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Wide-Beamwidth Broadband Antenna Using S-Shaped Dipole And Microstrip Antenna

Mr. Dinesh Kadam, Ms. ManaliJadhav, Ms. PoojaVichare
Electrical and electronics engineering
A C Patil College of Engineerig, KhargharNavi Mumbai
Dinesh.kadam786@gmail.com, poojav0786@gmail.com, jadhavmanali123@gmail.com
+919423683978, +91 8655436253, +918286961023

Abstract

Bandwidth of compact S-shaped Microstrip antenna has been increased by cutting S-shaped slot inside the patch. This paper presents a novel circularly polarized (CP) printed antenna with wide bandwidth and wide axial ratio (AR) beam width and the study of broadband response in slot cut S-shape Microstrip antenna. The wide beam width antenna is realized by bending a linearly polarized dipole into "S" shape with variable line width, which achieves circularly polarized radiation. It is found that this "S" antenna has some similar features to the linear polarized dipole, such as the feeding method, the radiation pattern in some main planes and nearly omnidirectional radiation in one main plane. The S-shaped slot modifies the surface current distribution at TM20 mode that gives broadside radiation pattern over complete bandwidth with peak broadside antenna gain of nearly 7.5 dBi.

Keywords: *circular polarization; dipole; wideband antenna S-shaped Microstripantenna higher order mode*

INTRODUCTION

No matter how good the circuit production technology is, we, as the design engineers, are in a position, to squeeze the best electrical performance out of it. Until then sketch of communication system are exercised, the most critical issue is the error free transmission and reception of electrical signals over the band of operation .In order to squeeze the limits of the production technology; we must be able to supply best of signal transmission

Wide bandwidth and wide AR beam width circularly polarized antenna elements are important for wireless systems such as Global Navigation Satellite Systems, wideband wide-angle-scanning circularly polarized phased arrays and satellite communications [1], [2]. Although numerous circularly polarized antennas were proposed, few suitable candidates can satisfy the requirements of wide bandwidth, wide AR beam width, circular polarization, compact size, simple structure and low cost simultaneously. The aim of this work is to fill this gap. One of the most commonly used antennas is the dipole antenna, especially the half-wavelength dipole. It is well known that the dipole radiates linearly polarized (LP) waves. For some applications such as the satellite communications, circularly polarized antennas are preferable [4]. However, there are no CP counterparts who have similar structure and similar radiation patterns to the LP dipoles. Using crossed dipoles fed with quadrature phase difference can yield CP radiation [5]. Nevertheless, each single dipole used in [5] is still LP. In this paper, an S-shaped wire antenna which radiates CP waves is presented and analyzed.

Microstrip antenna have several advantages, such as low profile planar configuration but they have lager patch size and narrow bandwidth (BW) in lower UHF frequency band (800 to 1200 MHz)

[1 – 3]. The smaller patch size has been realized by cutting the slot on the edges of the patch, which increases the surface current length at fundamental mode which reduces patch frequency [1 – 3]. The S-shape slot also modifies the surface current distribution at TM20 mode to give broadside radiation pattern over VSWR BW showing E-plane and H planes aligned along Φ = 450 and Φ = 1350 respectively. The slot cut S-shaped configuration yields broadside co-polar gain of more than 5 dBi over the operating frequency range with peak gain of more than 7 dBi. This will be useful as similar work that describing the working of slot cut compact antenna is not given in the available literature. In future scope of the work, resonant length formulation for slot cut compact MSA at its resonant modes will be developed as they will be useful in re-designing similar slot cut antennas at different frequency.

OBJECTIVE

Sketch simulate and compare Wideband Circularly Polarized Wide-Beam width Antenna Using S-Shaped Dipole with Broadband Slot cut S-Shaped Microstrip Antenna on the basis of their characteristics like data transmission rate, short range characteristics, linear phase response and power consumption.

Broadband S-Shaped Slot Cut Msa

The units of the patch and slot dimensions and frequencies referred throughout the paper are in mm and GHz, respectively. The S-shape slot is cut along the length of S-shape patch. The MSA is optimized using three layer suspended configuration in which two layers of glass epoxy substrate (h = 1.6mm, εr = 4.3, tan δ = 0.02) are separated by an air gap of thickness 2.4 cm. The antenna is fed using SMA panel type connector of 50 Ω impedance [11]. The dimensions of the slot (length ‘lh’ and ‘lh’ and width ‘w’) are chosen such that it adds a new resonant mode near the patch resonance frequency which increases overall BW [11]. The Shaped slot cut MSA yields measured BW of 69 MHz (>8%) as shown in Fig. 1(b). The S-shaped slot cut configuration is symmetric around Φ = 450 axis, hence its E and H-planes are aligned along 450 and 1350, respectively.

