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Comparative Study Of Circular Polarization – Slit Microstrip Antenna

Ms. Shinde V. S.
P. G. Student
VPCOE, Baramati,
Pune University.

Mrs. Shastri A. R.
Asst. Professor
VPCOE, Baramati,
Pune University.

Mr. Deshmukh V. U
Asst. Professor
VPCOE, Baramati,
Pune University.

Abstract

Four microstrip patch of Coaxial-feed circular polarized antennas with four-slits microstrip antennas are proposed and studied .By cutting slits in diagonal directions onto the rectangular microstrip patch antennas are realized for circularly polarized radiation with compact antenna size. The performances of the proposed antennas with several slit shapes onto the patch radiators are compared. Four patch designs with one hexagonal, one triangle, one circle and one square are experimentally studied. Good CP performances of the proposed antennas are achieved.. The proposed slit configurations are useful for compact circularly polarized microstrip patch antenna design.

1. Introduction

One of the advantages of microstrip patches over conventional antenna is their small size. However, there are many present day applications where even these small radiators are too large. A microstrip antenna incorporated with a single shorting pin is found to provide reduction in overall area with respect to a conventional patch. circular polarization is useful in particular when one or both of the systems are in rotating motion or when their respective orientation cannot be ensured [1]. Use of the circular polarization (CP) allows the data transmission independent of the transmitter and receiver. Many applications also need compact CPMAs; where the overall antenna size is a major consideration such as GPS Tracking, handheld RFID reader.

The single- and dual-feed structures are commonly used in CPMAs [1]. The dual-feed structure [2], [3] provides a larger circularly polarized bandwidth compared to the single-feed microstrip antennas [4],[6] but it requires a larger ground plane size for feeding network. Single-feed circularly polarized antennas are currently receiving much attention. Circular polarization is beneficial because current and future commercial and military applications (e.g., satellite, terrestrial communications) require the additional design freedom of the electric field vector at the receiving and transmitting locations.

Several types of the perturbation methods such as truncated corners, stubs, slits, notches, embedded slot onto the patch have been reported to generate CP radiation of the single-feed CPMAs [5].[6]. The well-known method of producing CP radiation of a square microstrip antenna by symmetrically truncating a pair of a square patch corners is widely used for single-feed CPMA [6]. The size reduction by using symmetric-slits microstrip patches have proposed by Chen *etal.* [7]. However, they have achieved the CP radiation using the conventional symmetrically corner truncating technique. In [5], a slotted ground-plane compact CPMA with truncated corners was reported. However, CP radiation with truncated corners method is not offered any size reduction. The symmetric-slit along diagonal directions and adding tails with diagonal directions on a patch radiator can also be used for small CPMA design [7]. However, the comparative study of CP – slit microstrip antenna patch radiator for size reduction has not been published in open literatures.

The slit-microstrip patch can be used for overall size reduction of the microstrip patch antenna with CP radiation. By slightly changimg circumference one of the diagonal slit as compared to other diagonal slit, the CP radiation of the antenna can be obtained. Performances of various slit-microstrip antennas are also compared. Each slitted patch is mounted on a same size thick foam substrate. Slit dimensions are optimized for good CP radiation with fixed antenna and patch sizes. The performances of the compact CPMAs are compared with various slit shapes. The antenna design and optimization were conducted with aid of commercial EM software, Ansoft HFSS 11.2.

2. STRUCTURE & DESIGN

Cross-section of the typical compact circularly polarized slit-microstrip patch antenna is shown in Figure 1.

