A STUDY ON THE MICROSTRIP YAGI-UDA ARRAY ANTENNA FOR SATELLITE SERVICE

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1. Introduction

Commercial digital satellite broadcasting services in Korea were started by KDB (Korea Digital Satellite Broadcasting) on March 2002. More than 600,000 customers had reserved for the services, and more than 280,000 customers were served in June 2002. Most of the antennas installed by KDB were parabolic type because of low cost. In the near future, a planar antenna for satellite service can be used in the fixed site and mobile systems because of simple and easy installation and maintenance. Since the planar antenna is one of the promising antennas, a great attention to improve its performance has been given for the applications of various wireless services. Especially, the parasitic patches have been studied on the attractive features such as high gain, wide bandwidth, and shaped beam [1~5].

In this paper, we proposed a microstrip Yagi-Uda array antenna for the reception of satellite signals by using low cost copper etched polyester films and foams. The configuration and coupling mechanism of the proposed antenna are similar to the dipole Yagi-Uda antenna. In order to receive DBS signals from KOREASAT 3 in Korea, main peak beam should be more than gain of 19dBi and tilted angle of 45°+/-2.5°. Pointing of the proposed antenna can be done easily because finding only in azimuth direction is required. Requirement specifications of the antenna are shown in Table 1.

2. Antenna Design

Basic microstrip Yagi-Uda antenna element is shown in Figure 1. A 2×2 element antenna array and its simulated performance are shown in Figure 2. Reflector, driver, and director are square, and a linearly polarized H-plane coupled microstrip Yagi-Uda antenna. The proposed antenna is composed of 3 polyester films and three layers of foam. In order to prevent unwanted radiation and coupling loss by microstrip feeding networks and parasitic patches, a stacked layer with rectangular slots above the driver patch array is inserted. Polyester film of the relative dielectric constant ε_r = 3.2 and thickness = 0.175mm are used, low cost foam layer of thickness 2mm and relative dielectric constant ε_r=1.06 are inserted between polyester film layers. Effective dielectric constant of the polyester film is similar to one of the foam because of its very thin thickness and foam of 2mm.

Microstrip Yagi-Uda antenna element can be designed according to well known guidelines [2]. These guidelines are available when dielectric constant of the substrate material is from 1.5 to 5, and all patches are etched on a single layer. Dimension ratio of the reflector to the driver patch is found experimentally to be between 1.1 and 1.3. Dimension ratio between the director and the driver patch should be from 0.8 to 0.95. But these specifications are different according to the structure and substrate of antenna. Therefore, all array dimensions are calculated and optimized by the commercially available antenna design software such as Ensemble and Microwave Studio.

3. Fabrication and Experimental Results

Using the developed microstrip Yagi-Uda antenna element and conventional T-junction power dividers, a 16×8 element microstrip Yagi-Uda array antenna is fabricated. A waveguide adaptor with E-plane corner and a waveguide to microstrip transition structure are used for feeding the gap coupled energy into the commercial LNB interface. Fabricated 16×8 element antenna array is shown in Figure 3. For easy integration and alignment of multi-layers and feeding structure, a radome and iron-bounded bottom plate with internal screws are used.

Tilted angle and beam patterns are affected by the gaps between all the patches and sizes of director and reflector patch, while the gain of the antenna is intensively affected by the size of the director patch and gap between driver and director patch. Measured return loss and radiation patterns at 11.85GHz are shown in Figure 4. The resonant frequency is shifted to 11.762GHz. This error is due to the sizes of the etched patches and coupling between the patches in the multi-layers and foams. The peak pattern of this fabricated antenna is directed at 43.8° from the broadside direction, its half power beam width is about 4.6°. A backward lobe of 15dBi is shown at –40.3° from the broadside direction. Therefore, the peak gain of 22.9dBi of the fabricated antenna is low as compared to the radiation of the conventional 16×16 array antenna. Gain penalties can be attributed to several sources such as the ineffective role of the reflector and the tolerance errors in fabrication and power mismatches in feed and at junctions. A design and fabrication with narrow gaps between patches and large sizes of the parasitic patches remain a challenge work for a good pattern.

