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Capacitive coupled corner truncated microstrip patch antenna suspended on air for broadband application

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Abstract: a design of a circular polarized microstrip patch antenna is presented. In this paper consist of corner truncated square patch is printed on FR-4 at top side, a corner truncation is introduced at center on main patch to achieved circular polarization, the design patch is placed on FR-4 is suspended from ground and air gap is introduced between it. To reduce the inductive effect from long feeding probe to main patch a capacitive feed is placed, series opposition will cancel it. Capacitive feed method to a rectangular patch placed beside the main driven patch. The proposed antenna combines the attractive features such as low volume, large AR Bandwidths, high gain and easiness of design, manufacture and integration, the antenna is simulated in IE3D software and operating at 4.8 GHz band. Simulated results show that the antenna achieves Impedance bandwidth is14.36 (3.66GHz-6.49 GHz) And 3-dB AR bandwidth of about 10.74% (4.67 GHz-5.12 GHz) with the antenna gain level at about 6.6dBi.

Index Terms: Axial Ratio, Broadband antenna, Circular polarization, Capacitive coupling, Corner truncation, Probe feed, Rectangular slot,

1. INTRODUCTION

Now a day's there has been interest in the study and analysis of Circular polarized patch antennas because of their low profile, low weight, easy fabrication, and low production costs. It is used in short distance high data transmission such as wireless local area network (WLAN). but their impedance bandwidth (VSWR>2) and axial ratio(BW<3dB) bandwidths are too narrow to that is limiting its practical application[1],To increase the impedance bandwidth and axial ratio bandwidth, several approaches Have been proposed using Broadband technique, different dielectric substrate, different feeding method, shape of radiating patch and dual feed structure with a rectangular strip[1].The input impedance of a thick microstrip patch antenna is inherently inductive. The patch can be matched by using a capacitive annular gap round the feed point. By varying the amount of capacitance the input resistance is also varied [2].A single-layer capacitive feeding mechanism, consisting of a small rectangular probe-fed patch, which is capacitively coupled to the radiating element, can be used to obtain wideband operation for probe-fed microstrip antennas on thick substrates [3].The model of the antenna incorporates the capacitive feed strip which is fed by a coaxial probe using equivalent circuit approach. The capacitive feed strip used here is basically a rectangular microstrip capacitor formed from a truncated microstrip transmission line and all its open ends are represented by terminal or edge capacitances [4].The small antenna comprises a air cavity in the substrate, a capacitively-fed patch which is attached by coaxial probe, and a cut slot on the edge obtained by adaptable length and width of the cut slot, air cavity, and feed patch [5],[7].To achieve wide AR bandwidth. In [6], CP operation is acquired by a corner truncated patch, and a horizontally meandered strip (HMS) feeding structure is proposed to achieve good impedance matching. All the mentioned antennas show wide CP band with antenna height of about 0.1λ0. In this letter, we have presented circular polarized with capacitive feed to corner truncated square patch on FR-4 on air substrate and ground conducting plane.

2. ANTENNA STRUCTURE AND DESIGN

The proposed antenna consist of corner truncated square patch length and weight is L=10 mm and truncation level S=5mm on opposite side of main radiating patch placed on top of FR-4 substrate thickness is about h=1.6mm, height and weight of FR-4 is Lg=40mm (ε_r=4.4, tan δ =0.02) at an height of g=7.4mm on ground plane. The rectangular slot is introduced at centre of radiating patch with the dimension is L2=5.6mm and W2=1.6mm.The ground plane is considered as infinite for simulating. The coaxial feed with SMA inner conductor is attached to rectangular patch L1=1.3mm, W1=3.6mm,capacitive feeding is observed between rectangular and main driven patch to reduce the inductive reactance offered by length of coaxial connector, Series opposition of inductor and capacitor will cancel each other.Fig.1 shows the details of structure of proposed antenna.

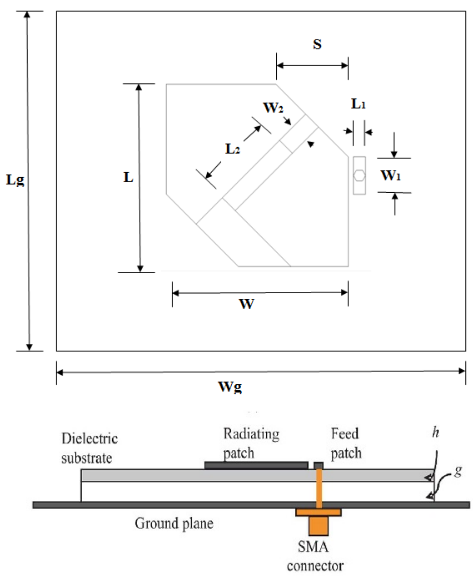

Fig.1. Basic geometry of design antenna (Top view and side view)

2.1 Gap Coupled capacitive feed mechanism:

The electromagnetically gap- coupled capacitive feed strip is represented by the equivalent circuit as shown in fig.2.This feeding mechanism provides compensation for the increased feed inductance. The effect of direct radiation from the open end of the microstrip line can be represented by a conductance across the shunt capacitor.

