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Research Article

Design and Implementation of 2x1 Microstrip Triangular Patch Antenna Array for X- Band Applications

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Abstract

This paper presents the design and implementation of 2x1microstriptriangular patch antenna array using microstrip line feed for x-band. The design of microstrip patch antenna array is realized using Quarter wavelength transformer. The operating frequency of microstrip patch antenna array isin the range of 8GHz-12GHz is chosen. Each antenna operates in its own operating resonant frequency. The array of two by two microstrip triangular patch antennas with edge feed technique were designed, simulated and measured with the IE3D Zeland software. The simulation and measurement results are able to operate in X-band. The array antenna is designed on GML 1000 having dielectric constant ($\mathcal{E}_r$) of 3.2 and thickness of 0.762mm, respectively. Further, the result shows that the proposed array antenna with triangular shaped patch has the gain of 7.7 dB, directivity of 10.2 dBi and the return loss of -15.05 dB at 9.7 GHz.

Keywords: *Array antenna, Microstrip line feed, Gain, Directivity, Return loss.*

1. Introduction

Microstrip antennas are currently one of thefastest growing segments in the telecommunications industry and promise to become the preferred medium of telecommunications in the future (D. M. Pozar *et al*, 1995).Wireless communication has experienced an enormous growth since it allows users to access network services without being tethered to wired infrastructure.Besides being able to indicate good signal to noise ratio and immunity to noise, the antennas in microwave links will have portray compact structure and ease of construction to be mounted on various devices (Saed *et al*, 2005). For high performance applications of the antennas where size, weight, cost, performance, ease of installation are constraints, low profile antennas are required to meet these requirements, microstrippatch antenna is preferred (Yuan *et al*, 2008). Microstrip antenna technology began its rapid development in the late 1970s. By the early 1980s basic microstrip antenna elements and arrays were fairly well establish in term of design and modelling (Kara *et al*, 1995). In the last decades printed antennas have been largely studied due to their advantages over otherradiating systems, such as light weight, reduced size, low cost, conformability in many applications and possibility of integration with active devices (Huque *al et*, 2011). Although microstrip antenna has several advantages like low profile, light in weight and simple to manufacture, it also has several disadvantages low gain, narrow bandwidth with associated efficiency is low (Anitha *et al*, 2009). These disadvantages can however be overcome with intelligent designs incorporated in whole antenna structures. One of the ways to overcome these problems is by constructing many patch antennas in array configuration (Wang *et al*, 2008).

2. Array Structure

The radiation pattern of a single element is relatively wide and each element provides low values of directivity and gain (Carver *et al*, 1981). In many applications, especially for point to point communication system it is necessary to design antennas with very directive characteristic (high gain) to meet the demands of long distance communication (Sze *et al*, 2001). This can be accomplished by increasing the electrical size of the antenna (Raja *et al*, 2009). Arraystructure is more versatile and canprovide more symmetrical pattern with lower side lobes. In addition it can be used to scan the main beam of the antenna toward any point in space.

The basic structure of microstrip patch antenna array is shown in fig 1.The design of the antenna array is started byselecting the suitable patch shape of the antenna. The triangular patch is chosen because it simplifies the analysis and performance prediction. This antenna has been designed to operate at 9.7 GHz with input impedance of 50 Ω, using GML1000(ε_r=3.2)

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and height (h) of 0.762 mm. The design starts with the simpler triangularmicrostrip antenna with edge feed. Then, the microstrip antenna is simulated using the IE3D Zeland software. It consists of 3 layers. The lower layer which constitutes the ground plane covers the entire rectangular substrate. The middle layer consists GML1000 which has a relative dielectric constant ε_r= 3.2. The upper layer is the patch which covers the top substrate. In this paper, the dielectric chosen is GML1000 with loss tangent of 0.001, height *h* of 0.762 mm with dielectric constant of the substrate εr= 3.2 for an antenna with resonating frequency (fr)= 9.7 GHz of X-band. Selection of these parameters is followed by calculation of patch dimension. The value of the patch width W can be calculated as (Yuan *et al*, 2008).

Width of the patch is given by

$$w = \frac{c}{2fr}\left(\frac{\varepsilon r+1}{2}\right)^{-0.5} \quad (1)$$

Length of the patch is given by

$$L = \frac{c}{2fr\sqrt{\varepsilon eff}} - 2\Delta l \quad (2)$$

Where

$$\varepsilon eff = \frac{\varepsilon r+1}{2} + \frac{\varepsilon r-1}{2}\left(1+\frac{12h}{w}\right)^{-0.5} \quad (3)$$

And

$$\Delta l = 0.412h\left(\frac{0.262h+(w/h)}{0.813h+(w/h)}\right)\left(\frac{\varepsilon eff+0.3}{\varepsilon eff-0.258}\right) \quad (4)$$

Characteristic Impedance of Patch is given by

$$Za = 90\frac{\varepsilon r^2}{\varepsilon r+1}(L/W)^2 \quad (5)$$

Characteristic Impedance of Transition section is given by

$$Z_T = \sqrt{50}*Za \quad (6)$$

Width of 50 ohm feed line is given by

$$Zo = \frac{120\pi}{\sqrt{\varepsilon eff}\left(1.393+\frac{W}{h}+\frac{2}{3}ln\left(\frac{W}{h}+1.444\right)\right)} \quad (7)$$

Where f_0 is the centre frequency of the patch, *c* is speed of light in free space, *h* is the substrate thickness and *εr*is the dielectric constant of substrate. The array antenna consists of a branching network of two-way power dividers. Quarter-wavelength transformers (70 Ω) are used to match the 100 Ω lines to the 50 Ω lines. The design of 2x1 planar array antennas with the corporate feeding network is proposed. The shape of the defect may be changed from a simple shape to the complex one for the better performance.

