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Design and Implemantation of 4 Elements Circular Patch Antenna with High Gain for 3.0 GHz Applications

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ABSTRACT

Microstrip patch antenna is a low profile antenna that is capable of maintaining high performance over a wide spectrum of frequencies. In this paper the practical and experimental results obtained from the design, construction and test of an array circularmicrostrip patch antenna were discussed. The aim was to obtain a gain of 12dB, an acceptable pattern and a reasonable reflection coefficient cavity model was applied to analyze the patch and proper combination of the formulae; ADS2000 and MATLAB 2013 softwares were used. The array includes four circular elements made of aluminum with equal sizes, equal spacing and was grown on a resin substrate, with insect feed techniques. Comparison between practical results and the results obtained from the simulation shows that we reach our goals by a great degree of validity.

***Keywords**: Microstrip patch antenna, inset feed, antenna gain, reflection coefficient, low profile*

INTRODUCTION

The demand for mobile communication services are growing at an explosive rate, with anticipation that communication to a mobile device anywhere on the globe at all times will be available in the near future. An array of antenna may be used in a variety of ways to improve the performance of communication systems. A very popular type of antenna arrays is the circular microstrip patch antenna which has several advantages over other schemes such as low cost, minimal weight and low profile [1-5].

Patch antenna play a very significant role in today's world of wireless communication systems. A patch antenna is very simple in the construction using a conventional microstrip fabrication technique. The patch can take any shape but rectangular and circular configurations are the most commonly used configurations. The development of the microstrip patch antenna has been expanded into three major program areas; mobile satellite (MSAT) communication, earth remote sensing and deep-space exploration. Patch antennas are popular, because they have a very low profile mechanically rugged and can be conformable; they are often mounted on the exterior of aircraft and spacecraft, or are incorporated into a mobile radio communications devices. Microstrip antenna is also inexpensive to manufacture and design because of the simple physical geometry [6-10].

MATERIALS AND METHOD

In this paper, an antenna array consisting of four equal circular elements with equal spacing, has been examined.

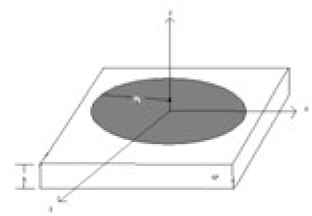

Figure 1: Geometry of circular patch antenna

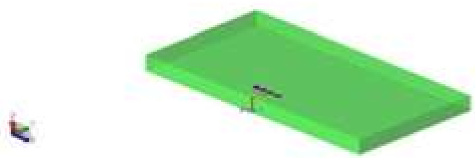

Figure 2: Geometry of the array of circular microstrip patch elements

In Figure 2, the way of arranging cicular patches and feeding is shown the antenna is fed from its center they have the same phase in their entries considering the shapes of feed lines for each of the circular patches.

THEORY

In Figure 1, the radius (a) of the circular patch is 2 cm. the height of the substrate (h) is 0.2mm. The dielectric constant (ϵr) is 4.5.
From [1] the first order approximation of the physical radius of the circular patches elements.

$$a = \frac{F}{\sqrt{\{1 + \frac{2h}{\pi \epsilon_r F}[\ln(\frac{\pi F}{2h}) + 1.7726]\}}}$$

Where $$F = \frac{8.791 \times 10^9}{f_r \sqrt{\epsilon_r}}$$

Thus the effective area of the circular patch element is given by [2]

$$A_{eff} = \pi a^2 \{1 + \frac{2h}{\pi \epsilon_r F}[\ln(\frac{\pi F}{2h}) + 1.7726]\}$$

Where f_r is the resonant frequency in (Hz).
The radiated field of the E-plane for a single element circular patch can be expressed by (Alade&Olabisi)

$$E = -jV_0 \frac{ak_0 e^{-jk_0 r}}{2r} \cos\phi J_1'(k_0 a \sin\theta)$$

The resonant frequency of a circular patch can be computed as

$$f_0 = \frac{cJ_{mn}}{2\pi r_{eff}\sqrt{\varepsilon_r}}$$

Where f_o = resonant frequency
J_{mn} =mth zero of the Bessel function or order n

RESULT AND DISCUSSION

The aim of this work is to develop an antenna with a directional pattern and a gain at least equal to with a directional pattern and a gain at least equal to 12 dB. An antenna array with equal spacing and uniform excitation was designed. The cicularmicrostrip antenna was stimulated by ADS2000 that is based on the method of moment; to obtain pattern for the antenna array.

In this paper, it is considered that the substrate permittivity of the antenna is ϵr= 4.5. (resin) height is 0.2mm and the resonance frequency of 3 GHz.

