New Circularly Polarized Capacitively Probe-Fed Wideband Microstrip Antenna

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Abstract — **This paper presents the design, simulation, and measurements of a novel circularly polarized wideband probe-fed microstrip patch antenna with capacitive feed mechanism. The proposed antenna is designed to achieve three targets; wide bandwidth up to 23%, perfect matching at the input (Zin ≈ 50 ohms), and circular polarization (CP) at resonance. It is designed to operate at 1.8 GHz. This antenna is applicable to Personal Communication System (PCS) which uses the frequency range from 1850-1990 MHz. It can be claimed that this is the first time to realize such microstrip antenna to achieve the three mentioned targets together. Calculated as well as measured results for this antenna are included.**

Keywords — **Patch antennas, Wideband, Polarization.**

I. INTRODUCTION

Many communications systems, such as mobile, satellite, radar, etc., require broadband circularly polarized (CP) antennas. Several microstrip antenna (MSA) configurations are available to generate CP, which can be obtained by either single feed or dual feed. Examples of single feed MSAs are nearly square, corner-chopped square, square or circle with a slot, circular patch with a notch, elliptical, pentagon, modified triangular patches, etc. [1-7]. However, these antennas have a very small axial ratio (AR) bandwidth (BW). A square or circular MSA fed at two orthogonal points with equal amplitude and 90^{o} phase difference yields a better AR BW than the single-feed MSAs. However these antennas have narrow impedance BW.

In this paper, a novel circularly polarized wideband probe-fed microstrip patch antenna with capacitive feed mechanism is proposed, this antenna is designed to achieve wideband performance, perfect matching at the input due to the capacitive feed, and wide axial ratio bandwidth due to the dual feed.

The IE3D package from Zeland Software Incorporated, which is based on the method of moments, was used for the design process and calculated results.

II. ANTENNA GEOMETRY AND OPERATION

The capacitively probe-fed microstrip antenna presented in [8] is now modified to produce circular polarization [9]. This is obtained by properly introducing another small rectangular probe-fed patch, which is also capacitively coupled to the radiating element.The proposed antenna is shown in Fig. 1.

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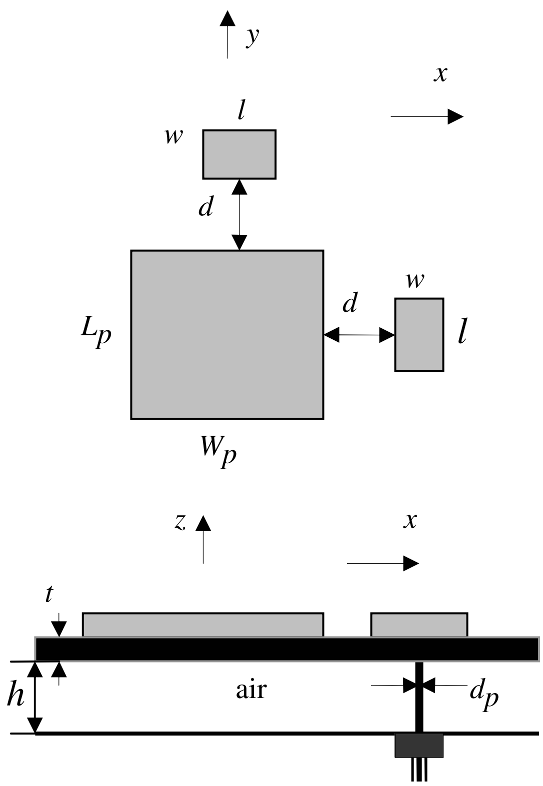

Fig. 1. The proposed circularly polarized wideband microstrip antenna

Each feeding probe is positioned in the center of the two small patches. Both the radiating element and the small patches are supported by a layer of FR-4, with t = 1.6 mm, ε_r = 4.4, and loss tangent tan δ = 0.02, which is suspended in air, at h = 15 mm above a copper ground plane of 100 X 100 mm. Each probe has a diameter of dp = 0.9 mm. The other parameters are Lp= Wp = 51 mm, d = 8 mm, l = 10 mm, w = 5 mm.

The proposed antenna was constructed and studied. Using a Vector Network Analyzer (Agilent 8719ES), which covers the frequency range of 50 MHz up to 13.5 GHz. A photo of the proposed antenna is shown in Fig. 2.

