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Design of High Gain Circularly Polarized Microstrip Patch Antenna Array for Small SatelliteApplications

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Abstract—Microstrip patch antenna is the most widely used antenna over a wide range of applications. This antenna is popular due to low price and easy fabrication . Due to this microstrip patch antenna is used in small satellite applications like cubesat. Many research studies have been performed for combining high gain antenna arrays and minimizing thicknessof the layers. In this paper the design of microstrip dual fed antenna array which includes truncated patches for wide CPrange is presented These microstrip patch antenna array works in C band . The frequency range is taken from 4 GHz to 8GHz since C band is selected for earth exploration satellite and space research. Here the fractional bandwidth obtained is 6.4% witha gain of 13dB and isolation of 21dB .The CP ranges between 5.4Ghz to 6.4Ghz. This design is one of the most excellent and satisfying solutions for the Small satellite applications.

I. INTRODUCTION

The CubeSat is an important member of the small satellite family. Satellites of this type strike the ideal mix between price, lifespan, and payload options. When a Surface Aperture Radars (SAR) payload is installed on one of these spacecraft, Earth monitoring becomes one of their primary functions. The antenna systems on these small satellites are among the most difficult to solve because of their compact size and high antenna performance. Shorting pins can be used to alter the resonance of a cubesat's antenna to match the required UHF band. parasitic elements can be used to increase overall benefit. When a tiny surface area is available for the coupling of antenna cells and solar cells, a microstrip antenna and commercial solar cells can be integrated. "Wideband patch antennas for nano satellites are being developed using an aperture coupled stripline fed wideband patch antenna. From
[1] through [6], because of their benefits over LP antennas, CP antennas have been widely utilised in numerous wireless communication systems. Broadband CP antennas are a popularresearch topic because of their potential to minimise the overall system cost and complexity. The design of CP antennas has been the subject of numerous studies. Design of a small slotted microstrip patch antenna in the shape of a cross. The CP radiation's performance can also be evaluated by adjusting the cross-shaped slot's size and angle change. Changing the dimen- sions .Ground plane CP radiation is obtained throughthe etching fractal defective ground structure (FDGS). [7]-
[13] Antennas that can operate across many bands benefit from bandwidth enhancement techniques. Metamaterials and a complementary split ring resonator between the ground and thepatch are used to increase the bandwidth by 800MHZ. Enhanc-ing performance in terms of impedance matching bandwidth and broadside gain by the introduction of four mushroomstructures A bandwidth increase of 98.3% can be achievedby etching numerous slots on the patch. [14]-[18] An antenna with a truncated patch is discussed in this study in order to acquire a wide range of coverage. An isolation of 21dB and a 13dB boost in fractional bandwidth yields 6.4 percent. The CP ranges from 5.4Ghz to 6.4Ghz in frequency.

II. ANTENNA GEOMETRY

It's a microstrip dual feed array with a one-layer substrate. The substrate material used is R04003 substrate with a di- electric constant of 3.3. Patch truncation produces circular polarization. Corners on the periphery of RMSA are shortened, which degrades TM10 mode into two or- thogonal modes that achieve CP. The diagonally opposing corners are chopped. In both modes, the diagonal currents change. Placing obtects between the patches allows for isolation between the ports. Tx/Rx antenna coupling is a common, well-researched issue made more challenging by the fact that the antennas must be close together and on the same plane. Even if new systems have smaller footprints, maintaining the same degree of isola- tion is still necessary. Large and heavy machined pieces have traditionally been used to solve the problem of coupling. Thereare two ports on the antenna. Objects are placed between the patches to increase isolation between the two ports, which is necessary to prevent mutual

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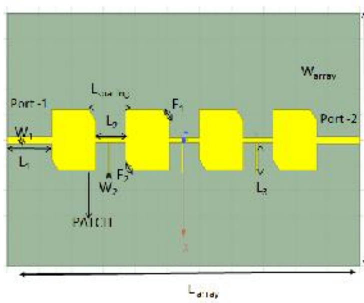
coupling.



