Circularly Polarization of Edge-Fed Square Patch Antenna using Truncated Technique for WLAN Applications

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Abstract: ***An antenna having a square radiating aperture named as patch is truncated at its opposite corners and power excitation is applied through its edge. This structure is best suitable for WLAN applications. Because of truncation the distribution of current over the patch is controlled and improves the axial ratio of the antenna, hence achieves circular polarization at two operating frequencies which are of 5.8 GHz and 9.2 GHz respectively. To validate the simulated results, prototype of proposed structure is done on FR4 substrate with a relative permittivity of 4.4 and thickness of 1.6 mm. Current design producing a peak realized gain of 7.5 dB at 5.8 GHz and 6.4 dB at 9.2 GHz. The complete structure was designed and simulated for results at CST microwave studio-based Antenna Magus tool and the measured results are analyzed with aniritsu combinational analyzer in anechoic chamber.***

Index Terms: Circular Polarization (CP), Axial Ratio (AR), Edge-Fed, WLAN.

I. INTRODUCTION

The Microstrip Patch Antenna (MPA) is the most popularly used antenna for wireless communication applications. The MPAs commonly work about the half-wave resonance frequency to obtain nominally real-valued input impedance. The fringing fields of MPA virtually increases its effective length, so in real, the patch length is less than a half wavelength in the dielectric medium. MPAs are uncomplicated and reasonably priced to manufacture, and can fabricate using modern printed-circuit technology[1-6].

In generally radiating aperture of MPA designed, so that its maximum radiating pattern is normal to radiating aperture of patch, this is achieved by appropriately selecting the mode of excitation underneath the patch [7-9]. For a MPA, the length of the element is usually between a third and half a wavelength in the substrate. Numerous authors presented in literature that by varying the feed arrangements one can achieve Circular and elliptical polarization. Another method proposed were suggesting that slender modifications made on the radiating aperture of antenna element, can produce two orthogonal modes with equal amplitudes and 90° time-phase difference. For instance, truncating any two opposite corners of square patch, can achieve quadrature phase coupling between the orthogonal TM01 and TM10 cavity modes and hence nearly circular polarization may be achieved.

Currently the antennas are flattering an essential part of body-centric communication systems and have latent applications for example health monitoring, surveillance and emergency services etc. These systems usually require wide band antennas with compact in size; with multiple application frequencies this is possible through the rising technologies [10-12].

The printed monopole antenna design (both radiating patch and corresponding ground) is more flexible. To meet the given specifications, the overall structure of antenna need more optimization, this is ever a challenging task to antenna engineers [13-18]. Modern communication systems are demanding multifunctional devices, means a single system or element need to perform multiple numbers of tasks, for example single antenna with multiple operating frequencies and pattern selectivity. To achieve so, multiband and wideband antennas with high bandwidth and considerable gain [19-22] and High-speed data rates.

II. ANTENNA GEOMETRY

The MPA proposed in this article, consists of a square shaped patch element with 50 ohm impedance matching at the feed line via power divider arrangement. The complete antenna design is presented in below Fig 1. Corresponding antenna side view is depicted in Fig 2. The description of dimensional parameters and its design values are tabulated and given in Table 1.

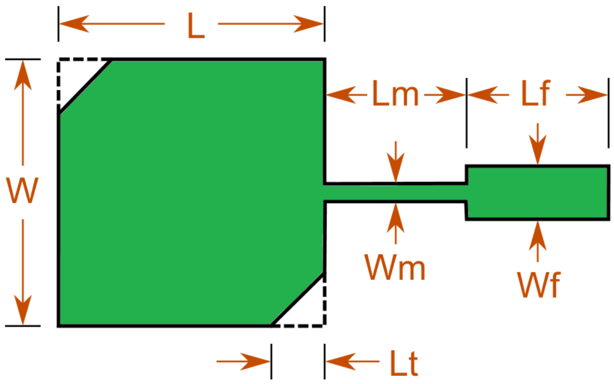

Fig 1. Model of Edge feed square MPA, truncated at its opposite corners to produce circular polarization.

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Fig 2. Side view of Edge feed square MPA, truncated at its opposite corners, placed over FR4 substrate backed by conducting ground.

Table 1. Description of Antenna parameters and its corresponding values.