III. EXPERIMENTAL RESULTS

Fig. 3 shows the measured and calculated return loss of the proposed antenna. It is clear that for a return loss (S_{11}) less than –10 dB the frequency band ranges from 1.67 to 2.09 GHz. It has a bandwidth of 22.3 % with the resonance frequency at 1.76 GHz which is very close to 1.8 GHz used in modern wireless communications.

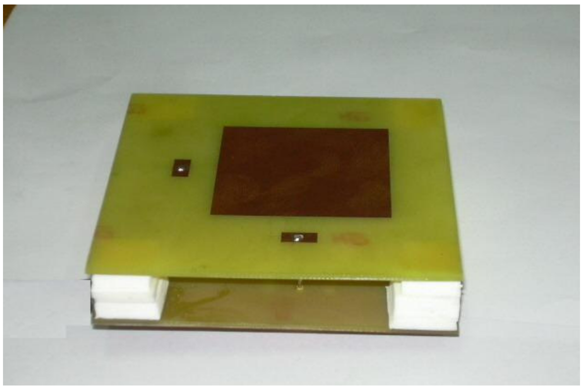

Fig. 2. A photo of the capacitively probe-fed wideband microstrip antenna.

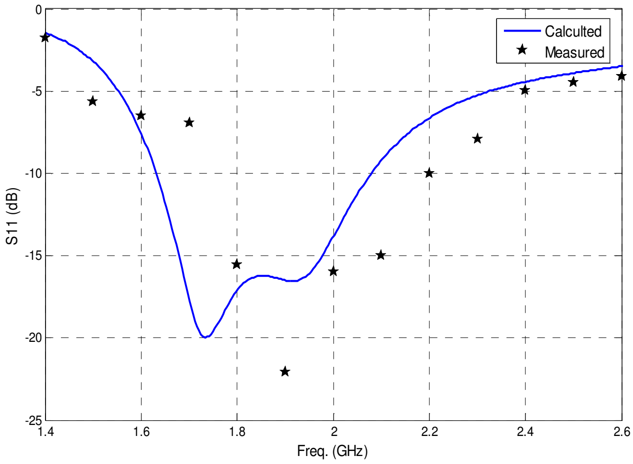

Fig. 3. Measured and calculated return loss of the proposed antenna.

Fig. 4 shows the measured and calculated VSWR of the proposed antenna. The antenna frequency bandwidth with VSWR < 2 covers the frequency range of 1.65 -2.11 GHz. This agrees with the less than –10 dB band of the return loss

The variation of the real part of the input impedance of the proposed antenna is shown in Fig. 5. It is clear that at 1.8 GHz, The real part of the input impedance is very close to 50 ohm, and the imaginary part (Fig. 6) is very close to zero ohms. This is of course, the effect of the capacitive feed mechanism which compensates for the inductive component associated with the probe.

The circular polarization can be verified by looking at the radiation patterns (Fig. 7) of the proposed antenna. When the 2-ports are excited with 90^{o} phase difference, the antenna yields good circularly polarized pattern with cross-polarization below -13 dB from theta = -60^{o} to 60^{o} at 1.78 GHz.

Figure 8 shows that the axial ratio is below 3 dB from 1.5 to 2.02 GHz, the axial ratio has an acceptable value of 2.2 dB at the resonant frequency of 1.8 GHz.

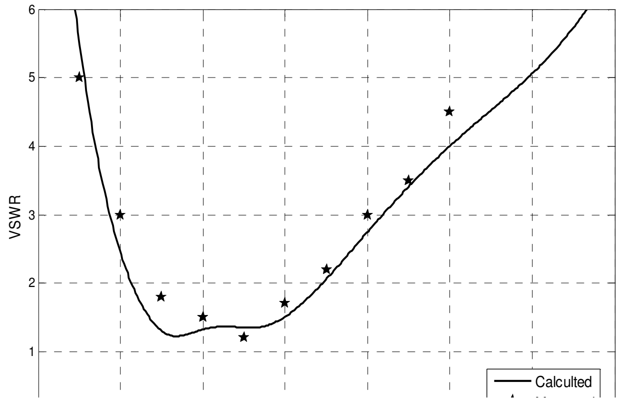

Fig. 4 Measured and calculated VSWR of the proposed antenna.

