Mutual Coupling Reduction of Circular Patch Antenna for Multiband Application

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Abstract - *In this paper it is shown that the Mutual Coupling between two circular patch antenna elements can be reduced significantly by six slot structure in the substrate. The size of the substrate is taken as 50mm×30mm. The structure is being simulated using HFSS (High Frequency Structure Simulator). The results prove that high efficiency of this configuration in multi-slot antenna system.*

Key Words: **Ka-Band, Circular Patch, HFSS, Mutual Coupling, Meta- Material Slab.**

1. INTRODUCTION

In the Year 2017, several methods are introduced to reduce the mutual coupling between two patch antenna[1]. In the year 2012, multi element antenna were designed[2-3] .Usually this antenna systems require the distance between two patch. However when these feed line comes closer to the patch antenna, then they suffer strong mutual coupling. To overcome from this disadvantage lots of technique were introduced it the year 2017[4-6]. Ka-band is more susceptible for rain attenuation as compare to the Ku-band, where Ka stands for Kurz-above band[7] .As Ka-Band allows higher bandwidth communication and it can be used for satellite communication[8-9]. In this paper a simple two circular patch has been implemented and 6 slot structure feed line are also introduced to reduce the virtual coupling between the two circular structured antenna. In the year 2017 different types of antenna were introduced and implemented for satellite communication and 5G communication[10-11].

2. ANTENNA DESIGN

A. Design of de-coupling structure of antenna.

The designed antenna has two circular patch antenna having radius 5mm. The substrate was FR4-Eproxy material. The height of substrate is 1.6mm and having dielectric constant 4.4. The ground plane is assigned at the bottom of the substrate and some boundary namely "Perfect E1". An outer box is designed using air material and having dielectric constant 1 and radiation on it. In this model We have taken two feed line which are connected at end point of one circular patch and the feed line height is same in both the sides and they are united to each other and then connected to the slots, we have assigned lump port L1 and L2 to both the circular patch. The circular patch above ground plane has been assigned Perfect E2.

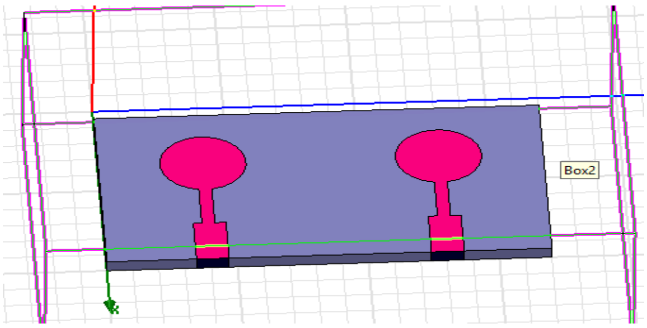


Figure1 Proposed Antenna with Radiation Interface

B. Modified and Integration of Meta-Material Slab

In this integrated metal material slab some extra intermediate slot having width 1mm and taking 0.5mm radius circle inside the rectangular slots are added to get the desired resonating frequency.

