Design of Circularly Polarized Equilateral-Triangular Microstrip Antenna Array for Satellite Communication

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1. Introduction

Recently microstrip antenna is widely accepted in numerous applications either in communication, navigation and radar system. One of the applications of microstrip antennas is antenna for quasi-zenith satellite that operated at frequency 2.6 GHz (2605- 2630 MHz) [1]. This geo-synchronous satellite is planned to have an orbit that pass over the eastern part of Indonesia.

This paper presents a modified of a direct-fed circularly polarized equilateral-triangular microstrip antenna with a single stub-tuner. In this design, the microstrip patch is designed to have a single stub-tuner and a Y-shaped slot with unequal arm lengths centered in the patch based on paper [2]. With the proper size of the unequal arm length, the splitting of the fundamental resonant mode of the modified Y-shaped slot microstrip antenna into two near-degenerate orthogonal modes for circular polarization (CP) radiation can be achieved by using a single direct feed. In addition, the proposed modified Y shape slot microstrip antenna can perform CP radiation with a reduced antenna size as compared to a regular circularly polarized equilateral-triangular microstrip antenna at a fixed operating frequency. A single stub-tuner is used to obtain an optimum impedance matching. The main beam of the proposed antenna is designed to have elevation at 40^0, since the proposed antenna will be used as terminal in western part of Indonesia.

2. Antenna Configuration and Design

Figures 1 shows the proposed geometry of a modified Y-shaped slot circularly polarized equilateral-triangular microstrip antenna. The design of triangular patch with its lower two arms facing to the tips of the bottom side of the triangular patch is for Right Hand Circular Polarization (RHCP) as shown in Fig. 1. The equilateral-triangular patch has a side length of l and is printed on a substrate of thickness h and relative permittivity ε_r.

The Y-shaped slot is centered in the triangular patch, with its lower two arms of equal length Y_b and upper arm of smaller length Y_a ($Y_a<Y_b$). The lower two arms and the upper one are all of equal width w. The feed point with the distance a shown in the Fig. 1, are for achieving right-hand and left-hand CP operations, respectively.

From varying the position of feed point, it is found that the optimum feed point is approximately located in the distance a = 21 mm at the bottom side of the patch. By choosing proper arm lengths (Y_a and Y_b) of the Y-shaped slot and selecting a single direct feed point at the bottom side of the triangular patch, CP operation of the triangular microstrip antenna can be obtained, and due to the presence of the Y-shaped slot in the patch, the excited patch surface current path is lengthened and thus the resonant frequency of the microstrip patch is reduced. A single stub-tuner is embedded to obtain an optimum impedance matching by measuring a stub position with the Smith Chart and selecting the proper stub length. Due to the presence of stub, impedance matching of direct feed triangular microstrip antennas would be easy implemented and for fine tuning. The stub length is 12 mm and placed at 16 mm from the bottom side triangular patch.

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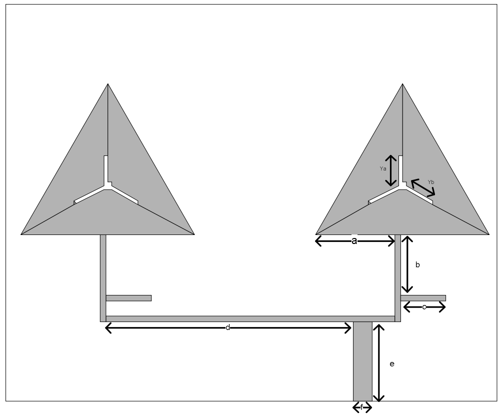


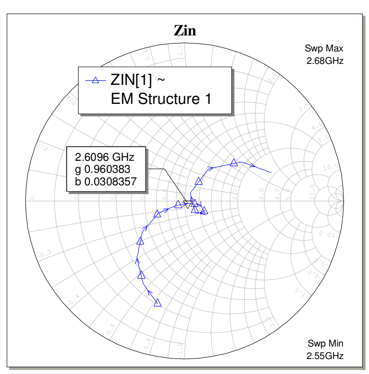
Fig.1. Antenna Design for RHCP with vertical length of substrate = 105 mm, horizontal length of substrate = 130 mm , length side of triangular microstrip antenna l = 46.14 mm, a = 67 mm. Y_a = 8 mm and Y_b = 8.9 mm, b = 16 mm, c = 12 mm, d = 67 mm, e = 21mm, f = 5mm.

Furthermore, the feed point of sub-array antenna is determined by varying d and located at d = 67 mm to obtain the main beam at elevation angle 40^0.

