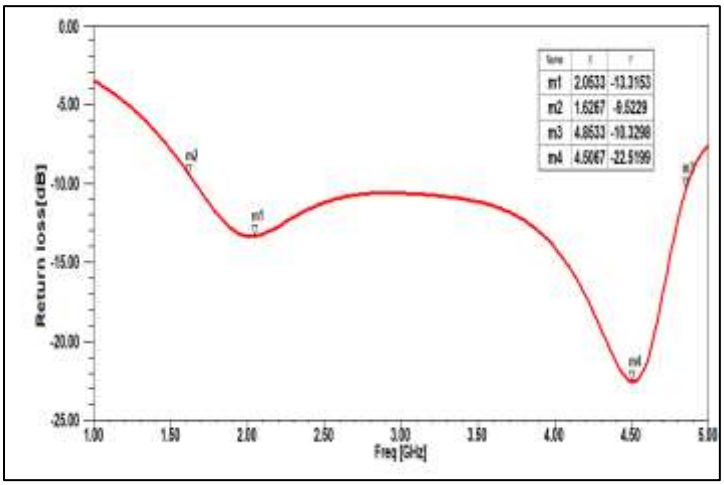


Fig. 4: Return loss of the Proposed CP antenna

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%.

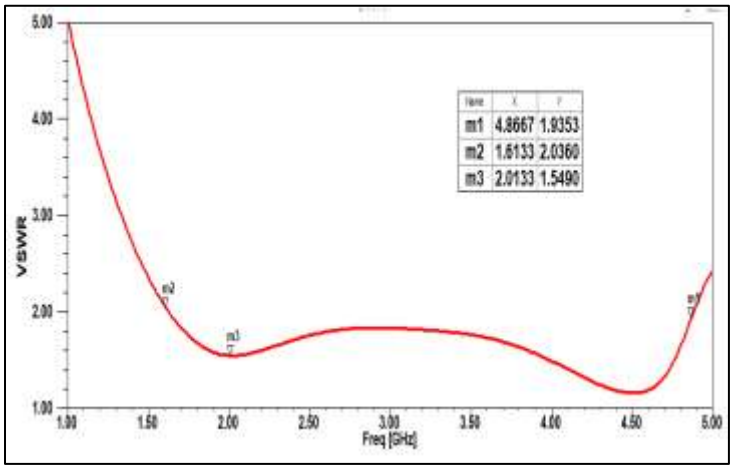


Fig. 5: VSWR of the Proposed CP antenna

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

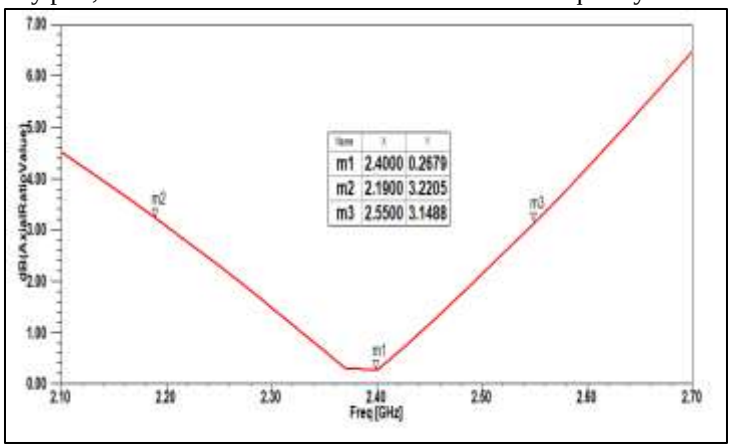


Fig. 6: Axial Ratio of the Proposed CP antenna

Fig.6 shows Axial Ratio bandwidth of proposed antenna ARBW of 15.63% (2.19 –2.55 GHz)

