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Polarization Diversity Array of E-shaped patch Antenna

Dr.Neela Rayavarapu
Department of Electronics and Telecomm,
SIT, Lavale
Pune,India
neela.rayavarapu@sitpune.edu.in

Mr. M. B. Kadu*
Department of Electronics and Telecomm,
SIT, Lavale
Pune,India
mahesh.kadu@gmail.com

Dr.S.B.Deosarkar
Dr BATU,Lonere
Raigad,India

Dr. R. P. Labade
Department of Electronics and Telecommunication
Amrutvahini College of Engineering
Sangamner,India
rplabade@gmail.com

***Abstract*— In this work a E-shaped microstrip patch antenna is design to resonate at 2.4 Ghz frequency. The FR4 material having dielectric constant of 4.4 is used as a substrate for the design antenna. Further a polarization diversity pair is proposed in which one E-shaped antenna element is horizontally polarized while other is design to be vertically polarized. Polarization diversity pair is oriented in space such a way to have mutual coupling between two E-shaped elements to be less than 40dB.Single patch antenna and the polarization diversity pair are optimized using HFSS simulation software. The designed antennas were manufactured and tested with Vector Network Analyzer.**

Keywords-Polarization diversity ,Microstrip,Return Loss,VSWR,

I. INTRODUCTION

Multiple antenna systems are very popular nowadays due to their ability to provide improved data rate for modern wireless communication systems. Microstrip patch antennas are used more commonly in this multiple antenna systems because of their features like low weight, planar structure and flexibility in design. Various designs of microstrip patch antennas having different patch shapes are available in literature[1][2].E-shaped patch antenna offers less mutual interference if used in array structure as reported in [3].Diversity schemes play an important role to keep the mutual coupling lowest in an array structure. Different diversity schemes like polarization diversity, spatial diversity, pattern diversity for multiple antenna system are given in [4].Therefore a microstrip patch antenna employing one or two of these diversity techniques become a good contender for multiple antenna systems. Various diversity schemes are exhibited in [5]-[7].

II. ANTENNA DESIGN

A. Design Equations

A rectangular patch for the desired resonant frequency is designed by using transmission line theory. The width and length of a rectangular microstrip patch antenna is calculated by using the following design formulae for given ISM band resonant frequency of 2.4 GHz [8][9].

Width of a rectangular patch antenna can be calculated as given in formula below

$$W = \frac{C}{2 f_r \sqrt{\frac{\varepsilon_r + 1}{2}}} \tag{1}$$

Where f_r is the resonant frequency of the designed rectangular microstrip patch antenna that will be use in wireless communication system.C denotes free space light velocity given as

Er is the dielectric constant value of the substrate used in design of rectangular microstrip patch antenna.

Effective dielectric constant is calculated as below considering antenna height equal to substrate thickness of 1.6mm.

$$\varepsilon_{reffective} = \frac{4.4+1}{2} + \frac{4.4-1}{2}\left[1+12\frac{height}{Width}\right]^{-\frac{1}{2}} \tag{2}$$

Extension in length of the patch antenna considering fringing field effect is derived as,

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$$\Delta L = 0.412\ h \frac{(\varepsilon_{reffective} + 0.3)\left(\frac{Width}{height} + 0.264\right)}{(\varepsilon_{reffective} - 0.258)\left(\frac{Width}{height} + 0.8\right)} \tag{3}$$

Effective length of the rectangular patch antenna with ΔL factor is calculated as

$$L_{eff} = \frac{C}{2 f_r \sqrt{\varepsilon_{reffective}}} \tag{4}$$

$$L = L_{eff} - 2\Delta L \tag{5}$$

Two parallel slots of length 12mm each are cut into the rectangular microstrip patch antenna converting into an E-shaped patch antenna. The slot width is varied and optimized to get the desired return loss parameter at the resonating frequency. A cut at center arm of E shaped patch was made to further optimize the design. Corners were cut with small square slots to improve the return loss parameter. E-shaped patch was fed with coaxial feed to offer simplicity in design.

Geometry of the designed E-shaped patch is shown in fig.1.

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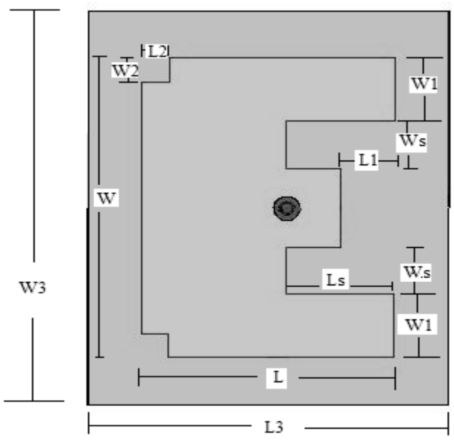


Fig. 1. E-shaped patch antenna (Top View)

III. ANTENNA ARRAY DESIGN

Polarization diversity antenna array of two elements of E-shaped patch antenna is designed and optimized. The two elements forming an array are identical to each other and etched with a common ground plane.

