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Design of Microstrip Patch Antenna for Wi-Fi Application

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Abstract : A Microstrip Patch Antenna (MPA) is designed to resonate at 5.2 GHz, primarily for Wi-Fi application. The proposed MPA ground plane etched as a Defected Ground Surface (DGS) with square shape of 5 mm X 5 mm and two rectangular slots of 0.5mm X 10 mm separated by 14 mm is resonating at 5.15GHz with a impedance matching -18.78 The MPA provides a broadside radiation gain of 4.5 dB with cross-pol suppression of approximately 7 dB compare to conventional MPA

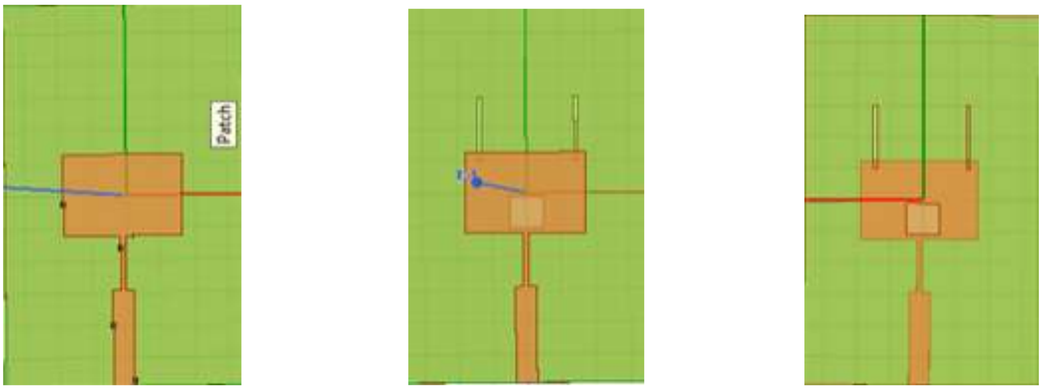
***IndexTerms* - Microstrip Patch Antenna, Defected Ground Surface, cross-pol.**

I. INTRODUCTION

The Rectangular Microstrip Patch Antennas (RMPA) are widely using for most of the wireless communications applications due to their attractive features, like low cost, light weight, compatibility to MMIC, easy fabrication and broadside radiations. The first time the MPA concept is presented in 1953 [1] but the first work patented in 1970 [2], now MPA's become playing major role in wireless communications by defecting its geometry in ground plane alone or patch alone or both for improvement of its performance. Some of its defect or modification in the designed antenna is required to control the cross-polarized radiations (XP) in prototype MPAs to provide good isolations and is very much essential in advanced sensor applications. From the open literature the cross polarized radiation (XP) are more significant in the H-plane than the E-plane [3]. As the angular region is concerned the cross polarization levels are 20 dB lower than co-polarization levels and is only few degrees near the broad side direction in H-plane, this restriction is not desirable in wireless applications like cellular, mobile land, etc., will require wide coverage is indicated [4]. Many researchers are working on suppression of cross polarized radiation in H-plane.

Some investigations are made by perturbing the conventional microstrip patch antenna for reduction of cross polarized radiation. One of the approach was stacked patch configuration gave overall cross polarized radiation below -16.5 dB [5]. A microstrip antenna with air substrate having complex feeding mechanism produces cross polarized radiation suppression to -25 dB and -23 dB is reported [6]. There are many researchers have used different feeding techniques to improve either to enhance the band width or for dual polarization or to reduce the cross polarized radiation among them some of them are Meandering the strip feed or differentially fed patch or comprised feeding structure with a compact annular-ring slot with a T-shaped microstrip feed line. All the above structures are producing 20 dB cross polarized radiations reported in [7-9]. A microstrip patch fed by two hybrid input ports, one port with two in-phase aperture coupled probe feeds and other with two out-of –phase gap-coupled feeds reported 40 dB isolation in L-band with XP suppression less than -20 dB [10]

Several research groups have taken an interest to reduce the cross polarized radiation since from last two decades. Recently, the defected ground structure (DGS) technique is proposed to suppress the XP radiation by Guha et al. [11]. Subsequently C. Kumar and



(a) (b) (c)

Figure-1: (a) Conventional MPA, (b) Modified MPA top view, (c) Modified MPA bottom view

