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DESIGN OF X-BAND MICRO STRIP PATCH ANTENNA ARRAY

KHALID MUZAFFAR*

ABSTRACT

The modern wireless communication demands high gain, wide bandwidth and reduced size antennas that are efficient to provide improved performance over a wide range of frequency spectrum, which can be easily obtained using micro strip patch antenna arrays. This paper presents the design of compact 4x4 micro strip patch antenna array. Corporate feed technique is used for excitation. The proposed antenna array is designed on RogersRT5880 substrate with dielectric constant (εr) of 2.2 and thickness 0.762mm. The simulation is carried using CST Microwave Studio. The antenna has been designed at 8 GHz and is therefore highly suitable for X band applications.

Keywords: Micro strip patch antenna, corporate feed, micro strip patch antenna array

INTRODUCTION

Antenna is a fundamental part of any wireless communication system. The demand for lightweight communication devices and the emergence of many systems, it is important to design compact and high gain antennas. [1]. Therefore there is a growing need for more compact antennas for communication devices. As communication devices are become smaller due to greater integration of electronics, the antenna becomes a bottleneck for size miniaturization as it occupies a significantly larger space of the overall package. In order to overcome the difficulties with size micro strip antenna is the favorable candidate for wireless applications. Micro strip patch antennas are light in weight, conformal, simple planar structure. They can be easily fabricated using printed-circuit technology [2]. The main advantages of a micro strip antenna are ease of construction, light weight, low cost [2-7]. In single patch antenna element antenna, the main lobe of the radiation pattern is very broad and the directivity is therefore relatively low. This problem can be mitigated by increasing the size of the element. Other way is to make an array by assembling number of elements. The performance of a micro strip patch antenna and array depends on various factors such as type of substrate, feeding mechanism, the thickness of dielectric and dielectric constant of substrate respectively. But it has few drawbacks like narrow impedance bandwidth, less gain and broad beam width.

To increase the bandwidth, directivity and gain, the most common method is to use an array [6, 7]. The efficiency of micro strip antenna arrays can be significantly increased by reducing losses in the feeding network. The choice of dielectric substrate used and its thickness are the main parameters in terms of size and compactness of the patch antenna. The array has an improved gain, band width and radiation pattern in comparison to that of a single patch antenna element [6]. In the present paper a micro strip patch antenna array suitable for X-band applications is designed. X-band is used in radar applications including continuous-wave, pulsed, single polarization, dual-polarization, synthetic aperture radar, and phased arrays. The proposed antenna is designed on the substrate material with dielectric constant (εr) of 2.2 and height 0.762mm.

*Department of Electronics & Communication Engineering Islamic University of Science & Technology, Awantipora, J&K,

FEEDING NETWORK

The feeding network used for exciting the Patch antenna array is corporate feed. In this configuration, the antenna elements are fed by 1: n power divider network with equal and identical path lengths from the feed point to each individual element. The corporate-feed network is used to maintain power splits of 2n (i.e. n = 2; 4; 8; 16; etc.). This method has more control of the feed of each element and is commonly used for antenna arrays. This feeding mechanism provides better directivity as well as radiation efficiency and minimizes the beam fluctuations over a band of frequencies. The phase of each element can be controlled by using phase shifters while amplitude can be adjusted using either amplifiers or attenuators [8-10].

DESIGN OF PATCH ANTENNA ARRAY

The main parameters for the design of a Micro strip Patch Antenna are [11-13]:

- Frequency of Operation: The resonant frequency of the antenna must be selected appropriately. The resonant frequency selected for the present design is 8GHz.
- Dielectric constant of the substrate (εr): The dielectric material selected for design has a dielectric constant of 2.2.
- Height of dielectric substrate): The height (h) of the dielectric substrate used is 0.762 mm.