4. Conclusion

The 16×8 element microstrip Yagi-Uda array antenna has been presented by experimental results. Its beam patterns are affected by many parameters such as sizes of the patches, gap between the patches, characteristics of the substrates, feeding method, etc. Owing to its complexities of various design parameters, both simulation and experiment were performed. The fabricated antenna received DBS signal from KOREASAT 3 by doing nothing but adjusting azimuth direction. But its design parameters should be optimized for adjusting the poor pattern quality. For the vehicle application, the studies on the wide beam-width and high peak beam patterns are necessary.

5. References

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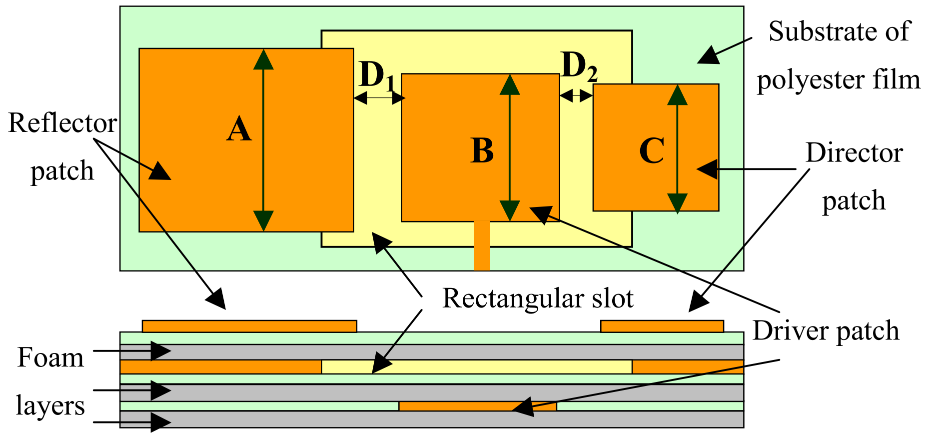
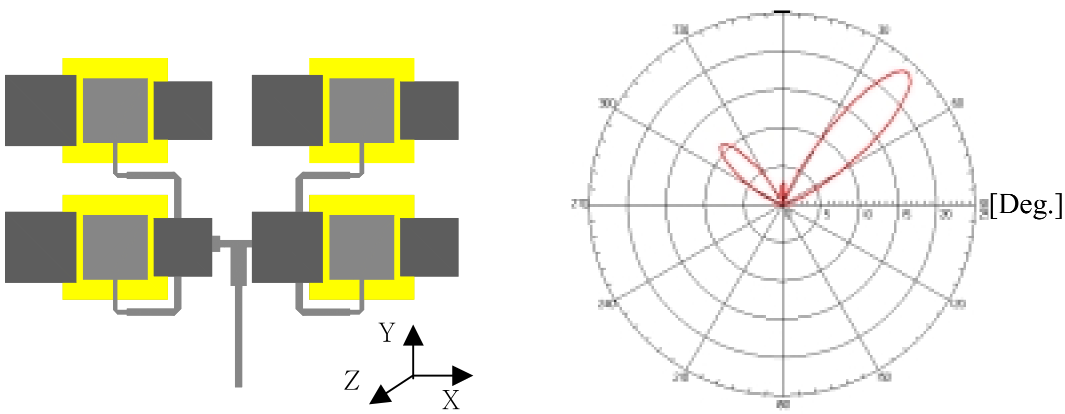
Table 1. Specifications of antenna

Operation frequency	11.7 ~ 12.0 GHz
Gain	>19dBi
Polarization	Linear
Tilted angle of peak beam	45°+/- 2.5°
Aperture dimensions	35Cm × 35Cm