S. No	Parameter	Description	Value
1	W	Width of Patch	17.61 mm
2	Lt	extent of Truncation	2.065 mm
3	Wm	Matching width of line	535.2 µm
4	Lm	Matching length line	10.22 mm
5	Wf	Feed width of line	1.066 mm
6	Lf	Feed length of line	10.10 mm
7	H	Thickness of Substrate	1.096 mm
8	εr	Relative permittivity	2.2
9	tanδ	Substrate's Loss tangent	0.002

III. ANALYSIS OF RESULTS THROUGH DISCUSSION

In general, MPA exhibits forward broadside gain of typically 7 dBi at its resonating frequency, but due to truncation method or other polarization techniques proposed in literature may affect the performance in bandwidth by reducing it and hence the performance of AR.

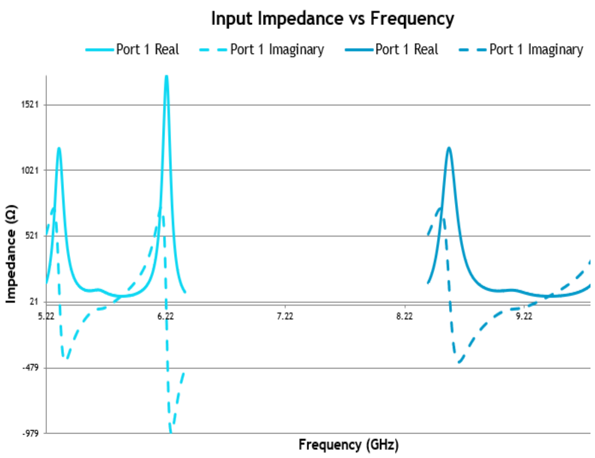

Fig 3. Impedance characteristics of truncated square MPA at two operating points that is 5.2GHz and 9.2GHz.

In current design, truncated edge feed square MPA is operating at 5.2GHz and 9.2GHz frequencies. Usually antenna impedance can be defined by its real value of resistance and imaginary value of reactance. Fig 3. Clearly showing the real value (indicated with continuous line) and reactance (indicated with discrete line) which are very much nearer to 50 ohms at both the operating points (that is 5.2GHz, 9.2GHz), this indicates at both the operating points the antenna is perfectly matched with its source through feed line. From Fig. 4, it can be observed that the return loss (magnitude of S_{11}) is less than -10 dB at both the resonance bands. The impedance bandwidths of 34% and 21% are obtained at 5.8 GHz, and 9.2 GHz frequencies respectively.

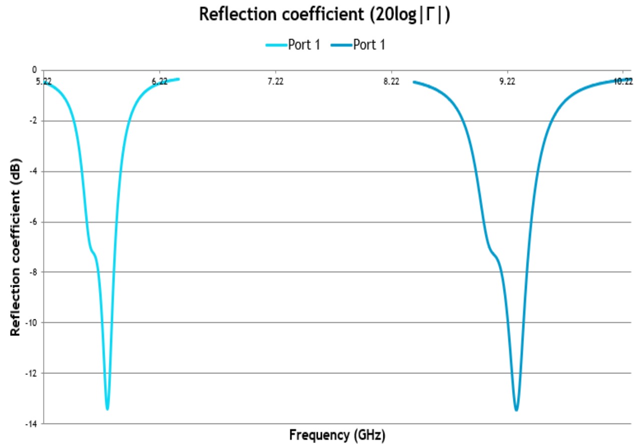

Fig 4. Return loss characteristics of edge feed truncated square MPA, operating at dual frequencies.

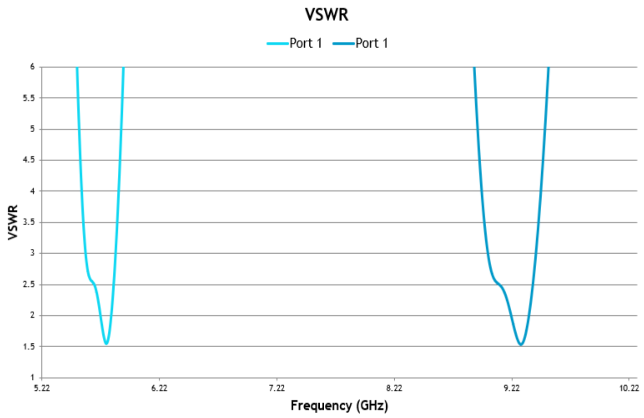

Fig 5. **VSWR characteristics of edge feed truncated square MPA, operating at dual frequencies.**

The amount of power, which is reflected back to source from the antenna due to impedance mismatch at feeding point, can be explained by using VSWR value. In current design VSWR ratio is 2:1, indicating that the designed antenna is at most perfectly matched. ratio. With the help of obtained VSWR value antenna reflection coefficient can be determined using following formula. Reflection coefficient = -10 log $[(VSWR-1)/VSWR+1)^2]$ –(1) Fig 6, is depicting the radiation characteristics of truncated square patch antenna. It is radiating maximum of its energy in forward direction. For better under understanding of obtained results they are presented in 2D view as well as in polar coordinates.