DESIGN PROCEDURE

Step1

Calculate the width of the patch as

$$W = \frac{1}{2f_r\sqrt{\mu_0\epsilon_0}}\sqrt{\frac{2}{\epsilon_r+1}} = \frac{\upsilon_0}{2f_r}\sqrt{\frac{2}{\epsilon_r+1}}$$

Step2

Calculate the effective dielectric constant for (W/h >1)

$$\epsilon_{\text{reff}} = \frac{\epsilon_r+1}{2} + \frac{\epsilon_r-1}{2}\left[1+12\frac{h}{W}\right]^{-1/2}$$

Step3

Calculate the length correction due to fringing

$$\frac{\Delta L}{h} = 0.412\frac{(\epsilon_{\text{reff}}+0.3)\left(\frac{W}{h}+0.264\right)}{(\epsilon_{\text{reff}}-0.258)\left(\frac{W}{h}+0.8\right)}$$

Step 4

The length of the patch can now be calculated as

Step 5

$$L = \frac{1}{2f_r\sqrt{\epsilon_{\text{reff}}}\sqrt{\mu_0\epsilon_0}} - 2\Delta L$$

The feed point position for 50 Ohms can be calculated using the following expression

$$R_{in}(y = y_0) = R_{in}(y = 0)\cos^2\left(\frac{\pi}{L}y_0\right)$$

Where *Rin(y=y*$_0$*)* is 50 Ohms and *Rin(y=0)*is roughly given as (Neglecting the mutual coupling of the slots)

$$Z_{in} = \frac{1}{Y_{in}} = R_{in} = \frac{1}{2G_1}$$

$$G_1 = \begin{cases} \frac{1}{90}\left(\frac{W}{\lambda_0}\right)^2 & W \ll \lambda_0 \\ \frac{1}{120}\left(\frac{W}{\lambda_0}\right) & W \gg \lambda_0 \end{cases}$$

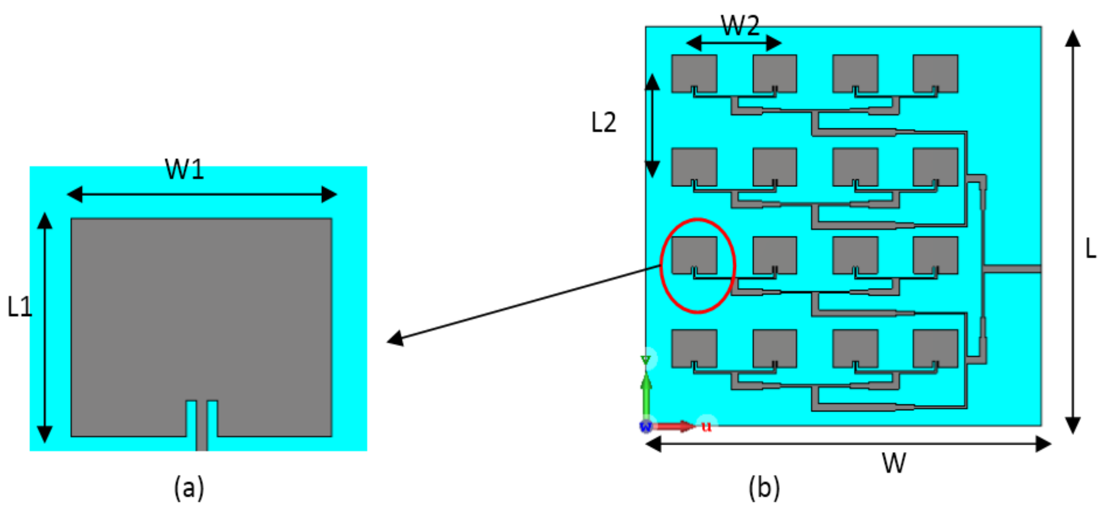

Fig. 1.(a) Single Element (b) Sixteen element corporate feed patch antenna array

The optimal dimensions of the designed antenna are as follows: W1= 15.5mm, L1= 11.9mm, W2=28mm L2= 30mm.On the back of the substrate, complete ground plane is used. The dimension of ground plane which is printed in the back side of the substrate is chosen to be W × L, where W=13.76 cm and L=12.75 cm.

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SIMULATION RESULTS

The simulated results obtained using CST Microwave Studio are shown in Figures 2-4. Figure 2 shows the return loss plot of the proposed antenna array. Figures 3 and 4 show the three dimensional and polar radiation patterns respectively of the proposed antenna array. The gain for the array is 20 dB.

