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Design, Simulation and Fabrication of Log Periodic Triangular Microstrip patch Antenna Array

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ABSTRACT

This paper describes the design, simulation and fabrication of three element log-periodic triangular microstrip antenna array. A comparative study ispresented between simulation and fabrication results. The three patches are fed by using inset feed line technique which are connected with a single transmission line by forming a log periodic array which operates over frequencies ranging from 2.9 to 3.4 GHz.The frequency response of the array is analyzed using the Zealands IE3D commercial software which implements the method of moments for showing Simulation results. The designed antenna is fabricated and tested, and a comparative study is made between simulation results and tested results.

Keywords: Log-periodic antenna, Triangular patch, Wideband, Microstrip.

1. INTRODUCTION

Printed Antenna technology is directed towards the miniaturization of antennas without losing the best performances. Its miniaturization character has made it possible to integrate them easily in transmission and reception systems. Microstrip patches are often used as single element antennas in certain applications, but in case of conventional microwave antennas, the requirement of characteristics such as beam scanning or steering capability, high gain, are possible only when discrete microstrip patches are combined to form arrays [1-2]. Advantages of microstrip antenna include inexpensive, easy to fabricate, conformable to planar and non-planar surfaces, low profile and they are versatile in terms of resonant frequency, impedance, polarization and pattern. Microstrip patch antenna presents a narrow bandwidth and weak gain, association in arrays makes it possible to compensate the single antenna limitations characteristic and to improve their gain and radiation performances. One ofthe Microstripantennas disadvantages remains a narrow band-width. Various techniques have been proposed to improve the operational bandwidth of microstrip antennas. Another successful attempt to enhance the bandwidth of microstrip antenna was made by applying the log-periodic technique to design a microstrip array [3-4].

This paper describes the design, simulation and fabrication of three element log-periodic triangular microstrip antenna array. The proposed antenna has been designed by combining three patch elements by using the log periodic technique with the scaling factor of 1.05. IE3D software has been used to carry out the simulation for the log periodic antenna and the antenna is fabricated. After the simulations were completed, fabricated antenna results and simulation results were compared in terms of return loss.

2. ANTENNA DESIGN

The geometrical structure of the proposed three element triangular log periodic microstrip antenna with reconfigurability is as shown in Figure 1. This antenna can perform in frequency range from 2.9 GHz until

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3.4 GHz. There are three triangular patches with inset fed lines, which are connected with a log-periodic array formation to a 50 &! microstrip transmission line on a top layer of substrate. The antenna structure is developed on a FR-4 substrate which has relative permittivity of 4.5, with a thickness of 1.6 mm and loss tangent of 0.019.

The log periodic microstrip antenna is a more conventional approach for the implementation of a broadband antenna.