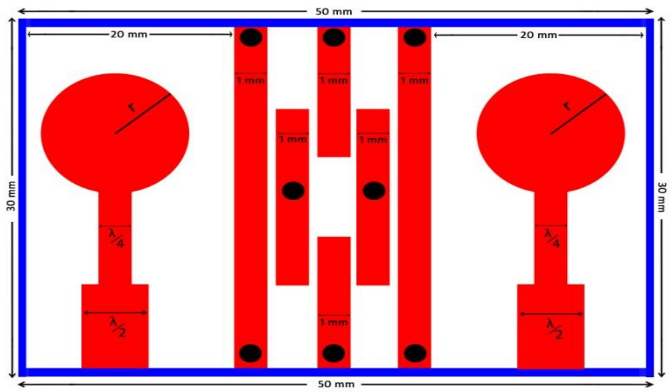


Figure2 Top-View of Integration Meta - Material Slab of Proposed Antenna

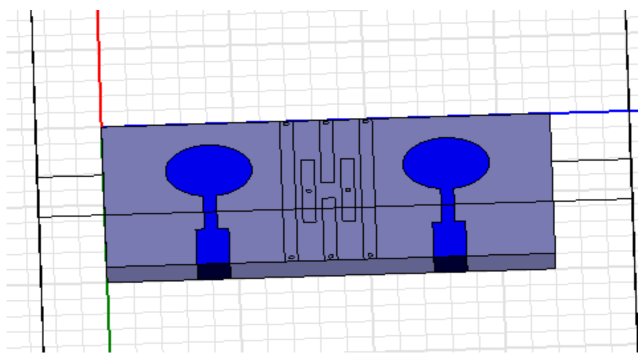


Figure3: Integration of Meta- Material Slab in HFSS

Table 1 Dimension of proposed Antenna

Parameter	Dimension
Height of substrate	1.6mm
Dielectric Constant of Substrate	4.4
Radius of Circle	5mm
Width of feed line	1 mm

3. SIMULATION RESULTS OF THE DE-COUPLING STRUCTURE PROPOSED ANTENNA

As we know that there are various methods to calculate the efficiency of the antenna. Here we have used HFSS which is very easy to calculate the efficiency of the proposed antenna [13].

a. Return Loss

Scattering parameter which generally describes the electrical behaviour of linear electrical system, this undergoes various steady state stimuli by electrical signal. S parameter describes the input and output relation between ports in an electrical system.

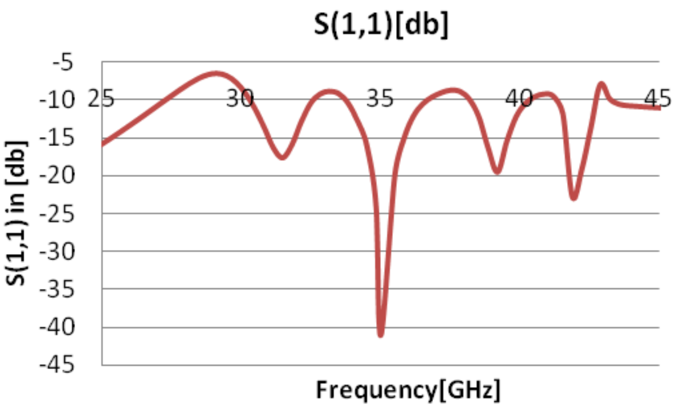


Figure 4 : This figure shows the Return loss in Integration Meta - Material Slab of Proposed Antenna.

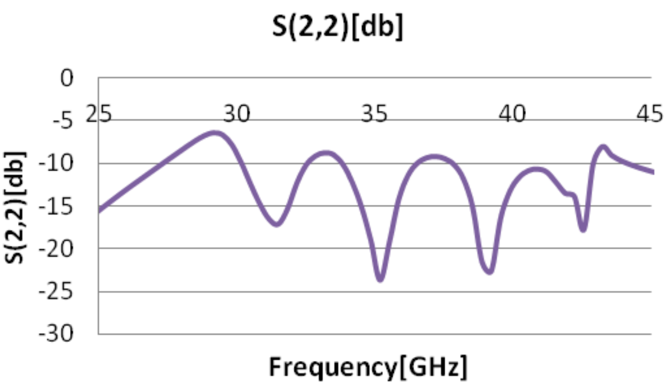


Figure 5 : S(2,2) in Integration Meta - Material Slab of Proposed Antenna. As it shows dual band nature,and had a return loss of 34.45GHz.

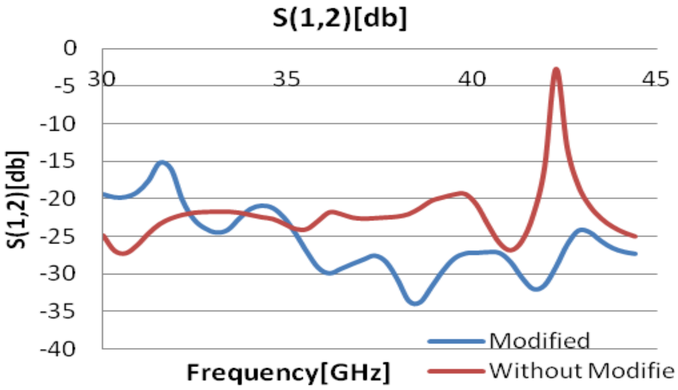
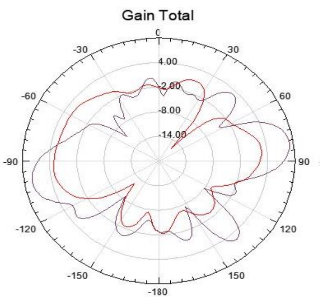


Figure 6: Comparision between Modified and Without Modified Proposed Patch Antenna in S(1,2) Parameter.