In such kind of antenna configuration, the radiation pattern becomes asymmetric due to capacitive loading. The radiation pattern can also be rotated electronically, by varying capacitive loading. This facility can be made use of to reduce the multipath fading in urban mobile communication when the antenna is mounted on a vehicle.

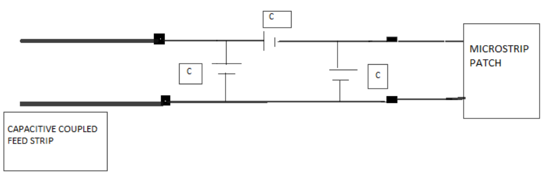

Fig.2: Equivalent Circuit of a Gap Coupled Capacitive Feed Mechanism

2.2 EFFECTS OF DESIGN PARAMETERS ON ANTENNA PERFORMANCE:

The key design parameters of the antenna are air gap at which antenna substrate is located above the ground plane, the distance between radiator patch and the feed strip, probe diameter and the dimensions of feed strip and radiator patch. By properly choosing the size of feed strip, separation distance between the substrate and the radiator patch and the Height of air gap, the impedance bandwidth can be Significantly improved.

A. Effect of air gap:

It is well known that whenever the effective substrate height increases or permittivity decreases, it result into wider bandwidth [8]. Although the present configuration is different than a rectangular patch but it appears nearly a rectangular patch so when two resonant frequencies are close enough, these may merge into single operational band with return loss below -10db but it occurs only at particular range of air gap. Effects of variation of air gap on the VSWR bandwidth of the antenna is listed below [9], [10].

B. Effect the separation distance between feed strip and Radiator patch:

The dimensions and location of the feed strip play an important role in obtaining the wide bandwidth for the proposed antenna as distance between radiators patch and the feed strip on the impedance bandwidth of antenna. Actually the separation distance is very small but variation in it affects the input impedance of an antenna. But input impedance of an antenna has reactive and resistive parts which depend upon the separation distance. As the separation distance is increased, the resistive part decreases and the reactive part increase. VSWR bandwidth is increases by increasing the separation distance between radiator patch and feed strip. But this increment of the separation distance results in slightly improved bandwidth is observed within certain range. This effect is occurs due to the slots on the patch. The variations in the reactive and resistive parts have adjusted due to the slots across the width. It has observed that the bandwidth is increases only at the separation distance from 0.1mm to 0.75mm, by keeping air gap at 5mm [9], [10].

C. Effect of shape of the radiating patch:

Microstrip antenna with rectangular radiating patch with capacitive feeding can attain percentage bandwidth nearly up to 50% [11].It has observed that bandwidth can be increased up to 10 to 15% by making rectangular or triangular slots[9]. Slots on the both radiating and non-radiating edges of the patch can improve the fringing field and thereby bandwidth. The field distribution is occurs at the edges of the patch so if slot is present over the patch it further increases the edges of patch and thereby increases the fringing field(voltage distribution). Another advantage of having slots over the patch is the reactive and resistive parts of antenna impedance can be balanced so proper impedance matching can be easily achieved [9].

3. EXPERIMENTAL VERIFICATION

The proposed antenna is simulated on IE3D software. The resonant frequency is of 4.8 GHz is chosen. As shown in simulated result fig.3 is graph of axial ratio Vs Frequency of circular polarized antenna the antennas achieved the 3-dB axial ratio bandwidth is 10.74% (4.67 GHz-5.12 GHz).

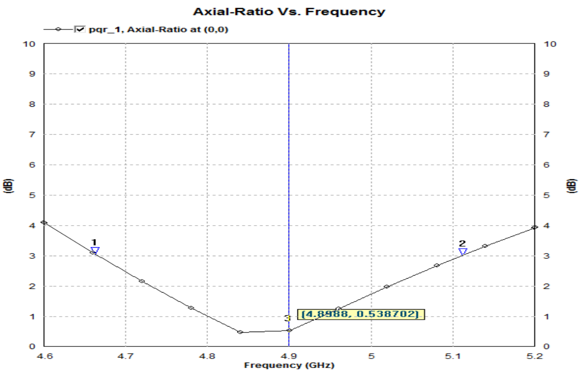

Fig.3 is graph of axial ratio Vs Frequency

As shown in simulated result Fig.4 is graph of Total Field Gain Vs Frequency of proposed antenna achieved the 6.6dBi at 4.8GHz.

