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Circular Patch Microstrip Antenna Array for Ku Band Satellite Communications

Siddhartha Pal[1,] Kousik Roy[1], Atanu Nag[2], Adarsh Kumar Tiwary[1]

Department of Electronics and Communication Engineering, Asansol Engineering College, Asansol, West Bengal, India[1]

Modern Institute of Engineering and Technology, Hooghly, West Bengal, India[2]

ABSTRACT: The paper represents a circular patch microstrip antenna functioning in a single band of frequency 10GHz. Moreover it shows the steps in details of designing the circular patch microstrip antenna along with its simulated product. From the outcomes, technique of the fabricated mobile antenna is established to have a good performance**.** The recommended Circular patch microstrip array antenna is essentially a phased array comprising of 'n' elements (circular patch antennas) placed in a rectangular grid. The dimension of every element is decided by the operating frequency. The incident wave from satellite reaches at the plane of the antenna with identical phase across the surface of the array. Each and every 'n' element achieves a little amount of power in phase with the others. Feed networks link every element to the microstrip lines with an identical length. Therefore the signals arriving at the circular patches are all joined in phase and the voltages combine together.

KEYWORDS: Microstrip Patch Antenna, Circular Patch, IE3D, VSWR, Return Loss.

I. INTRODUCTION

Satellite communication is unaffected to a large extent by the communication distance or configuration of the ground. Moreover satellite communication, which is contrasted to terrestrial communication, possess an easiness of line facility, effectiveness of long distance telecommunication, and resistance to different disasters. Due to this cause, satellite communications have increased considerably during modern times. Satellite communications can be categorized in accordance with the communication link (unidirectional and bidirectional communication) and mobility (fixed and mobile communication). In recent wireless communication technique and growing wireless applications, broader band-width, is needed. Usually every antenna operates at a single frequency band, where a different antenna is required for various applications. This will initiate a limited gap and place difficulty.

So as to overcome this trouble, multiband antennas can be utilized where a single antenna can operate at numerous frequency bands. One method to build a multiband antenna is by applying fractal form into antenna geometries. In comparison to the rectangular patch, circular patch is more beneficial because of the following reasons :(i) a rectangular patch has two degrees of freedom (length and width), while a circular patch has only a single degree of freedom (radius), because of which it is simpler to manage the radiation attributes , (ii) in case of identical frequency, a circular patch takes up smaller area in comparison to a rectangular patch. The Patch Antenna is usually made up of conducting materials like copper or gold and the patch can be of any probable shape. Both the radiating patch and feed lines are photo etched on the dielectric substrate. Owing to the finite measurements of the patch, fields at the edges of the patch experience fringing. The patch could be fed by different techniques like Microstrip line Feed, Coaxial Cable, Aperture Coupling and Proximity Coupling. Microstrip Line feed is easy to manufacture and match, but posses additional spurious radiations.

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II. ANTENNA CONFIGURATION

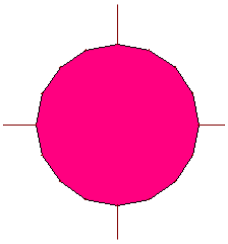

Fig. 1 (a) Geometry of circular patch

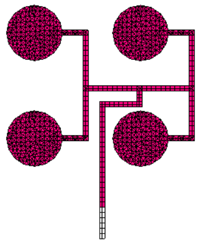

Fig. 1 (b) Circular Patch Antenna Array

The antenna geometry illustrated in Fig.1 (a) has just one patch, which is simpler than conventional broad-band microstrip antennas. Antenna is devised by way of line feed to resonate at frequency of 3.5 GHz. The patch is mounted on a glass substrate with relative permittivity, ε_r as 2.2 mm, radius of patch as 5.25 mm and height of patch as 0.1588 mm. The antenna portrayed above in Fig.1 (b) includes the sub - array designing of Microstrip Patch antenna where the same four elements are built to construct a 4x1 sub array. The feeding strip is linked with an additional strip that goes through a layer of air linking to a 50 Ohm microstrip feed line on a ground substrate

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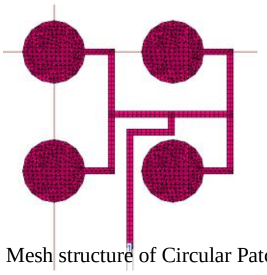

Fig. 1(c) Mesh structure of Circular Patch

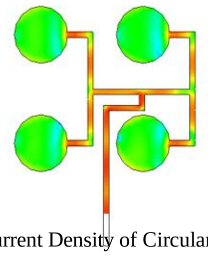

Fig.1(d) Current Density of Circular Patch

Fig. 1 (c) portrays the circular shaped antenna at 10 GHz frequency with 30 cells for each wavelength which looks like a meshed structure. Essentially it is done so as to develop the bandwidth and diminish the cross polarization of the antenna measurements of gain, The figure denoted in Fig.1 (d) demonstrates the current distribution behavior of circular -Shape patch at 10 GHz excitation. The important alteration in radiation pattern of arrays can be attained by altering current distribution array of the antenna, including phase delay among elements, variation in the radiation features of each and every radiating structure in an array, alteration in the geometry of the array and by varying the inter-element spacing.