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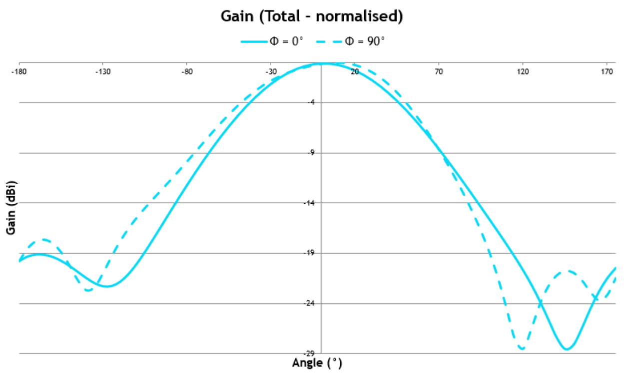
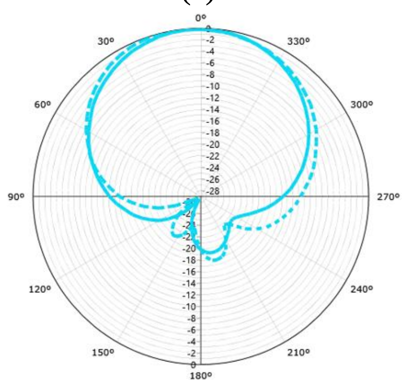
The radiation plots of Fig 7 and 8 show the left hand and the right-hand circular polarization. The radiation patterns are expressed by the antenna LHCP and RHCP gain in the units of dB.

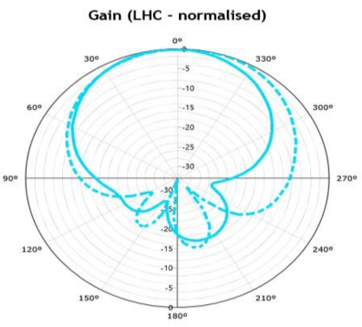


(a)

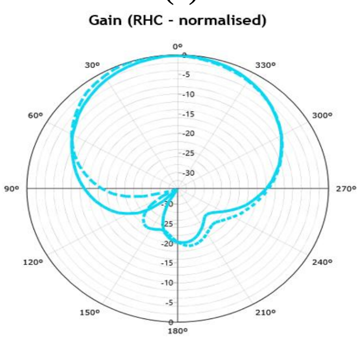


(b)

Fig 6. Radiation Pattern (Total Gain) of truncated square patch antenna in 2D and in Polar plot at 5.8 GHz, (a) Two-Dimensional Gain, (b) Polar Radiation pattern.

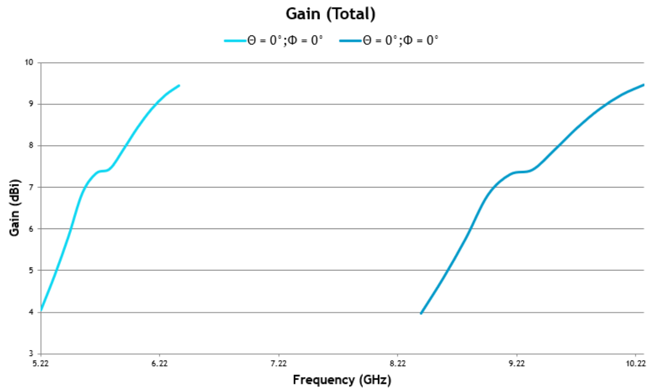


(a)