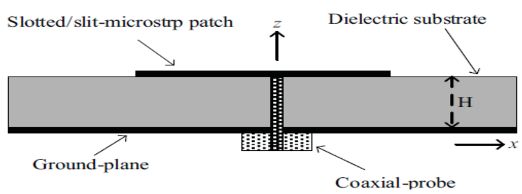
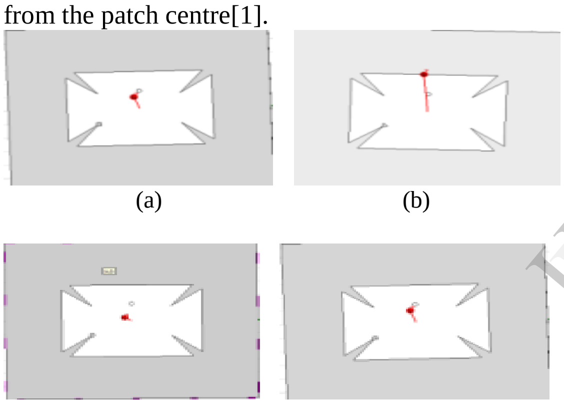


Fig.1 Cross-section view of the proposed CP slit-microstrip antenna.

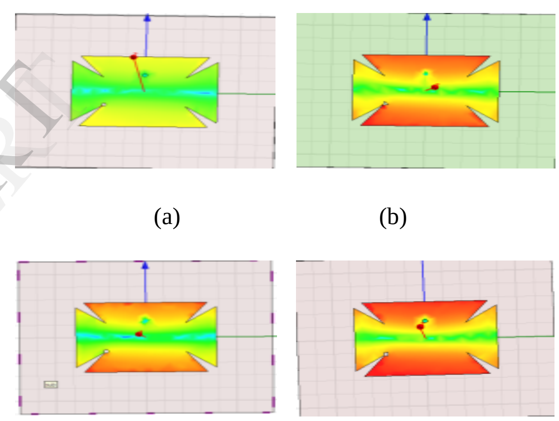
A rectangular patch with dimension of L is etched onto a substrate with a thickness of H. The coaxial-feed location (F) is along the orthogonal axis (y-or x-axis) from the patch centre[1].



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

Fig.2 CP-Slit-microstrip patch structures are: (a) Antenna#1, (b) Antenna#2, (c) Antenna #3 and (d) Antenna #4.

Various slit-microstrip patches are shown in Figures.2(a) – 2(d) for CP radiation with compact antenna size. Ground-plane size of 70 mm × 60 mm is fixed for all patch radiators. Rectangular patch size of all patch radiators is also fixed (27.8 mm X 39 mm). The proposed CP antenna can be operated in 2.4 GHz frequency. Microstrip patches are designed on a FR4 substrate (thickness H=1.59mm, $\pounds_r$ = 4.4 and tan δ=0.02). The coaxial-feed location (F), (y_0 = 6.5 mm) is selected for good impedance matching and it is fixed for all examples. As illustrated in Fig. 2(a), the symmetries can also be realized by adding symmetrical V-shaped slits. The size of the four-slit is fixed (5 mm X 5 mm X 1.59 mm),& the asymmetry is added along one diagonal direction from the one slot (hexagonal, triangle, circle&square) on the patch center. The length of the slots [hexagonal (-0.45 mmX -0.45mm X 1.59 mm), triangle (-0.65 mmX -0.65mm X 1.59 mm), circle (r=0.7 mm), square (L=1.2 mm)] is optimized for good CP radiation. Four above mentioned slit microstrip patch antennas are simulated for return loss better than 20 dB and good CP radiation. Figure 2(a) shows the Four V-shaped slit Rectangular patch with one Hexagonal slot (Antenna#1). Triangle slot along one of the diagonal axes at the centre of the patch radiator for CP radiation is also designed as illustrated in Figure 2(b) (Antenna#2). Figure 2(c) shows the CP Circular slot microstrip patch (Antenna#3). Figure 2(d) exhibits a Square slot microstrip patch for CP radiation (Antenna#4).



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

Fig 3: The current distribution of CP-slit Microstrip patch radiators are;(a) Antenna#1, (b) Antenna#2, (c) Antenna #3 and (d) Antenna #4.

