A dual-band and dual-polarized microstrip antenna subarray design for Ku-band satellite communications

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***Abstract*-In this paper, a dual-band and dual-polarized microstrip subarray antenna is designed for Ku-band phased array antenna system used in satellite mobile communication. The antenna has a vertical polarization for receiving band and a horizontal polarization for transmitting band. Aperture coupled feed, symmetry feed and parallel feed techniques are used to achieve high gain and high isolation level. The simulated results show that the proposed 4×4 subarray antenna obtains good performance. The return loss values of both ports are lower than -15dB. The isolation between two ports is higher than 30dB in receiving band. The proposed array antenna obtains the gain of 16.7dB in receiving band, and 18.3dB in transmitting band.**

I. INTRODUCTION

In recent years, the satellite mobile communication is rapidly increasing due to its unique advantages of wide area coverage, fast service initiation and high data rate. The low profile system using microstrip antenna have rapidly emerged and may become the main trends and evolution goals of the future mobile communications [1,2]. Sharing the same aperture in the transmitting (Tx) and receiving (Rx) bands is a proper way to reduce the size and weight of the antenna. But it may also cause some design challenges. The most important one is that the two bands signal may be coupled to each other to an undesired level, although the orthogonal polarization technique is normally adopted. In this paper, a dual-band and dual-polarized microstrip subarray antenna is designed for the Ku-band phased array antenna system used in satellite mobile communication. In order to obtain high isolation and good cross-polarization level, a medial ground layer with feeding slot is used to separate the feeding network of two band. A 4×4 microstrip antenna subarray with good performance is constructed by using electromagnetic simulation software optimizing.

II. ANTENNA STRUCTURE AND DESIGN

The basic design of multilayered dual-polarized antenna is shown in Figure 1. This structure can flexibly get the best bandwidth and gain by adjusting the dielectric constant and thickness of each layers [3,4]. The upper substrate layer adopts RO5870 material with permittivity 2.2 and thickness 0.787 mm. In order to reduce the insertion loss in the feed network and increase the strength of the antenna plate, the lower substrate layer use RO4350 material with permittivity 3.48 and thickness 0.508 mm.

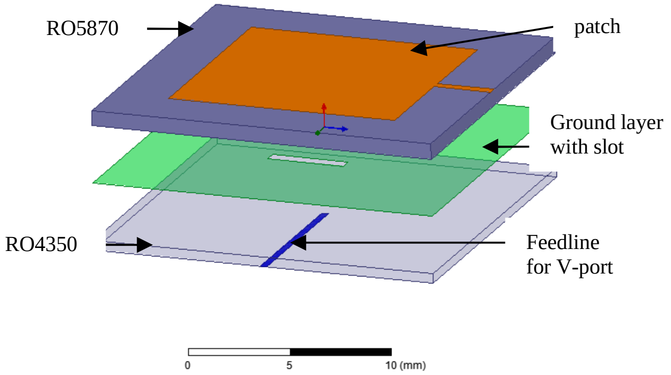
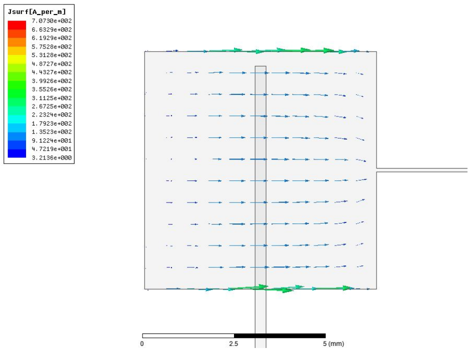
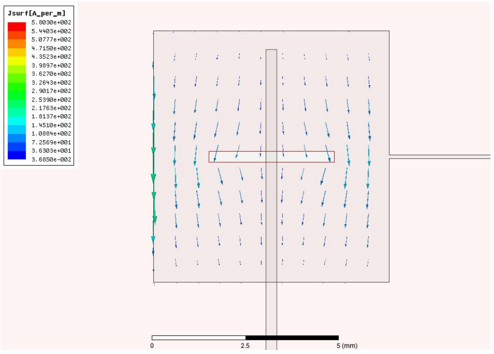


