1×4 Rectangular Patch Array Operating at 10GHz Using Corporate Feeding Technique

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***Abstract*—Present day communication systems need more compact design with low cost, less weight and better performance over wide spectrum of frequencies. The microstrip antenna is best suited for above all requirements. Here a rectangular patch microstrip antenna is designed to operate at 10 GHz frequency using HFSS software. After that a 1×4 array is designed using that rectangular patch element for better performance in various parameters like gain, return loss and VSWR. This antenna is designed for X-band applications like radar, satellite communications, medical and some wireless communications.**

***Index Terms*—Micro-strip line, feed, patch, array, VSWR, return loss.**

I. INTRODUCTION

Microstrip antennas are simple to design, low cost and capable of maintaining high gain performance over wide spectrum of frequencies. Micro-strip antennas are constructed using a patch, dielectric medium, ground plane and feeding techniques. There are different feeding techniques like micro-strip line feed, co-axial feed, aperture coupled and proximity coupled feed [1]. Micro-strip line feeding is employed to design this antenna at 10 GHz frequency. This antenna has wide range of applications in X-band like in radar, satellite communications, medical applications and military applications.

First the antenna is designed using a single rectangular patch element to operate at 10 GHz frequency. But single micro-strip patch antennas have some disadvantages like low gain, low directivity, narrow band width and low efficiency. To overcome thes e disadvantages more number of patch elements is taken to improve the parameters like gain, directivity and cancel out interference from a set of directions [2]. Hence a four patch elements are taken to improve the gain compared to single element. Corporate feeding technique is used to feed the four elements for easy and better performance [3]. This paper presents the response of both single element antenna and 1×4 array antenna. Different parameters like gain, VSWR, return loss and radiation patterns are plotted and measured for both antennas.

II. DESIGN OF SINGLE ELEMENT MICRO-STRIP ANTENNA

The antenna was designed using High Frequency Structural Simulator (HFSS) software. A dielectric material RT duroid 5880 of dielectric constant 2.2 and height 1.5748 is taken for the antenna design. The dimensions for rectangular patch to operate at 10 GHz frequency are calculated as follows [4].

$$W = \frac{c}{2L\sqrt{\frac{\varepsilon_r+1}{2}}} \qquad (1)$$

By using Eq.1 width of the patch is obtained as 11.8586 mm. The effective dielectric constant is obtained by the Eq.2. Substitute the effective dielectric constant value in Eq.3 and Eq.4.

$$\varepsilon_{eff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left(1 + 12\frac{h}{w}\right)^{-1/2} \qquad (2)$$

$$L_{eff} = \frac{c}{2f_0\sqrt{\varepsilon_{eff}}} \qquad (3)$$

$$\Delta L = 0.412h\,\frac{(\varepsilon_{eff}+3)\left(\frac{w}{h}+0.264\right)}{(\varepsilon_{eff}-0.258)\left(\frac{w}{h}+0.8\right)} \qquad (4)$$

Then finally the length of the patch is obtained by substituting the values of L_{eff} and ΔL in the Eq.5. The obtained length of the patch is 9.07088 mm.

$$L = L_{eff} - 2\Delta L \qquad (5)$$

To calculate the length and width of ground, use Eq.6 and Eq.7.The calculated ground dimensions are 9.2598 × 10.6537 mm^2.

$$L_g = 6h + L \qquad (6)$$

$$W_g = 6h + W \qquad (7)$$

Now micro-strip line feeding technique is employed to provide feeding to the patch. A feed line of λ/4 width is taken to provide feed to the antenna. Now construct the antenna by using above all equations as shown in fig.1.

