ISSN (Print) : 2319-5940
ISSN (Online) : 2278-1021

International Journal of Advanced Research in Computer and Communication Engineering
Vol. 2, Issue 3, March 2013

Parasitic Gap Coupled Microstrip Patches with Slot for Broadband Performance

Pankaj Garg[1], O.P. Sharma[2]

M. Tech student, Dept of ECE, Poornima College of Engineering, Jaipur-302022, Rajasthan, India[1]

Professor, Dept of ECE, Poornima College of Engineering, Jaipur-302022, Rajasthan, India[2]

Abstract: This paper presents the radiation performance of stacked arrangement of square microstrip patches. The lower patch (driven patch) is modified by inserting two narrow slots at two opposite corners of square patch while the stacked upper patch is a conventional square patch. Both patches are identical in dimensions. These patches are prepared on glass epoxy FR-4 substrates and are separated through an air gap. The simulation analysis is carried out by using method of moment based IE3D simulator. The optimization of slot lengths, width, angles and applied air gap of proposed arrangement is carried out to achieve much improved bandwidth (44.16%). With proposed feed arrangement, antenna also displays right circular polarization. In the range of frequency where antenna is displaying broadband performance, radiation patterns are identical in shape with direction of maximum intensity inclined at an angle 45^o with plane of patch. The free space performance of this arrangement of patches is compared with that of a stacked arrangement of conventional square patch antenna of identical size.

Keywords: Microstrip antenna, circular polarization, broadband, axial ratio

I. INTRODUCTION

Microstrip patch antennas have gained importance in present days due to possibility of their application in modern wireless and mobile communication systems. Compact circularly polarized microstrip antennas are becoming useful structures for communication systems including GPS systems[1] while broadband antennas are highly suitable for mobile and wireless communication systems [2-3]. These compact antennas may be put inside the handset without protruding out.

However conventional microstrip antennas may not be applied for communication systems because they inherently have narrow bandwidth, low gain and normally operates at a single resonance frequency corresponding to their dominant mode [2]. In recent times, several efforts have been reported to achieve compact antennas with improved performance [4-9]. In this paper, the radiation performance of stacked arrangement of modified square patch antennas with stacked arrangement of conventional square patch antennas is reported. Each patch of this arrangement is designed on separate glass epoxy FR-4 substrate and a narrow air gap of thickness 'd' is applied between them by using Teflon screws. The simulation analysis is carried out by using method of moment based IE3D simulation software [10]. The size of both stacked and driven square patches is taken identical. Different radiation parameters are analyzed and results are presented systematically. The obtained simulated results suggest that proposed compact antenna with improved performance may be suitable for modern communication systems.

II. STACKED ARRANGEMENT OF SQUARE PATCHES

A conventional square patch antenna having length ‘a’ = 25mm designed on glass epoxy FR-4 substrate ($\varepsilon r = 4.37$, $\tan\delta = 0.025$, substrate thickness ‘h’ = 0.158 cm) with infinite ground plane resonates at frequencies 2.99 GHz, 5.416 GHz and 6.31GHz corresponding to TM11, TM21 and TM22 modes of excitation. The impedance bandwidth (2-3%) and gain (1- 2dB) presented by antenna are very low though by applying suitable feed arrangement, circularly polarized radiations from this antenna may be achieved. Under this condition, square patch antenna is not suitable for application in modern communication systems which require larger bandwidth, high gain and circular polarization in certain applications. Therefore this square patch is arranged in a stacked arrangement with another square patch antenna having same patch dimensions as

ISSN (Print) : 2319-5940
ISSN (Online) : 2278-1021

International Journal of Advanced Research in Computer and Communication Engineering
Vol. 2, Issue 3, March 2013

shown in figures 1(a) –(c). A small air gap of thickness d = 0.5 mm is applied between these two patches as shown in figure-1. Both these patches are again designed on glass epoxy FR-4 substrate. The lower square patch named as driven element is fed through SMA