Antenna Configuration And Operation Principle

In order to explain operational principle of CP radiation, the surface current distribution on the curved arms at different time slot is shown. Hence, the null area of the surface current is transmitting along the curved arms, showing that a travelling wave current is aroused along the curved arms and thus a CP radiation can be achieved.

Geometry Parameters

Each arm of the “S” antenna can be obtained by subtracting a small ellipse from a bigger one. The major axis radius of the bigger ellipse is denoted by R while the minor axis radius is denoted by R/m, leading to a ratio between the major and minor axis radius of m. The ratio m is kept unchanged for the smaller ellipse and the major axis radius of the smaller ellipse is n×R. The “S” antenna is printed on a 0.508mm thick Rogers RO4003C substrate with dielectric constant of 3.55 and dielectric loss tangent of 0.0027. All the parameters R, m, n and α affect the electrical length of the proposed antenna. The angle α can be determined to be 10o to 30o and n ranges from 0.75 to 0.9 for good CP radiation. Once these two parameters are determined, the working frequency can be tuned by changing R and m

From LP Dipole to CP S-shaped Antenna

The LP dipole and the CP “S” antenna have two arms and are fed by an AC source which provides 180o phase differences to the two arms. Each arm of the S-shaped antenna can be realized from the single arm of a LP dipole by bending it into a curved shape with variable wire width.

The LP dipole radiates linearly polarized wave with the E-field along ±Z axis the LP dipole has a figure of “8” radiation pattern in the E-plane (yoz plane) while omnidirectional radiation exists in the H-plane (xoy plane). Analogously, the proposed CP “S” antenna has a figure of “8” radiation pattern in the yoz plane while radiating CP fields. The situation is a little different to the “S” antenna in the xoy plane. Ideally, the “S” antenna can radiate CP waves at nearly all angles in the xoy plane except for the ±X direction. Considering that the radiated CP E-field in the xoy plane by the “S” antenna rotates clockwise, the change of the propagating direction results in the radiated E-field in different CP sense, i.e., LHCP in the +Y region and RHCP in the –Y region. The alteration of CP sense causes a high axial ratio (AR) in the region close to ±X. Apart from this small region, the “S” antenna radiates CP waves at all angles in the xoy plane.

Analysis Of S-Shaped Slot Cut S-Shaped MSA

The optimized slot cut S-shaped MSA is simulated using IE3D software and its smith chart and resonance curve plot. This current variation gives average current distribution along patch diagonal axis that leads to E-plane being directed along Φ = 45. The equivalent S-shaped MSA is analyzed first for varying feed point locations (xf and yf) and their resonance curve plots. The surface current distribution for feed at xf = 1.5 and yf = 15 mm are shown in Fig. 3(b – d). For this feed position three resonant modes are observed. The surface currents at first mode shows one half wavelength variation along S-shaped patch length.This is the fundamental mode and it is referred to as TM10 mode. At second mode, currents show two half wavelength variations and it is referred to as TM20 mode. At third mode, currents shows one half wavelength variation along patch length and width and it is referred to as TM11 mode.

Simulation Result And Discussion Comparison with LP Dipole

The radiation patterns of the “S” antenna in the yoz plane and the xoy plane, respectively. Both the radiation patterns shape like a figure of “8” which is similar to the dipole’s radiation pattern in the E plane. However, the AR beamwdith in the xoy plane is rather broad, which indicates that the proposed antenna radiates CP waves at nearly all azimuth angles. This characteristic is similar to the LP dipole which radiates LP waves omnidirectional in the H plane. Although the magnitude of the radiated CP waves in the xoy plane of the “S” antenna is not even at all azimuth angles, the radiated CP fields at nearly all azimuth angles make it “quasi-omnidirectional” with CP radiation in the xoy plane.

Parameter Studies to Axial Ratio

To ease the study, the major axis radius of the bigger ellipse R and the rotation angle α is fixed to be 15mm and 100 the resonating frequency shifts to higher frequencies when m increases. This is because larger m brings reduced electrical length of the antenna and shorter travelling wave current propagation path. When m is 1, the axial ratio with different n .the resonant frequency shifts to higher frequencies when n increases. This phenomenon can be explained that the increase of n also results in a shorter electrical length as the width of the S-shaped arm decreases when n increases. It is also shown that not all values of n can bring a good CP radiation. Typically, the value of n can be determined from 0.75 to 0.9.

Parameter Studies to Axial Ratio Bandwidth

The proposed “S” antenna radiates CP fields at all azimuth angles except for the regions close to ±X axis. It is meaningful to investigate the effect of parameters m and n to the 3-dB AR beam width. The radiated CP fields at nearly all azimuth angles make it “quasi-omnidirectional” with CP radiation in the xoy plane.