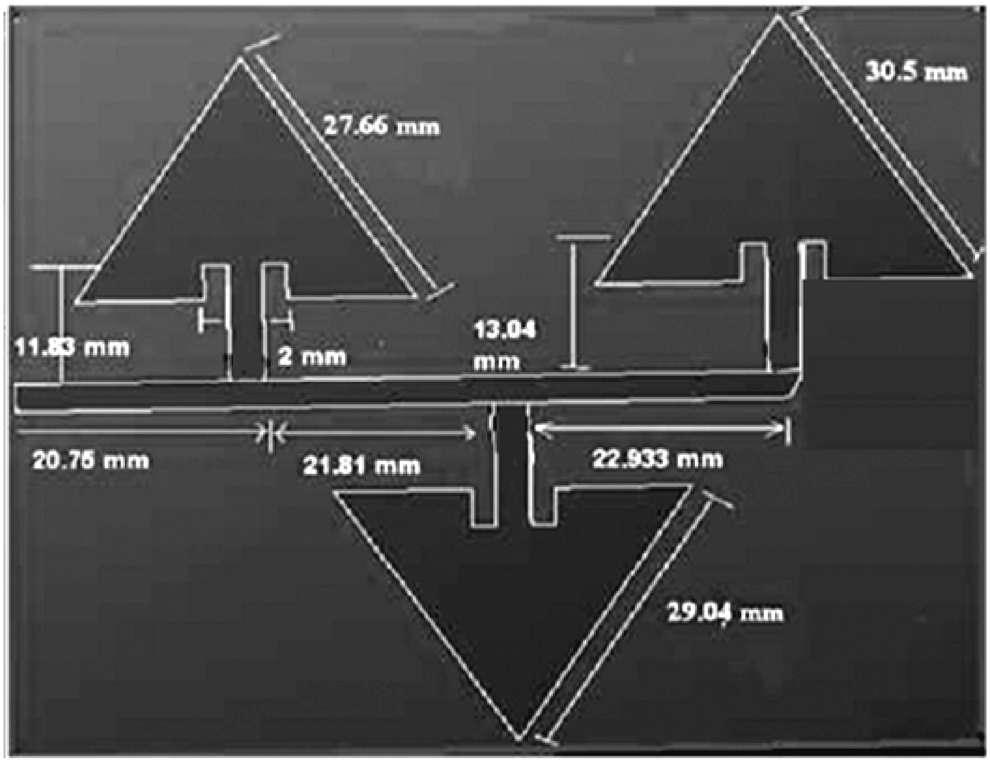

Figure 1: Top view of Three Element Triangle shaped Log periodic Antenna Array

The basis of this design is the linear array of coplanar patch antennas with the size and spacing of the patches increasing in a log periodic manner. The design principle for log-periodic wideband microstrip antenna requires scaling of dimensions from period to period so that the performance is periodic with the logarithm of frequency. The patch side length (d) and the inset feed distance (I) are related to the scaling factor (τ) by equation as shown below.

$$\tau = \frac{d_{m+1}}{d_m} = \frac{I_{m+1}}{I_m} \tag{1}$$

The first patch (lower frequency) side length of is 27.66 mm with resonant frequency at 3 GHz and it is scaled by a factor of 1.05 to obtain the second patch dimension of 29.04 mm which has a resonant frequency at 3.15 GHz. Second patch diameter is once again scaled by a factor of 1.05 to obtain the third patch side length of 30.05 mm with a resonant frequency at 3.3 GHz.The space between each patch (Dm) is a half wavelength apart thus giving a forward fire radiation pattern and reducing mutual coupling effect.

The design equations for the side length ‘a’ and effective side length ‘a_e’ of triangular patch are shown below as[6]:

$$a_e = \frac{2c}{3 f_r \sqrt{\varepsilon_r}} \tag{2}$$

$$a_e = a\left[1 + 2.199\frac{h}{a} - 12.853 - \frac{h}{a\sqrt{\varepsilon_r}} + 16.436\frac{h}{a\varepsilon_r} + 6.182\left(\frac{h}{a}\right)^2 - 9.802 - \frac{1}{\sqrt{\varepsilon_r}}\left(\frac{h}{a}\right)^2\right] \quad (3)$$

where c is the velocity of light, f_r is the resonant frequency and E_r is permittivity of the dielectric substrate used.

3. SIMULATION RESULTS

The proposed log-periodic microstrip antenna has been simulated using Zealand's IE3D software to carry out the results of the antenna performances. Figure 2 shows the Return loss Vs Frequency responsecharacteristics for three element triangular shaped LPA and has -10dB bandwidth of 0.48 GHz and it operates from 2.92 GHz until 3.4 GHz or over 15.31 % bandwidth.

Figure 3 shows the Gain Vs Frequency response for three elements triangular shaped LPAand the gain remains almost flat around 4 to 6 dBi from 2.92 GHz to 3.40 GHz.