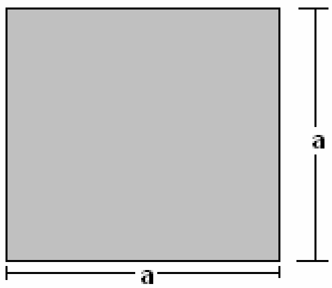

Figure 1 (a) Conventional square (Stacked) patch antenna

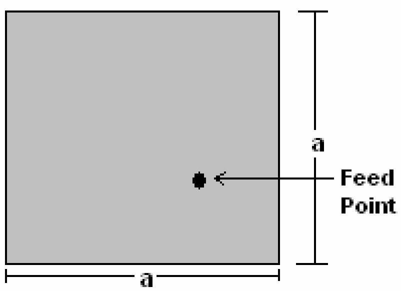

Figure 1 (b) Modified square (driven) patch antenna

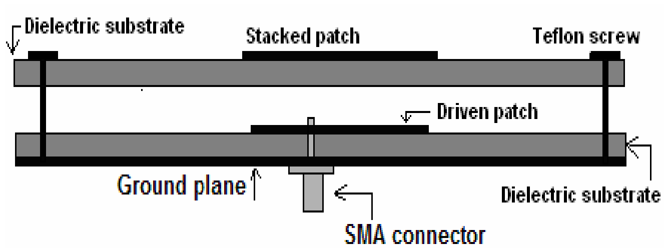

Figure-1(c): Side view of stacked arrangement of square patches

connector with associated 50 ohm feed line. This arrangement of patches is simulated with method of moment based IE3D simulation software. The air gap between patches is optimized and it is realized that on applying air gap equal to 'd' = 0.5mm between stacked and driven elements, best performance from antenna may be realized. The variation of reflection coefficient (S11) with frequency for the present system of antennas is shown in figure 2 while variation of input impedance of antenna as a function of frequency is shown in figure 3. Antenna is still resonating at two frequencies (5.24GHz and 6.02GHz) corresponding to TM21 and TM22 modes of excitation but the two resonance frequencies are marginally reduced in comparison to those we realized for conventional single layered square patch antenna. The simulated bandwidth of proposed arrangement of patches is more than ten times higher than that for the conventional single layered square patch antenna. With proposed stacked arrangement, the overall thickness of antenna is increased (3.23mm) which decreases the resonance frequency of antenna while effective dielectric constant and dielectric loss are decreased which increases the resonance frequency of antenna. The simulated input impedances of antenna at two resonance frequencies are (49.63 +j 0.44) ohm and (50.23 – j 1.75) ohm which suggests excellent patching between antenna and feed arrangement at both resonance frequencies. The simulated axial ratio variation with frequency of antenna shown in figure 4 suggests that antenna is circularly polarized in nature as at frequency 6.2 GHz, axial ratio (2.59dB) is lower than desired 3dB value. The simulated input impedance variation of antenna with frequency also presents a small loop at frequencies 6.2 GHz which again suggests the presence of circular polarization. The simulated input impedance of antenna is having a small loop therefore the axial ratio value (2.59dB) is higher than desired value (0dB).

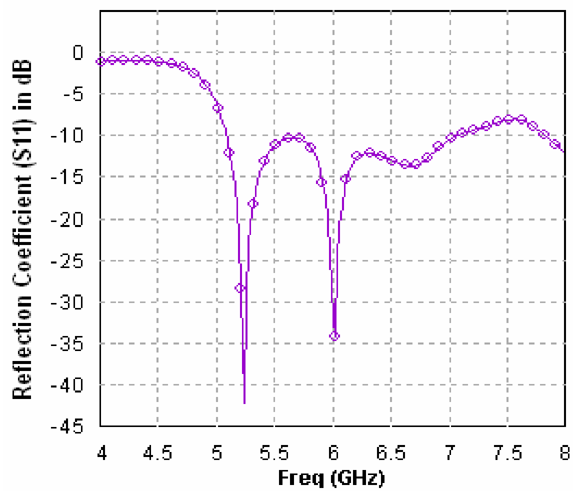

Figure 2. Simulated reflection coefficient (S11) of stacked arrangement of square patches with frequency

