Design and Simulation of Dual Frequency Circularly Polarized Shared Aperture Antenna Array

E. Samuel John Antony*
Department of ECE,
University College of Engineering Pattukkottai,
Thanjavur, Tamil Nadu, India.

A. Thenmozhi
Department of ECE,
Thiagarajar College of Engineering,
Madurai, tamil Nadu, India.

***Abstract*—This paper discusses the 2×2 array of Aperture Coupled Microstrip Antenna (ACMA). That generates orthogonal circularly polarized waves at two different frequencies in a simultaneously. This array of antennas can be used as a communication tool in satellite internet (VSAT) and wireless applications. Sequential rotation technique was applied to create dual frequency. The technique was verified in a 2×2 array of aperture coupled microstrip antennas with frequency of operation at 4GHZ and 6GHZ . Simulation result shows that the return loss is -35 dB. For both the low band and high band mode of operation. The isolation between the two modes is around --30dB.**

***Keywords*— Aperture Coupled Microstrip Antennas (ACMAs); dual frequency; very small aperture terminal; shared aperture.**

I. INTRODUCTION

In modern days of communication, several satellite communication application like TV and internet access (like VSAT) make use of the compact shared aperture dual frequency array with specific polarization features and provides isolation between two modes of operation. Very Small Aperture Terminals(VSAT)[1].It is used for the reliable transmission of data or voice via satellite with maximum speed reaching 2Mbps.

VSAT equipment consists 2 units,

1. Outdoors for a line of sight to the satellite.

2. Indoor to interface with the user's communications device (e.g.dataterminal equipment).

A shared aperture reduces size, weight and cost. It helps to improve the performance in focal-plane arrays since the phase centers for both frequencies are at the same location. Antenna aperture can be reused for transmitting (6GHZ) and receiving (4GHZ) data. Electronic beam scanning over a limited scan range requirement was fulfilled in this array of microstrip antennas. The antenna is required to generate circular polarization with excellent receive (Rx) versus transmit (Tx) isolation. Some recent papers have reported on shared apertures for dual polarization and dual frequency. The antenna for the low band and high band operation are used and are integrated into each other.

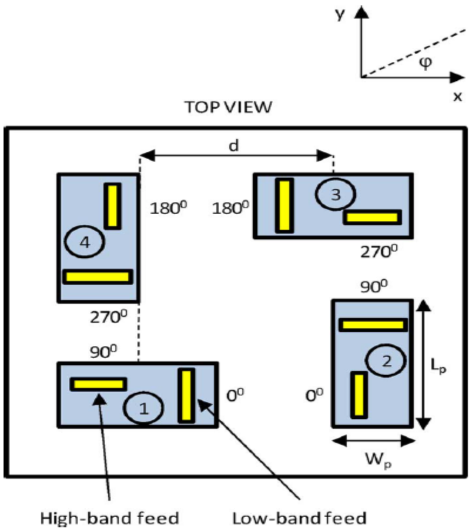


Figure.1 Shared aperture antenna array

In order to avoid grating lobes, the element spacing for the low frequency operation is chosen different from the element spacing for the high frequency band. This concept typically lack ease of manufacturing and have limitations with respect to aperture and cross polarization levels. In this study we explore a concept in which the antennas physically "share" the same aperture for the low band and high band mode of operation. The most elegant way to create circular polarization (CP) with linearly polarized (LP) elements in an array by using the sequential rotation technique as introduced by Huang, An extension of this technique in a 2×2 array for dual frequency operation with circular polarization[2]-[6]. The specifications of the antenna are:

1. Circular polarization of low band and high band with separation in the frequency.

2. Isolation between lower and higher frequency bands. It will eliminate the need of using a filter.

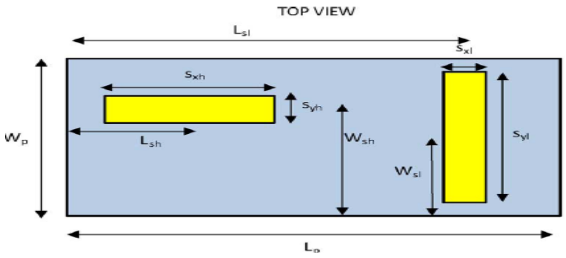
3. Compact aperture-reflector for both frequencies benefit from a compact shared aperture.

