Suppression of Spurious Mode and Cross-Polarized Radiations in Rectangular Microstrip Patch Antenna

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Abstract : This paper proposes a suppression of spurious modes and cross-polarized (XP) radiations. The rectangular microstrip patch antenna with two symmetric slots etched ground plane is proposed. The technique is simple, innovative, easy to implement for practical applications. The XP suppression of about -16dB is achieved over a broadside radiation. This configuration shows a co-pol peak gain of 5.33 dBi. A prototype has been fabricated using commercially available low-loss dielectric material FR4 (glass epoxy) with dielectric constant (ε_r) = 4.4. The Experimental validation is good agreement with the simulation results.

***IndexTerms* - Spurious mode, Cross-polarized (XP) radiation, defected ground structure (DGS), Microstrip patch antenna (MPA).**

I. INTRODUCTION

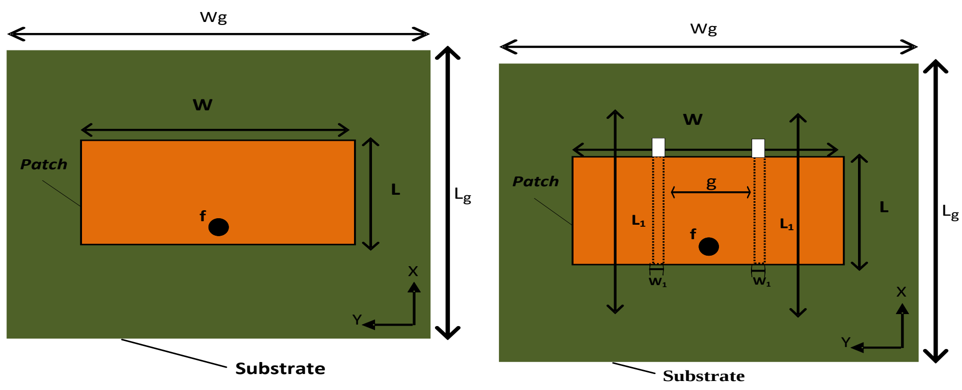
The microstrip antennas were suitable for the use on flat surfaces are highly demand for mobile devices and microwave services, has several commercial and military applications. The antennas must reach a high miniaturization level with light weight, low-cost are desirable. The electromagnetic interference (EMI) caused by harmonics from integrated components in an antenna is one of the major problems in microwave systems[1]. Harmonic-rejecting antennas without pre-filters are employed in the active antenna systems will bring the advantages of low cost, simple design, and high conversion efficiency[2].Introducing over-coupling to the end stages and enhancing the image impedance of the filter the suppression of spurious frequencies were achieved [3]-[4]. Many techniques for modes suppression have been applied, such as photonic bandgap (PGB) and defected ground structures (DGS)[5]-[6], split-ring resonators [7], and wiggly line resonators [8]. Compact defected ground structures suppress the higher harmonics and their radiations in microstrip antennas The size of DGS slots is also an important to suppress the XP values without affecting the radiating mode [9]-[11].

The spurious modes are unwanted signal it will interfere with other wireless systems. For this reason the control of spurious modes and also cross polarized radiation (XP) suppression is discussed in this paper.

In this paper, we proposed two slots of length equal to λ/4. Two symmetric resonant slots etched in the ground plane for the suppression of XP fields additionally it provide suppression of spurious modes. The configuration is simple and easy to implement for real applications. The simulated result shows the XP fields about -16dB over a broadside radiation. In result and discussion, the return loss and radiation patterns are discussed in the view of suppression of spurious mode. All the results are compared with the conventional microstrip antenna results.

II. ANTENNA CONFIGURATION

Microstrip patch antenna designed using analytical formulas and simulation studies done through optimization. The conventional antenna and proposed antenna top view is shown in Fig 1(a) and (b) respectively. MPA designed using FR-4 substrate with ε_r = 4.4, thickness=1.575 mm and resonating at frequency 3GHz. The probe feed location 'f' is chosen to excite ideal mode with proper impedance matching of 50Ω. The size of ground plane is ($W_g \times L_g$) and the patch length and width based on TLM. The MPA shows good impedance match, return loss characteristics with broadside radiations. The proposed MPA configuration were made by etching a pair of resonating slots with dimensions$W_1 \times L_1$ in the ground plane as DGS slots. The two identical resonant slots of λ/4 length with a width of 1.5mm are etched in the ground plane. The positions of the slots are decided based on optimization using series of simulations

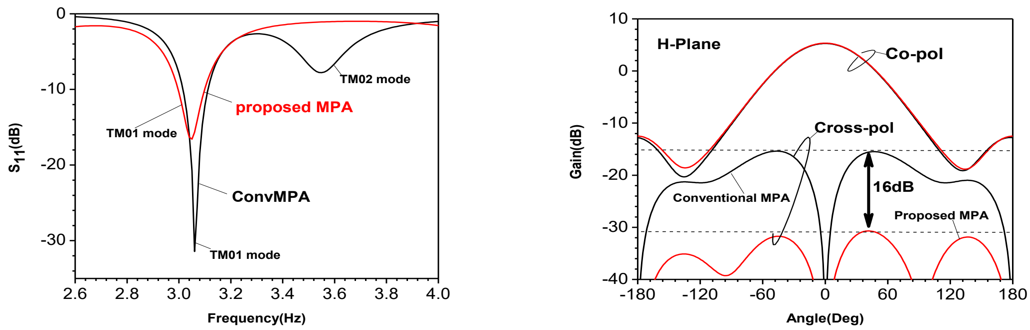


(a) (b)

Figure 1: The MPA with and without DGS (a) Conventional MPA (b) Proposed slot etched DGS MPA.