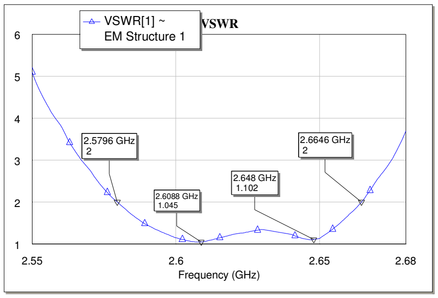
3. Result and Discussion

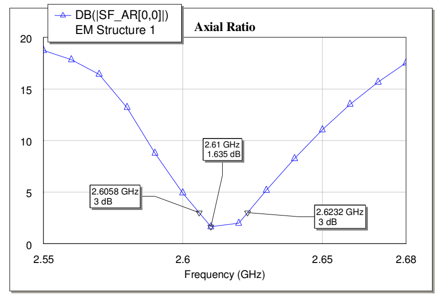
a. Simulation Result

The sub-array antenna design is then simulated by using Microwave Office (MWO). The parameters are performed for input impedance characteristic, VSWR and axial ratio, as shown in Fig. 2. Fig. 2 shows the result of antenna design for RHCP. The normalized admittance is 0.96 + 0.03j, at frequency 2609 MHz as shown in Fig. 2 (a). The antenna bandwidth, determined from VSWR 2, is about 85 MHz or about 3.24 %, respect to center frequency (2621.5 MHz) as shown in Fig. 2 (b). Fig. 2 (c) shows that circular polarization (RHCP) can be obtained at center frequency 2610 MHz with axial ratio 1.63 dB. It is observed that the CP bandwidth, determined from 3 dB axial ratio, is about 18 MHz or about 0.68 % with respect to the center frequency (2614.5 MHz).



(a)



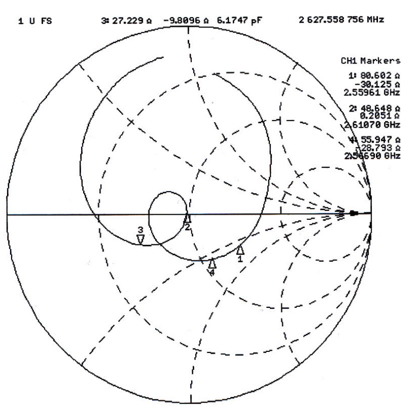


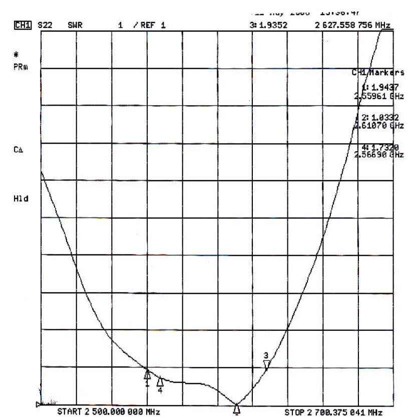
(b) (c)

Figure 2. (a) Input impedance characteristic, (b) VSWR characteristic, (c) Axial ratio characteristic

b. Experimental Result

The Proposed design for RHCP has been fabricated using dielectric substrate Taconic TLY-5-0620-CH/CH with thickness 0.0620 inch, $\varepsilon_r = 2.2$ and $\tan \delta = 0.0009$. The input impedance is 48.65 + j0.21 ohm at frequency 2610 MHz as shown in Fig. 3 (a). The VSWR = 2 antenna bandwidth is about 68 MHz or about 2.62 % respect to center frequency (2588,5 MHz) as shown in Fig. 3 (b).

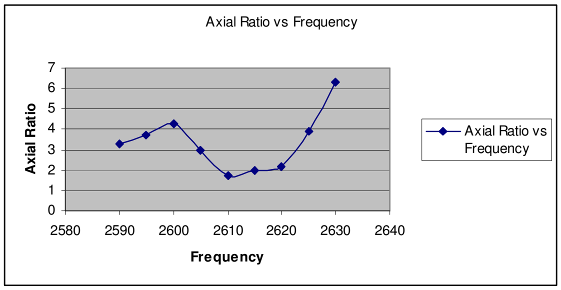




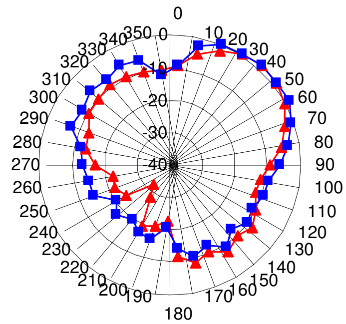
(a) (b)

Fig. 3. (a) Input impedance characteristic of the proposed antenna, (b) VSWR characteristic of the proposed antenna

Fig. 4(a) shows axial ratio bandwidth is about 15 MHz or 0.57 %, respect to the center frequency (2612.5 MHz). Fig. 4 (b) shows the measured radiation pattern of the proposed antenna. From Fig. 4 (b) it can be seen that the main beam of the radiation patterns has elevation angle at 40^0. The circular polarization is obtained for the present study at the center frequency 2610 MHz. Moreover, the antenna gain for 2-element array is 11.1 dB at frequency 2610 MHz.



(a)



(b)

Fig. 4. (a) Axial ratio bandwidth measurement of the proposed antenna, (b) Circularly polarized radiation pattern of the proposed antenna

4. Conclusion

The design of sub-array antenna for circular polarization has been successfully demonstrated. It is shown that the measurement results are in a good agreement with the simulation. The directivity of this antenna can be increased by extending the array.

Acknowledgement

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References

[1] MPHPT Communication News, (2003), "Frequency allocations for sound broadcasting satellite via Quasi-Zenith satellites", www.soumu.go.jp/joho_tsusin/eng/releases/NewsLetter/Vol14/Vol14_08/Vol14_08.html.

[2] Yang K.P., K. L. Wong and J.H. Lu, "Compact circularly polarized triangular microstrip antenna with Y-shaped slot," *Microwave and Optical Technology Letters*, vol.20, no.1, pp.123-126, Jan. 1999

[3] Garg, R., P. Bhartia, I. Bahl, and A. Ittipiboon, "*Microstrip* Antenna *Design Handbook"*. Artech House, 2000.

[4] James, J.R., and P.S. Hall (Eds.), "*Handbook of Microstrip* Antennas*,"* Peter Peregrinus, London, UK, 1989.