



## 1:4 Microstrip Compact Patch Antenna Array

<sup>1</sup>Swati Gupta, <sup>2</sup>Dhirendra Kumar<sup>1</sup> PG Student, APJ Technical University, Lucknow, Uttar Pradesh, India<sup>2</sup> Electronics and Communication Department, Rajkumar Goel institute of Technology, Ghaziabad, Uttar Pradesh, India

**Abstract**—The paper presented here is dealing with the design of compact patch antenna array. The array of 1:4 patch antenna with microstrip line feeding technique is proposed on operating frequency of 5GHz. The antenna proposed is conventionally using microstrip rectangular patch, the designed antenna is fed with the matching lines inset fed then the power divider has been utilized to design an array of 1:4. Inhibiting characteristics of a single microstrip patch, like low gain and smaller bandwidth, make it more popular for array configuration. the microstrip patch antenna array is able to provide frequency agility, feed line flexibility, broad band-width, beam scanning omnidirectional patterning. A systematic approach has been taken to design the antenna array. The design and measurement results of the antenna are discussed below.

**Keywords**— microstrip patch antenna, antenna array, s11 parameter, 5Ghz, IE3D simulation

### I. INTRODUCTION

Today is the age of communication and the ever growing demand for wireless communications is constantly increasing. The need for better coverage, improved capacity, higher transmission quality and good bandwidth has been raised. Wireless communication has now become an integral part for modern world. Thus, a more efficient use of the radio spectrum is required and antenna systems are capable of efficiently utilizing the radio spectrum for an effective solution to the present wireless systems. So the rapid growth of wireless communication systems has increased the demand for compact antennas with suitable operating frequencies. There is huge demand for new kind of antennas such as small antennas, multi-frequency antennas, broadband antennas for mobile and satellite communication systems. Since patch antennas can be easily and directly printed on to a circuit board these are becoming increasingly popular. In recent years there has been observed the demand for low-profile high-gain microwave antennas with reduced losses due to the advances made in wireless communication and radar systems. One of the possible solutions for fulfilling such conditions is the realization of antennas in the microstrip technology, which allows for achieving low antenna dimensions and desired antenna parameters, when appropriate design techniques are applied [1]. Further high antenna gain can be achieved with the use of multiple radiating elements forming an antenna array [2]. In high- performance spacecraft, aircraft, satellite, and missile applications, where weight, size, cost, performance, easiness of installation and aerodynamic profile are constraints, and low profile antenna may be required. To meet these requirements, microstrip antennas are used that provide attractive features such that, light weight, low profile, easy fabrication, and conformability to mounting hosts [3]. As conventional antennas are often bulky and also costly part of an electronic system, micro strip antennas based on photolithographic technology are seen as an engineering achievement [4]. Different feeding techniques like inset feed, circular coaxial probe feed, proximity coupled feed [5], [6] are used to enhance bandwidth of microstrip patch antenna. Usually radiation pattern of a single element is relatively wide, and each element provides the low values of directivity. In several applications, it is necessary to design antennas with very high directive characteristics (very high gain) to meet the demands of long distance communication. This can be accomplished by increasing the electrical size of the antenna. Enlarging the dimensions of single elements often leads to more directive characteristics [7][8][9]. Another way to enlarge the dimensions of the antenna, without increasing the size of individual element, is to form an assembly of radiating elements in an electrical and geometrical configuration. This new antenna formed is referred to as an array [10]. The antenna arrays are of vast importance and are widely used nowadays for various purposes.

### II. CALCULATION OF PHYSICAL PARAMETERS

Important antenna parameters have been calculated by the transmission line method [11][12] and are explained to simplify the design process, this model is written in Matlab script and the results of each parameter are given below. The three required parameters for the design of a rectangular Microstrip Patch Antenna are: Frequency of center operation ( $f_0 = 5$  GHz), substrate dielectric constant ( $\epsilon_r = 4.5$ ) and height ( $h = 1.5$  mm). Calculating the wavelength ( $\lambda$ ), since  $C = 3 \times 10^8$  m/s so  $\lambda = C / f_0 = 60$ mm.