Figure 1. The dual-band dual-polarized unit

The driven patch and the horizontally polarized feed network are both formed on the layer 1 while the vertically polarized feed network is printed under the layer 3. Two polarization feed networks are separated by a ground plane which locates between layer 1 and layer 3. The coupling slots on the ground plane are used as exciting aperture. Since the array antenna is designed for two bands, 12.25~12.75GHz for receiving and 14.00~14.50GHz for transmitting, where the higher band operates in the horizontal polarization while the lower band operates in the vertical polarization, in order to improve cross-polarization level, the microstrip feedline of the horizontally polarized port (H-port) on layer 1 must be vertical to the aperture-coupled feedline of the vertical polarization port (V-port) on layer 3 [5]. Surface current distributions of the two bands are shown in Figure 2. It can be seen that the current vector of the two bands are orthogonal, then the orthogonal isolation between the two port is basically guaranteed.



(a)



(b)

Figure 2. Surface current distribution at a)14.25GHz and b)12.5GHz

Figure 3 shows a 4×4 subarray antenna constructed by parallel feed network which is easy to satisfy amplitude requirement by adjusting power distribution ratio, and phase requirement by adjusting the electrical length of the feedline [6]. Meanwhile, by using the co-phase feeding technique, the design of parallel feed network is simple and effective for the absence of inverter production. To improve the array antenna performances in terms of gain, efficiency and cross-polarization as much as possible, we adopt symmetrical feeding network [7,8].

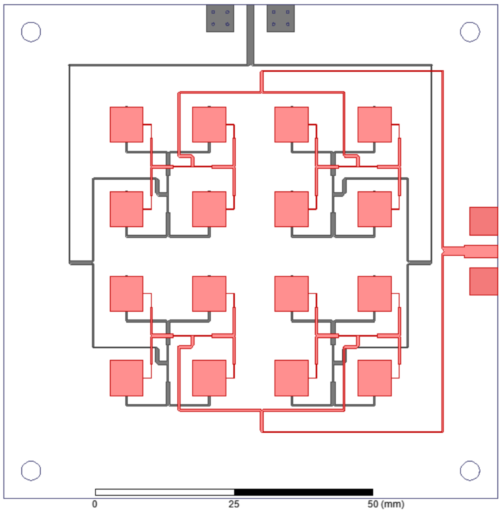


Figure 3. 4×4 subarray antenna

III. SUTIMULATION AND RESULTS

Figure 4 shows return loss curves of both H-port and V-port. At the operating frequency, both ports have return loss values lower than -15dB. The isolation between two ports is higher than 40dB in operateing band. The results show that the proposed array antenna obtains enough bandwidth at H-port, but the bandwidth at V-port is inferior to H-port in order to ensure the high isolation performance.

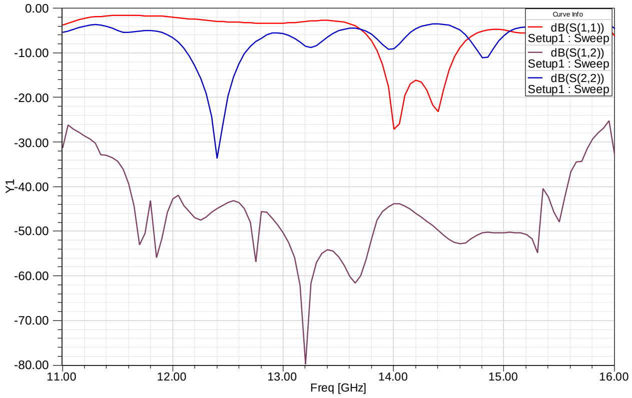
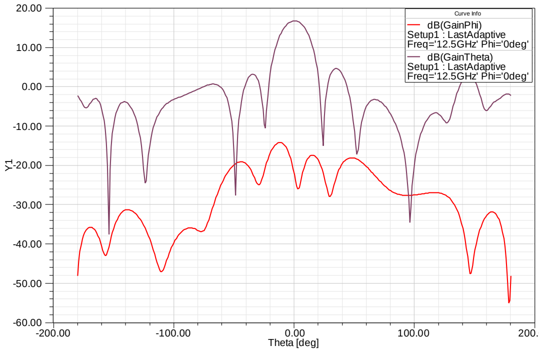
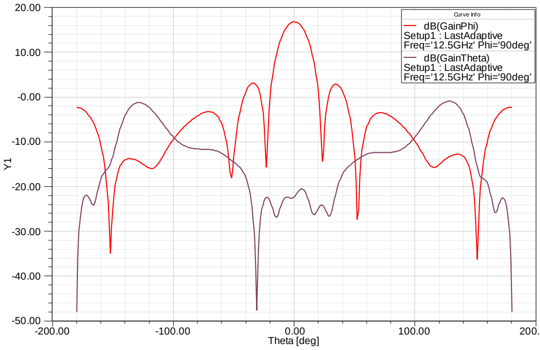