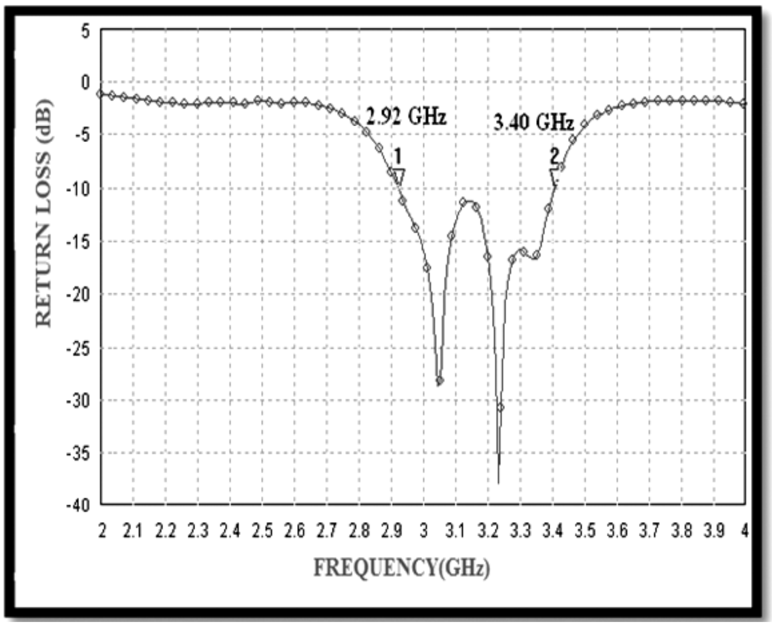

Figure 2: Simulated Return Loss characteristics for three element triangular patch LPA

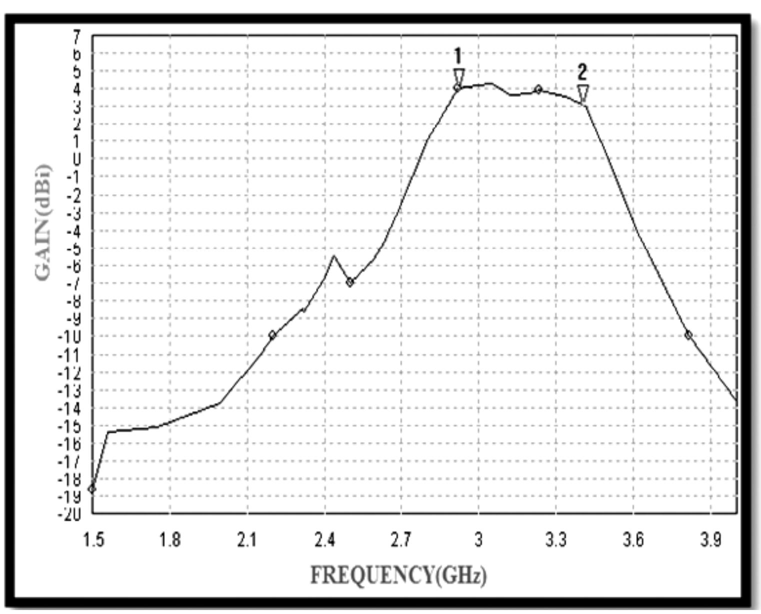

Figure 3: Gain vs Frequency Response for three element triangular patch LPA

4. EXPERIMENTAL RESULTS

The simulations show good results. To further justify the results, the designed antenna has been fabricated using photolithography and then tested on a Vector Network Analyzer.

Figure 4 shows the fabricated three element triangle shaped log periodic antenna array. Figure 5 shows the Return loss Vs Frequency response for fabricated three elements triangular shaped LPA and has -10dB bandwidth of 0.33 GHz and it operates from 2.99 GHz until 3.32 GHz or over 11.03 % bandwidth