Guha team carried out the work further using DGS technique et al. [12-15]. The dot-shaped DGS helps in suppression of orthogonal fields as probe is moved towards the matching point demonstrated [12]. The arc shaped DGS provides 30 dB co-pole to cross pole isolation in H-plane and XP level found to be more than 30 dB isolation from the peak value is reported in [13]. A circular Microstrip patch antenna (CMPA) with two new geometrics of defected ground structure (DGS) improves the XP of 5 to 7 dB reported compared to normal ground plane [14]. Circular microstrip patch antenna excited with dominant mode radiates linearly polarized fields along the broadside radiation determined by imaginary vertical plane with annular and circular DGS has reported 10 dB to 12 dB suppression is reported [15]. Rectangular microstrip patch integrated with rectangular and folded rectangular DGS provides a cross polarized radiation up to 12 dB [16]. Asymmetric geometry of Defected ground surface achieved more than 20 dB from co-pole to XP suppression [17]. The complex symmetric structure type DGS has indicated the suppression about 17dB for W/L=0.8 [18]. All the above works are done using RT/Duriod substrate with ε_r =2.33 and thickness h=1.575mm.

The proposed antenna being defected in the ground plane called as DGS to reduce cross polarized radiation up to 7 dB using commercially available material FR4. The ground plane etched with two symmetric rectangular slots placed and a square slots eparated by 14 mm along the Y – axis and its dimension are finalized based on optimization. The length of the slots are 0.5 mm X 10 mm and square slot of 5 mm X 5 mm.. The square DGS is optimized and finalized at X = -2.5, Y = -5,5, Z = 0. The roposed antenna configuration bottom view and top view is shown in figure – 1(b), & (c).

II. ANTENNA CONFIGURATION

The conventional rectangular microstrip patch antenna with a quarter wave transformer feed is designed to resonate at 5.2 GHz using design equations [20]. The designed conventional antenna is simulated using HFSS [19] is resonated at 5.15 GHz. A rectangular microstrip patch using a copper sheet of length L=12.56 mm and width W=17.56 mm was designed with a material FR4 epoxy substrate of dielectric constant of ε_r = 4.4 and thickness h =1.6 mm. The designed RMPA is fed through a quarter wave transformer line feed; its length and width are chosen to match a source impedance of 50Ω as shown in figure-1(a). The ground plane dimension is to be considered 35.9mm X 58.94mm. The ground plane length is approximately equals to λ/2 + length of patch and width is approximately equals to λ/2 + width of the patch.

The proposed antenna being defected in the ground plane called as DGS to reduce cross polarized radiation up to 7 dB using commercially available material FR4. The ground plane etched with two symmetric rectangular slots placed along the Y – axis and its dimension are finalized based on optimization. The length of the slots are optimized 10 mm and width of the optimized slot 0.5 mm. The Square DGS of 5 mm X 5 mm, its position is optimized and finalized at X = -2.5, Y = -5,5, Z = 0. The proposed antenna configuration bottom view and top view is shown in figure – 1(b) & (c). The ground plane of RMPA is defected with a square slot of size 5 mm X 5 mm etched at (-2.5 ,-5.5 ,0) is resonated at 5.14 GHz with impedance matching of -18.97 dB. The RMPA provides a broadside radiation gain of 4.2 dB with cross-polarization -25 dB either side of a radiation characteristics. The size of rectangular sot is optimized and provides almost same gain but deteriorate in cross-polarization is shown in Table-1.

Slot Size variation	Resonating Frequency (f_o) (GHz)	Gain (dB)	XP level		XP Suppression
			+θ	-θ	
Conventional (0,0,0)	5.2	4.66	-23	-23	-
5 mm X 5 mm	4.9	4.45	-23	-22	-
4 mm X 4 mm	5.0	4.38	-25	-23	2dB
3 mm X 3 mm	5.1	4.5	-23	-22	-
2 mm X 2 mm	5.2	4.56	-23	-22	-

Table-1: Square Slot Size Variation

Along with square slot two rectangular slots etched in the ground plane of symmetrical size (2.5 X 10) mm at a position (-7 ,5 ,0) is resonated at 5.15 GHz with impedance matching is -22 dB. The RMPA provides a broadside radiation gain of 4.6 dB with cross-polarization -26 dB almost either side of a radiation characteristics is shown in Table-2.

Along with square slot two rectangular slots etched in the ground plane of symmetrical size (2.5 X 10) mm at a position (-7 ,5 ,0) and (7 ,5 ,0) respectively is resonated at 5.15GHz with impendence matching is -28dB almost along the X-axis. The RMPA provides a broadside radiation gain of 4.6dB with cross polarization almost either side of a radiation characteristics is shown in Table-3.