#### Mathematical calculations [13]

**Width of the Patch (W):** Numerically, the width of the microstrip patch is calculated using the equation as,

$$W = \frac{c}{2f_o \sqrt{\frac{(\epsilon_r + 1)}{2}}}$$

After calculations, W= 18.09mm

**Length of the Patch (L):** The length of the patch can be calculated only if the effective dielectric constant is known, and the effective dielectric constant is calculated as

$$\epsilon_{r_{eff}} = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2} \left[ 1 + 12 \frac{h}{W} \right]^{-\frac{1}{2}} = 3.99$$

The length extension

$$\Delta L = 0.412h \frac{(\epsilon_{r_{eff}} + 0.3) \left( \frac{W}{h} + 0.264 \right)}{(\epsilon_{r_{eff}} - 0.258) \left( \frac{W}{h} + 0.8 \right)} = .6807\text{mm}$$

The effective length Leff

$$L_{eff} = \frac{c}{2f_o \sqrt{\epsilon_{r_{eff}}}} = 15.02253\text{mm}$$

$$L_{eff} = L + 2\Delta L$$

$$L = L_{eff} - 2\Delta L = 13.66\text{mm}$$

So the final length and width of the antenna are calculated as 13.66mm and 18.09mm which is taken as a base for the design of 1:4 antenna array.

### III. 1:4 PATCH ANTENNA ARRAY

The single entity microstrip patch antenna design and dimensions are presented here. as displayed in Fig. 1; the proposed design is simulated using IE3D for operating frequency of 5GHz

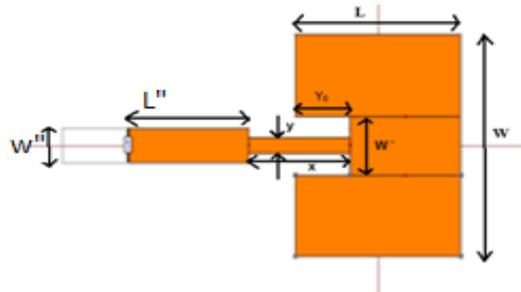


Fig. 1 Single Entity Design

The 4 elements microstrip antenna array as shown in Fig.2 has been designed using the geometry of the patch antenna element as shown in Fig. 1. The designed 4 element antenna array consists of 4 E shaped antennas which have been configured in form of an array.

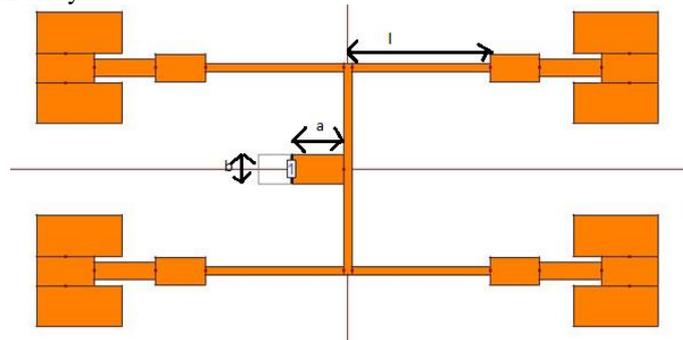


Fig. 2 1:4 Patch Antenna Array

Table -1 shows the summarize dimensions of 1:4 patch antenna array.

Table -1: Dimensions of 1:4 patch antenna array

L (mm)	W (mm)	x (mm)	y (mm)	L'' (mm)	W'' (mm)	l (mm)	a (mm)	B (mm)
13.66	18.09	8	4.5	10	2.8	23	9	4.85

#### IV. RESULTS

The presented design is simple and it achieves a very good return loss of -27dB as displayed in Fig. 3.

