MUTUAL COUPLING REDUCTION BETWEEN PLANAR MICROSTRIP PATCH ANTENNAS BY USING A ELECTROMAGNETIC BAND GAP STRUCTURES

Dr.H.C.Nagaraj[1], Dr.T.S.Rukmini[2], Mr.Prasanna Paga[3], Mr.Kamal Lamichhane[4]
[1]*Principal*, [2]Professor, [3]Associate Professor, [4]Undergraduate Student
Email: 1principal@nmit.ac.in, 2prasannapaga@gmail.com, 3klamichhane18@gmail.com

Abstract— Mutual coupling is an inevitable phenomenon in multi antenna systems, usually reducing the system performance. Numerous works have focused on the reduction of this effect. The aim is maintaining the mutual coupling suppressing structure as simple as possible while having a high amount of mutual coupling reduction. This letter presents a novel structure suppressing the mutual coupling between nearby patches. It is composed of a simple EBG structures in a microstrip, which reduces the mutual coupling considerably. The structure has been constructed and tested. The measurement results prove the high efficiency of this configurations.

Index Terms**—About Antenna arrays, mutual coupling reduction, parasitic coupling, parasitic element.**

I. INTRODUCTION

Mutual coupling (MC) has a direct impact on the performance of multiple-input–multiple-output (MIMO) and antenna array systems. This interaction between elements degrades the system performance in two ways, namely by and by distorting the radiation pattern. This increasing problem smainly arises when the antennas are close to each other. Dealing with the problem of MC has been a topic of interest since the early days of antenna array design. Several authors have proposed different methods to reduce the MC while keeping the antenna elements close to each other. Some of the most referred methods in literature for printed antennas are using defected ground structures (DGS) [1]–[3], electromagnetic band-gap (EBG) [4], [5] structures, and parasitic elements between the antennas [6]. The use of high impedance Electromagnetic Band gap (EBG) structures has been well publicized over many years for improving the input match of antennas, which are placed near metallic ground planes for many applications such as vehicular and aerospace[1,2].One of the limiting factors of using EBGs is the bandwidth that is available. Much work has been carried out on optimizing EBG geometries to increase bandwidths or to make use of multiband operation, without significantly increasing the thickness of the structure [3].However [4] illustrated that there is a fundamental thickness to bandwidth limits that can only be overcome with the use of EBGs that are reconfigurable i.e. the parameters of the EBG can be controlled by some external stimuli. It has also been demonstrated in [5] that tunable EBGs are feasible for beam steering applications. The aim of this paper is to illustrate the advantages of using varactor diode devices in a simple EBG structure to tune the reflection phase over a much larger bandwidth than would be available for a passive structure and its application in compact antenna design. Predictions and measurement of an active EBG/ antenna topology is demonstrated over the frequency range of 800 to 2000MHz.

Insertion of a slot was suggested in [1], with considerable MC reduction. Although it has the advantage of simplicity, it considerably changes the radiation pattern, especially at the rear side. In [2], a ground plane pattern was proposed that efficiently decreases the MC. However, this also significantly distorts the radiation pattern. Other DGS and EBG structures are used [3]–[5] to suppress the surface waves, but they are complex structures, and optimum designs are more difficult to achieve. A simple structure composed of two parasitic elements is presented in [6]. The difficulty with that scheme is that it needs an additional layer, along with metalized holes for grounding. The radiation pattern is also changed. In [7], the antenna elements are physically linked via a narrow line. This technique also causes high MC reduction, but suffers from radiation pattern degradation, mainly due to the cross-polar component related to the current flowing over the long linking line. In general, even now a days, establishing an efficient mutual coupling reduction technique while conserving the radiation pattern is still highly challenging. Table I summarizes a qualitative comparison between some common techniques presented in the literature along with the method proposed in this letter.

The Electromagnetic Band Gap microstrip line section inserted between the coupled elements. The coupling reduction bandwidth fully covers the operating bandwidth of the antennas, and the structure is dedicated to linear polarization. It can be easily fabricated together with the printed antennas without any extra cost. This research was mainly inspired by the unfolding research activities in the field of MIMO technology, biomedical applications, and radar applications where, in many cases, a two-element antenna is used and an isolation as high as possible is needed between transmit and receive antenna. This can be seen in the large number of publications using two-element structures, including [1]–[4], [6], and [7]. The idea can also be directly applied to the MC reduction in arrays. The approach and design of a prototype are explained in Section II, and results are presented in Section III. Conclusions are drawn in Section IV.

II. ANTENNA STRUCTURE

- ***2 element patch array antenna design using Coaxial feed line, without Electromagnetic Band Gap structures***

The position of the coaxial cable can be obtained by using equation for same rectangular micro strip patch antenna.

$$X_f = L/(2\sqrt{\varepsilon_{reff}}) \qquad (1)$$

Where Xf is the desire input impedance to match the coaxial cable and εreff is the effective dielectric constant.