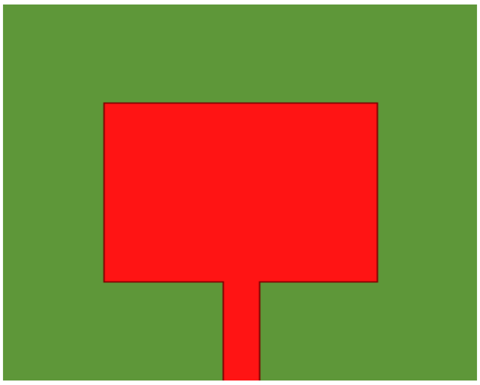

Fig.1 Single rectangular patch antenna

III. DESIGN OF 1×4 ELEMENT ARRAY ANTENNA

Micro-strip antennas are very popular in arrays. Major drawback with micro-strip antennas is inefficient radiation over narrow band of frequencies. To overcome that various array designs with different feeding techniques, ground plane, dielectric materials are chosen. Among all different techniques, corporate feeding network is employed to design a 1×4 micro-strip patch array. Improving various parameters like gain, return loss can be easily increased with array, which is difficult to increase using single element antenna [5]. Here four elements are used to design array using the same dimensions of single patch element. Four elements are taken horizontally maintaining a λ/4 distance in between each element [6]. The array is designed to improve the gain of the antenna. The 1×4 array is shown in Fig.2.

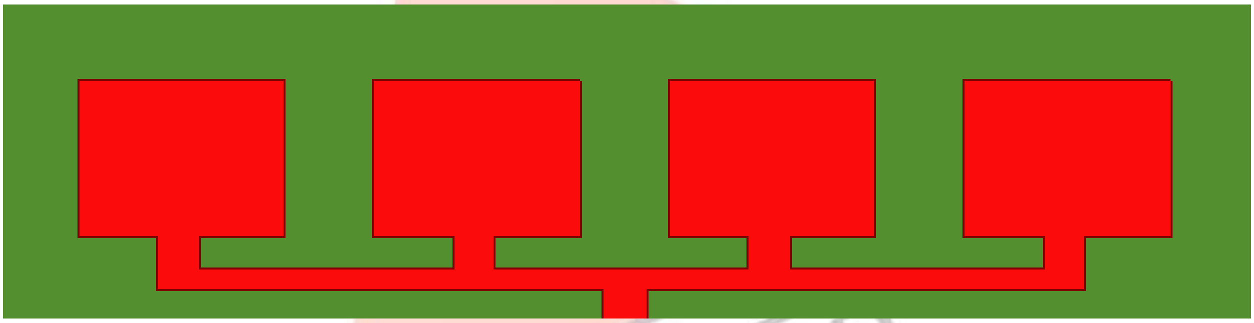

Fig.2 1×4 Rectangular patch Array

IV. SOFTWARE USED

High Frequency Structural Simulator (HFSS) software is used to design and simulate the antenna. HFSS is the standard for simulating 3-D, full-wave and Electro Magnetic field. It has high performance computing technology, good accuracy and advanced solver make it essential tool for the design of high frequency and high speed electronic devices. It integrates simulation, solid modeling, visualization, and automation in an easy-to-learn environment where solutions are quickly and accurately obtained. HFSS employs brilliant graphics to give you unparalleled performance and insight to all of your 3D EM problems. HFSS can be used to calculate VSWR, gain, radiation pattern and S-parameters.