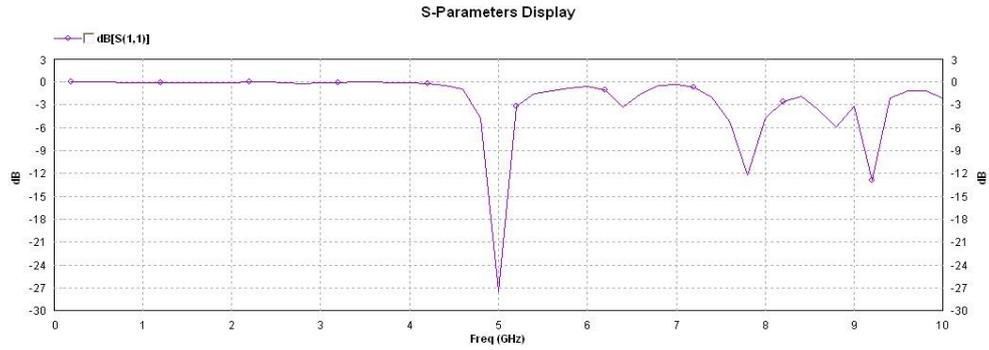


Fig. 3 Return Loss of 1:4 Patch Antenna Array

The radiation pattern of proposed antenna array is displayed in Fig. 4.

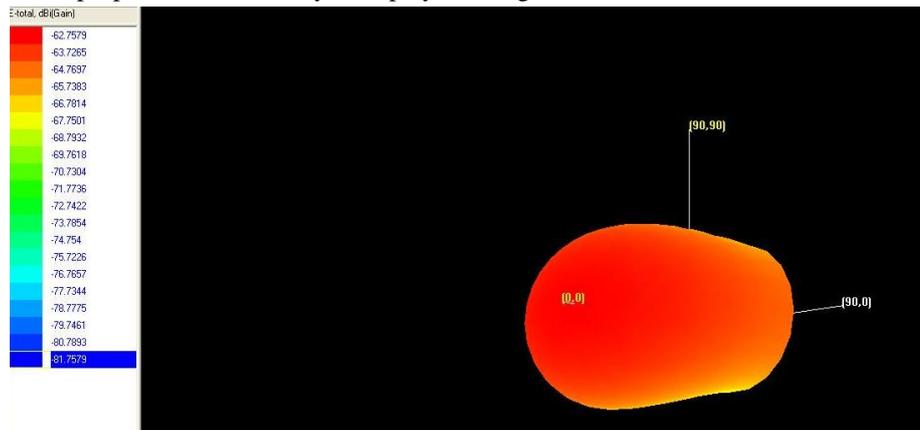


Fig. 4 Radiation pattern of 1:4 Patch Antenna Array

Other parameters of 1:4 patch antenna array are displayed below.