II. DUAL BAND SHARED APERTURE ARRAY USING THE SEQUENTIAL ROTATION TECHNIQUE

Circular Polarization (CP) can be achieved by applying proper phase shifts to the sequentially rotated Linearly Polarized (LP) antenna elements. This idea was extended in this 2x2 prototype array which is a part of larger array[8]. The configuration of Figure.1 generates Right Hand Circular (RHC) Polarization at low band operation and Left Hand Circular (LHC) Polarization at high band operation. Each patch is fed by two microstrip lines that are coupled via slot apertures in the ground plane. In sequential rotation technique each patch is placed at different angles to create circular polarization. One of the main drawbacks of sequential rotation with linear polarized elements is that relative high side lobes of cross polarization may appear in the diagonal plane. This effect depends on the element spacing d, So it is also taken into account for design.

III. ARRAY DESIGN AND EVALUATION

The proposed shared aperture antenna uses 4GHz for low band and 6GHz for high band operation. The prototype is designed in order to scale upto higher frequencies of 20/30 GHz in future. In order to introduce the phase shifts, the Wilkinson Power dividers and delay lines were used in the array. The prototype demonstrates the concept only for broadside scan. The beamforming networks contains the phase shifters that generate the required phases for creating RHC polarization for low-band operation and LHC polarization for high-band operation . The radiating element is a rectangular microstrip patch antenna, of which the length L_P is approximately $\lambda/2$ at the lower frequency band and the width W_p is approximately $\lambda/2$ at the higher frequency band, where λ is the effective wavelength of the substrate on which the patch is printed and a single element is shown in Figure.2[9]-[10]. Each patch is fed by two microstrip lines that are coupled to the patch via slot apertures in the ground plane. In this way, each of the elements can operate in two frequency bands. This particular choice increases the isolation between lower and upper band[11]. The element spacing of d=35mm in the array avoids the grating lobes in both frequency bands. The low band and high-band signals are each connected to a feed network consisting of delay lines and three 1:2 Wilkinson power dividers and the array was optimized[12]. The main advantages of the configuration of Figure.1 as compared to conventional solutions are its simplicity, compactness, and the fact that mutual coupling between the elements is reduced.