The antenna prototype and the current distribution on CP-slit Microstrip patch radiator are shown in Fig.3 (a) to (d).

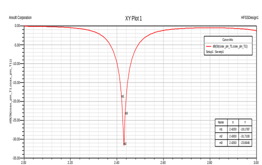
3. Simulated results and comparison

Simulated return loss, axial-ratio and gain of the CP slit-microstrip antennas are compared. The CPMA using Antenna#1 shows the lowest resonance frequency. However, it has narrow 10- dB return loss bandwidth as compared to other Antennas. The 3-dB axial-ratio (AR) bandwidth of aAntenna#1 is also narrow. The VSWR is 1 for all CPMAs over the 3-

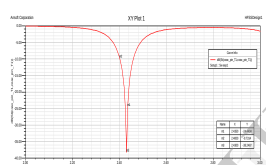
dBAR bandwidth except Antenna#1. The gain of Antenna#1 is little bit lower due to the fact that the antenna is electrically small as compared to the other patch antennas. It is found that the return loss, AR and VSWR of the antennas do not depend on the slit shape. All antennas are optimized for good CP radiation (min imum AR) and good impedance matching.

TABLE1: SIMULATED RETURN LOSS RESULTS OF CP MICROSTRIP ANTENNAS

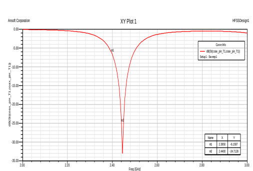
Sr.No.	**Different Slits**	**Frequency(GHz)**	**Retun Loss(dB)**
1	Hexagonal	2.4350 GHz	-24.4404 dB
2	Triangle	2.4200 GHz	-19.1787 dB
3	Circle	2.4400 GHz	-24.7128 dB
4	Square	2.4150 GHz	-30 dB



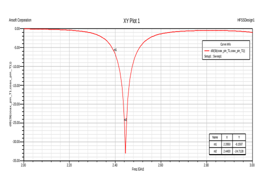
(a)



(b)



(c)



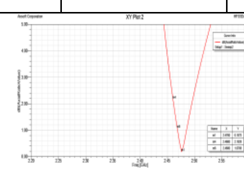
(d)

Fig.4 Simulated Return loss performances of the CP slit-microstrip antennas are;(a) Antenna#1, (b) Antenna#2, (c) Antenna #3 and (d) Antenna #4.

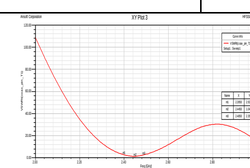
The simulated results for Return loss of all four antennas are shown in Fig. 4 (a) to (d). The simulated Return Loss performances of the antennas are summarized in Table 2. Return loss was found to be -24dB for Antenna#1,-19dB for Antenna#2,-24dB for Antenna#3 & -30 dB for Antenna#4 & the bandwidth calculated from it is 60 MHz (2.4150-2.3850GHz) as shown in fig.4 (d).

TABLE 2: SIMULATED VSWR RESULTS OF CP MICROSTRIP ANTENNAS

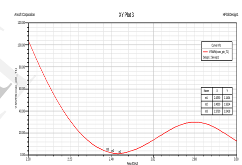
Sr.No.	**Different Slits**	**Frequency(GHz)**	**Vswr**
1	Hexagonal	2.4350 GHz	1.1276
2	Triangle	2.4350 GHz	1.1404
3	Circle	2.4450 GHz	1.0454
4	Square	2.4100 GHz	1.08



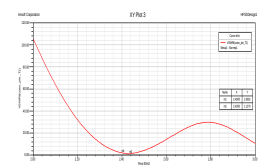
(a)



(b)



(c)