To keep mutual coupling below the required threshold spacing between the elements is fixed at λ/2 cm which equals 62mm on ground plane. Out of the two elements in array one element is oriented in such a way in space so that waves from it are horizontally polarized. While the other element is oriented to support vertical polarization. Thus an orthogonal polarization relation is formed between the two elements .This polarization diversity scheme results in lower mutual coupling between the two elements in the array structure.

Below figure 2 shows the geometry of designed polarization diversity array with coaxial feed.

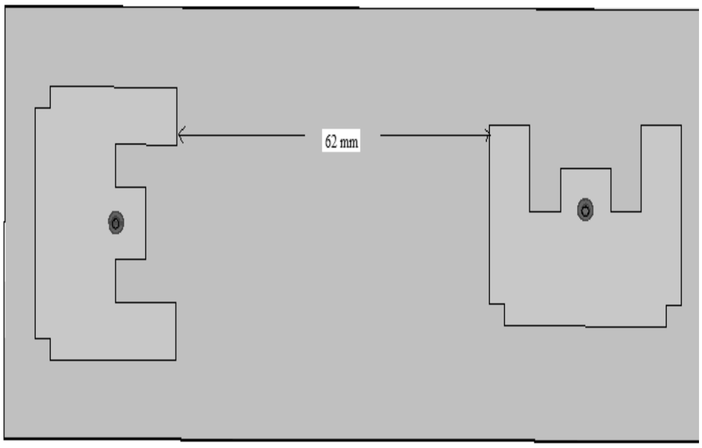


Fig. 2. Geometry of polarization diversity array

IV. RESULTS AND DISCUSSION

A. Comparison of simulated and measured return loss

As shown in fig 3 return loss value for both simulated and manufactured E-shaped antenna matches comfortably. The value is found to be 30 dB for resonating frequency of 2.4 GHz. Simulation is carried out using HFSS simulator [10].

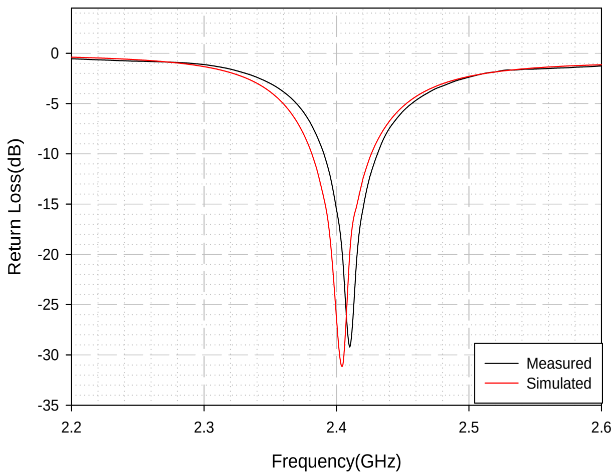
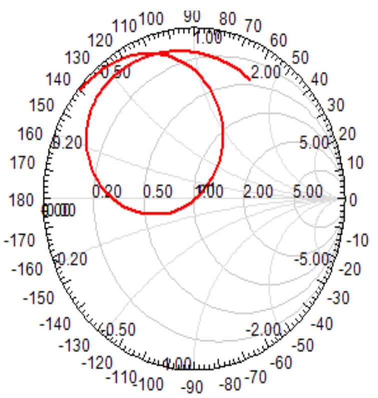


Fig. 3. Graph of VSWR Vs frequency of antenna

B. Impedance.

A 48 Ω impedance is found out from smith chart given below in fig.4.



Name	Freq	Ang	Mag	RX
m1	2.4000	35.8156	0.0481	1.0793 + 0.0609i

Fig. 4. Smith chart of antenna

C. Gain.

Gain of 4 dBi is obtained from simulation results at resonating frequency of 2.4 GHz clearly visible in fig.5.