V. RESULTS OF SINGLE ELEMENT ANTENNA

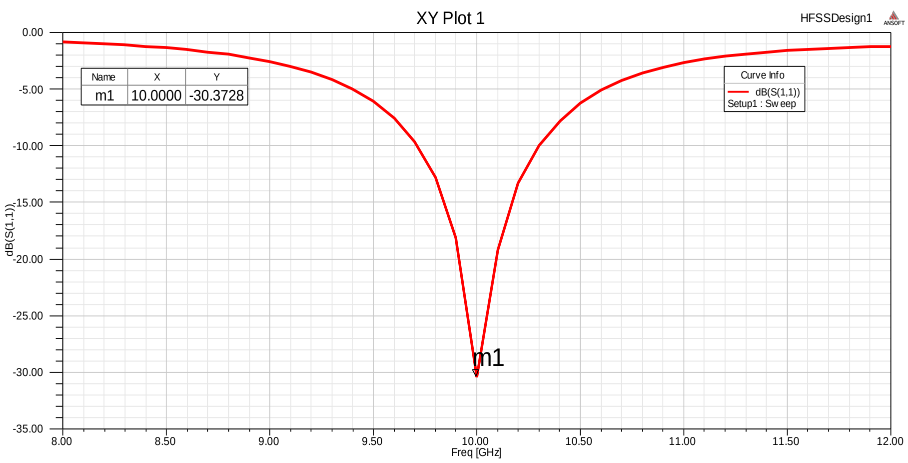

Fig.3 Return loss of Single patch antenna

Using HFSS computer simulation can be performed before going for fabrication. Figure.3 shows the return loss of single element antenna. The antenna radiates at 10 GHz frequency with -30.3728 dB return loss. The VSWR pattern of single element antenna is shown in Fig.4. The VSWR obtained for this antenna is 0.5264. The gain and radiation pattern of single element antenna is shown in Fig.5. The antenna radiating at 10 GHz frequency results in gain of 7.9412dB.

