International Journal of Modern Engineering Research (IJMER)
www.ijmer.com Vol.2, Issue.6, Nov-Dec. 2012 pp-4754-4756 ISSN: 2249-6645

Analysis of Microstrip Antenna Array

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Abstract: *Antenna exhibits a specific radiation pattern. The overall radiation pattern changes when several antenna elements are combined in an array. Arrays of antennas are generally used to direct radiated power towards a desired direction. This is due to array factor .It is this factor which quantifies the effect of combining radiating elements in an array without the element specific radiation pattern taken into account This paper presents a design approach for four element antenna array. Simulation results show that the antenna array shows good performance in the operating frequency band of (1-1.89GHz) in L-band with return loss of -13db.*

Keywords: Antenna array, Microstrip patch antenna, radiation pattern, Array factor.

I. INTRODUCTION

The overall radiation pattern of an array is determined by array factor combined with the radiation pattern of the antenna element. The overall radiation pattern results in a certain directivity and gain. Directivity and gain are equal if the efficiency is 100%. The number of antenna elements, geometrical arrangement, relative amplitudes and phases of the array elements depend on the angular pattern that must be achieved. Once an array [2] has been designed to focus towards desired direction, it becomes easier to steer it in some other direction by simply changing the relative phases of the array elements—a process called steering or scanning. Figure 1. shows an example of one- and two-dimensional arrays consisting of identical linear antennas.

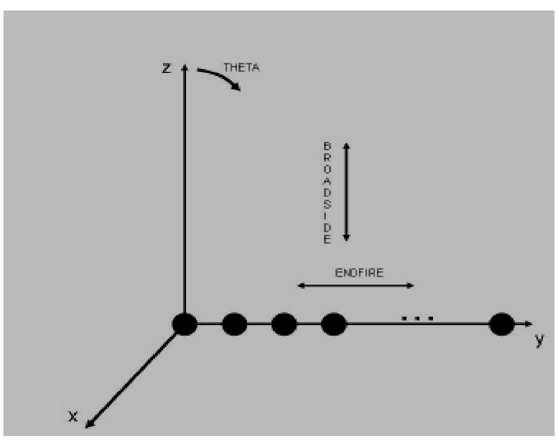

Fig1.Topology of linear array

Broadside vs. end fire arrays

Arrays can be designed to radiate in a direction perpendicular to array orientation (the z axis in figure 1) are called **Broadfire** or if the radiation is in the same direction as the as the array orientation (the y axis in figure 1) are called E**nd fire .**Generally broadside arrays are used and radiation in the z direction is considered. This allows an easy transformation to 2dimensional planar arrays with the elements in the xy plane. There are several applications in this above mentioned L-band. The L band is held by the military for telemetry, thereby forcing digital radio to in-band on-channel (IBOC) solutions. Digital Audio Broadcasting (DAB) is typically done in the 1452–1492-MHz range as in most of the world, but other countries also use VHF and UHF bands [2].

In this paper four element microstrip patch antenna array is proposed which is capable of operating at a frequency of 1.89GHz which lies in L-band .The design of the array is adapted from the formulas found in [1] and [4]. Simulations were carried out using IE3D software and various performance analysis parameters such as S-parameters, gain, directivity; radiation pattern was analyzed to prove the effectiveness of the proposed design at such a high frequency.

This paper is organized as follows: Section II presents design approach of four element microstrip patch antenna in which its design equations and design parameters are discussed. Section III shows simulation results of the antenna array and finally in section IV conclusions are drawn.

II. DESIGN APPROACH

Fig.2 shows a schematic layout of a four element microstrip patch antenna array. Four ports are used to provide maximum coupling between all the four elements which in turn provides good return loss and radiation pattern.

Generally for the Rectangular Patch length of the element [1] is kept as $\frac{\lambda_o}{3} \le L \le \frac{\lambda_o}{2}$ where λ_o is the wavelength of wave.

Because of fringing fields the actual effective length becomes

$$Leff = L + 2\Delta l$$

Where $$\Delta l = \frac{0.412h\left(\varepsilon_{reff} + 0.03\right)}{\left(\varepsilon_{reff} - 0.258\right)} \frac{\left(w + 0.2644h\right)}{\left(w + 0.8h\right)}$$,it

depends on width to height ratio and effective dielectric. Effective dielectric is taken into consideration as there is board dielectric on one end and on top is usually air, it is given by

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2} \frac{1}{\sqrt{\left[1 + \left(\frac{12h}{w}\right)\right]}}$$

There are numerous substrates that can be used for designing of the microstrip antenna. Their dielectric constants are generally in the range $2.2 \le \varepsilon_r \le 12$.Antenna performance is most desirable with thick substrate whose dielectric constant is low as they provide better efficiency and larger bandwidth. But by doing so the element size will increase. If we use thin substrate with high dielectric constant no doubt the element size will reduce but gain, efficiency and bandwidth will be affected and so a compromise has to be made between the antenna performance and the circuit design.