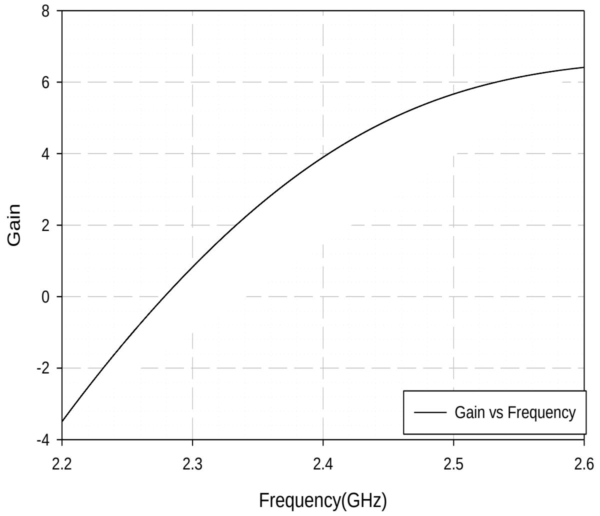


Fig. 5. Graph of Gain Vs Frequency

D. Radiation Pattern

The radiation pattern for the frequency 2.4 GHz is shown in figure 6. The difference between E-plane and H plane is around 50dB at an angle of 0°.

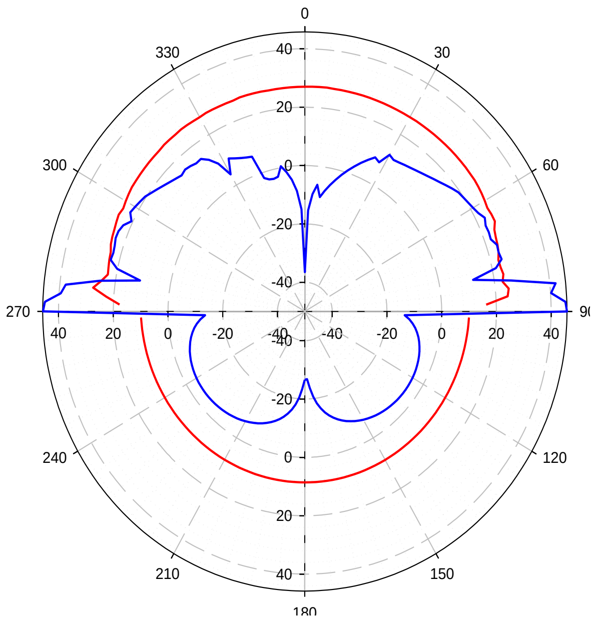


Fig. 6. Radiation Pattern

E. Measurement of mutual coupling between two E-shaped patch elements.

Fig 7 shows that mutual coupling between two elements used in array structure is below -40 dB below value of mutual coupling is obtained due to spatial and polarization diversity schemes employed in forming of array structure.

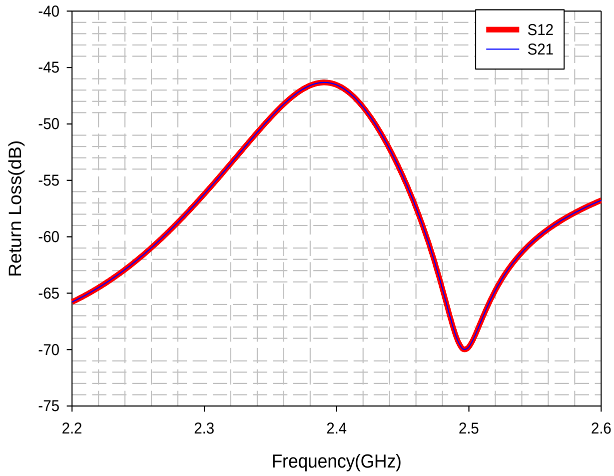


Fig. 7 Mutual coupling parameter between two array elements

F. Prototype testing Single E-shaped patchantenna and its polarization diversitya antenna array using VNA.

Following fig 8a) and 8b) shows the prototype testing arrangement using vector Network analyzer at 2.4 GHz resonating frequency. .

Fig. 8a). Photograph of Single E-shaped patch antenna.

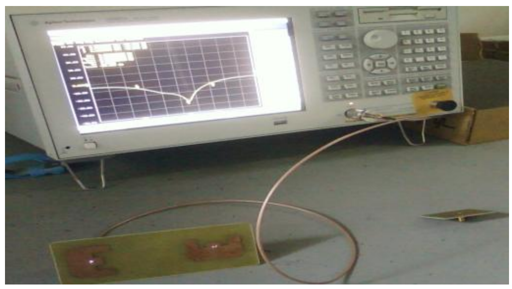


Fig. 8b). Photograph of manufactured polarization diversity antenna.

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V. CONCLUSION

A single E-shaped patch antenna was designed and optimized using HFSS simulation software. Prototype of designed patch antenna was manufactured and tested using VNA. Further a polarization diversity pair of E-shaped patch antenna was designed and optimized. Polarization diversity pair was manufactured and tested using VNA for return loss and VSWR.Mutual coupling between elements of array was found far below the accepted parameter of industry. Simulated and measured results were found to be in good agreement with each other.

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