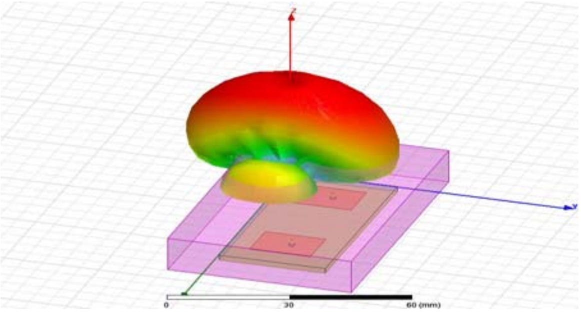

Fig 1. 2 element patch array antenna

$$Y_f = W/2 \qquad (2)$$

So (X_f, Y_f, Z) represent the coordinate on patch for 50Ω impedance point in patch.

The impedance with 50Ω coaxial wire is given by equation

$$Z_0 = 138 * \log_{10}(D/d)/\sqrt{\varepsilon_{reff}} \qquad (3)$$

- ***Patch antenna design using Coaxial feed line, with Electromagnetic Band Gap structures***

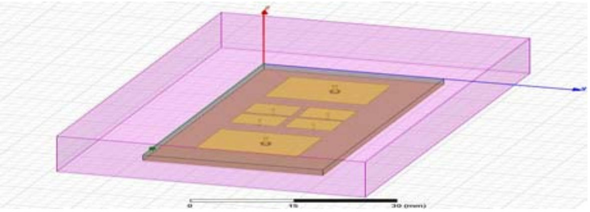

Fig 2. Patch array with EBG structures

$L=\mu_0 * h$ (4)

Where L= Inductance of the EBG cell.

μ_0=Absolute permeability of the medium

h=Height or the substrate thickness

$C=W\varepsilon_0(1+\varepsilon_r)/\pi * \cosh^{-1}[(W+g)/g]$ (5)

Where C=Equivalent capacitance of EBG

ε_0= Absolute permittivity

ε_r=Relative permittivity.

W=Width of EBG

g=Gap between the successive EBG cells

P=periodicity =W+g.

The resonant frequency is given by, $\omega_0=1/\sqrt{LC}$

III. EXPERIMENTAL RESULTS

Results for 2 element Patch array antenna using Coaxial line feed without EBG.

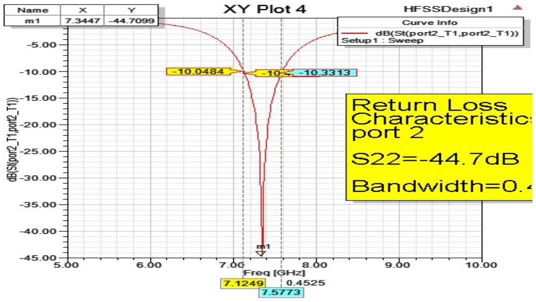

Fig 3: Return loss = -44.7 dB(Centre frequency f_r=7.5GHz, BW=0.4524GHz)

Fig 4.Voltage standing wave ratio=1.0170

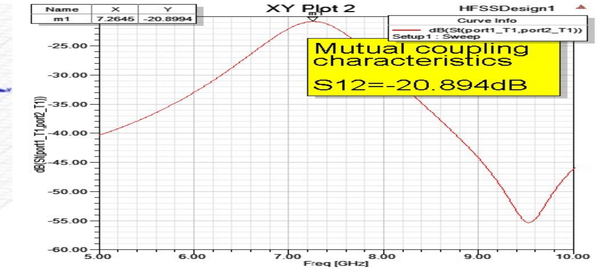

Fig 5. Mutual Coupling S12 = -20.894 dB

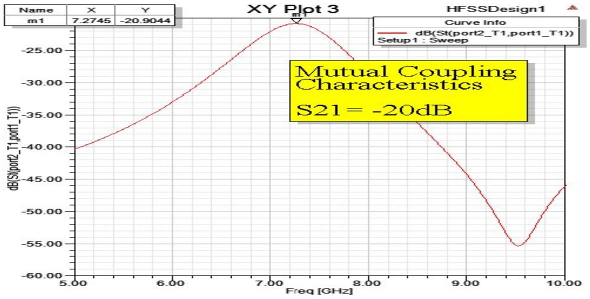

Fig 6. Mutual Coupling S12 = -20 dB

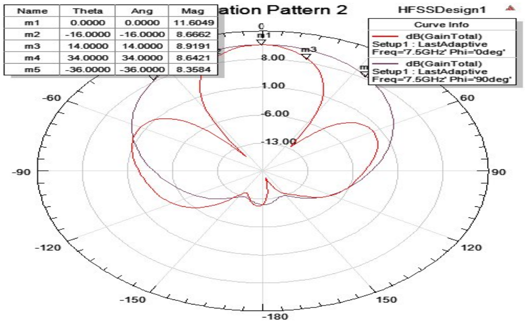

Fig 7. 2D Radiation pattern plot

Results for 2 element Patch array antenna using Coaxial line feed with EBG.