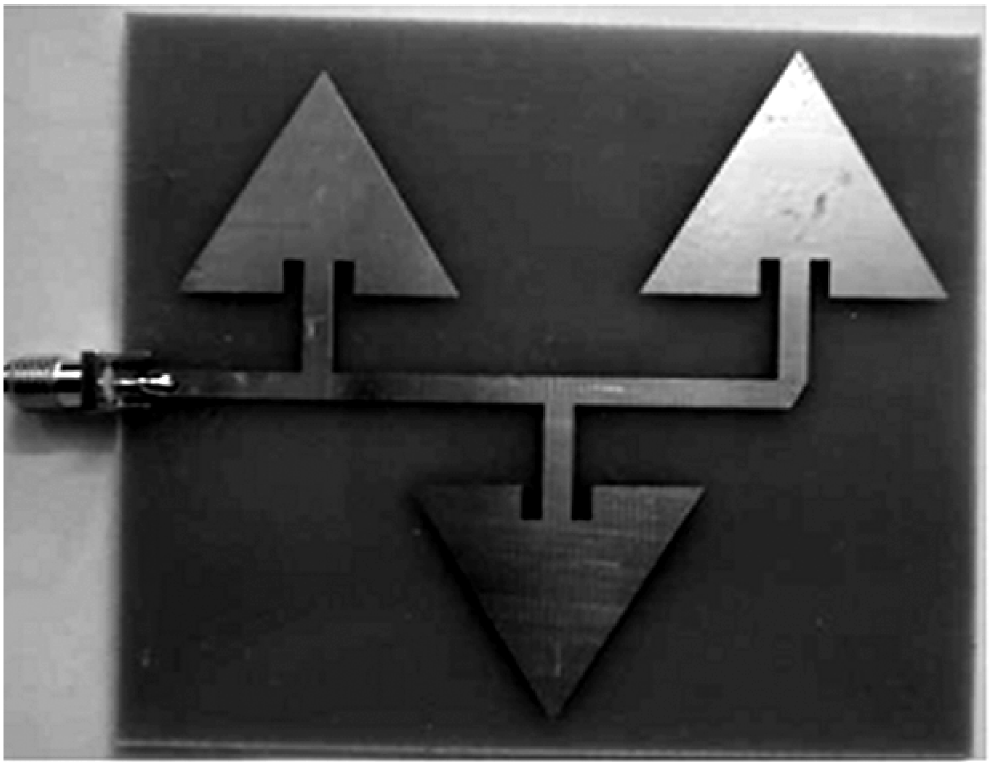

Figure 4: Fabricated three element Triangle shaped Log periodic Antenna Array

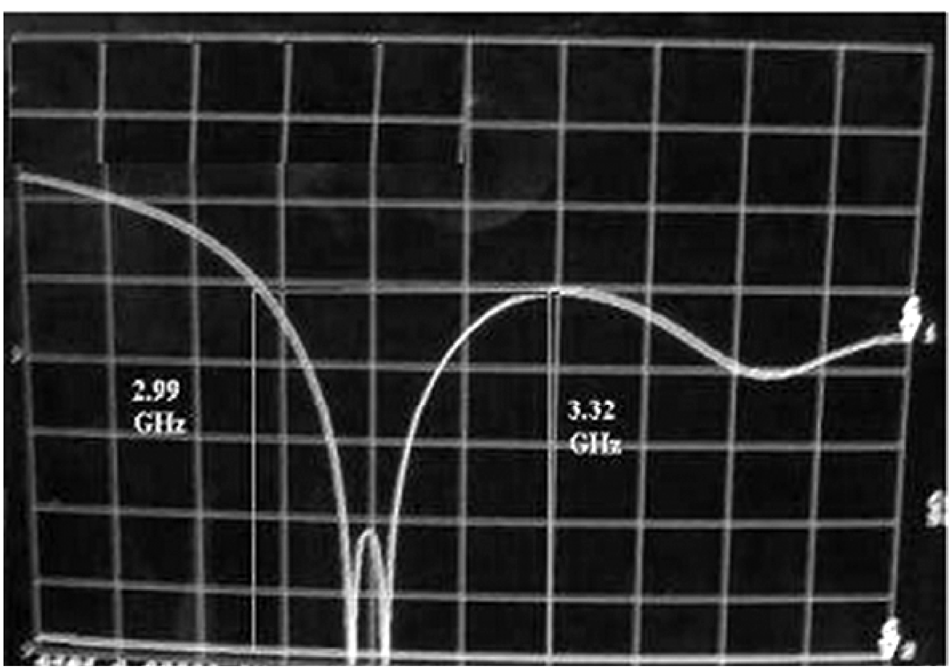

Figure 5: Measured return loss characteristics for Triangular shaped patch LPA

5. CONCLUSION

The three element triangular patch shaped Log-periodic microstrip antenna has been designed, simulated, fabricated and tested. It operates from 2.9 GHz to 3.4 GHz with realised gain of 3 dBi to 6 dBi. It is observed that the gain was increased as the number of patches increased. This shows that the antenna exhibited a better frequency independent behaviour. Therefore, the proposed antenna with more elements with further wide bandwidth can be achieved.

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