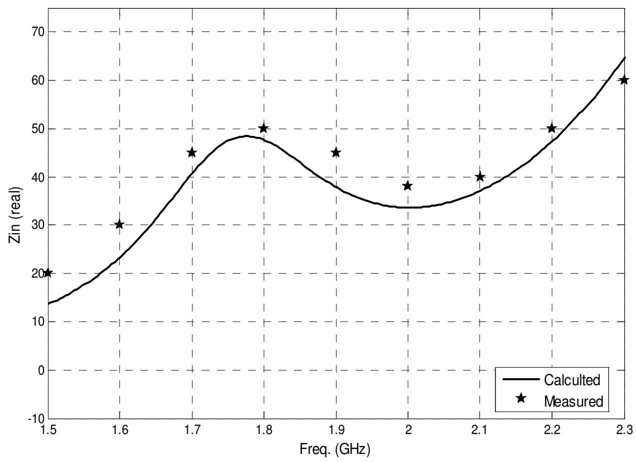

Fig. 5 Measured and calculated real part of the input impedance of the proposed antenna.

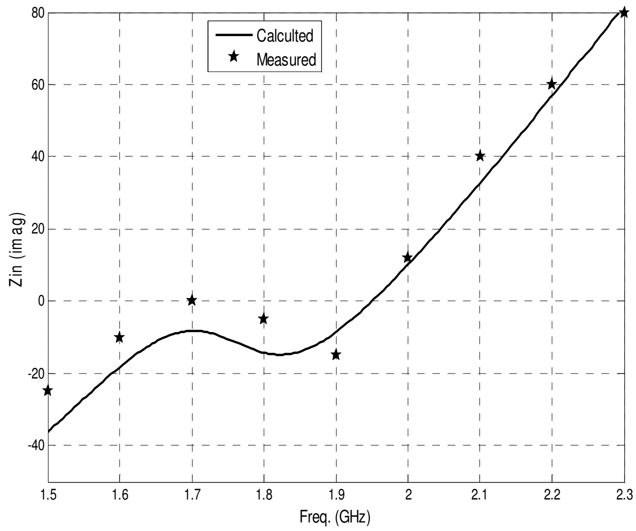

Fig. 6 Measured and calculated imaginary part of the input impedance of the proposed antenna.

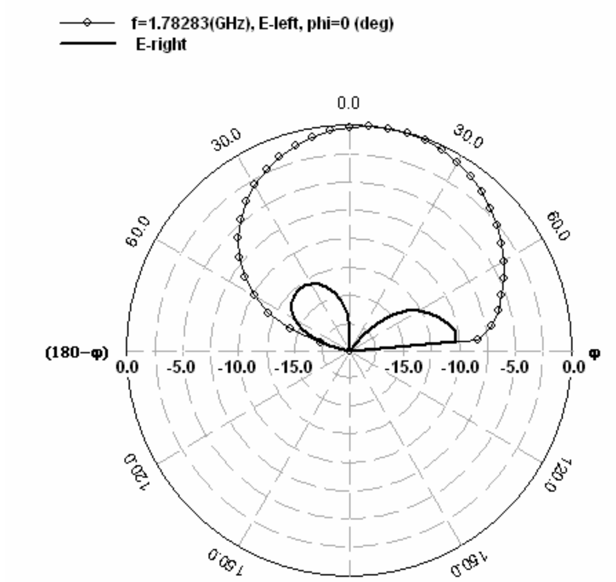

Fig. 7 The radiation pattern of the proposed circularly polarized capacitively probe-fed wideband microstrip antenna.