Width is calculated as

$$W = \frac{1}{2 f_r \sqrt{\mu_o \varepsilon_o}} \sqrt{\frac{2}{\sqrt{\varepsilon_{r+1}}}}$$

Or

$$W = \frac{v_o}{2 f_r} \sqrt{\frac{2}{\sqrt{\varepsilon_{r+1}}}}$$

Characteristic impedance is $Z_0 = \dfrac{60 \ln\left(\dfrac{8h}{w} + \dfrac{w}{4h}\right)}{\sqrt{\varepsilon_{reff}}}$

III. Simulation

The specifications mentioned in section II is designed and simulated using IE3D software. The return loss is shown in Fig.3 and from this it is quite clear that good results are obtained as the loss is well below -10db and a sharp frequency is obtained at 1.89GHz. Smith chart obtained in Fig 4 shows that most of the points are located at the bottom of the circle, means impedance is capacitive in nature. Fig 5.shows that VSWR is less than 2 at about 1.8GHz.VSWR of the antenna can be considered desirable as it is less than 2.Various other parameters like Magnitude Vs. Frequency, 3D-geometry, Radiation pattern, Current distribution pattern and Gain Vs. Frequency are given below.

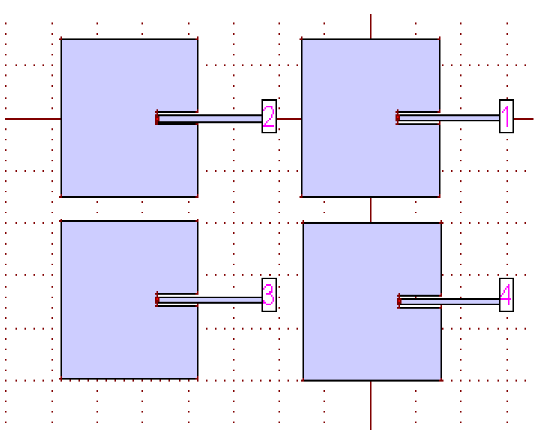

Fig 2.Design of 4- element Microstrip patch array

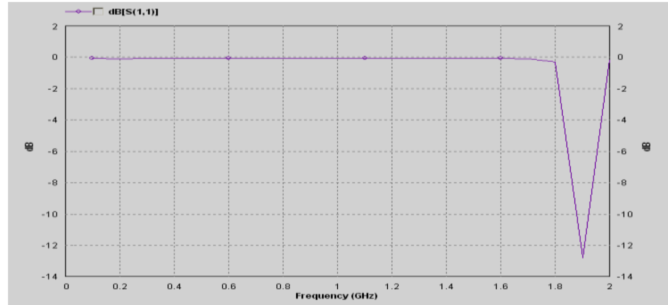

Fig 3.Return Loss

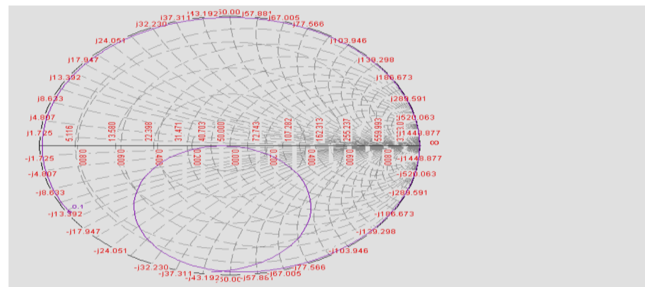

Fig 4.Smith Chart

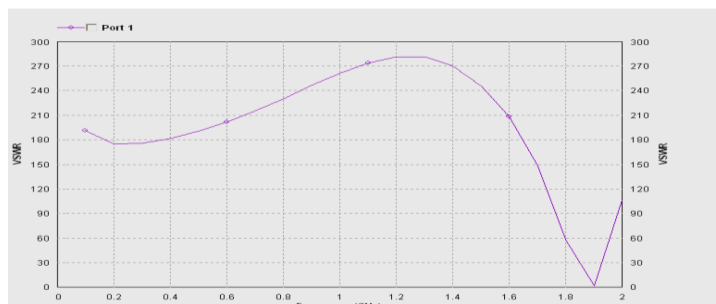

Fig 5.VSWR

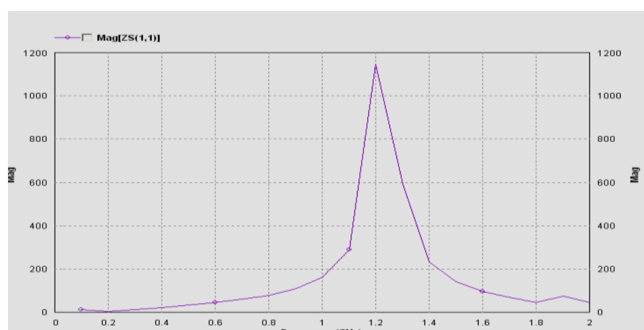

Fig 6.Magnitude Vs. Frequency

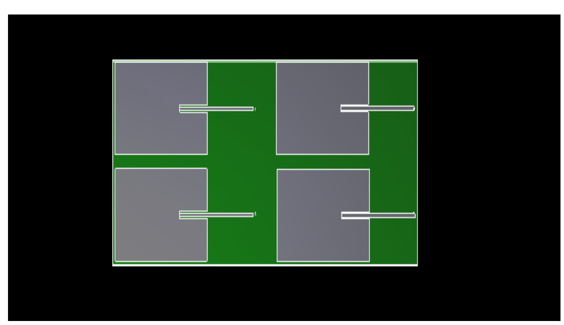

Fig 7.3D-geometry

View

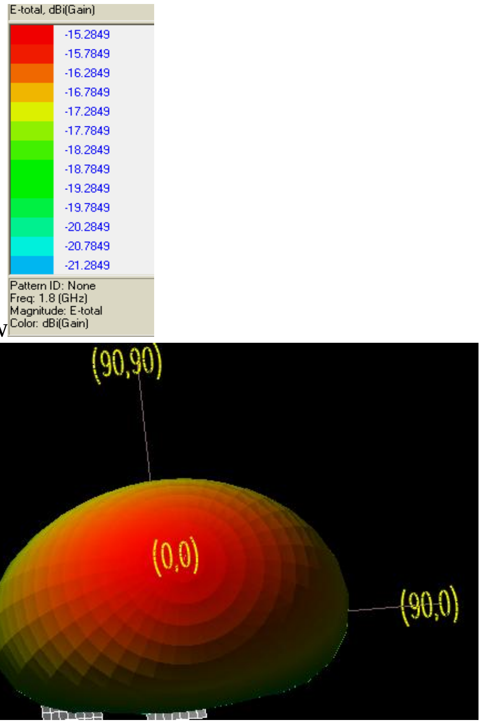

Fig 7.3D Radiation pattern

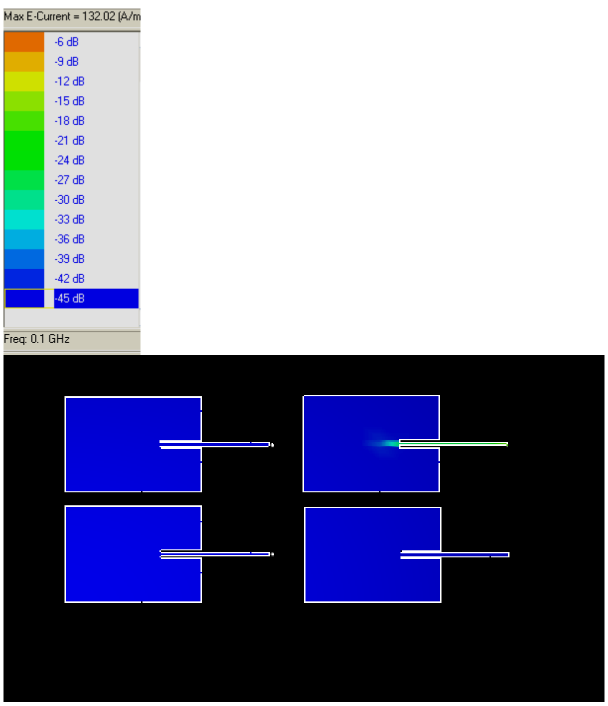

Fig .8 .3D Current distributions

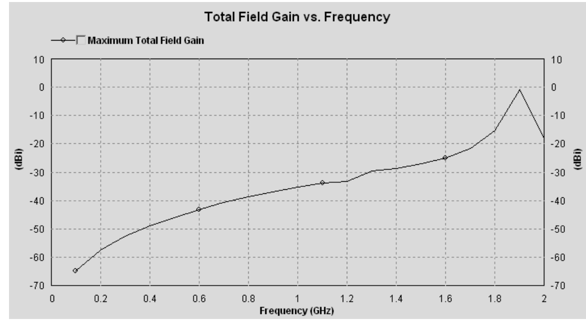

Fig.9.Gain Vs.Frequency

IV. CONCLUSIONS

A design approach for four element antenna array has been presented.L-band four-element array has been simulated. The simulated array has shown very good performance in terms of radiation pattern and S-parameter values.

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