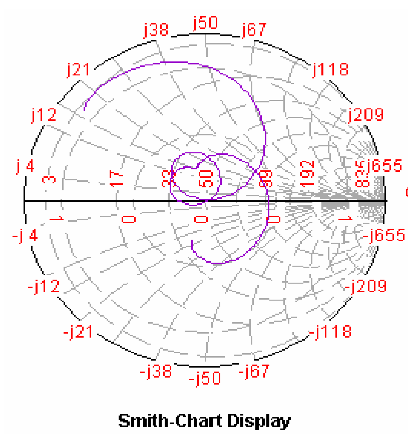

Figure 3 Simulated input impedance of stacked arrangement of square patches with frequency

ISSN (Print) : 2319-5940
ISSN (Online) : 2278-1021

International Journal of Advanced Research in Computer and Communication Engineering
Vol. 2, Issue 3, March 2013

With present feed arrangement, the radiations are right circularly polarized in nature as shown in figure 5. The left circularly polarized radiations are nearly 9dB higher than that of right circularly polarized radiations. Testing of this antenna is currently underway and hopefully the designed antenna will provide good results. The results of this circularly polarized antenna are encouraging as the achieved bandwidth of antenna is improved significantly than conventional square patch antenna hence this antenna is modified further to achieve further improved performance.

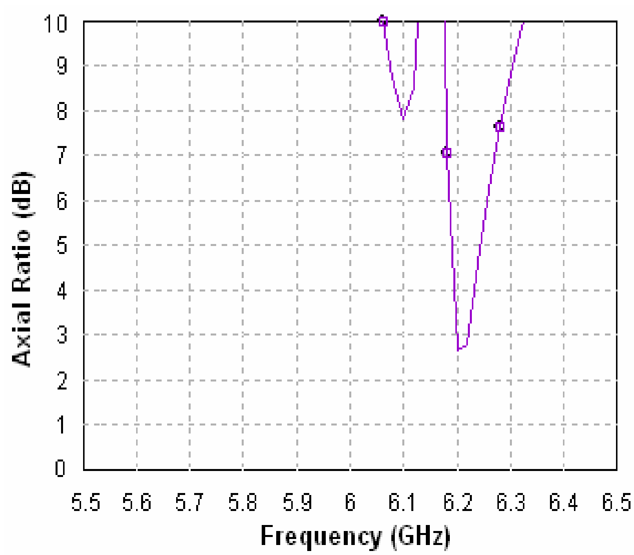

Figure 4 Simulated variation of axial ratio of stacked arrangement of square patches with frequency

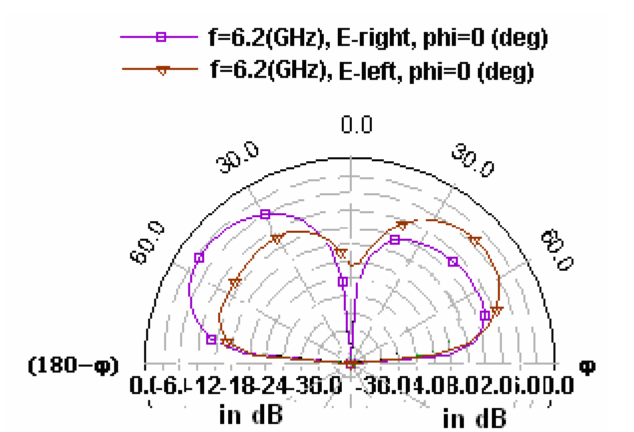

Figure 5: Simulated elevation pattern of proposed arrangement of patches under two polarization conditions