Rectangular Slot Position Variation	Resonating Frequency (f_o) (GHz)	Gain (dB)	XP level	
			+θ	-θ
3	5.17	4.7	29	28
4	5.17	4.6	27	26
5	5.16	4.5	29	27
6	5.16	4.6	26	27

Table-3: Square slot Position variation

1.5	5.15	4.5	28	30
1	5.15	4.6	28	29

Table-2: Square slot Size variation

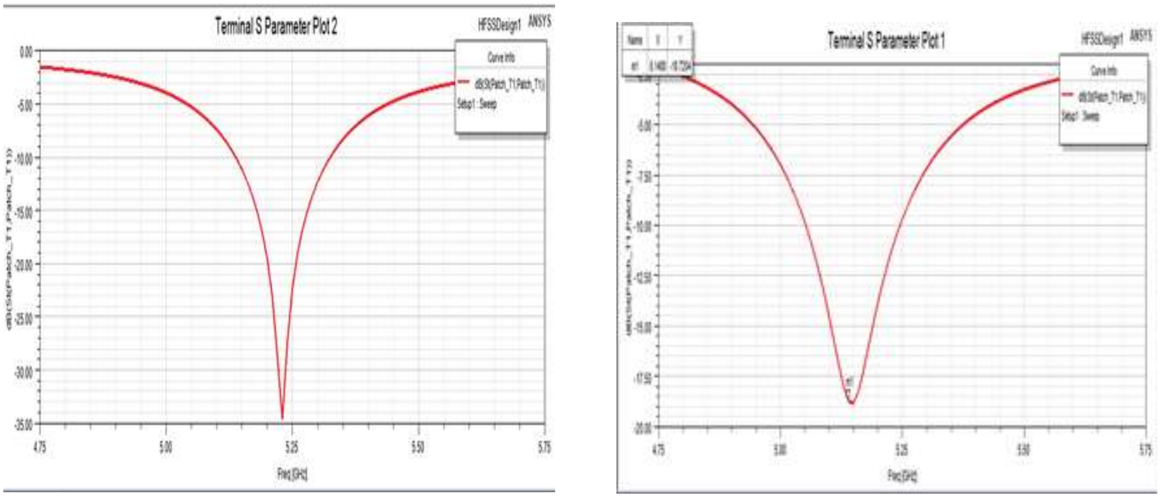
By retaining the rectangular slots of symmetrical size (2.5 X 10) mm at a position (-7 ,5 ,0) and (7 ,5 ,0). Only square slot is varied in steps 1 mm along either side of Y-axis and its optimized antenna parameters values are tabulated in Table-4. During this analysis at a position Y= -3 mm the RMPA provides better result with a co-polarized gain of 4.48 dB and cross-polarization of -29dB and -30dB either side with total suppression of 7 dB is achieved compare to conventional microstrip patch antenna. The modified RMPA resonates at 5.1GHz with a compactness of 0.1 GHz.

Square Slot (5 X 5) mm position variation	Resonating Frequency (f_o) (GHz)	Gain (dB)	XP level		XP Suppression
			+θ	-θ	
Conventional (0,0,0)	5.2	4.66	-23	-23	-
Y = 1mm	4.9	4.45	-23	-22	-
Y = 2mm	5.0	5.19	-24	-23	-1dB
Y = 3mm	5.1	5.10	-20	-22	-3dB
Y = 4mm	5.2	4.84	-19	-19	-4dB
Y = 5mm	5.2	4.74	-17	-18	-6dB
Y = 6mm	5.2	4.81	-18	-18	-5dB
Y = 7mm	5.2	4.83	-19	-19	-4dB
Y = -1mm	5.0	4.28	-26	-27	-3dB
Y = -2mm	5.0	4.38	-28	-27	5dB
Y = -3mm	**5.1**	**4.48**	**-29**	**-30**	**7dB**
Y = -4mm	5.2	4.69	-27	-27	5dB
Y = -5mm	5.3	4.82	-25	-25	3dB

