

# Rectangular Slotted Ground Structure to Reduce Mutual Coupling in Microstrip Patch Antenna Array

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**Abstract** –In microstrip patch antenna array, the mutual coupling is very critical due to surface wave excitation. It leads to degradation in radiation pattern and reduction in gain. Therefore in order to increase the performance of the antenna array mutual coupling should reduce. In this paper, Rectangular microstrip antenna array is designed using transmission line model at 900MHz, dielectric constant of substrate is 2.2 and height of the substrate is 1.6mm. Distance between two antennas from center to center is kept  $0.75\lambda$ . To reduce mutual coupling two rectangular slots of width  $0.06\lambda$  are etched in the ground plane. These Rectangular slots disturb shield current leads to reduction in mutual coupling. Designed microstrip antenna array using with and without slots are simulated using Ansoft HFSS 13. Simulated results showed that by using without slots mutual coupling is -30dB and with slots mutual coupling is -35dB. By using microstrip antenna array with using slots mutual coupling is reduced by 5dB compared to without using slots. Therefore this Slotted Ground Structure technique can be used to increase the performance microstrip antenna array.

**Index Terms** – Mutual coupling, SGS, Patch antenna array, Surface wave, Microstrip patch antenna.

## I. Introduction

In wireless communication system, there is a demand for compact and high performance devices. Microstrip technology is used in various microwave components. One of such microwave component is Microstrip patch antenna [1]. It has several advantages such as low profile, low-cost, light weight, easy to fabricate and ease of integration with other printed circuits [2]. Single Microstrip antenna has limitation of low gain and directivity [3]. In order to overcome this limitation, many microstrip antennas are arranged in array. Therefore array is used where high gain and high directivity is required [4]. Microstrip antenna array is mainly used in aerospace, satellite and radar applications.

The main problem in microstrip patch antenna array is mutual coupling effect. It is due to excitation of surface wave, space wave and near field overlapping of the array elements. Mutual coupling effect leads to element radiation pattern distortion,

side lobes higher than the desired and mismatch of individual elements to their feed [5].

But mutual coupling depends on inter element separation and it causes undesirable effects on antenna characteristics [6]. Therefore it is necessary to reduce mutual coupling effect in microstrip patch antenna array.

There are different methods to reduce mutual coupling like Electronic Band Gap (EBG) Structure [7], UC-EBG [8], and Spiral resonators (SR) structures [9]. Even though these techniques can reduce mutual coupling upto 10dB, but they have some disadvantages compact and difficult to fabricate vias in EBG and cost expensive. In this paper, a simple two rectangular slots are etched in ground plane of microstrip patch antenna array.

## II. Inset fed Patch Antenna

Inset fed Rectangular Microstrip Patch antenna is designed using transmission line model [5] at 900MHz, dielectric constant is 2.2 and height of the substrate is 1.6mm. The designed antenna dimensions are as follows. The width of the antenna is 131.76mm, length is 111.69mm, and inset distance is 34.113mm. The designed antenna is simulated. Return loss is analyzed.

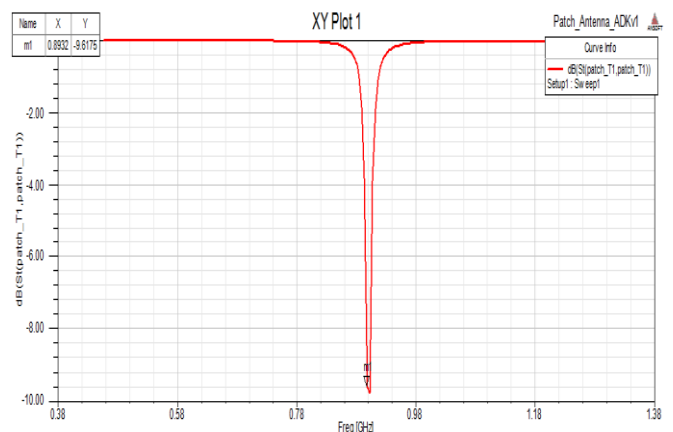


Fig 1: Return loss of an single antenna

Singe Rectangular Microstrip patch antenna is simulated and the outputs are shown in figure. Return loss is around -9.6175 dB at resonating frequency 0.8932MHz.