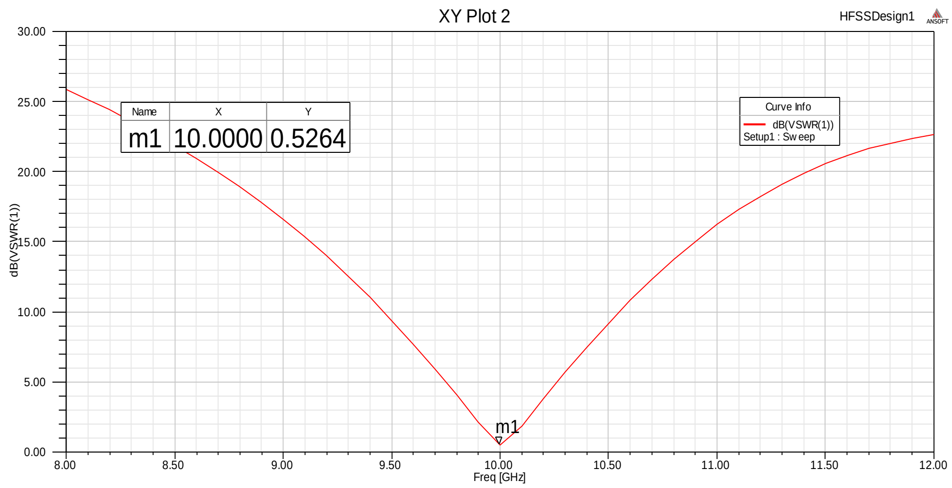

Fig.4 VSWR pattern of single rectangular patch antenna

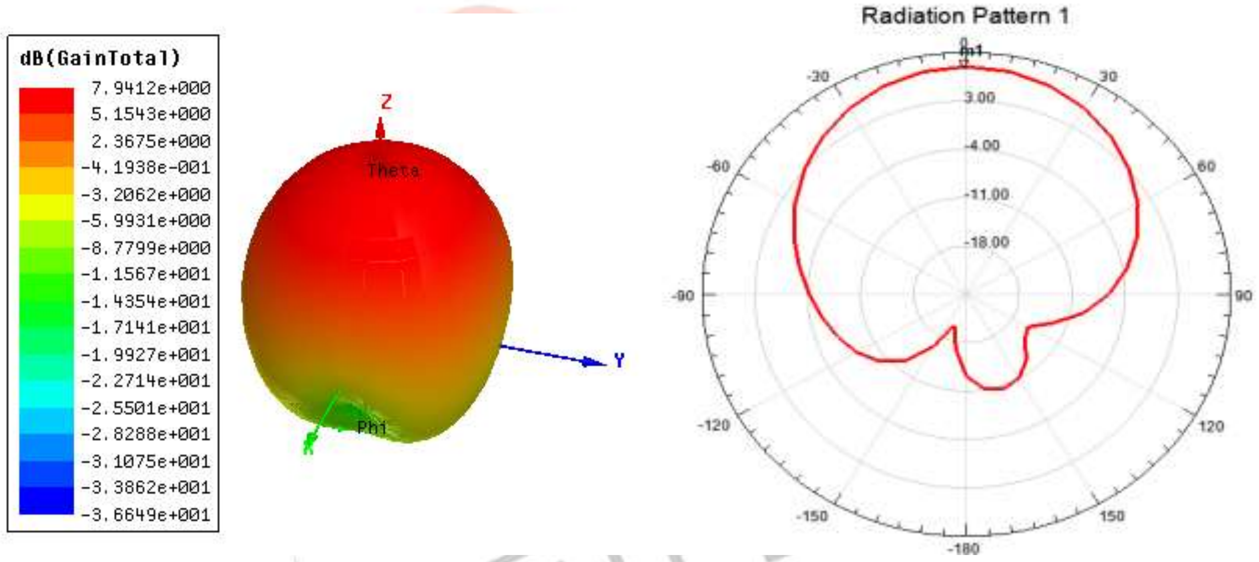

Fig.5 Gain and Radiation pattern of single element antenna

VI. RESULTS OF 1×4 ARRAY ANTENNA

Various parameters like gain, VSWR and return loss are plotted for 1×4 array antenna to compare the results with single rectangular patch antenna. Figure 6 shows the return loss pattern for array antenna radiating at 10 GHz. The return loss obtained for array antenna is -25.4815dB.

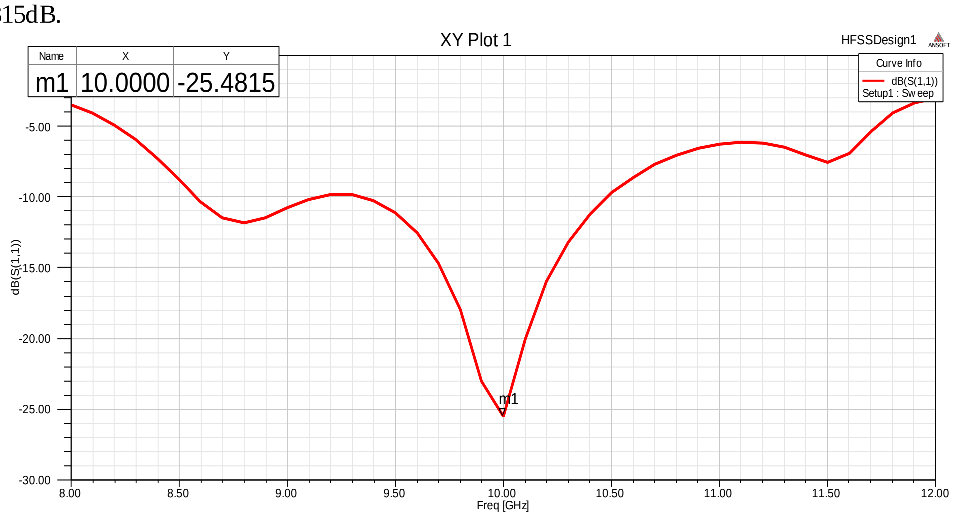

Fig.6 Return loss pattern of 1×4 Array antenna

The VSWR obtained for 1×4 array antenna is shown in Fig.7. The VSWR for array antenna radiating at 10 GHz frequency is 0.9251dB.

