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DESIGN OF MICROSTRIP PATCH ANTENNA AND A CONFIGURATION TO IMPROVE GAIN

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ABSTRACT

Microstrip antennas are a rapidly growing area of research. The applications of microstrip antennas are limitless, because of their compact size, ease of manufacturing and light weight. A variety of approaches have been taken, including modification of experimentation with substrate parameters, the patch shape, Most notably mobile communication systems where many frequency ranges could be accommodated by a single antenna. This paper deals with the design of microstrip patch antenna and the configuration to improve the gain so that the distance for communication can be enhanced. The proposed configuration involves the Broadside patch antenna of six elements built in an array to improve the gain whereas the existing method involved four radiating elements designed in E-Shaped. The gain of Microstrip Antennas can be increased by building a broadside array. By exciting a number of microstrip antenna elements to make them radiate in the same phase at the broadside direction, the broadside gain will increase with the number of elements. In this paper a microstrip patch antenna is designed and the parameters analyzed are s-parameter and gain.

Keywords: microstrip, broadside, array.

1. INTRODUCTION

In high performance satellite, aircraft spacecraft and also in missile applications where the performance, size, cost, ease of installation and aerodynamic profiles are constraints, so that the low profile antennas are required. There are many government and commercial applications like mobile and wireless communications have similar specifications. Microstrip antennas are used because of the advantages it possess to meet these requirements. Microstrip antennas are inexpensive and it can be integrated with the Printed Circuit Boards [9]. They are mechanically robust when mounted on rigid surfaces. When particular patch shapes are selected then they are unique in terms of resonant frequency, pattern impedance and polarization. The gain of microstrip antennas can be increased by building a broadside antenna array. By exciting a number of microstrip antenna elements to make them radiate in the same phase at the broadside direction [1]. The efficiency can be improved by increasing the height of the substrate.

2. MICROSTRIP ANTENNA AND ITS CHARACTERISTICS

The microstrip antennas are also called patch antennas. These are narrow band and wide beam antennas [5]. It consists of a patch which is very thin and is placed above a ground plane. The patch is very thin ($t << \lambda o$ where λo is the free space wavelength).The microstrip antenna is designed so its pattern maximum is normal to the patch (broadside radiator). For a rectangular patch the length L is usually $\lambda o/3 < L < \lambda o/2$. The strip and the ground plane are separated by a dielectric sheet [3] as shown in the Figure-1.

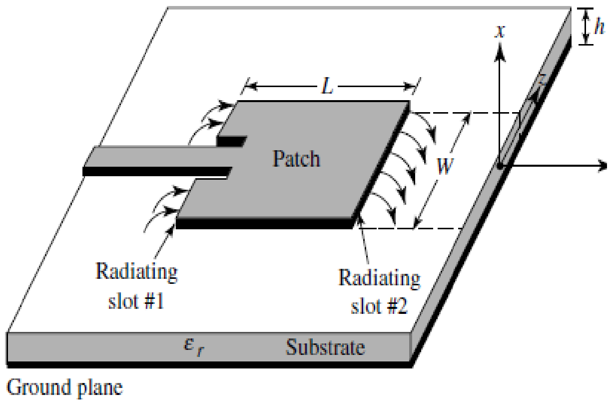

Figure-1. Microstrip Patch Antennas.

There are many types of substrates that can be used for the design of microstrip antennas and their dielectric constants are in the range of $2.2 \le \varepsilon r \le 12$.The thick substrates are usually preferred whose dielectric constant is in the lower end of the range because they provide better efficiency, larger bandwidth, loosely bounded fields for radiation but at the expense of larger element size. The height of the substrate should be in the range $h << \lambda o$, usually $0.003\ \lambda o \le h \le 0.05\ \lambda o$. The radiating elements and feed lines are usually photoetched on the dielectric substrate [5].

3. DESIGN PROCEDURE

The rectangular patch is the most widely used configuration. It is easy to analyze using both the transmission line and cavity models, which are more accurate for thin substrates. The transmission line model is simpler than the cavity model. The cavity model is the most accurate method but it is difficult to model coupling. Basically the transmission line model represents the microstrip antenna by two slots separated by a low impedance Z_c transmission line of length L. The dimensions of the patch are finite along the length and width; the fields at the edges of the patch undergo fringing. The fringing must be taken into account because it influences the resonant frequency of the antennas. As L/h>>1 and ϵ_r>>1, the electric field lines concentrate mostly in the substrate.

When fringing occurs the microstrip line look wider electrically compared to its physical dimensions. Since few waves travel in the substrate and few in the air, an effective dielectric constant ϵ_{reff} is introduced to account for fringing and the wave propagation in the line.

