A Multi-Bands Circular Polarized of Series Triangular Microstrip Patch Antenna Array

Adnan M. Affandi , Abdullah M Dobaie, Navin Kasim, Nawaf A. Al-Zahrani Electrical and Computer Engineering King Abdulaziz University



Abstract: In this paper, the microstrip line fed wide band triangular patch antenna with rectangular slot has been designed and simulated by using ADS software in order to study the effects of various parameters on the antenna's radiation characteristics. Also, two, four, eight and sixteen elements of triangular microstrip patch antenna array has been discussed. The effect on the antenna parameters due to increase in the antenna elements (array) is clearly observed on antenna bandwidth. This type of antenna can be used for Astronomy and Remote Sensing applications.

Keywords: Triangular Microstrip Antenna, Circular Polarization, Antenna Array, Series Feeding Network, Wide Bandwidth

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1. Introduction

Microstrip patch is one of the most widely used radiators for circular polarization. Figure 1 shows some patches, including square, circular, pentagonal, equilateral triangular, ring, and elliptical shapes which are capable of circular polarization operation. However square and circular patches are widely utilized in practice.

Electric field vectors of a circularly polarized electromagnetic wave have a constant magnitude but their direction changes in rotary manner as showing in Figure 2.

The classical sinusoidal plane wave solution of the electromagnetic wave equation for the electrical and magnetic fields is

| $E(r,t) = E \operatorname{Re} \{Q \mid \psi > \exp[i(kz - \omega t)]\}$ | (1) |
|---|-----|
| ٨ | |

$$B(r,t) = z \times E(r,t) \tag{2}$$

where k is the wave number,

 $\omega = ck \tag{3}$

The circularly polarized antennas can be obtained by different types of configuration and feeding such as dual feeding, single feeding and thin slot on the patch [1].

In this paper, novel type of microstrip patch antenna with thin slot on ground plane technique is used to obtain the circular polarization.

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Figure 1. Various types of circularly polarized microstrip patch antennas: (a) triangular patch, (b) square patch, (c) circular patch, (d) ring, (e) pentagonal patch, and (f) elliptical patch



Figure 2. Circular Polarization Vectors

2. Antenna Design

A triangular patch antenna with thin slot on ground plane has been designed in single layer of Alumina dielectric material with dielectric constant, $\varepsilon r = 9.6$. Table 1 shows the antenna specifications.

| Operating Frequency, f | 55GHz |
|---------------------------------|---------|
| Dielectric material | Alumina |
| Dielectric thickness, h | 25 mm |
| Dielectric constant, <i>ɛ</i> r | 9.6 |

Table 1. Antenna Specifications

Figure 3 shows the triangular patch antenna with rectangular slot along with single microstrip line feeding method.



Figure 3. Triangular Patch Antenna with Slot

A Special program Advance Design system (ADS) has been used to analyze and simulate the antenna parameters. The antenna parameters are S11 Return Loss = (-25) dB at operating frequency f = 55 GHz with Bandwidth = 16 GHz for return loss less than (-10) dB as showing in Figure 4. Moreover, the *antenna Gain* = 10.09 dB and *Directivity* = 10.09 dB. Finally, The antenna polarization is circular polarization as showing in Figure 5.



Figure 5. 3D Antenna Radiation Pattern

3.2x1ANTENNAARRAY

This design is used as an element to generate a 2x1 array in order to improve the antenna efficiency, directivity and gain for the radiating system. The 2x1 triangular patch antenna array is shown in the Figure 6.

S11 response of the antenna and radiation pattern are showing in Figures 7 and 8 respectively.



Figure 7. S11 Response of 2x1 Antenna Array



Figure 8. 3D Antenna Radiation Pattern of 2x1 Antenna Array

4.4 x1 Antenna Array

Further design is used as an element to generate a 4x1 array in order to improve the antenna efficiency, directivity and gain for the radiating system. The 4x1 triangular patch antenna with series feed array is shown in the Figure 9.

S11 response of the antenna and radiation pattern are shown in Figures 10 and 11 respectively.



Figure 94x1 Antenna Array



Figure 11. 3D Antenna Radiation Pattern of 4x1 Antenna Array

5.8x1ANTENNAARRAY

Upper level of antenna array is designed by using 8x1 array in order to continue the improvement in the antenna efficiency, directivity and gain for the radiating system. The 8x1 triangular patch antenna with series feed array is shown in the Figure 12.

S11 response of the antenna and radiation pattern are shown in Figures 13 and 14 respectively.



Figure 12. 8x1 Antenna Array



Figure 13. S11 Response of 8x1 Antenna Array



Figure 14. 3D Antenna Radiation Pattern of 8x1 Antenna Array

6.16x1 Antenna Array

Upper level of antenna array is designed by using 16x1 array in order to continue the improvement in the antenna efficiency, directivity and gain for the radiating system. The 16x1 triangular patch antenna with series feed array is shown in the Figure 15.

S11 response of the antenna and radiation pattern are shown in Figures 16 and 17 respectively.



Figure 15 16x1 Antenna Array



Figure 16. S11 Response of 16x1 Antenna Array



Figure 17. 3D Antenna Radiation Pattern of 16x1 Antenna Array

| | | Gain Obtained | Directivity Obtained BW | (S11 < -10 dB)(dB) | Return Loss | Remark |
|-------------------|-------------------------|------------------|----------------------------|-----------------------|-------------|-----------------|
| Single Element | Triangluar with slot | 10.086dB | 10.088dB | 16GHz | -25 | Multi Bandwidth |
| 2 Array | Triangluar with slot | 10.82dB | 10.824dB | 14GHz | -45 | Dual Bandwidth |
| 4 Array | Triangluar with slot | 10.02dB | 10.027dB | 14GHz | -40 | Dual Bandwidth |
| 8 Array | Triangluar with slot | 15.76dB | 15.77dB | 3GHz | -35 | Dual Bandwidth |
| 16 Array | Triangluar with slot | 13.27dB | 13.32dB | 15GHz | -38 | Dual Bandwidth |

Table 2. Comparison Results Summary

7. Simulation Results Discussion

From comparison results summary Table 2, Circular polarization has been obtained from Triangular patch Antenna with thin slot as illustrated in summary table which shown antenna parameters by using the antenna arrays in series arrangement and increasing the number of the antenna arrays up to 16x1 array. We obtain circular polarization with very wide bandwidth around 15 GHz and there is some improvement observed in the return loss. However, the antenna gain and directivity are mostly same with little bit improvement as indicated in above table for the same.

Furthermore, we got dual and multi bandwidths which can be utilize in several frequency bands applications.

The major applications for such extremely high frequency range for this kind of antenna are Astronomy and Remote Sensing applications.

8. Conclusion

In this paper, a triangular microstrip antenna element and its integration into 2x1, 4x1 and 8x1 and 16x1 planar arrays are introduced. This array can be used in Astronomy and Remote Sensing applications. The proposed element consists of only one single dielectric material with two metal layers, which makes it cheaper than other elements of more layers usually used for this application.

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