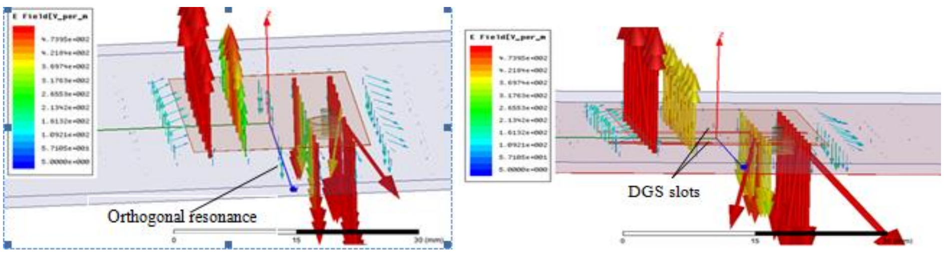
III. Results and Discussions

Conventional antenna works in the fundamental mode (TM_{01} mode) 3.06GHz .Spurious mode (TM_{02} mode) take place at the frequency 3.55GHz. The simulated [12] return loss characteristics and H-plane radiation of conventional and proposed microstrip patch antenna is as shown in Fig. 2. The comparison plot shows that the conventional MPA gives dominant mode at 3.06 GHz with good impedance matching, good gain of 5.27 dBi. 3.05 GHz is dominant mode for the proposed MPA with co-pol peak gain of 5.33 dBi but one higher mode at 3.55 GHz, this spurious mode is suppressed by placing two symmetric resonant DGS slots. These causes inductive load and hence the effect on the impedance matching is observed, which indeed causes a relative shift in S_{11} minima from -32 dB to -17dB. It is also acting as a filter to suppress the spurious modes. Two slots have been introduced on the ground plane in such a way that the dominant mode field structure will not be disturbed while it affects the field structure of higher-order orthogonal modes (particularly TM02 mode) that are mainly responsible for XP radiation. The XP level of -16dB symmetric with broadside. The presence of orthogonal resonance causing the XP radiation.DGS slots weakens the orthogonal resonance as revealed from Fig 3.



(a) (b)

Figure 2: Simulated S_{11} and H-plane radiation characteristics of conventional and proposed MPA configurations: (a) return loss characteristics, (b) H-Plane radiation characteristics of a rectangular patch with and without DGS.

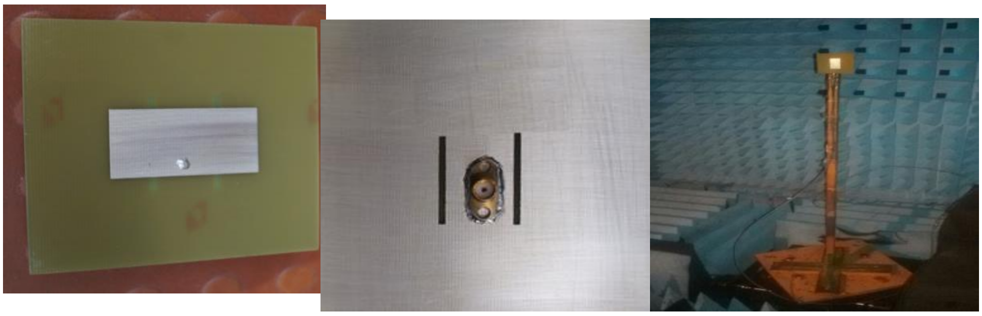


(a) (b)

Figure 3: Dominant mode electric field with and without DGS. (a) Conventional MPA Electric fields along orthogonal axis. (b) Proposed MPA weak orthogonal field.

IV. Prototypes and Experimental Verification

A set of prototypes of conventional and proposed MPA has been fabricated for experimental verification. Fig. 4 (a) shows a top view of conventional MPA and Fig. 4 (b) shows bottom view of proposed probe fed rectangular MPA. In order to validate the simulation data a set of experiments conducted at microwave laboratory at Indian Institute of Science (IISc) Bangalore.



(a) (b) (c)

Figure4: Prototype of probe fed rectangular microstrip patch antenna: (a) Top view of conventional MPA (b)bottom view of proposed MPA with resonating slots as DGS in ground plane. (c) Radiations measurement

Table 1: Comparative results of Conventional with Proposed microstrip antenna

Parameter	Conventional MPA		Proposed MPA	
	Simulated	Measured	Simulated	Measured
Return Loss(dB)	-32	-28	-17	-16
Resonant frequency(Hz)	3.06	3.09	3.05	3.09
Peak gain(dBi)	5.27	5.28	5.33	5.30
H-plane XP level	-14.3	-13.4	-30.2	-29.6

Table 1 represents the comparative results of conventional with proposed microstrip antenna. From the above table 1, it is clear that the performance parameters of antenna with DGS slots are better than conventional antenna.

V. Conclusion

This paper presents a simple technique results cross-polarized (XP) radiations and spurious modes are effectively suppressed by using a pair of $\lambda/4$ resonators etched ground plane. The XP suppression of about -16dB is achieved. This configuration is good for wireless sensor applications. In addition, more symmetric radiation patterns and gains have been obtained.

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