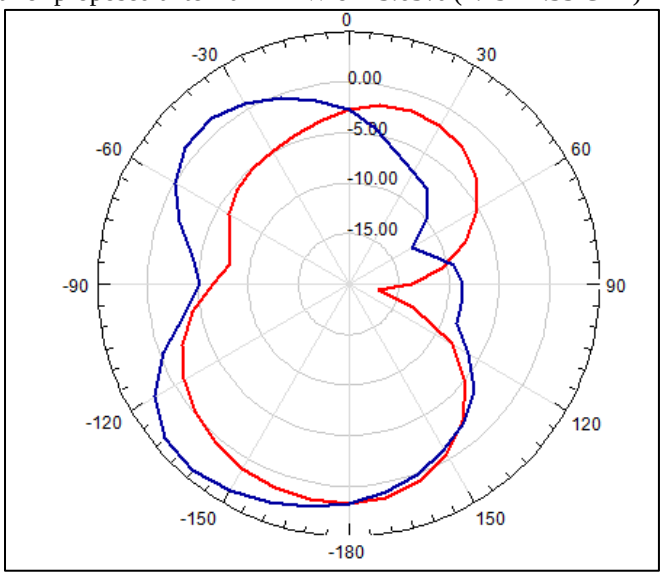


Fig. 7: Radiation Pattern of the Proposed CP antenna

Fig.7 it is observed that the radiation patterns of antenna.

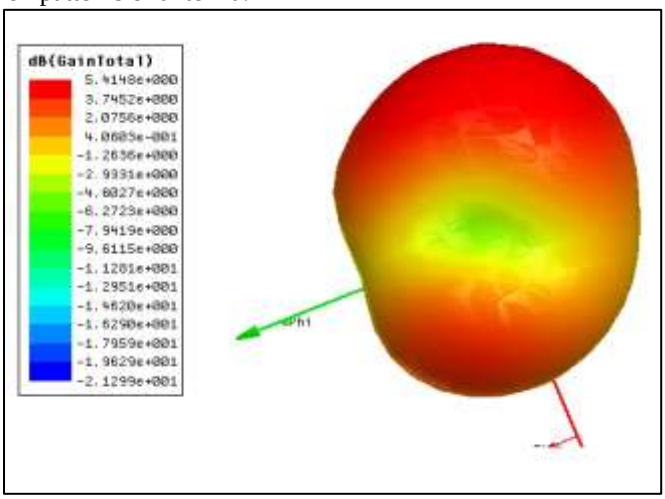


Fig. 8: Axial Ratio of the Proposed CP antenna

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.

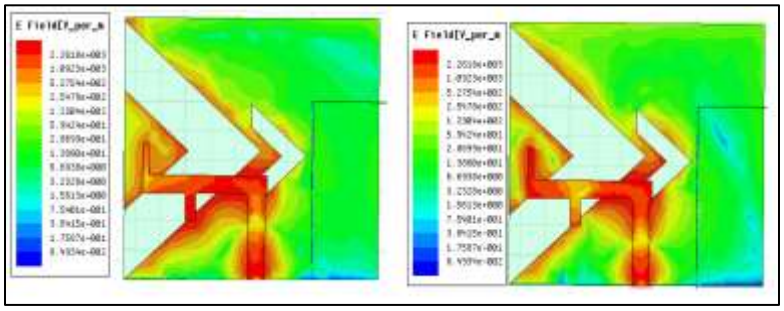


Fig. 9: Surface current distributions at (a) 2.4GHz and (b) 3.5 GHz

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.

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IV. COMPARISON TABLE

To improve the performance of this antenna, Stub element and V shaped slot is added in antenna geometry is introduced.

Table – 2
Comparison table of iterations

Sr.no.	*Type of MSA*	*Freq (GHz)*	*Return loss(dB)*	*VSWR*	*BW (MHz)*	*Axial ratio (dB)*	*Gain (dB)*
1.	*CP Antenna1*	*2.0-2.7*	*-12.78*	*1.59*	*700*	*1.63*	*2.4*
2.	*CP Antenna2*	*1.6-2.7*	*-12.37*	*1.63*	*1100*	*0.87*	*3.6*
3.	*CP Proposed Antenna3*	*1.6-4.8*	*-13.32*	*1.54*	*3200*	*0.26*	*5.4*

V. CONCLUSION

In this paper, a simple broadband CP right-angled V-shaped slot antenna has been proposed. The antenna is composed of a Z-shaped feedline with a stub, a patch and symmetrically etched two right-angled V-shaped slots along the center line. After introducing the stub in the Z-shaped feeding line, multi-resonances are obtained, and broad impedance bandwidth is achieved. The proposed broadband circular polarized antenna exhibits wide impedance bandwidth of 135.5% which obtained by the stub element in Z feed line placed in a proper position and the symmetrically etched right-angled V-shaped closed slot along the center line. The proposed CP antenna covers frequency bands of 1.61-4.85GHz. The CP Broadband antenna covering UTMS, PCS, 2G, 3G, WLAN, LTE and WiMAX band applications.

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