III. STACKED ARRANGEMENT OF MODIFIED PATCHES

In this section, stacked arrangement of square patches reported in previous section is modified to achieve further improved performance. Different views of proposed compact broadband circularly polarized stacked arrangement of patches are shown in figures 6(a) – 6(c). The driven patch is modified a square patch while stacked patch is a conventional square patch. The modified square patch has two slots drawn on opposite corner of square patch antenna and is considered as driven element. After extensive optimizations, it is realized that best performance from antenna may be realized on making slots of identical dimensions with slot length 2.83mm and slot width 2.83 mm. Both these microstrip elements are designed on glass epoxy FR-4 substrate and separated through an air gap of thickness 'd' = 1.0mm by applying Teflon screws at the corner as shown in figure-6(c). The overall thickness of proposed structure is close to 4.18mm. The driven element is fed through single inset feed arrangement using SMA connector. The sizes of stacked and driven elements are taken identical.

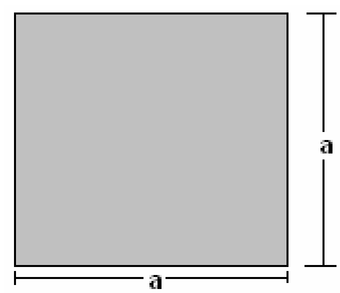

Figure 6 (a) Conventional square (Stacked) patch antenna

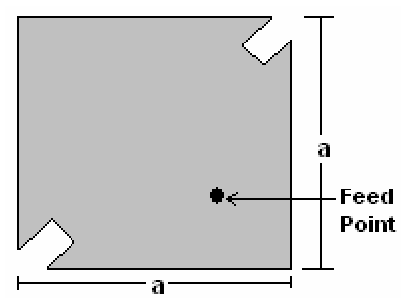

Figure 6 (b) Modified square (driven) patch antenna

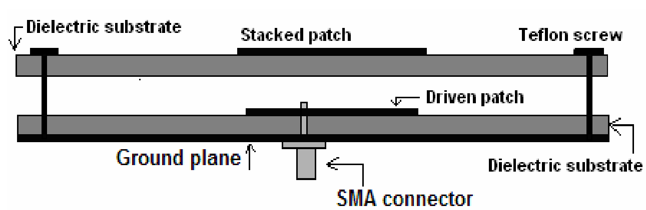

Figure-6(c): Side view of stacked square patches

ISSN (Print) : 2319-5940
ISSN (Online) : 2278-1021

International Journal of Advanced Research in Computer and Communication Engineering
Vol. 2, Issue 3, March 2013

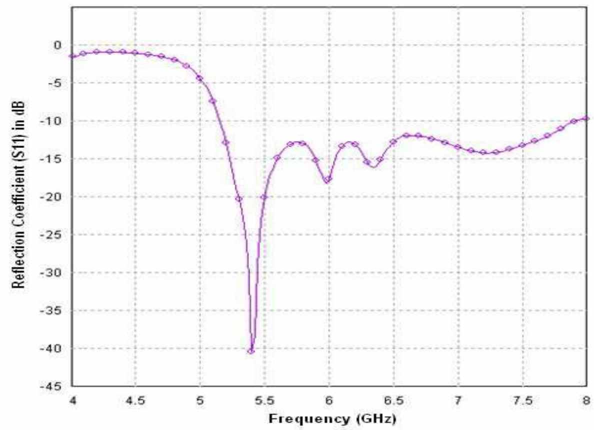

Figure 7: Simulated reflection coefficient (S11) of proposed arrangement of patches with frequency