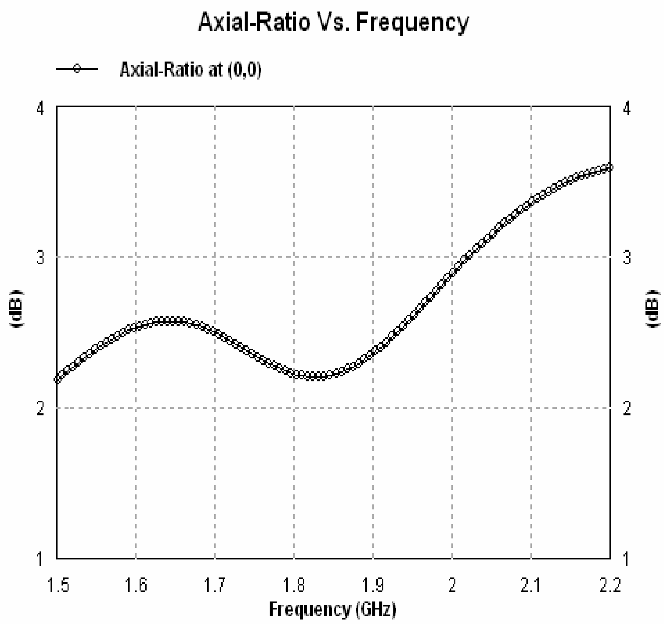

Fig. 8 The axial ratio of the proposed circularly polarized capacitively probe-fed wideband microstrip antenna.

The effective bandwidth (where both the S_{11} is less than -10 dB AND the axial ratio is less than 3 dB) is from 1.67 to 2.02 GHz. The effective bandwidth equals 18.9 %.

Figure 9 shows that the directivity of the proposed circularly polarized capacitively probe-fed wideband microstrip antenna has an acceptable value of 7.7 dBi at the resonant frequency of 1.8 GHz. Figure 10 shows that the radiating efficiency of the proposed antenna has a good value of 93 % at the resonant frequency of 1.8 GHz.

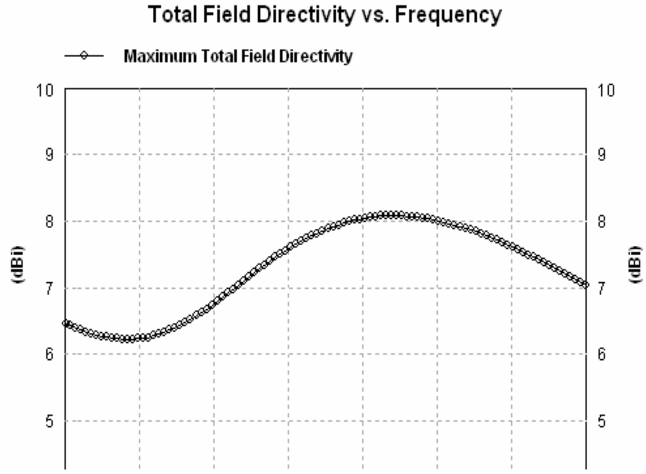

Fig. 9 The directivity of the proposed circularly polarized capacitively probe-fed wideband microstrip antenna.

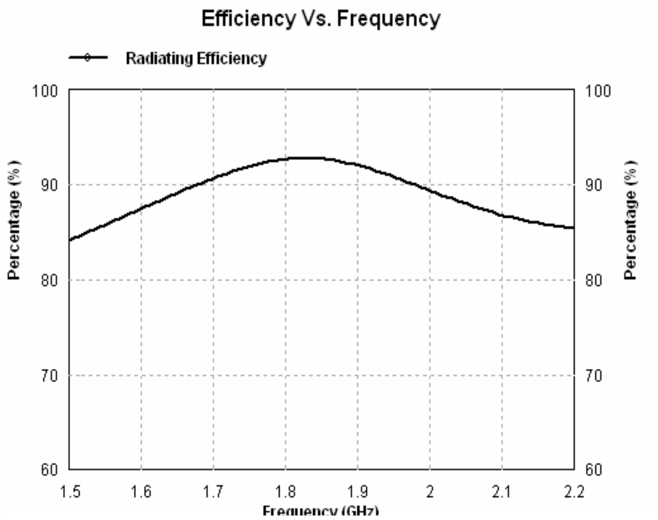

Fig. 10 The radiating efficiency of the proposed circularly polarized capacitively probe-fed wideband microstrip antenna.

IV. CONCLUSION

In this paper, a new circularly polarized capacitively probe-fed wideband microstrip antenna is presented. This antenna consists of two small probe-fed rectangular patches, which are capacitively coupled to the radiating element. The proposed antenna is designed to achieve three targets; wide bandwidth up to 23 %, perfect matching at the input (Zin ≈ 50 ohms), and circular polarization at the resonance. It can be claimed that this is the first time to realize such microstrip antenna to achieve the three mentioned targets together.

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