### III. Simulated Results of Microstrip Patch Array without Slots

Two inset fed rectangular microstrip patch antennas are separated by distance  $0.75\lambda$  is designed and simulated. The results are shown below

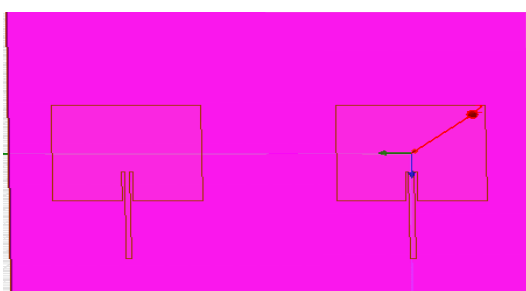


Fig 2: Microstrip Antenna Array without slots

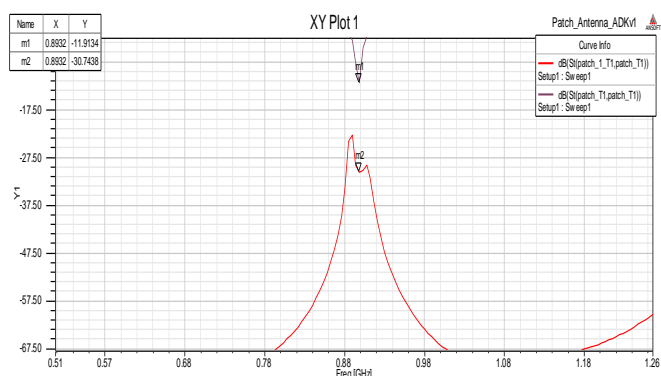


Fig 3: Return loss and S21 of Microstrip Antenna Array without slots

Figure 2 shows Microstrip patch antenna array without slots and figure 3 shows return loss of -11.9134 dB and Mutual coupling around -30.7438dB and Gain is 7.9756 dB

### IV. Simulated results of Microstrip Patch Array with Slots

Two rectangular slots are etched on the ground plane. These two slots are etched between two antennas. Rectangular slot dimensions are as follows, width of the slot is  $0.06\lambda$  and length of the slot is same as the patch length. The patch antenna and rectangular slot is separated by a distance of  $0.03\lambda$ . These slots disturb the shield current of microstrip antenna leads reduction mutual coupling of microstrip antennas in an array. Reduction of mutual coupling leads to increase in gain.

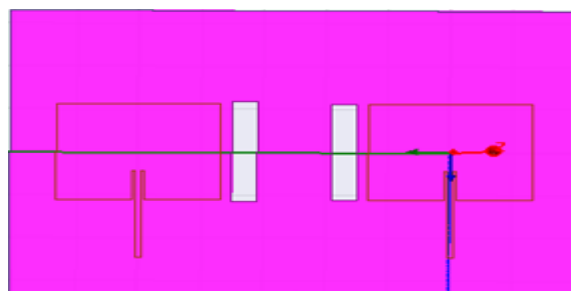


Figure 4: Microstrip Patch Array with two  $0.06\lambda$  Rectangular Slots

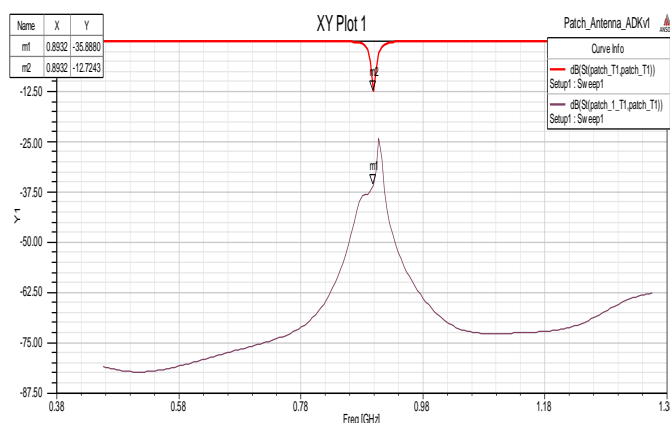


Fig 5: Return Loss and S21 of Microstrip Antenna Array with Slots

Simulated results shown in figure 5. Return loss is -12.7243 dB, mutual coupling is -35.880 dB and gain is 8.0302 dB is achieved using two rectangular slots on ground plane in Microstrip antenna array.

### V. Comparison of results of Microstrip patch antenna array using with and without slots

Parameters	Without Slots(dB)	With Slots (dB)	Comments
Mutual Coupling	-30.7438	-35.880	By using slots Mutual coupling is reduced to 5.1362 dB
Return Loss	-11.9134	-12.7243	Return loss is increased by 0.8109 dB
Gain	7.9756	8.0302	Gain is increased by 0.0546 dB

Table 1: Comparison of parameters of antenna using with and without slots

From the above table, it shows that by using two rectangular slots on ground plane of an antenna array we can reduce the mutual coupling effect by 5dB, return loss increased by 0.8109dB and gain is increased by 0.05

## VI. Conclusion

Even though many techniques like EBG, DGS, UC-EBG and Spiral Resonator (SR) are used to reduce the mutual coupling effect in antenna array. These techniques have their own disadvantages. For example, EBG is complicated structure, difficult to fabricate vias and cost expensive. In this paper, Slotted Ground Structure (SGS) is used to reduce the mutual coupling effect in an antenna array. Simulation is carried by Ansoft HFSS 13. Advantages of SGS are easy to fabricate and cost effective. By using SGS Mutual coupling is reduced by 5dB. Because of its simple structure it can be used effectively to increase the performance of microstrip antenna array.

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