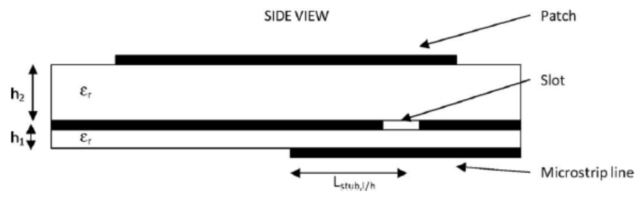


Figure. 2 Single element of an array

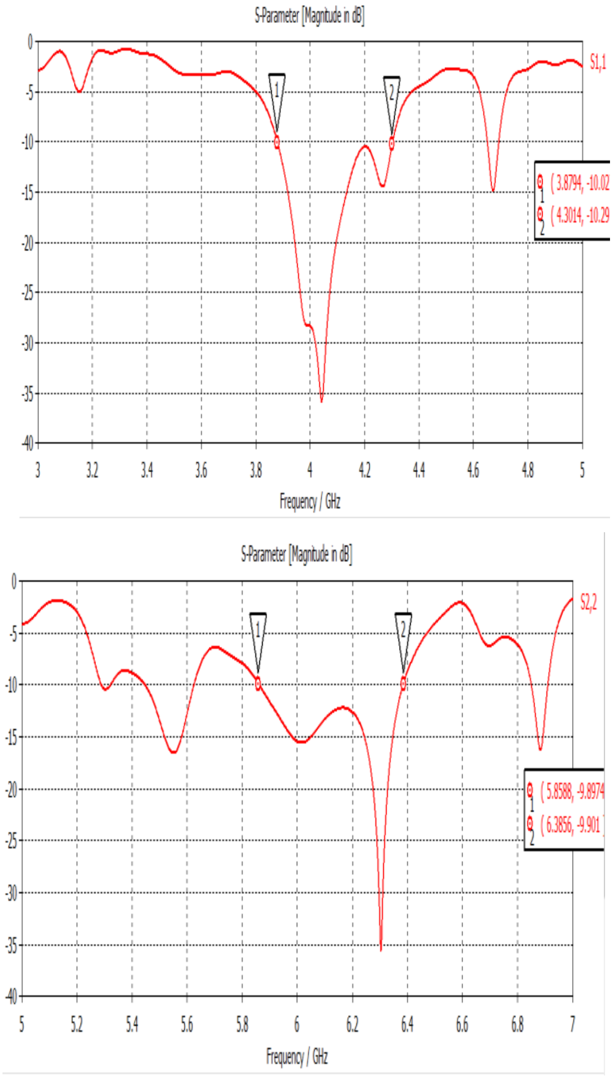


Figure. 3 Return loss of an array

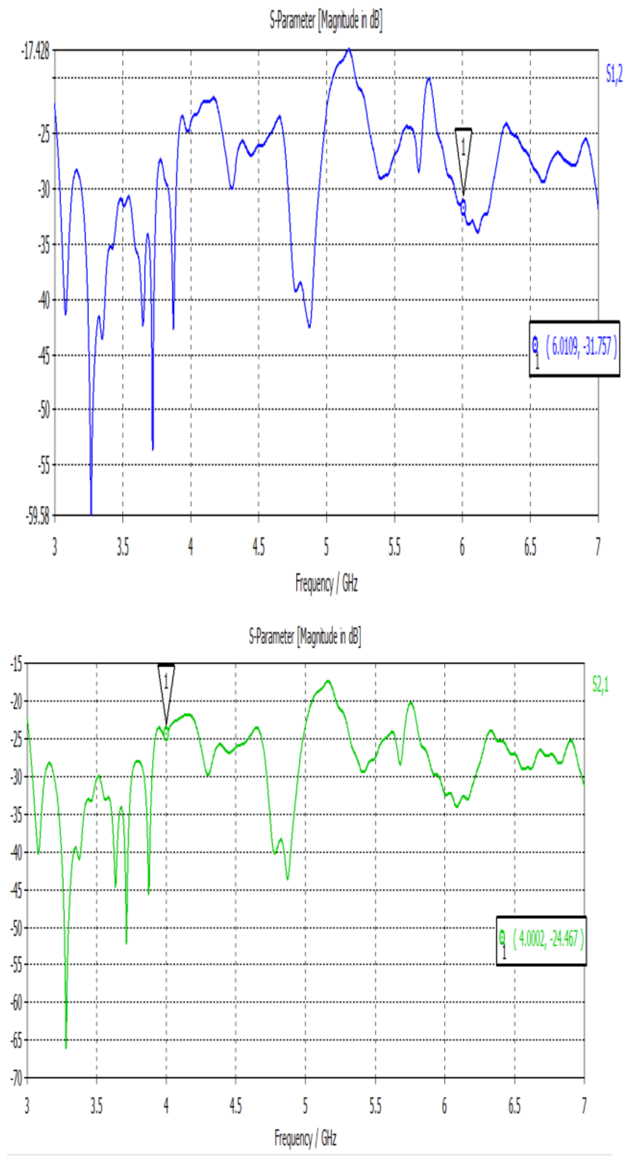


Figure. 4 Isolation of an array

As a first step in the evaluation of the prototype, the return loss of the 2x2 array with 4-GHz and 6-GHz feed network was simulated and the results was measured using the Computer Simulation Technology (CST) software[13]. The simulation results is shown in Figure.3 for the low and high-band mode of operation. The return loss for both high band and low band in the array was found to be-35dB. Secondly, The isolation is measured between the antenna elements for both the high band and low band ports,it is shown in Figure.4 and its found to be around -30dB. The emphasis is not done on the gain,since the array is a prototype and the gain for this array in both bands is 9dBi.