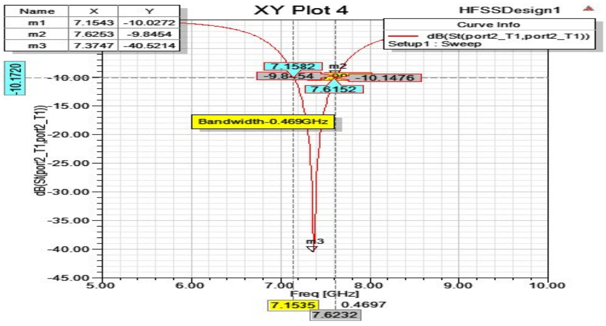

Fig 8: Return loss = -40.5214 (Centre frequency f_r=7.5GHz, BW=0.4697GHz)

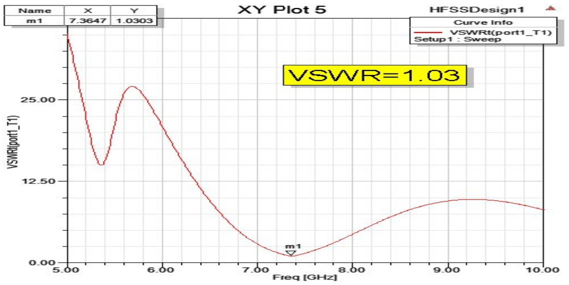

Fig 9.Voltage standing wave ratio=1.0303

Fig10. Mutual Coupling S12 = -25.714 dB

Fig11. Mutual Coupling S12 = -25.7 dB

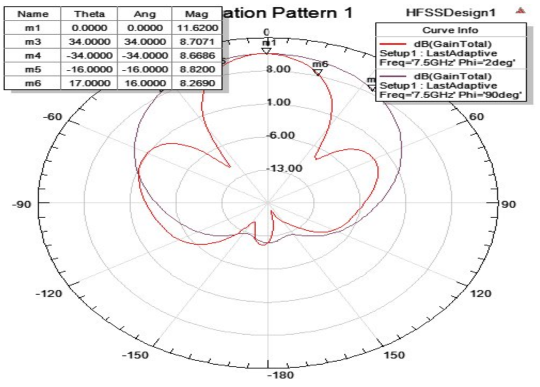

Fig 12. 2D Radiation pattern plot

Table 1. Comparision of 2 element antenna array without and with EBG using coaxial line feed

Parameter	RESULTS WITHOUT EBG STRUCTURE	RESULTS WITH EBG STRUCTURE
Resonant frequency	7.5 GHz	7.5 GHz
Return loss	-41 dB	-40.3 dB
VSWR	1.017	1.05
Mutual Coupling	-20.95 dB	-25.6 dB
Gain	9.26 dB	8.234 dB
Directivity	9.27 dB	9.27 dB

IV. CONCLUSION

In this paper, we have designed antenna array with and without EBG structure. There is almost the same return loss value for both the type of structure with and without EBG. The mutual coupling of the array with EBG structure is more. There is also an improvement in the VSWR in case of EBG structured antenna array. Gain is reduced in case of EBG structure which shows that there are radiation losses.

REFERENCES

[1] J. Ou Yang, F. Yang, and Z. M. Wang, “Reducing mutual coupling of closely spaced microstrip MIMO antennas for WLAN application, IEEE Antennas Wireless Propag. Lett., vol. 10, pp. 310–312, 2011.

[2] F.-G. Zhu, J.-D. Xu, and Q. Xu, “Reduction of mutual coupling between closely-packed antenna elements using defected ground structure,” Electron. Lett., vol. 45, no. 12, pp. 601–602, 2009.

[3] M. M. Bait-Suwailam, O. F. Siddiqui, and O. M. Ramahi, “Mutual coupling reduction between microstrip patch antennas using slotted-complementary split-ring resonators,” IEEE Antennas Wireless Propag. Lett., vol. 9, pp. 876–878, 2010.

[4] H. S. Farahani, M. Veysi, M. Kamyab, and A. Tadjalli, “Mutual coupling reduction in patch antenna arrays using a UC-EBG superstrate,” IEEE Antennas Wireless Propag. Lett., vol. 9, pp. 57–59, 2010.

[5] L. Minz and R. Garg, “Reduction of mutual coupling between closely spaced PIFAs,” Electron. Lett., vol. 46, no. 6, pp. 392–394, 2010.

[6] Antenna Theory, Analysis & Design, Constantine A.Balanis.

[7] Antenna by Kraus.

[8] Ajay Kumar Beesetti, K. Lalitha and Rajyalakshmi Valluri, “Performance analysis of rectangular patch antenna using coaxial feeding and microstrip line feeding methods,” VSRD International journal of Electronics & Communication Engineering, Vol. iii Issue viii August 2013