T junction power divider and quarter wave transformer impedance matching sections were used to couple the power to each element for radiation. The output line impedances Z1 and Z2 can then be selected to provide various power divisions ratio.

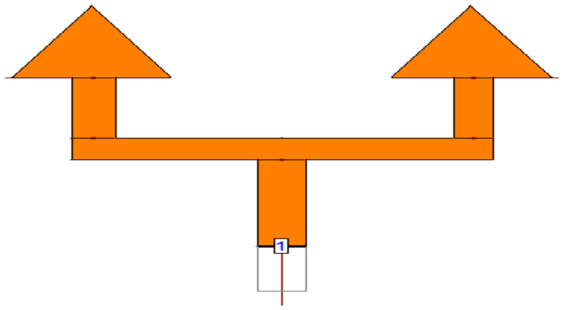


Fig.1 Geometry of the triangular shaped microstrip antenna array

3. Result and Discussion

Fig 2 shows the return loss plot of two element triangular shaped microstrip patch antenna array. The simulation result shows that 2x1 patch antenna array gives the return loss of -15.05dB at the resonance of 9.7 GHz.

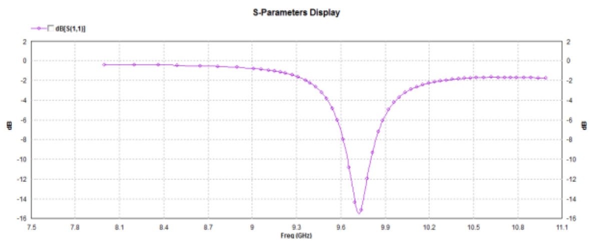
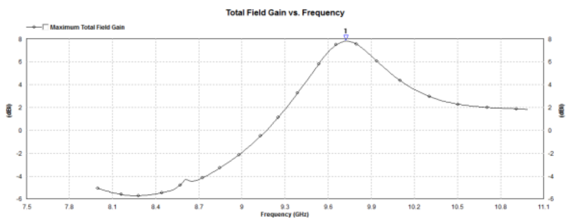


Fig.2 Return loss plot of 2x1 triangular shapedmicrostriparray antenna

Fig 3 and 4 shows the gain and directivity of 2x1 microstrip array antenna with triangular-shaped patch. Gain of 2x1 microstriip array antenna with triangular-shaped structure is 7.74 dB and directivity of 2x1 planar array antennas with triangular-shaped structure is 10.24dB.



Fig,3 Gain of 2x1 microstrip patch antenna array with triangular shape

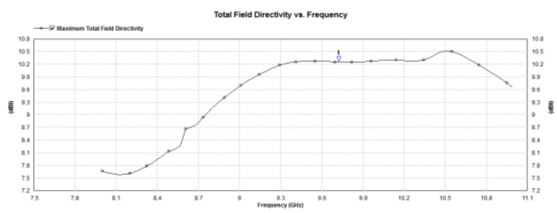


Fig.4 Directivity of 2x1 microstrip patch antenna array with triangular shape

Fig 5 and 6 shows the 50 ohm impedance matching of the 2x1 microstrip antenna array of triangular shaped patch that is resonating at 9.7 GHz and the 3D view of the proposed antenna.

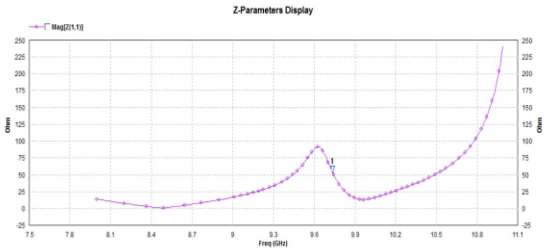


Fig.5 Impedance matching of triangular shaped microstrip antenna array

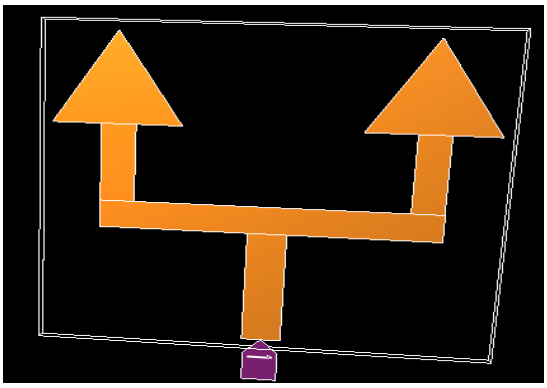


Fig.6 3D view of the 2x1 microstrip antenna array

Conclusion

A new printed 2x1 micro-strip array antenna with triangular patches using edge feeding technique has been designed and simulated in this paper. The proposed antenna provides a relatively wide band having bandwidth of 120 MHz. It is depicted from the results that arranging the micro-strip patches in a planar form can enhance the antenna array performance in terms of the broad bandwidth and high gain. The simulation results complied with the design requirements. The further scope of this paper is the design of the Feed Network and Hardware realization.

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