At the intermediate frequencies its values begin to monotonically increase and eventually approach the values of the dielectric constant of the substrate. The initial values of the effective dielectric constant which is a function of dielectric constant(ϵ_r) , substrate height (h) and patch width (W) and are given by the equation (1).
W/h>1;

$$\epsilon_{reff}= \frac{\epsilon_r+1}{2} + \frac{\epsilon_r-1}{2}\left[1+12\frac{h}{w}\right]^{-1/2} \quad (1)$$

The fringing effect makes the patch of the microstrip antenna looks greater than its physical dimensions. The dimension of the patch along its length has been extracted on each end by a distance ΔL. The effective length is a function of the effective dielectric constant and the width to height ratio (W/h) and is given by the equation (2).

$$\Delta L = h\,(0.412)\,\frac{(\epsilon_{reff}+0.3)(\frac{w}{h}+0.264)}{(\epsilon_{reff}-0.258)(\frac{w}{h}+0.8)} \quad (2)$$

Since the length of the patch has been extended by ΔL on each side, the Effective length of the patch is now

$$L_{eff}=L+2\Delta L \quad (3)$$

For an efficient radiator, a practical width that leads to good radiation efficiency is given by the equation (4)

$$W = \frac{v_o}{2f_r}\sqrt{\frac{2}{\epsilon_r+1}} \quad (4)$$

The actual length of the patch can now be determined by using the equation (5)

$$L = \frac{1}{2f_r\sqrt{\epsilon_{reff}}\sqrt{\mu_o\epsilon_o}} \quad (5)$$

where f_r is the operating frequency.

It is essential to have a finite ground plane. The size of the ground plane is greater than the patch dimensions by six times the substrate thickness all around the periphery. Hence, the ground plane dimensions are obtained from the equation (6)

$$L_g = 6h + L$$
$$W_g = 6h + W \quad (6)$$

where L_g is the length of the substrate and W_g is the width of the substrate.

4. PROPOSED CONFIGURATION OF PATCH ANTENNA ARRAY

The proposed method is to build a Broadside patch antenna of six elements built in an array to improve the directional properties whereas the existing method thin and compact four element broadside patch antenna array involves four radiating elements designed in E-shape. The gain of Microstrip Antennas can be increased by building a broadside array. By exciting a number of microstrip antenna elements to make them radiate in the same phase at the broadside direction. The gain of the broadside array will increase with the number of elements. The number of elements in the proposed system is increased in order to increase the gain. The Figure-2 represents the configuration of microstrip antenna with six elements where RE represents Radiating Elements. The proposed method can be implemented for Wi-Fi, WiLAN, WiMAX etc., communication depending upon its operating frequencies. In this method all the six patches will be arranged on a single substrate so that it remains a single layer structure. The parameters like Directivity, Radiation pattern, Half Power Beam Width and Return Loss will be analyzed.

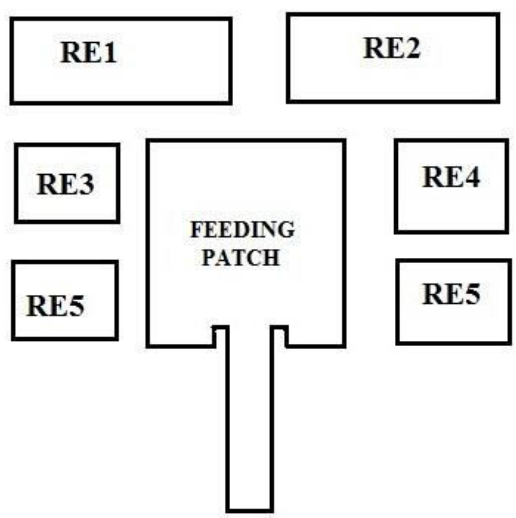

Figure-2. Configuration of six element broadside patch antenna array.

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The main difference of the proposed array and the ESPAR (Electrically Steerable Passive Array Radiator) [1] is the design objective. The ESPAR is designed for beam steering, while the proposed design is a broadband array that aims to increase the gain at the broadside direction compared to the case where only a single element is used. The patch ESPAR should apply reactive loadings that can complicate the overall structure, and sometimes even multilayer structure was applied. However, since the proposed array does not need reactive loadings, the resultant design has a simple single layer structure [2]. It does not require more than one layer, as in the case of the coax-fed stacked patches and the aperture-coupled stacked patches.