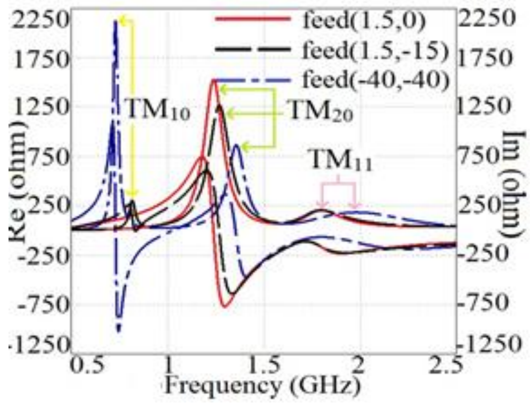

Fig1:*Parameter Studies – effectiveresistance*

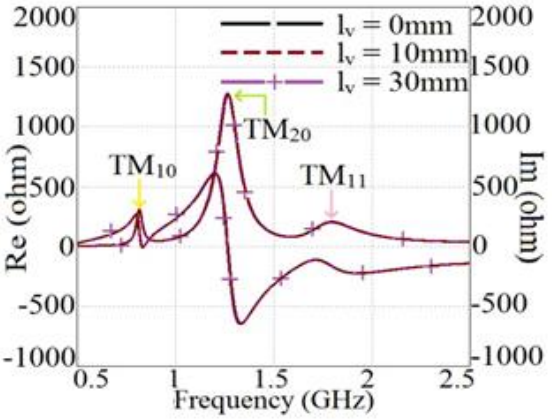

Fig2: *Parameter Studies-Frequency*

Hence its frequency remains constant. As currents show two half wavelength variations along patch length, for ‘lv’ > 50 mm, TM20 mode frequency reduces as shown in Fig. An increase in horizontal slot length ‘lh’ is parallel to surface currents at TM10 mode hence its frequency remains constant. However again due to two half wave length variations in currents at TM20 mode, its frequency reduces with increase in ‘lh’. The input impedance locus for varying slot length

When feed point is placed in the patch center, i.e. yf = 0, the TM10 mode in the resonance curve plot is absent whereas all the modes are observed when feed is placed towards the path edge i.e. xf = -40 and yf = -40 mm. Further, for feed at xf = 1.5 and yf = -15 mm, slot of dimension ‘lh’ and ‘lv’ is cut in the patch center and resonance curve plots for the slot length variation is shown in‘lh’ is shown in Fig.

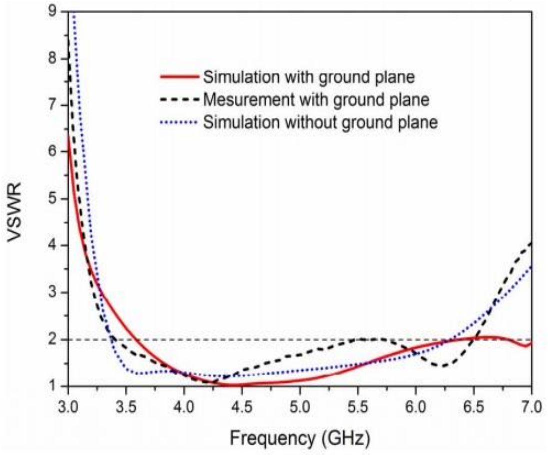

Fig3:*Simulation Result*

The simulated and measured VSWR of the ground plane backed inverted-S antenna is shown in Fig. 11. As can be seen, the measured impedance bandwidth (VSWR is from 3.4GHz to 6.5GHz (63%). Compared with the VSWR without ground plane backed, it is shown that the ground plane has limited influence to the impedance matching of the proposed antenna while the balun affects considerably.

CONCLUSION

The detailed analysis to understand the broadband response in compact slot cut S-shaped MSA is presented. The slot tunes spacing between patch TM10 and TM20 resonant modes to yield broader BW. The S-shaped MSA gives simulated and measured BW of 72 MHz (~8.8%) and 74 MHz (>8.84%), respectively The novelty of proposed work lies in providing detailed explanation for the broadband response reported in slot cut S-shaped MSA which is not given in the reported literature. This will be helpful to understand the broadband response in similar slot cut compact MSAs. To re-design similar slot cut antennas, in future work formulation in resonant lengths at modified patch modes in terms of patch and slot dimensions will be developed. Due to geometry of S-shaped patch, the discussed configuration shows broadside radiation pattern with E and H-planes aligned along Φ = 450 & 1350 respectively.

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