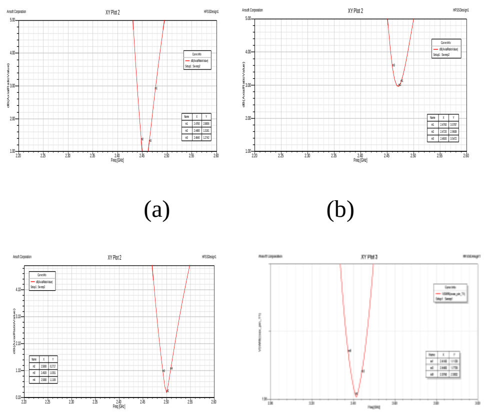
(d)

Fig.5 Simulated VSWR performances of the CP slit-microstrip antennas are ;(a) Antenna#1, (b) Antenna#2, (c) Antenna #3 and (d) Antenna #4.

The simulated results for VSWR of all four antennas are shown in Fig. 5 (a) to (d). The simulated VSWR performances of the antennas are summarized in Table 3. VSWR was found to be 1.12 for Antenna#1, 1.14 for Antenna#2, 1.04 for Antenna#3 & 1.08 at 2.4100 GHz frequency for Antenna#4 as shown in fig.

TABLE3:SIMULATED AXIAL RATIO RESULTS OF CP MICROSTRIP ANTENNAS

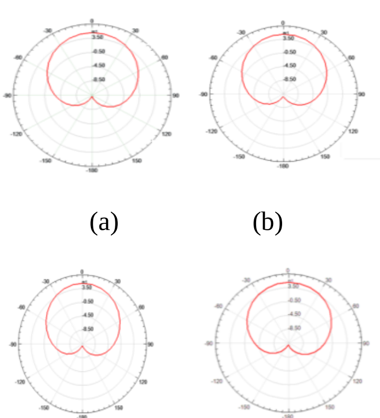
Sr.No.	**Different Slits**	**Frequency(GHz)**	**Axial Ratio (dB)**
1	Hexagonal	2.4350 GHz	1.46 dB
2	Triangle	2.4200 GHz	3.87 dB
3	Circle	2.4450 GHz	0.65 dB
4	Square	2.4150 GHz	0.18 dB



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

Fig.6 Simulated Axial Ratio performances of the CP slit-microstrip antennas are ;(a) Antenna#1, (b) Antenna#2, (c) Antenna #3 and (d) Antenna #4.

The simulated results for Axial Ratio of all four antennas are shown in Fig. 6 (a) to (d). The simulated Axial Ratio performances of the antennas are summarized in Table 4. Axial Ratio was found to be 1.46 for Antenna#1, 3.87 for Antenna#2,0.65 for Antenna#3 & 0.18 for Antenna#4 & bandwidth calculated from it is 52 MHz (2.4760-2.4670 GHz) as shown in fig.6 (d).



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

Fig.7 Simulated Radiation Pattern performances of the CP slit-microstrip antennas are ;(a) Antenna#1, (b) Antenna#2, (c) Antenna #3 and (d) Antenna #4.

The simulated results for Radiation Pattern of all four antennas are shown in Fig. 7 (a) to (d). The overall gain of all four antenns is 3.5 dB.The simulated results of return loss, axial-ratio and VSWR are obtained by using HFSS software. The overall size of a proposed antenna is 39 mm X 27.8 mm X 1.529 mm.

4. Conclusion

Microstrip patch antennas have been simulated for CP radiation. CP-slit microstrip patch antenna designs with four types of the slit shapes have also been studied and compared for CP radiation with compact antenna size. The proposed CP antenna can be operated in 2.4 GHz frequency. It has also been found that the impedance matching and AR can be optimized easily by adjusting the slit sizes It has been found that the return loss, AR and VSWR of the antennas do not depend on slit shape. When we introduce slot in patch, it helps to reduce size of patch & increasing axial ratio bandwidth. A circularly polarized slit microstrip antenna was simulated to validate the proposed CP technique experimentally. The overall size of the antenna is 39 mm X 27.8 mm X 1.529 mm.

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