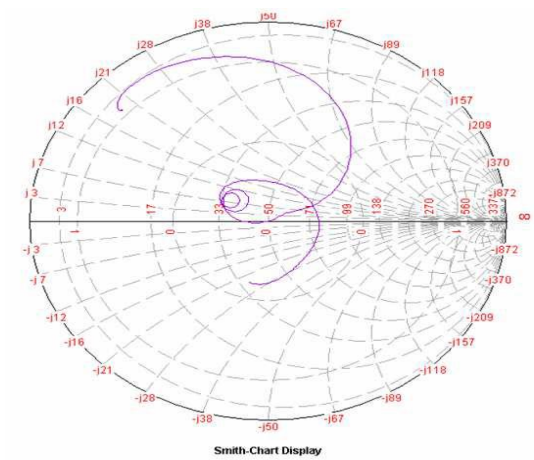

Figure 8: Simulated input impedance of proposed arrangement of patches with Frequency

The simulated reflection coefficient of this arrangement of patches as a function of frequency is shown in figures 7. Antenna arrangement resonates predominantly at a single frequency 5.41 GHz and presents good matching between antenna and feed arrangement. Though few other frequencies corresponding to higher order modes are also realized where antenna may resonate but matching between antenna and feed for these frequencies is poor and hence these frequencies are discarded for the present study. The simulated impedance bandwidth shown in figure 7 is 2.65GHz or 44.16% with respect to central frequency which is around ten percent higher than that realized in previous case for stacked arrangement of conventional square patch antennas. The VSWR presented at resonance frequency 5.41GHz is well within desired 2:1 value. The input impedances of antenna at resonance frequency is ohm as shown in figure 8 which again suggests good matching between antenna and feed arrangement. Presence of two small loops one in another in the input impedance variation suggest the presence of circular polarized radiations from the antenna at two frequencies. From this variation two dips in the figure-9 are realized at two frequencies 5.96GHz and 6.28 GHz. For frequency 5.96GHz, lowest axial ratio 2.12 dB is achieved hence this frequency is considered as the central frequency. This axial ratio bandwidth is very narrow (1.75%) in present case which needs further improvement. With present feed arrangement, the radiations are right circularly polarized in nature as shown in figure 10. The right circularly polarized radiations are nearly 8dB higher than that of left circularly polarized radiations.

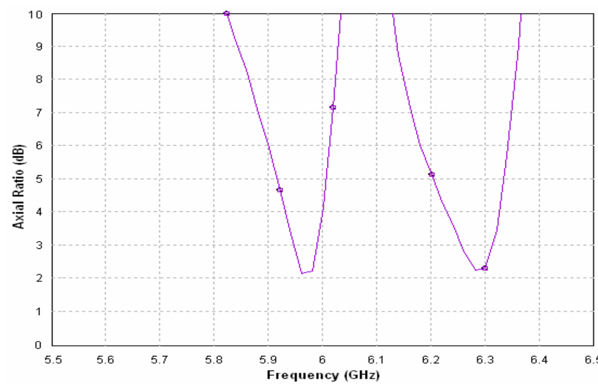

Figure 9: Simulated axial ratio of proposed arrangement of patches with Frequency

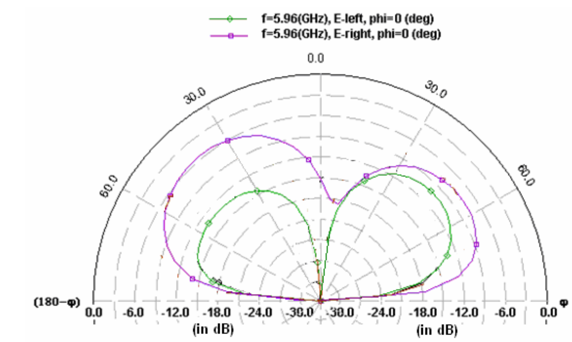

Figure 10: Simulated elevation pattern of proposed arrangement of patches under two polarization conditions