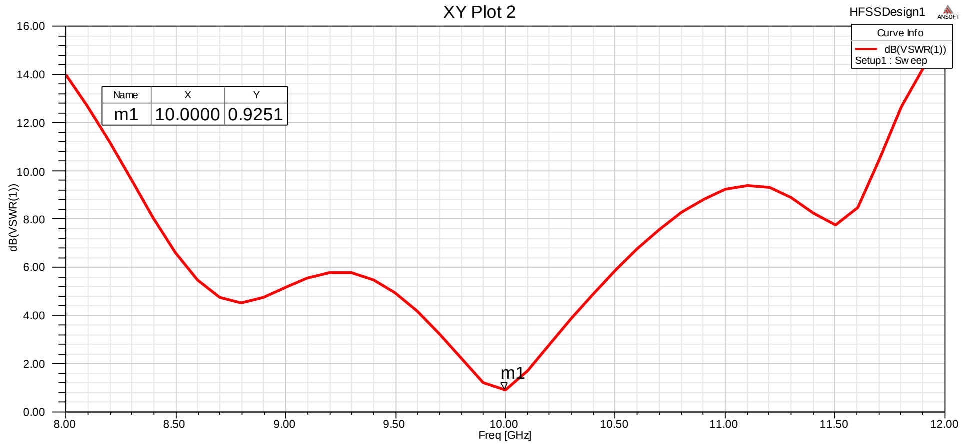

Fig.7 VSWR pattern of 1×4 Array antenna

The gain and radiation pattern of the array antenna operating at 10 GHz frequency is shown in Fig.8. The gain obtained for array antenna at theta zero degrees is 11.578dB. The gain of the array is increased by 36%. Hence the designed array antenna shows better gain and directivity than single rectangular patch antenna.

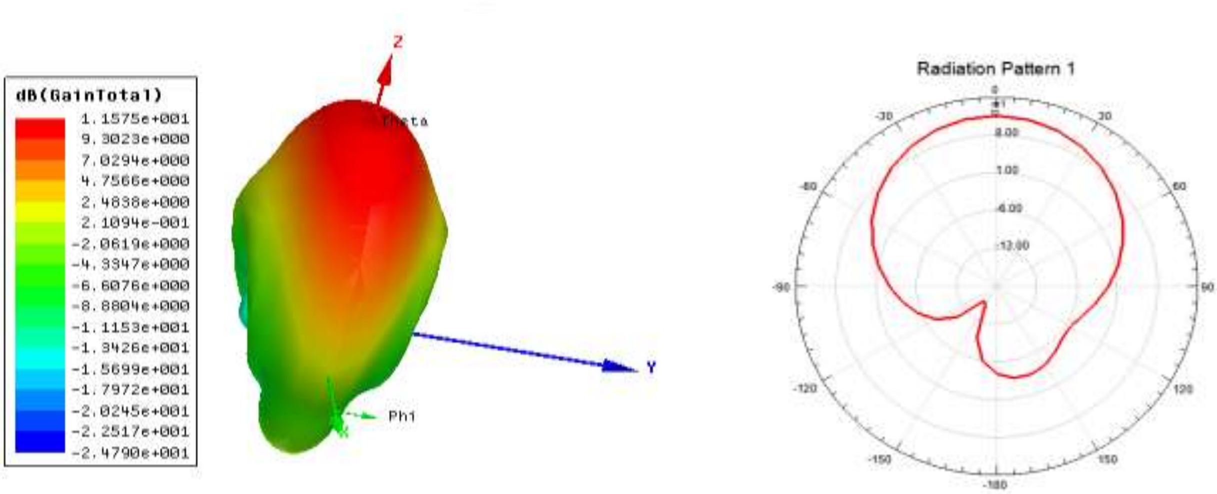

Fig.8 Gain and Radiation pattern of 1×4 Array Antenna

VII. CONCLUSION

The rectangular patch is chosen to design the antenna radiating in X-band at 10GHz frequency. X-band has wide range of applications in radar, satellite communications, medical communications and some wireless applications. The single patch antenna operating at 10 GHz frequency results in gain of 7.9412dB, return loss of -30.3728dB and VSWR of 0.5dB. Later a 1×4 Rectangular patch array is designed using corporate feeding technique. The array antenna results in 11.575dB gain, -25.4815dB return loss and 0.9251dB VSWR. The array antenna shows better performance compared to single element antenna with 36% improvement in gain and with good directivity.

VIII. ACKNOWLEDGMENT

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