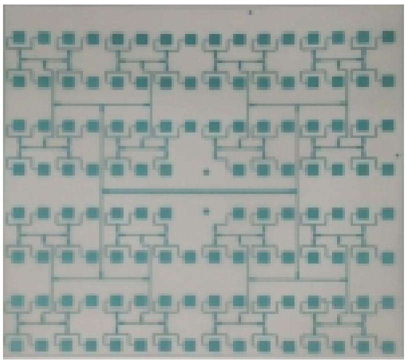
A: 10.45mm B: 9.5mm C : 8.55mm D_1: 1.03mm D_2: 0.98mm

Figure 1. Structure of basic antenna element

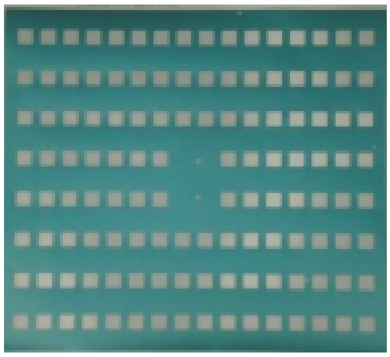


(a) Top view (b) Simulated beam pattern at 11.85GHz

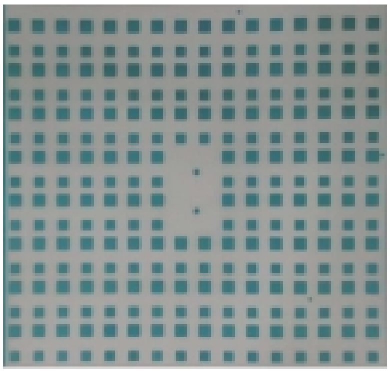
Figure 2. A 2×2 element microstrip Yagi-Uda antenna array



(a) Driver and feeding network



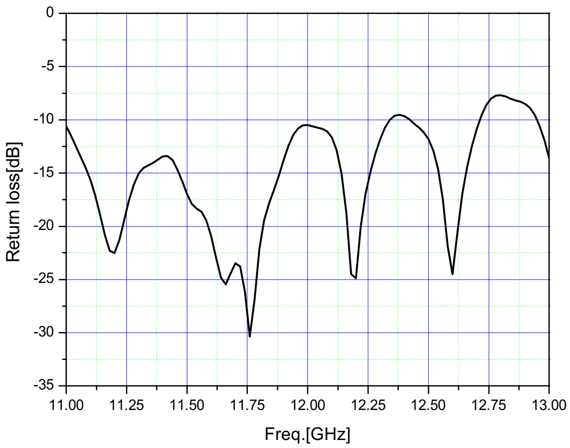
(b) Rectangular slots



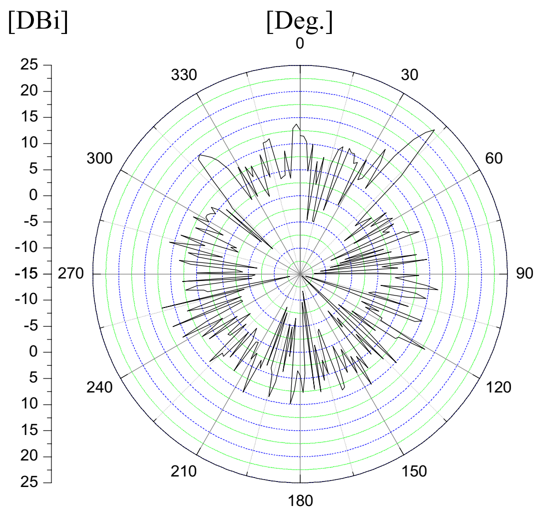
(c) Reflector and director

(d) Installation of the fabricated antenna

Figure 3. Photos of the fabricated 16×8 element array



(a) Return loss



(b) Radiation patterns at 11.85GHz

Figure 4. Measured performance of a 16×8 element microstrip Yagi-Uda antenna array