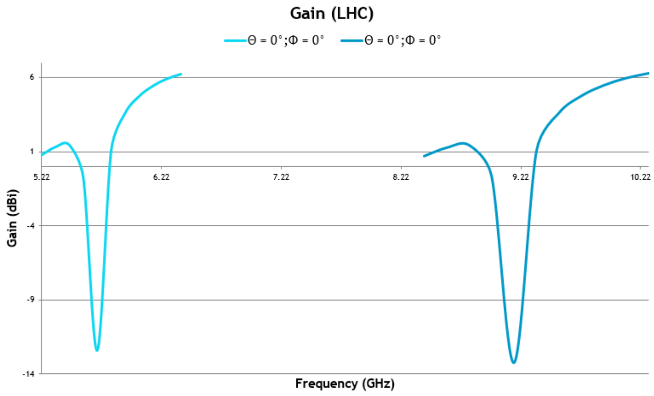


(b)

Fig 7. Radiation Pattern Characteristics of truncated square patch antenna at 5.8 GHz, (a) LHCP, (b) RHCP



(a)



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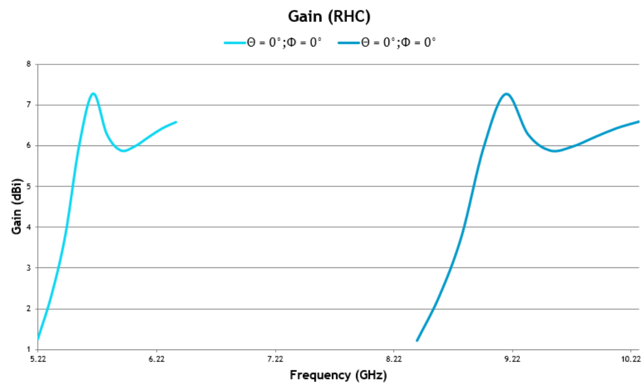

(c)

Fig 8. Gain Plot (a) Total Gain, (b) Gain LHCP, (c) Gain RHCP

The operating frequency of MPA can be altered by varying the patch length and width. The operating frequency increases when decreasing the width and length of patch and vice versa. To design square aperture of patch, its width and length are made equal. The square patches opposite corners are truncated such that good circular polarization is achieved. The two truncated corners should always be opposite one another.

The position of the truncations will change the handedness of the antenna between LHC and RHC. Height of substrate material influences the axial ratio of an antenna, when height of substrate increases axial ratio will be poor.

Fig 9 and 10 showing the obtained axial ratios of proposed design, presented in 2D and 3D plots.

