

Substrate Height and Dielectric Constant Dependent Performance Analysis of Circular Microstrip Patch Array Antennas for Broadband Wireless Access.

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Abstract. Corporate series feed circular microstrip patch array antennas have been designed for three different substrate heights and dielectric constants of substrate. Bandwidth and radiation pattern have been analyzed by using General Electromagnetic Solver (GEMS). Effect of bandwidth due to change of substrate height and dielectric constant have been investigated. Finally, bandwidth for each substrate height and dielectric constant are measured for selecting the optimal patch array antenna which is used for Broadband Wireless Access .

Keywords: Microstrip patch antenna, return loss, bandwidth, surface waves, radiation pattern.

I. INTRODUCTION

Microstrip patch antennas get more and more important in these days. This is mostly due to their versatility in terms of possible geometries that makes them applicable for many different situations. The lightweight construction and the suitability for integration with microwave integrated circuits are two more of their numerous advantages. Additionally the simplicity of the structures makes this type of antennas suitable for low cost manufacturing and this is also one key feature of microstrip patch antennas are used in mobile communications applications.

Although patch antenna has numerous advantages, it has also some drawbacks such as restricted bandwidth, low gain, excitation of surface waves and a potential decrease in radiation pattern. Various techniques like using Frequency Selective Surface, Employing stacked configuration, using thicker profile for folded shorted patch antennas, slot antennas like U-slot patch antennas together with shorted patch, double U-slot patch antenna, L-slot patch antenna, annular slot antenna, double C patch antenna, E-shaped patch antenna, and feeding techniques like L-probe feed, circular coaxial probe feed, proximity coupled feed are used to enhance bandwidth of microstrip patch antenna. The substrate height and dielectric constant of the substrate are very important factors that influence the variation of bandwidth as well as the surface waves. The substrates of dielectric constants are usually in the range of 2.2 to 12. The ones that are most desirable for antenna performance are thick substrates whose dielectric constants are in the lower end of the range because they provide better efficiency, larger bandwidth, loosely bound fields for radiation in the space.

In this paper, we proposed corporate series feed circular patch array antennas with three different substrate heights and dielectric constants. Polypropylene with dielectric constant 2.2,

plamitic acid with dielectric constant is 2.3 and polystyrene with dielectric constant is 2.4 are used to investigate the effect of bandwidth. All designed antennas are operated at 10GHz frequency which is used for Wireless broadband access. The remainder of the paper is organized as follows: In section II, antenna design and configuration is discussed. In section III presents the simulation results. The conclusion of this paper is provided in section IV and future scope is described in section V.

II. ANTENNA DESIGN AND CONFIGURATION

In this paper, a 4 element circular patch antennas are designed. The width, depth and height for ground plane are 50mm, 90mm and 0.2mm respectively. The substrate heights are 0.2mm, 0.4mm and 0.6mm with dielectric constants of substrate are 2.2, 2.3 and 2.4 are taken to design the antennas. The operating frequency is 10GHz. By using these values the radius of the patch can be calculated by the following equation.

$$a = \frac{F}{\sqrt{1 + \frac{2h}{\pi \epsilon_r F} [\ln(\frac{\pi F}{2h}) + 1.7726]}} \quad (1)$$

where,

a= radius of the patch (mm)

$$F = \frac{8.791 \times 10^9}{f_r \sqrt{\epsilon_r}}$$

h= height of the substrate (mm)

ϵ_r = dielectric constant of the substrate.

f_r = operating frequency of the antenna.

The operational mode was TM_{110} . The antenna was excited by a microstrip transmission line feed. Figure 1 shows the two dimensional view of proposed circular patch antenna.