The blue coloured line shows the modified results and red colured line shows the result of Without modified Patch Antenna.

b. Radiation Pattern

When power is given to the teminal of the patch antenna, electromagnetic wave are generated. The radiation is a graphical representation of the relative field strength transmitted or received by the antenna. The radiated power per unit surface is proportional to the squared electrical feild of the electromagnetic wave.



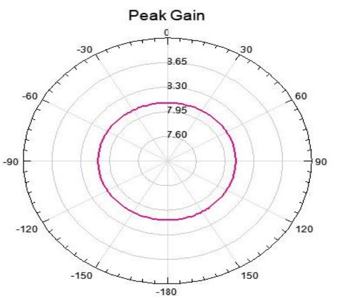
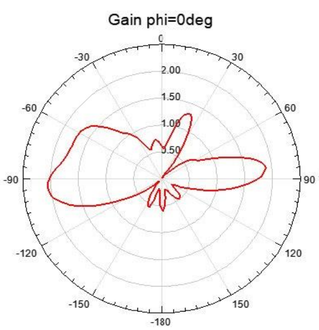


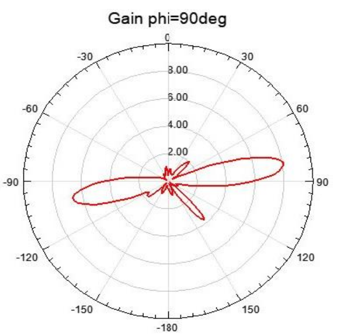
Figure7(a) Antenna Gain in modified Proposed Antenna.

Figure 7(b) Peak Gain in modified Proposed Antenna

Peak Gain obtain is 7.95dB



7(c)



7(d)

Figure 7(c) phi=0deg in Integration Meta - Material Slab of Proposed Antenna.

Figure 7(d) phi=90deg in Integration Meta - Material Slab of Proposed Antenna.

c. Directivity

Directivity is a fundamental antenna parameter.It defines the radiation intensity in a specific direction .Directivity plays a vital role when the antenna is designed to radiate in a specified direction. The Peak Directivity obtain from the stimulation was 4.68.

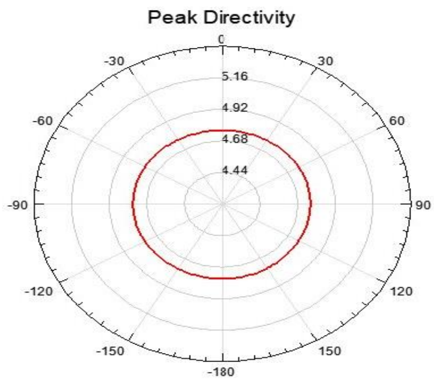


Figure 8 Peak Direcivity in Modified Proposed Antenna

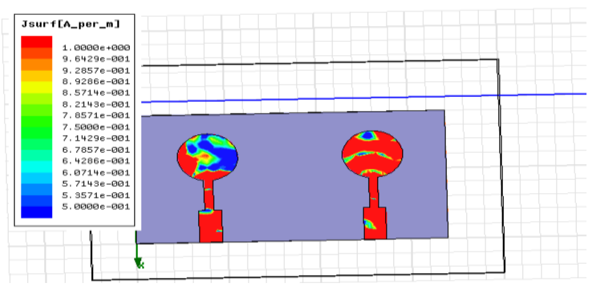


Figure 9 Surface Density in without inter meta material Antenna

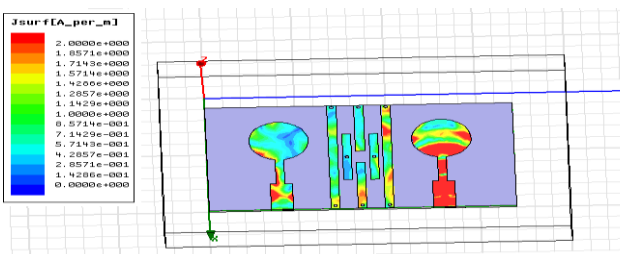


Figure 10 Surface Density in Modified Proposed Antenna

Table 2 : Simulated Parameters of Proposed Antenna using HFSS.