PARAMETER	VALUE(mm)
L_{array}	95
W_{array}	80
$l_{spacing}$	15.4
F_1	1.6mm
F_2	1.6mm
L_1 L_2 L_3	14mm 9.5mm 6mm
W_1 W_2	1.5mm 0.5mm

Fig. 1. Microstrip dual feed antenna array

III. ANALYSIS

A. Characterstic Mode Analysis

Antenna character mode analysis is used to examine this an-tenna. A comprehensive set of orthogonal modes CM extends any induced currents stimulated by a specified external source. The total induced current on a perfect electric conductor can be stated as follows [10]:

a) : A conventional antenna is used to measure gain. Isotropic antenna and resonant half-wave dipole antenna are the most commonly used reference antennas". The radiation from an isotropic antenna is uniformly distributed. The dif- ference between the energy emitted by an antenna and the energy emitted by an isotropic antenna in the same direction is known as the gain of the antenna in that direction. Analyzing the antenna's directivity and overall efficiency helps determine its peak realised gain. In this case, the maximum gain is 13dB.

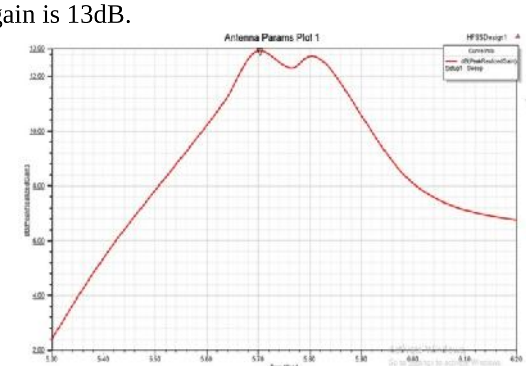


Fig. 2. Peak realized gain of C Band antenna array

Fig. 3. Axial ratio of C Band antenna array

$$\mathbf{J}_{total} = \sum_{n=1}^{N} \alpha_n \mathbf{J}_n \qquad (1)$$

where jnˆ corresponds to the characteristic current of the mode n. anˆ the complex modal expansion coefficient for mode n, which can determine the weighting of the total current. This is the normalised amplitude of the characteristic current, which is MSn. MSn is a crucial parameter in the construction of the CP antenna, since it determines the amplitude of the characteristic current. An further crucial component is the characteristic angle (CAn), which is the phase angle between a characteristic current and its corresponding characteristic field. According to CAn's

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definition :

$$CA_n = 180^\circ - \tan^{-1}(\lambda_n) \qquad (2)$$

The simultaneous excitation of two orthogonal characteristic modes with a 90-degree phase difference is required to produce a single band CP radiation. In accordance with the CMA, the following are the requirements for each mode: First, the distributions of these two modal currents should be orthogonal to one another. 2. The MS values of these two modes should be close to one another: MS1 = MS2. There should be a 90° phase delay between the CAs of these two modes, so that CA1 = CA2 90°. At the radiation angle, both modes should have the same directivities.

IV. Result and Discussion

The microstrip dual feed antenna array design for C band is implemented and the following results are obtained.

b) : For circularly polarised fields, an axial ratio of 0dB is optimum. Antennas with circular polarisation are frequently referred to by their axial ratio. It's safe to assume that the angu-lar range across which the deviation in circular polarisation is less than 3 dB is greater than the axial ratio achieved when it's less than 3dB from the main beam. The antenna is circularly polarised between 5.4 and 6.4 GHz, resulting in an axial ratio of less than 3dB.

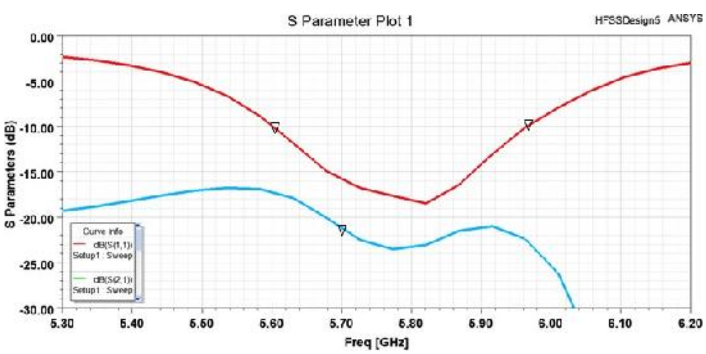

Fig. 4. S paramter plot

c) : Bandwidth of an antenna refers to range of frequen- cies over which the antenna can operate correctly.Fractional bandwidth measures how wideband the antenna is.The frac- tional bandwidth ranges between 0 and 2, and is often quoted as a percentage (between 0% and 200%). The higher the percentage, the wider the bandwidth.Here fractional bandwidthis 6.3% with an isolation of 21dB.

V. Conclusion

Design complexity was decreased by using a microstrip dualfeed antenna array. With a fractional bandwidth of 6.4% and a cp range of 5.4 GHz to 6.4 GHz, the gain achieved was13 dB. For tiny satellite applications, this is one of the best options.

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