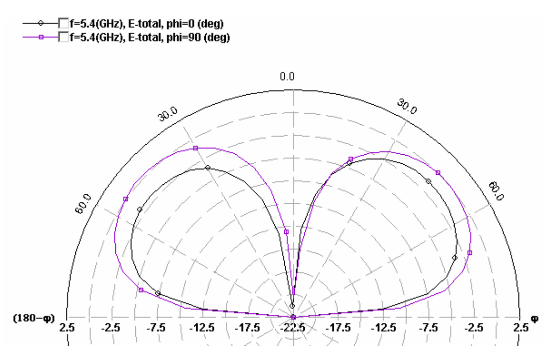

Figure 11: Simulated E and H plane elevation pattern of proposed arrangement of patches

ISSN (Print) : 2319-5940
ISSN (Online) : 2278-1021

International Journal of Advanced Research in Computer and Communication Engineering
Vol. 2, Issue 3, March 2013

The representative E and H-plane radiation patterns of proposed structure at resonance frequency 5.4GHz are shown in figure 11. The radiation patterns are almost identical in shape and nature. The direction of maximum intensity in the patterns for each frequency is inclined at an angle 45o with respect to plane of patch geometry.

IV. CONCLUSION

The radiation performance of stacked arrangement of modified square patches is simulated by using IE3D simulation software and its performance is compared with that of stacked arrangement of conventional square patches. On optimizing air gap between driven and stacked elements together with length, width and angle of applied slots in driven patch geometry, it is realized that proposed antenna resonates at predominantly at a single frequency with much improved impedance bandwidth (44.16%) than stacked arrangement of conventional square patches. Antenna also provides circularly polarized radiations. In the range of frequency where broadband performance from antenna is observed, the directivity and gain are low but these are almost constant. The radiation patterns in entire bandwidth are almost identical in shape and nature. The direction of maximum radiation from antenna is inclined at an angle 45o with the plane of patch. The testing of these antennas is currently underway at our center. The simulated performance of antenna is encouraging and hopefully after proper testing, this antenna may be proved a suitable structure for modern communication systems.

REFERENCES

1. K.L. Wong, "Compact and Broadband Microstrip Antennas" New York: J. Wiley and Sons, 2002.
2. R. Garg, P. Bhartia, I. Bahl, and A. Ittipiboon, Microstrip Antenna Design Handbook, Artech House, Norwood, Mass, USA, 2001.
3. J. R. James, "Handbook of Microstrip Antenna", Peter Peregrinus Ltd.: London, 1989.
4. S. Shekhawat, P. Sekra, D. Bhatnagar, V.K. Saxena and J.S. Saini"Stacked Arrangement of Rectangular Microstrip Patches for Circularly Polarized Broadband Performance." IEEE Antennas and Wireless Propagation Letters, Vol. 9, pp 910-913, 2010.
5. Pankaj Garg, Khushboo Gupta and O.P Sharma “Bandwidth Efficient Stacked Arrangement of Square Patches”, National Conference on Numerical and Mathematical Modeling in Electrical Engineering and Applied Sciences, Jaipur, January 2012.
6. K. L. Wong and W. Hsu, "Broadband triangular microstrip antenna with U-shaped slot", *Electronics Letters*, 33, 1997, pp 2085 – 2087.
7. Gh. Z. Rafi and L. Shafai "Wideband V-Slotted Diamond-Shaped Microstrip Patch Antenna" *Electronics Letters*, Vol. 40 No. 19, 2004.
8. Vijay Sharma, V.K. Saxena, J.S. Saini, D. Bhatnagar, K.B. Sharma and L.M. Joshi, "Broadband Gap Coupled Assembly of Patches Forming Elliptical Patch Antenna" Microwave and Optical Technology Letters Vol. 53, No. 2 , 2011 pp 340-344.
9. H. Lee, D. College, J. Jung and Y. Lim "A Design of Wideband Folded Dual Monopole Antennas for Wireless Communications." Microwave Journal, Vol. 50, No. 6, June 2007.
10. IE3D Software, Release 8, Zeland Software, Inc., Freemont, US