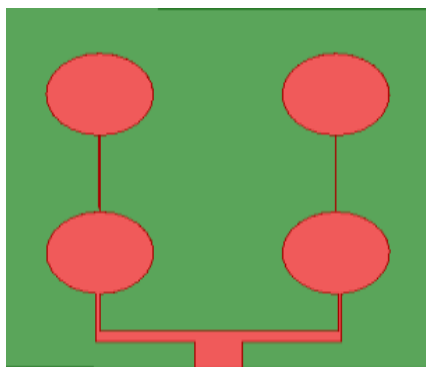


Figure 1: Two dimensional view of proposed 4 array circular microstrip patch antenna

III. SIMULATION RESULTS

Now a day, it is a common practice to evaluate the system performances through computer simulation before the real time implementation. A simulator “GEMS” based on finite element method (FEM) has been used to calculate return loss, impedance bandwidth, radiation pattern. This simulator also helps to reduce the fabrication cost because only the antenna with the best performance would be fabricated. Figure 2 shows the simulated results of the return loss of the proposed antenna for three different substrate heights and dielectric constants values.

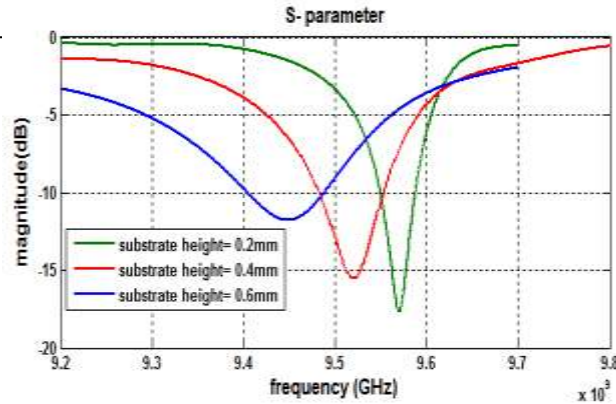


Figure 2: Return loss curves for three different substrate heights

It is seen from the figure 2, with substrate height 0.2mm the return loss is -18dB at resonance frequency of 9.572 GHz, with substrate height 0.4mm the return loss is -15dB at resonance frequency of 9.52 GHz, and with substrate height 0.6mm the return loss is -11.75dB at resonance frequency of 9.452 GHz. A negative value for return loss shows that this antenna had not many losses while transmitting the signals. The return losses are changed due to the change of substrate heights.

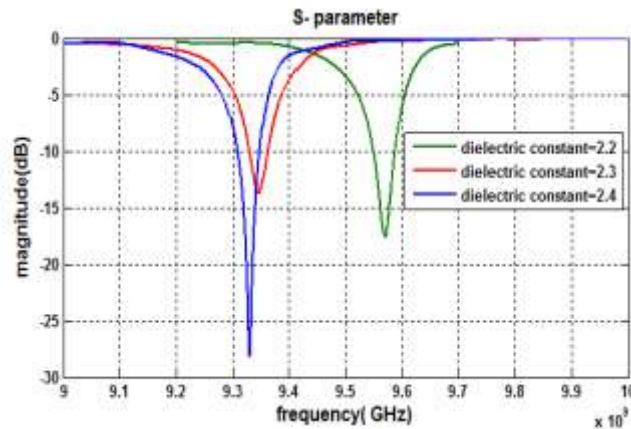


Figure 3: Return loss curves for three different dielectric constants.

It is seen from the figure 3, with dielectric constant 2.2 the return loss is -17.6dB at resonance frequency of 9.57 GHz, with dielectric constant 2.3 the return loss is -13.5dB at resonance frequency of 9.353 GHz, and with dielectric constant 2.4 the return loss is -28 dB at resonance frequency of 9.342 GHz.

The bandwidth of the each designed antenna is measured from the return loss curve. Theoretically bandwidth is measured from the -3dB point of the return loss. Due to various antenna losses we have chosen the reference point of return loss is -5dB. According to this method the measured bandwidth of the antennas are given in the following table. Table 1 shows the measured bandwidth for three different substrate heights.

Table 1: Bandwidth variation with substrate height.

| Substrate height(mm) | Dielectric constant | Bandwidth (MHz) |
|----------------------|---------------------|-----------------|
| 0.2 | 2.2 | 90 |
| 0.4 | 2.2 | 170 |

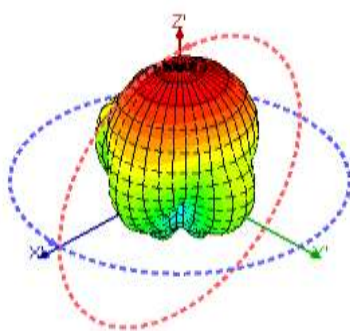
| | | |
|-----|-----|-----|
| 0.6 | 2.2 | 277 |
|-----|-----|-----|

Table 2 shows the measured bandwidth for three different dielectric constants.