5. DESIGN OF MICROSTRIP PATCH ANTENNA

The microstrip patch and the feeding patch are designed using CADFEKO. The union of patch and the feeding patch are built on the same substrate. The dielectric substrate used is FR4 matrerial. The port involved is a wire port. The length and width of the patch are 36.99mm and 25.57mm. The feeding patch from the centre patch is of 25.22mm length and 3.80mm width. The substrate height chosen is 1.57mm and the ground plane dimension is 72.1 x 146.9 mm^2. The sampled frequency points of the lower and the higher operation bands in this process are chosen as XL=3.7GHz and XH=5.25GHz, respectively. Frequency bands around 3.5 and 5–6 GHz are popular in wireless communication standards such as WLAN and WiMAX. The WLAN standard 802.11 operates on 3.65–3.70 GHz. Many other WLAN standards are operating at different frequencies around 5–6 GHz. Also, many WiMAX systems operate at around 3.5 GHz.

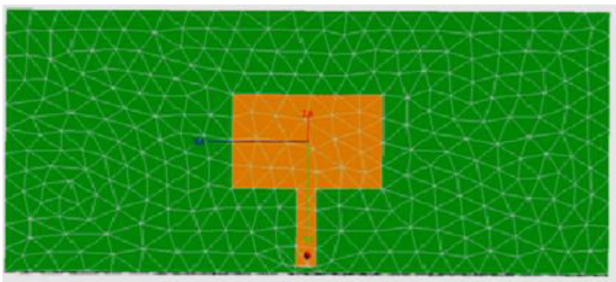

Figure-3. Design of Microstrip antenna using CADFEKO.

6. RESULT AND DISCUSSIONS

The resonant frequency of a Microstrip antenna can be calculated by using the parameters like width (W), length (L), permittivity of the substrate (εr) and height (h) of the substrate. The resonance of the antenna occurred at two different frequencies approximately 4.35 GHz and 4.85GHz. At these frequencies the antenna becomes purely resistive. S11 represents the power that is reflected from the antenna, and hence it is known as the reflection coefficient. If S11=0 dB, then all the power is reflected from the antenna and nothing is radiated. If S11=-10 dB, this implies that 3 dB of power is delivered to the antenna.

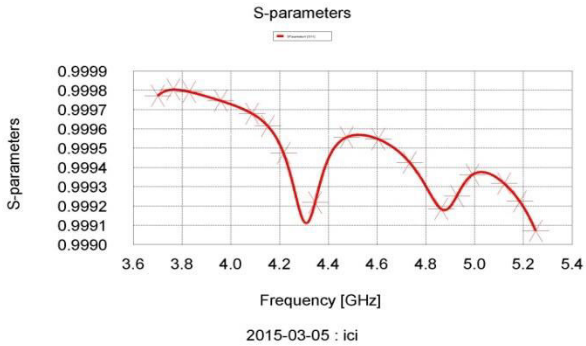

Figure-4. S-Parameter graph.

Antenna gain is usually defined as the ratio of the power produced by the antenna from a far-field source on the antenna beam axis to the power produced by a hypothetical lossless isotropic antenna, which is sensitive to signals from all directions. When more number of patches are introduced the resonance of the antenna will be improved. The gain of the designed microstrip patch antenna obtained is 4.5dB. When the number of radiating elements are increased then the gain will also increase. The three dimensional view of gain is shown in the Figure-5.

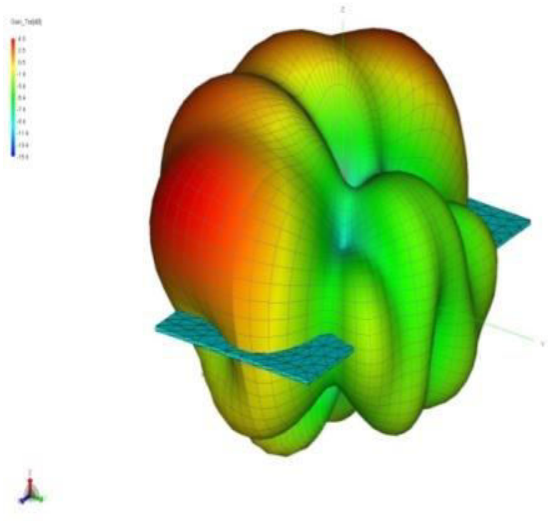

Figure-5. Gain 3D view.

7. CONCLUSION

The design procedures were followed and the microstrip patch antenna has been designed. The parameters like gain and S-Parameter are analyzed. The resultant antenna has not involved a complex feed [2]. The gain is increased when the dimensions of the patch and ground plane are reduced. The work can be further extended by building the proposed six element broadside patch antenna array and the parameters like Directivity, Radiation pattern, Half Power Beam Width and Return

Loss of the six element Patch antenna will be analyzed and compared with the existing four element array.

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