Parameter	Values
Resonant Frequency(f_r)	35GHz
S_{11}	34.45GHz
Return loss	32dB
Peak Gain	7.95dB
Directivity	4.68

Table 3 : Performance of the Proposed Circular antenna as compare to the previously Published Antenna

References	Method	Mutual reduction(db)
[14]	EBG structure	17
[15]	DGS Structure	15
[16]	Parasitic Element	15.5
Modified Proposed Antenna	Parasitic Element in Circular Antenna	32

4. CONCLUSION

In the above proposed paper the design of a simple circular patch antenna provides a very high mutual coupling reduction between the two patch antennas. From the above research data show that 32db mutual coupling reduction is obtained at the frequency without affecting the radiation pattern. The proposed antenna is smaller in size, gives high bandwidth suitable or large distance communication and requires very less energy to operate. Hence, it can be used for Ka band communication and also can be used for Iridium next satellite series and also in James Web Space Telescope.

REFERENCE

1) Ahmad Emadeddin,Saeideh Shad,Zahra Rahimian, H.R.Hassani, “High mutual coupling reduction between microstrip patch antennas using novel structure,” Int. J.Electron. Commun., vol. (AE0)71, pp. 152-156, 2017.

2) Xin Mi Yang,Xue Guan Liu,Xiao Yang Zhou “Reduction of Mutual Coupling Between Closely Packed Patch Antennas Using Wave guided Meta materials,” IEEE Antenna And Wireless Propagation, vol. 11, pp. 389-391, 2012.

3) Microfluidically Frequency-Reconfigurable Microstrip Patch Antenna and Array,” IEEE Access., vol. 5, pp. 20470-20476, 2017.

4) Zeeshan Qamar,Umair Naeem,Shahid A.Khan “Mutual Coupling Reduction for High-Performance Densely Packed Patch Antenna Arrays on Finite Substrate” IEEE Antenna And Wireless Propagation.,vol. 64, pp. 1653-1660, 2016.

5) Farahani Hs,Veysi M. Kamyab M,Tadjalli A, “Mutual Coupling reduction in patch antenna array using a UC-EBG superstrate,” IEEE Antenna And Wireless Propagation., vol. 9, pp. 957-960, 2010.

6) Neyestanak AAL “Mutual Coupling reduction between two microstrip patch antennas,” Electrical and Computer Engineering Candian Conference., pp. 739-742, 2008.

7) Wikipedia.com/K_a-Band

8) F.Yang and Y.rahmat-Samii "Microstrip antennas integrated with electromagnetic bandgap structure," IEEE Antenna And Wireless Propagation., vol. 51, pp. 2936-2946, 2003.

9) S.V.Hum and H.Y.Xiong, "Analysis and design of differentially-fed frequency agile microstrip patch antenna IEEE Antenna And Wireless Propagation., vol. 58, pp. 3122-3130, 2010.

10) Ribhu Abhusan Panda, Eswar Prasad Panda, Ranajit Sahana, "Comparison between Microstrip Rectangular and Circular Patch Antenna for 5G Application." IJAREEIE journal, Vol.6, issue.9, pp.6793-6799, 2017.

11) Ribhu Abhusan Panda, Eswar Prasad Panda, Ranajit Sahana, Nidhi Kumari Singh "Modified Rectangular Microstrip Patch Antenna for 5G application at 28GHz," IOSR., vol. 12,issue. 6, pp.06-10, 2017.

12) C.A. Balanis, Antenna Theory, 2nd Ed., John wily & sons, inc., New York.1982.

13) Ansoft HFSS. Ver 12 Ansys Corporation.

14) Tariqul islam M, "EBG Structure for alleviating Mutual coupling reduction between patch antennas array element," IEEE Antenna And Wireless Propagation., 137:425-38, 2013.

15) Hazra R,Ghosh CK,Parui SK " Mutual coupling reduction between closely spaced microstrip patch antennas using DGS," J Academia Ind Res., 2:142-5, 2013.

16) Farsi S, "EBG Structure for alleviating Mutual coupling reduction between planar antenna by using a simple microstrip u-section." IEEE Antenna And Wireless Propagation., 11:1501-3, 2012.