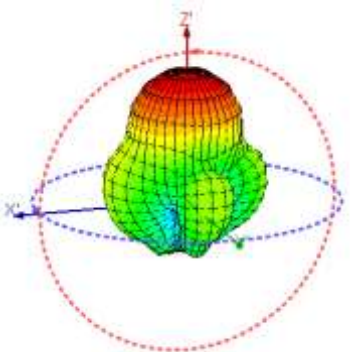
Table 2: Bandwidth variation with dielectric constant.

| Substrate height(mm) | Dielectric constant | Bandwidth (MHz) |
|----------------------|---------------------|-----------------|
| 0.2 | 2.2 | 90 |
| 0.2 | 2.3 | 85 |
| 0.2 | 2.4 | 81 |

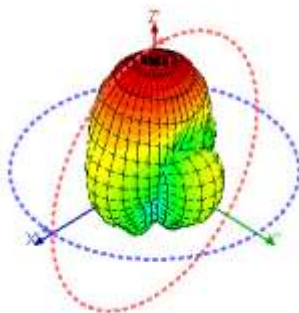
Figure 4 shows the three dimensional radiation patterns for three different substrate heights and dielectric constants.



(a)



(b)



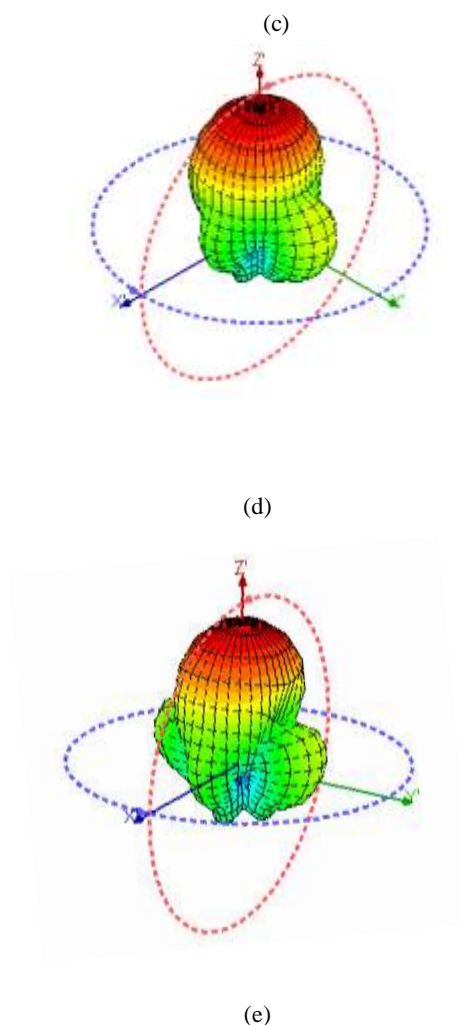


Figure 4: 3- dimensional radiation pattern for (a) substrate height 0.2mm and dielectric constant 2.2 (b) substrate height 0.4mm and dielectric constant 2.2 (c) substrate height 0.6mm and dielectric constant 2.2 (d) substrate height 0.2mm and dielectric constant 2.3 (e) substrate height 0.2mm and dielectric constant 2.4.

IV. CONCLUSION

We designed 4 array circular microstrip antennas with the variation of substrate heights and dielectric constants at frequency of 10GHz. The observation shows the antenna bandwidth increases with the increase of substrate heights and with the decrease of dielectric constants. We got the return losses in the range -11dB to -33dB at resonance frequency.

V. FUTURE SCOPE

Higher order array antenna having higher directivity and radiation efficiency can be used to implement the smart antenna in the application of the Space Division Multiple Access (SDMA) technique. Different feeding methods can be applied to enhance the bandwidth. Bandwidth enhancement can also be done using Stacked Patch and Slot.

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Biographies

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