Table-4: Square slot position variation along Y-axis

III. SIMULATED RESULTS

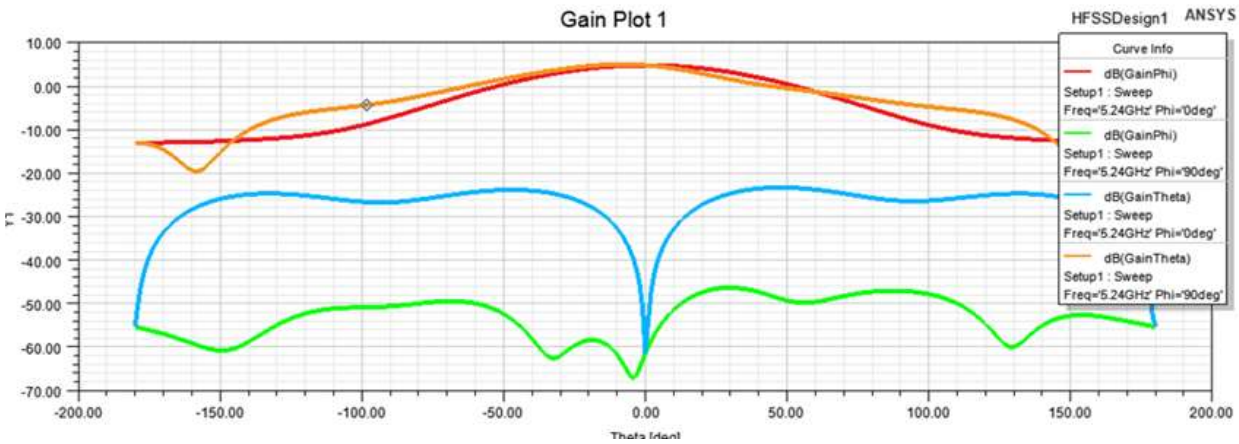
The reflection coefficient of conventional MPA and modified MPA is shown in figure-2. It is observed that, for a conventional



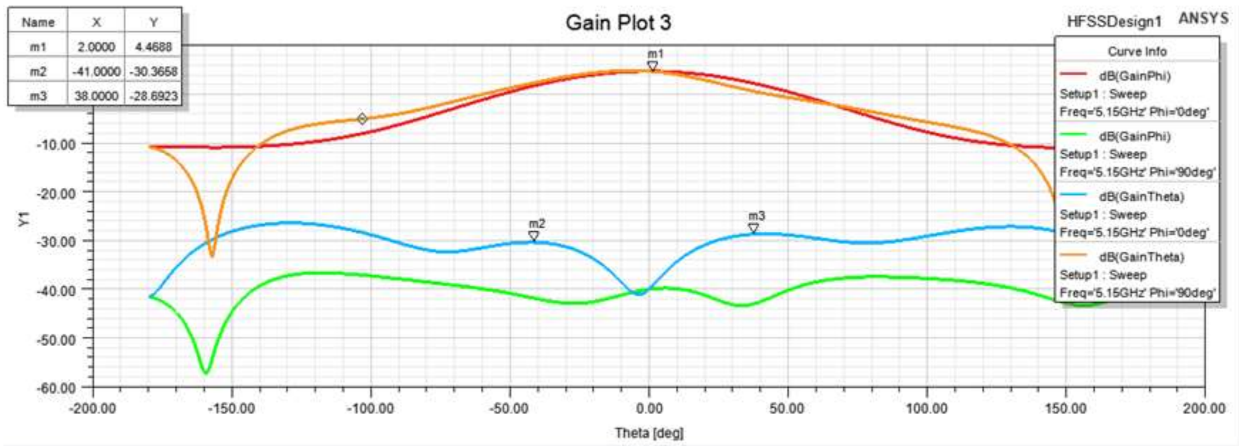
(a) (b)

Figure-2: (a) Return loss of Conventional RMPA (b) Return loss of Modified RMPA

MPA resonating at 5.24 GHz with a good impedance matching (S11=-37dB) and a bandwidth of 185MHz. But for modified



(a)



(b)

Figure-3: (a) Radiation characteristics of conventional RMPA (b) Radiation characteristics of Modified RMPA

patch due to two rectangular slots, square slot etched in the ground plane gives a compactness of 0.1 GHz of the MPA because of slots in the ground plane a decrease in its impedance matching (S11=-18.72dB) and maintains the same bandwidth. The conventional MPA gives good broadside radiations of co-pole with a peak gain of 4.66 dB and cross-pole radiation of -23dBi. The proposed MPA shows compactness by shifting resonating frequency from 5.24 GHz to 5.15 GHz and provides a good isolation between co-pole radiations to cross-pol radiation of approximately 35 dB. The radiations also affected in H-plane without affecting the E-plane (co-pole) radiations. The average H-plane XP is -35dB when it compared to conventional MPA shows that the suppression of 7 to 8dB as shown in Figure 3 (a) & (b).

IV. CONCLUSION

A rectangular microstrip patch antenna with defected ground plane and defected patch using quarter wave transformer feed is proposed for reducing cross polarized radiations to provide more isolation between co-pole and XP. An attempt is made to reduce the XP and succeeded to reduce almost 7dBi compare to conventional patch antenna. The proposed antenna is simulated using HFSS V13.0.

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