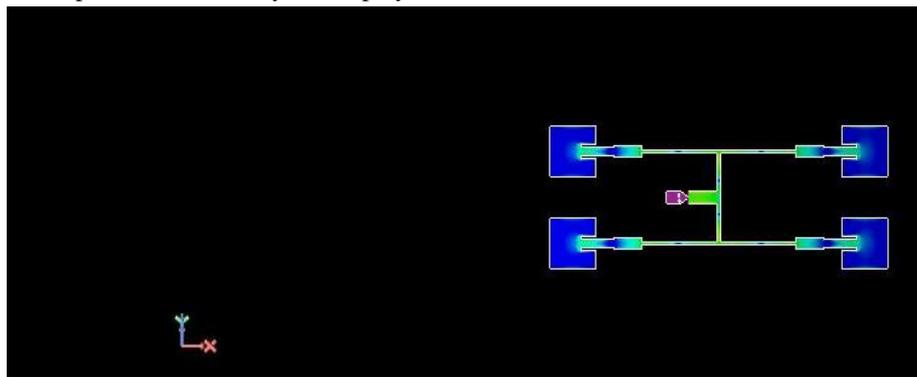


Fig. 5 Current distribution of 1:4 patch antenna array

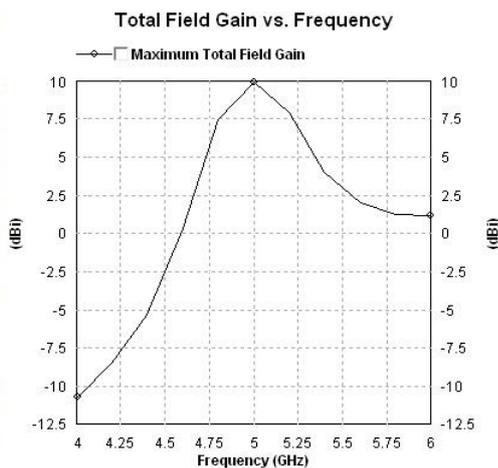


Fig. 6 Field gain of 1:4 patch antenna array

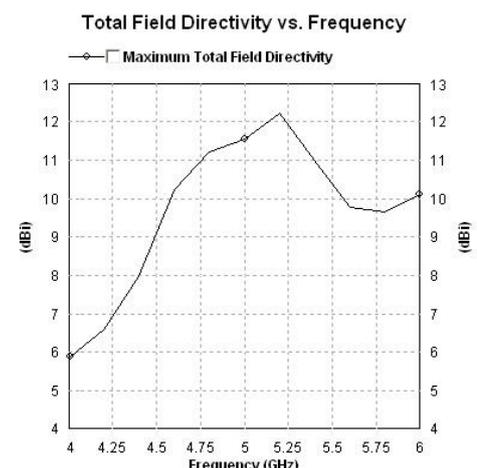


Fig. 7 Field directivity of 1:4 patch antenna array

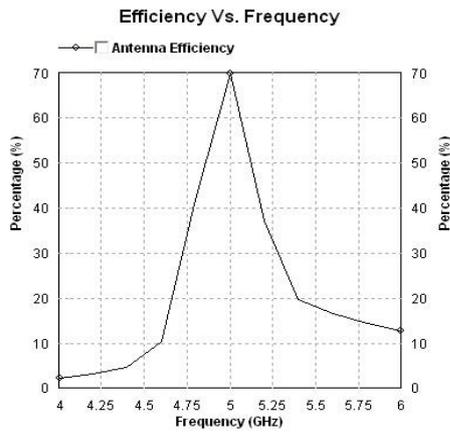


Fig. 8 Antenna efficiency of 1:4 patch antenna array

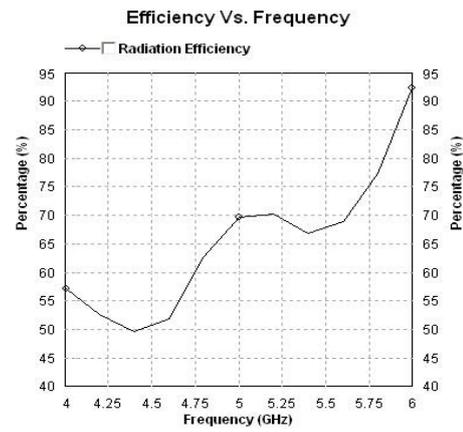


Fig. 9 Radiation efficiency of 1:4 patch antenna array

**Summarised result of all parameters:**

Final summarised table is given below for various parameters of 1:4 patch antenna array:

Table -2: Parameters of designed 1:4 patch antenna array

Element	S11 (dB)	Gain (dB)	Directivity (dB)	Antenna efficiency (%)	radiation efficiency (%)
1:4 patch antenna array	-27	10	12	70	70

**V. CONCLUSION**

The proposed 1:4 antenna array in this paper designed and analyzed through different parametric studies using IE3D simulation software. The antenna designed is based on a simple structure with very good return loss and have achieved good stable radiation pattern and satisfied efficiency and directivity. In addition, the proposed antenna has good radiation characteristics and gains. The obtained results of designed antenna display great potential for the utilization in wireless communication.

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