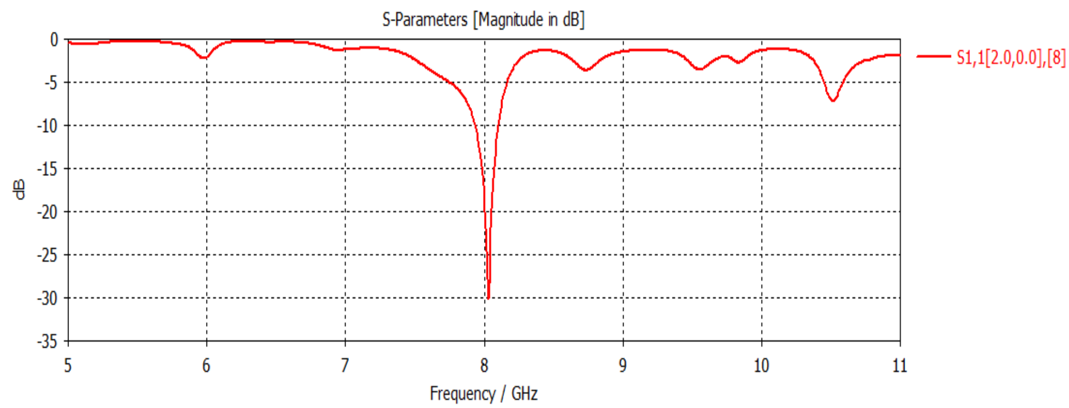

Fig. 2.(a) Return Loss plot of the Array

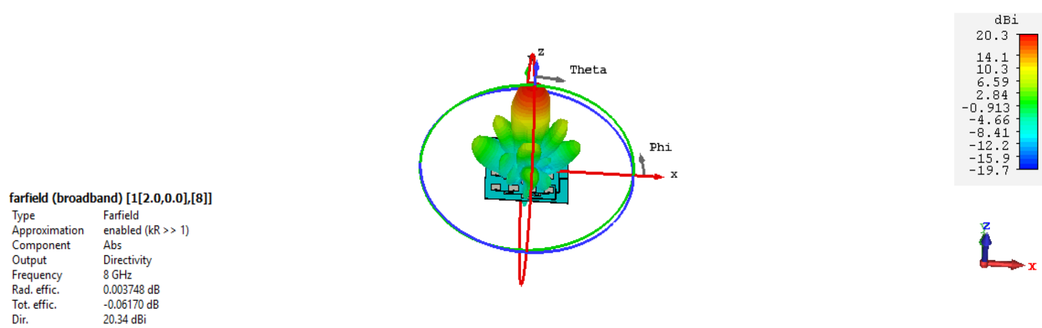

Fig. 3. Three Dimensional Radiation Pattern of the Antenna array

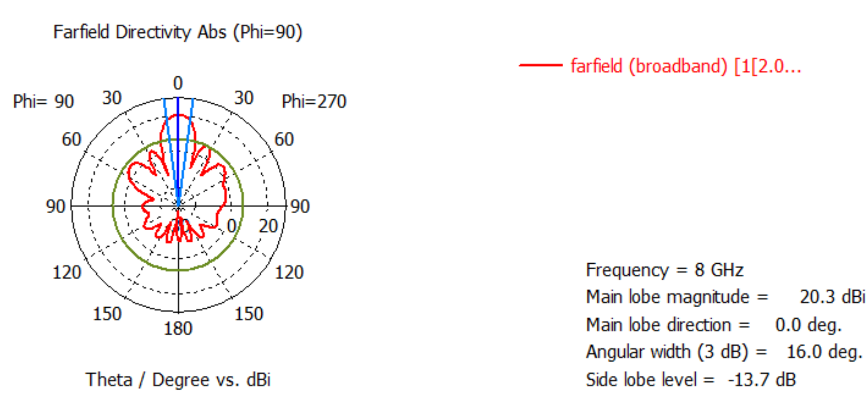

Fig. 4. Polar plot of the radiation pattern of the Antenna Array

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