IV. CONCLUSION

In this paper, a shared aperture antenna array was designed that operates at two frequency bands simultaneously and generates orthogonal circular polarization. A novel implementation of the sequential rotation technique provides excellent circular polarization properties of a 2x2 array of dual-frequency ACMAs. The concept was demonstrated with a prototype consisting of a 2x2 sub array of ACMA radiators and the low-band and high-band feed networks. The isolation between both bands is larger than 26 dB, eliminating the need of high-performance duplexers in the overall system ACMA radiators and the low-band and high-band feed Networks. The return loss of both the bands is about- 35dB and it is satisfactory. Further improvement is done by using Electromagnetic Band Gap (EBG) structures or by using electronic phase shifters which can enable in beam scan.

REFERENCES

[1] J. Dell, "The maritime market: VSAT rules," SatMagazine, vol. 6, no.8, pp. 30–34, Dec. 2008.

[2] D. M. Pozar and S. D. Targonski, "A shared-aperture dual-band dualpolarizedmicrostrip array," IEEE Trans. Antennas Propag., vol. 49,no. 2, pp. 150–157, Feb. 2001.

[3]] M. Meng, F. Zhang, X.Ding, K. Ding, and L. Li, "Design of a sharedaperture dual-band dual- polarized microstrip antenna," in IEEE AP Symp. Dig., 2009, pp. 680–683.

[4] S. Chakrabarti, "Development of shared aperture dual polarized microstrip antenna at L-band," IEEE Trans. Antennas Propag., vol. 59,no. 1, pp. 294–296, Jan. 2011.

[5] J. Granholm and N. Skou, "Dual-frequency, dual-polarization microstrip antenna development for high-resolution, airborne SAR," in Proc. Asia–Pacific Microw. Conf., 2000, pp. 17–20.

[6] J. Huang, "A technique for an array to generate circular polarization with linearly polarized elements," IEEE Trans. Antennas Propag., vol. AP-34, no. 9, pp. 1113–1124, Sep. 1986.

[7] P. S.Hall, J. Huang, E. Rammos, and A. Roederer, "Gain of circularly polarized arrays composed of linearly polarized elements," Electron.Lett., vol. 25, no. 2, pp. 124–125, 1989.

[8] P. S. Hall, "Application of sequential feeding to wide bandwidth, circularly polarized microstrip patch arrays," Proc. Inst. Elect. Eng., vol. 136, pt. H, pp. 390–398, May 1989.

[9] D. M. Pozar, "Microstrip antenna aperture coupled to a microstrip line," Electron. Lett., vol. 21, pp. 49–50, Jan. 1985.

[10] F.Corq and A. Papiernik, "Large bandwidth aperture coupled microstrip antennas," Electron. Lett., vol. 26, pp. 1293–1294, Aug. 1990.

[11] C. H. Tsao, Y. M. Hwang, F. Killburg, and F. Dietrich, "Aperture coupled patch antennas with wide bandwidth and dual polarization capabilities,"in IEEE AP Symp. Dig., Jun. 1988, pp. 936–939.

[12] M.Edimo, A. Sharaiha, and C. Terret, "Optimized feeding of dualpolarized broadband aperture coupled printed antenna," Electron. Lett., vol. 28, pp. 1785–1787, Sep. 1992.

[13] Computer Simulation Technology (CST) software version 2010.