III. DESIGN SPECIFICATIONS

On the basis of the cavity model formulation, a design method is drawn which leads to realistic designs of microstrip antennas. The method presumes that the specific information incorporates the dielectric constant of the substrate (ε_r), the resonant frequency (f_r) and the height of the substrate h. The method is worked out from the following steps [2]

[a] Step: - 1

Specification of dielectric constant (ε_r), resonant frequency f_r in (Hz), and height of substrate h in (cm)

Step:- 2

Calculation of actual dimension (a) of patch

Step:-3

Determination of the patch:

The patch is formularized by the following equations

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$$a = \frac{F}{\left[1+\frac{2h}{\pi\varepsilon_r F}\left\{\ln\left(\frac{\pi F}{2h}\right)+1.7726\right\}\right]^{\frac{1}{2}}} \quad \ldots. \quad [1]$$

Where $F = \frac{8.791\times10^9}{f_r\sqrt{\varepsilon_r}}$ $\quad a_e = a\left[1+\frac{2h}{\pi a\varepsilon_r}\left\{\ln\left(\frac{\pi a}{2h}\right)+1.7726\right\}\right]^{\frac{1}{2}}$

-------- [2]

Where, a_e = effective dimension of the patch, f_r= resonant frequency of the antenna, a = dimension of the patch, h = height of the substrate, ε_r = dielectric constant of the substrate.

[b] We have the design parameters ε_r = 2.2, h=1.58mm, f_r= 10 GHz. Putting these parameters in the design equations we get F= 0.593,a=5.25mm.

IV. PERFORMANCE EVALUATION

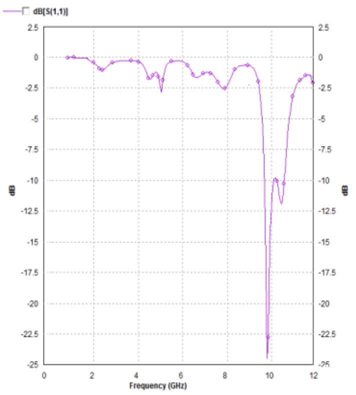

Fig. 2 (a) Return Loss Curve of Circular Patch

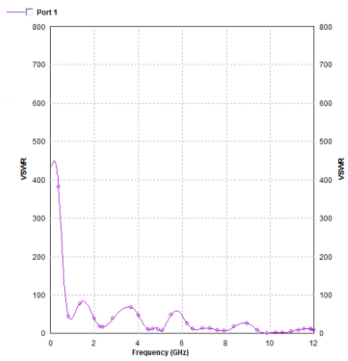

Fig. 2(b) VSWR of circular patch

The graph in Fig. 2 (a) demonstrates the Return loss attained at 10 GHz frequency which is approximately.73 dB. Return loss is associated to standing wave ratio (SWR) as well as reflection coefficient (Γ). It is a determination of how fine devices or lines are matched. The above graph in Fig. 2 (b) portrays the VSWR (Voltage Standing Wave Ratio) of the antenna attained at 10 GHz about 1.2. VSWR is an assessment of the quantity of power which is conveyed to an antenna. The VSWR is as well as a determination of how nearly the source as well as load impedance are matched.

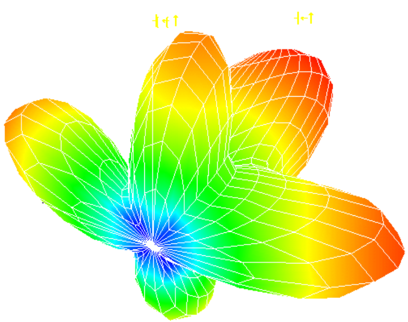

Fig. 2 (c) Gain Pattern of Circular Patch

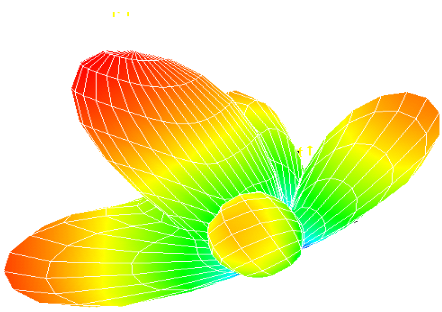

Fig. 2 (b) Directivity Pattern of Circular Patch

The above Fig. 2 (c) demonstrates the 3D pattern of gain in dB scale for the antenna. Gain as a parameter determines the directionality of a specified antenna. An antenna having a low gain emits radiation in each and every direction uniformly, while a high-gain antenna will preferentially emit in specific directions. The diagram above in Fig. 2 (d) signifies the 3- D directive pattern of the antenna. Antenna directivity is described as the ratio of maximum radiation intensity (power per unit surface) radiated by the antenna in the maximum direction divided by the intensity radiated by an hypothetical isotropic radiating identical full power as that of an antenna.

V. DISCUSSION

The patch antennas perform a very important task in the area of wireless, mobile and satellite communications. Owing to their little size, compact and light weight attributes, patch antennas are of immense demand, particularly at microwave and millimeter wave frequencies. The gain and directivity of these antennas have been developed by building an array of 4 elements, as the number of elements enhances gain. There is a growing demand for the utilization of microstrip antennas in wireless communication because of their low back radiation, easiness of compliance in comparison to wire antennas. From the outcomes of simulation, we can observe that the gain possibly can be developed by enhancing the number of elements. The technique portrayed here is easy, and so as to acquire higher gain values, it can be employed along with other confirmed methods too. The design has been achieved by utilizing practicably available IE3D software. The devised antenna has revealed good performance in accordance with return losses and radiation.

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