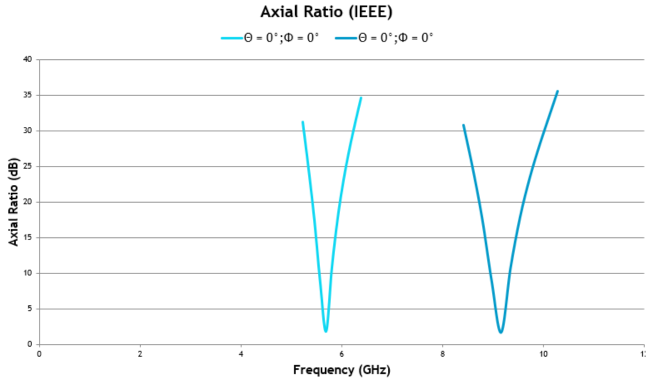

Fig 9. Axial Ratio Vs Frequency

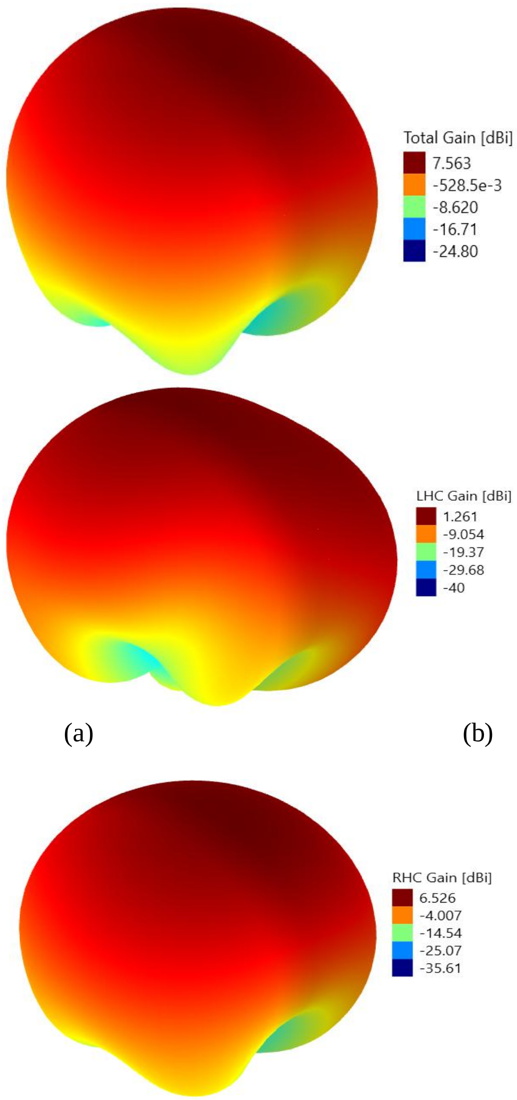

Fig 10. 3D-Gain Plots, (a) Total Gain, (b) LHCP Gain, (c) RHCP Gain

In order to make wireless communication modules more efficient and accurate, it is very much necessary to have good correlation between modules. For instance, to minimize the losses in any communication module, it is very much importance to have high degree correlation between a transmitted signal and received signal. To determine the transmission characteristics of proposed edge feed truncated square patch antenna, considered transmitting and receiving antennas arranged one to one face with a distance of 50cm apart. The transmitted and received signals are indicated s(t) and r(t) respectively. The correlation between transmitted and received signals can determine using following formula.

$$F = Max_{\tau}\left|\frac{\int_{-\infty}^{+\infty} S(t)r(t-\tau)dt}{\sqrt{\int_{-\infty}^{+\infty} S(t)^2 dt \int_{-\infty}^{+\infty} r(t)^2 dt}}\right| \quad \text{--- [2]}$$

Fig. 11 showing the time domain analysis of received signal in comparison with transmission signal. Here the received signal amplitude and shape are changing. In this study, fundamental pulses are considered for both transmission and the reception cases; The response of antenna is very quick even for a small change in the input signal.

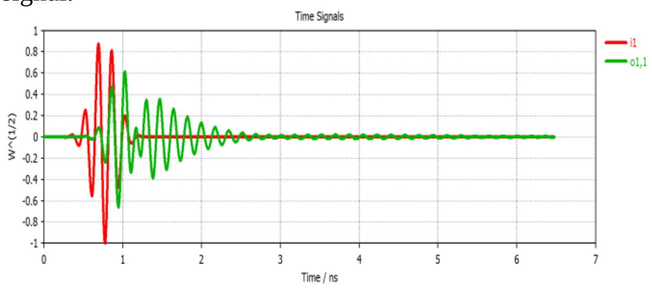

Fig 11. Comparative study of transmitted and received pulses in Time domain.

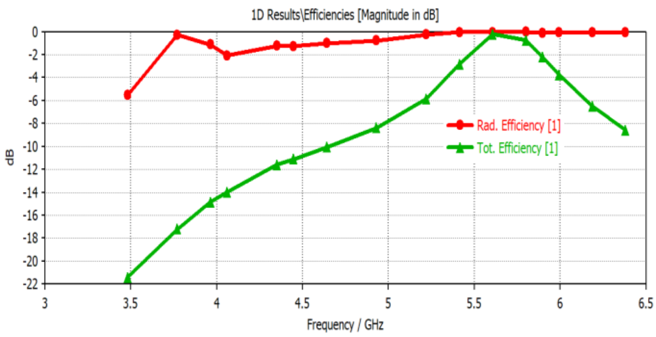

Fig 12. Frequency Vs Efficiency

The efficiency of antenna is another parameter, through which obtained results can be validated much effectively. From, Fig 12. It is evident that the total efficiency is high at the resonant frequency 5.8 GHz and constant at remaining frequency range.

Ref No	Size in mm	Operating Bands GHz	Gain in dB
[3]	46X42X1.6	Single Band	3.45
[6]	48X44X1.6	Dual Band	4.32
[8]	54X48X1.6	Triple Band	3.65
[11]	56X52X1.6	Dual Band	4.86
[15]	45X40X1.6	Single Band	5.28
Proposed Antenna	32X17.6X1.6	Dual Band	7.56

IV CONCLUSION

Current design of circularly polarized antenna is most suitable for wireless communication applications is designed to operate at two centre frequencies (i.e 5.8GHz, 9.2GHz) with impedance bandwidth of 34% and 21% and presented. The dimensions of radiating aperture antenna are 32X17.6 square mm on FR4 substrate of height 1.6 mm. By truncating technique, the axial ratio of antenna is improved hence forth circular polarization is achieved, by controlled the current distribution over the antenna aperture.

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