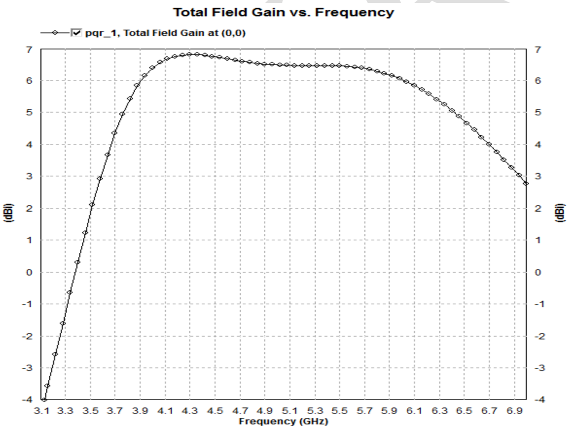

Fig.4 is graph of Total Field Gain Vs Frequency

As shown in simulated result Fig.5 is graph of VSWR Vs Frequency of proposed antennas, the impedance bandwidth (VSWR>2) is 14.36 %(3.66GHz-6.49GHz).

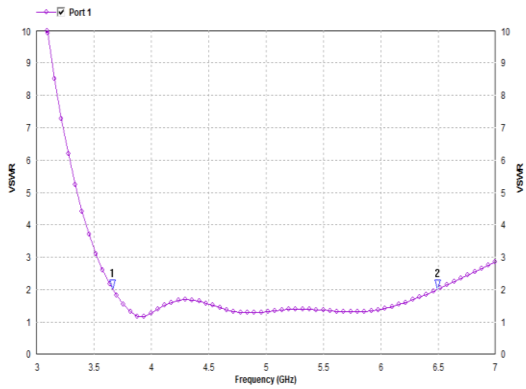

Fig.5 is graph of VSWR Vs Frequency

As shown in Fig.6 Current distribution of proposed antenna

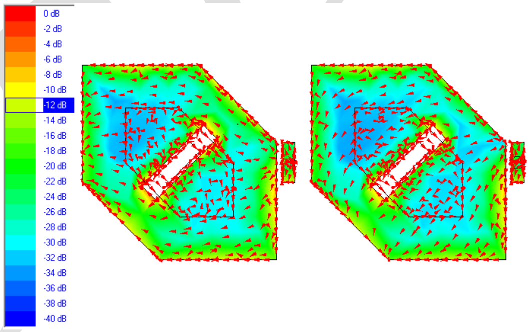

Fig.6 Current distribution on Driven patch

As shown in Fig.7 radiation pattern of Proposed antennas

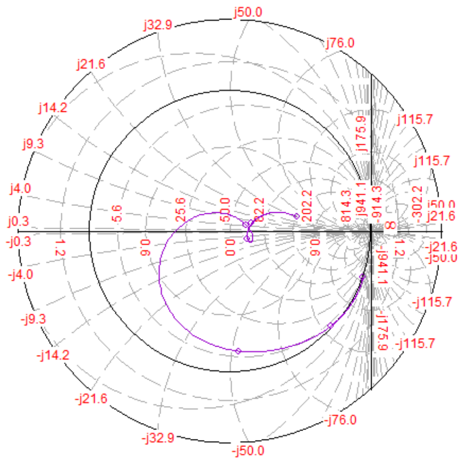

Fig.7 Radiation Pattern

4. CONCLUSION

In this paper, a technique to design a Circular polarized corner truncated square patch with capacitive feed to main driven patch single-fed capacitive coupled low profile broadband patch antenna is presented. A prototype design operating at 4.8 GHz will be designing in IE3D software and measured to validate the concept for practical application. The proposed systems shows the impedance bandwidth (VSWR>2) is 14.36 %(3.66GHz-6.49GHz), 3-dB axial ratio bandwidth is 10.74% (4.67 GHz-5.12 GHz) and a peak gain of 6.6 dBi is achieved. Due to use of slot on main driven patch and suspended structure on air concept. The presented antenna has a low profile, good radiation characteristics, large BW, high gain as well as easiness of design using simulation software. Which is makes it a good choice for broadband CP applications.

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