Figure 4. S-parameters for the 4×4 array antenna

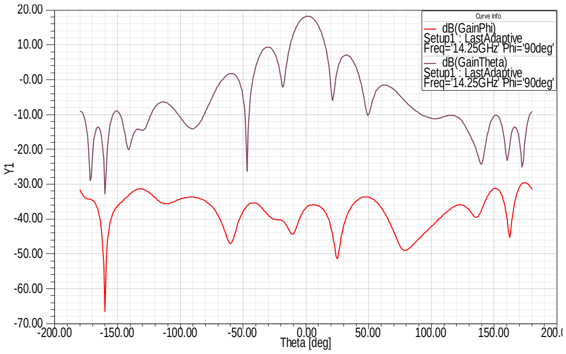
Figure 5(a)-(d) plot the main polarization and cross-polarization curves of the two ports in the $\varphi = 0^\circ$ and $\varphi = 90^\circ$ plane. From figure 5(a) and (d), in the $\varphi = 0^\circ$ plane, the peak gain levels are 18dB for H-port and 16.7dB for V-port respectively. However, cross polarization levels are nearly -10db because of feedlines for V-port also inspired ground layer. From figure 5(b) and (c), in the $\varphi = 90^\circ$ plane, cross polarization levels for both ports are below -30dB in the beamwidth.



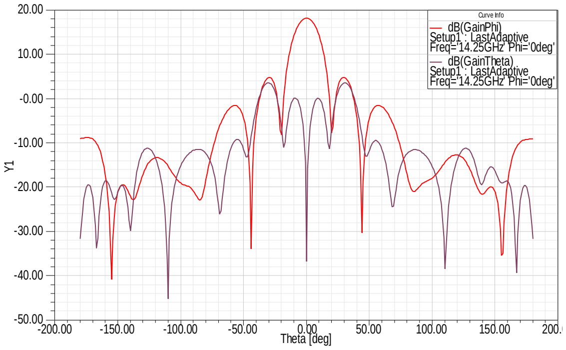
(a) $\varphi = 0^\circ$ plane(E-plane) at 12.5GHz



(b) $\varphi = 90^\circ$ plane(H-plane) at 12.5GHz



(c) $\varphi = 90^\circ$ plane(E-plane) at 14.25GHz



(d) $\varphi = 0^\circ$ plane(H-plane) at 14.25GHz

Figure 5. Antenna radiation patterns for two ports

IV. CONCLUSION

In this paper, aperture coupled feed, symmetry feed and parallel feed techniques are used to achieve a high gain, high isolation of the dual-band and dual-polarized microstrip antenna. The antenna structure is simple, easy to fabricate. Two kinds of polarized within the working frequency band achieve maximum gain of 18.6 dB and 16.7 dB respectively, cross-polarization below -30 dB. The above results show that the antenna subarray has a good performance, can be the basis for the design to meet the needs of phased array antenna for satellite communication transceiver.

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