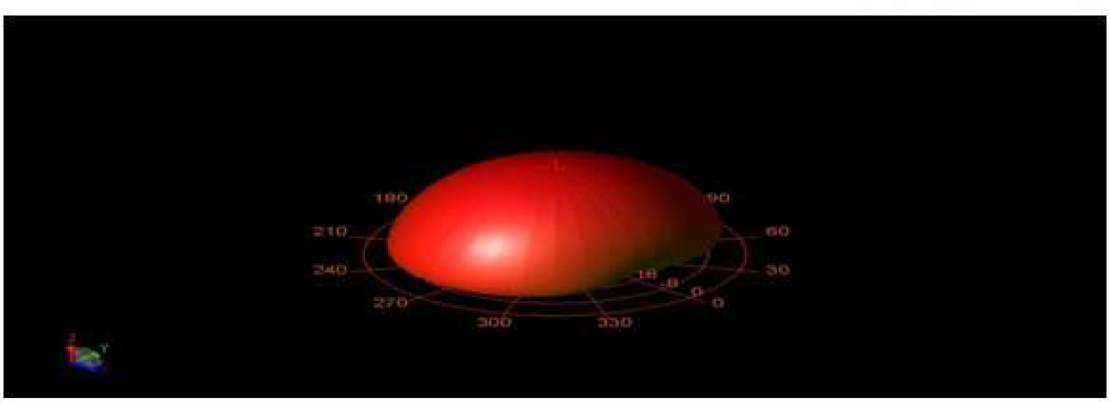

Figure 3: 3-D Radiation Pattern 4x1 Antenna Array

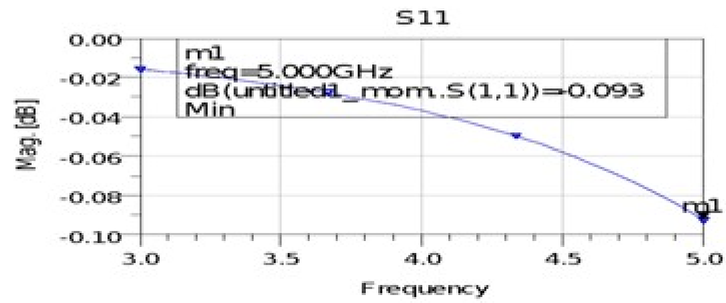

Figure 4: The input reflection coefficient of the circular patch microstrip array antenna

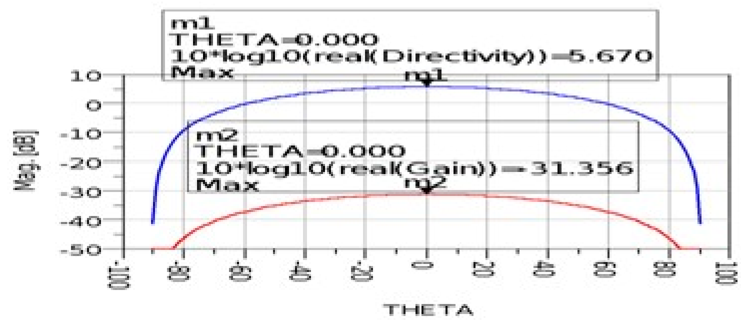

Figure 5: the Gain

The reflection coefficient is not really perfect but it could be used and the gain is negative but radiated power is perfect which gives it advantage over the gain .the antenna was simulated on ADS2000 and frequency range of 5 GHz.

The array was constructed as shown in Figure the dimension and structural diagram of the antenna are shown in this figure too. The fabricated patch was designed to operate at 3 GHz. The patch is probe feeding and the ground plane is finite for this patch and has dimensions of 15 by 4cm. by selecting proper values of microstrip line width the length and the position of the feed point, a good impedance matching can be obtained. An inset feed scheme is employed to match the patch antenna to a 50 Ω coaxial probe feed. The dielectric material has a permittivity of 4.5 and a thickness of 0.2mm. The substrate of the antenna is made of resin.

Figure 6: Front view of 4 elements microstrip patch antenna

Figure 7: Back view of 4 elements microstrip patch antenna

In the practical test carried out by GSP730 spectrum analyser, the value of VSWR in central frequency was 1.5433 that was well in agreement with the theoretical analysis (figure) variation in the measured performance is mainly due to imprecise fabrication by a milling machine. The spectrum analyser should be calibrated for a suitable frequency range containing the band where the antenna will operate. (Figures)

Conclusion

A small microstrip patch antenna has been presented. The antenna has been designed to be used in WLAN, WIMAX, applications in the c-band. In fact this antenna was designed for 3GHz and 12dB gain. The antenna has good pattern and proper VSWR at 3GHz. The design has been accomplished using commercially available ADS 2000, MATLAB 2013 softwares. The design antenna has shown good performance in terms of return losses and radiation (a prototype has been fabricated and tested) good agreement has been obtained between simulation and experimental results, providing validation of the design procedure. Good performance has been obtained for the envisaged applications

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