Hybrid-fed Equilateral Triangular Antenna with Tuning Stub for Circularly Polarized Bandwidth Enhancement

Eko Tjipto Rahardjo, Munawar and Djoko Hartanto
Antenna Propagation and Microwave Research Group
Center for Information and Communication Research
Department of Electrical Engineering, University of Indonesia, Depok
eko@ee.ui.ac.id

Munawar_tektel@yahoo.com djoko@ee.ui.ac.id

Abstract - In this paper, a circularly polarized bandwidth enhancement using an equilateral triangular antenna is proposed. This antenna is designed to work at frequency range of 2.605 GHz - 2.630 GHz for satellite communication purpose. To enhance the axial ratio bandwidth of the proposed antenna, a feeding system composed by modified hybrid circuit with tuning stub at the edge of the patch is introduced. From the simulation and experiment it is shown that an enhancement of axial ratio bandwidth is achieved.

I. INTRODUCTION

Recently, many types of microstrip antenna have been investigated to enable mobile satellite communication. Where, in satellite communication a circularly polarized microstrip antenna is required. In principle, the circular polarization can be excited by using single- or dual-fed system. Single-fed circularly polarized antenna usually has a very narrow axial ratio bandwidth though the feed system is simple. On the other hand, dual-fed system is used due to wider bandwidth.

In this paper, a modified dual-fed is proposed to be designed and fabricated on a single layer and low dielectric constant of the dielectric substrate to achieve wider bandwidth. The modification is done by inserting the tuning stub at one arm of the modified hybrid circuit in order to enhance the axial ratio bandwidth.

The patch element which is used in this study is triangular shape. The shape is chosen because for similar performance as other shape (rectangular, circular and ring) a triangular has a smaller size compared to others [1-2].

The proposed antenna in this study is designed to work at the frequency 2.605 - 2.630 GHz which will be used for Japan Quasi-Zenith satellite communication in which the satellite will be launched in 2008 [3]. The satellite orbit path will pass above the eastern part of Indonesia.

II. ANTENNA DESIGN

The proposed antenna configuration is shown in Fig. 1. The antenna is designed to be working at the resonant frequency of 2.62 GHz with the impedance bandwidth of, at least, from 2.605 to 2.630 GHz. This antenna is designed on a substrate which the specification is shown in Table 1.

Tabel 1. Subtrate Spesification

The state of the s	
Substrate type	TLY-5-0310-CH/CH
Electric constant (\mathcal{E}_r)	2,2
Thickness (t)	0,8 mm
Loss tangen (tan δ)	0,0001

The side length of the equilateral triangular patch is 49.8 mm. Then the dual-fed system is positioned at 19.8 mm from each tip of the triangular patch as shown in Fig.1. The feeding system uses 50 Ω characteristics impedance microstrip line. The hybrid is modified so that the vertical side length is 18 mm and the horizontal side length is 29 mm, as shown in Fig. 1. The circular polarization is then can be generated as left hand circular polarization (LHCP) when the left connector is terminated, and vice versa; therefore, when the right connector is terminated the polarization is right hand circular polarization (RHCP).

The tuning stub is inserted between one arm of the hybrid and at one side of the triangular. This stub is positioned 7 mm from the lower tip triangular.

Firstly, we studied the antenna system without the tuning stub. Then the tuning stub is inserted by varying the position from the tip to the feed point as depicted in Fig. 2.

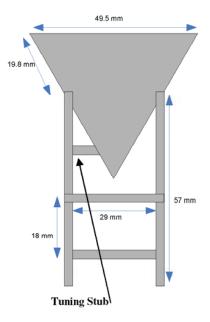


Fig 1 Hybrid Fed Equilateral Triangular Patch Antenna with Tuning Stub

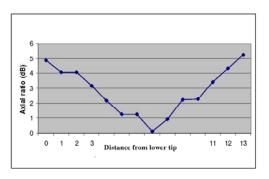


Fig. 2 Shorting stub position characterization to improve axial ratio for a certain frequency

 The tuning stub is designed to improve the matching input impedance of the triangular antenna. For antenna without tuning stub, the simulation design already have some result in desired frequency with VSWR < 2 and axial ratio < 3 dB.

III. RESULTS and DISCUSSION

In this study, the antenna is first simulated by using method of moment for antenna without tuning stub. Then the tuning stub is inserted for optimizing the axial ratio bandwidth by varying its position. Finally, the experiment is carried out to verify the simulation results.

A. Simulation Result

Axial ratio bandwidth for the antenna without tuning stub can be observed in Fig. 3. It is found that the 3 dB axial ratio bandwidth is 15 MHz ($2.605~\mathrm{GHz} - 2.625~\mathrm{GHz}$), which is still below requirement as aforementioned.

Meanwhile, the return loss characteristic for the antenna without tuning stub is 135 MHz ($2.56~\mathrm{GHz}-2.695~\mathrm{GHz}$) as can be seen in Fig. 4.

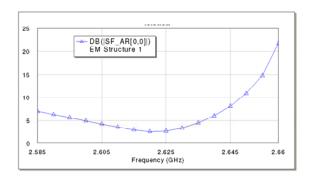


Fig.3 Hybrid Fed Equilateral Triangular Patch Antenna Computed axial ratio Result

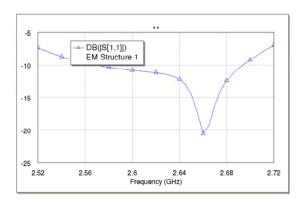


Fig. 4 Hybrid Fed Equilateral Triangular Patch Antenna Computed Return Loss Result

Furthermore, axial ratio bandwidth for the antenna with tuning stub is displayed in Fig. 5. It is found that the 3 dB axial ratio bandwidth is enhanced, i.e. from the frequency 2.60 GHz to 2.65 GHz. This is an increasing of 40 MHz or 2.67 times. Hence satisfy the bandwidth demand for Quasi-Zenith satellite communication requirement.

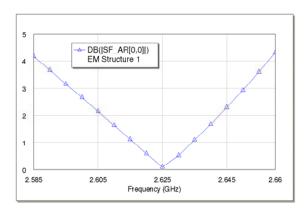


Fig. 5 Hybrid Fed Equilateral Triangular Patch Antenna with Tuning Stub Computed axial ratio Result

Meanwhile the return loss characteristic for the antenna with tuning stub is $195~\text{MHz}\ (2.51~\text{GHz}-2.705~\text{GHz})$ as can be seen in Fig. 6.

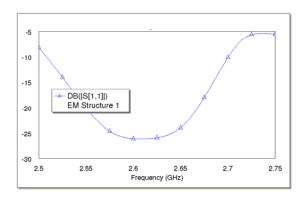


Fig. 6 Hybrid Fed Equilateral Triangular Patch Antenna with Tuning Stub Computed Return Loss Result

It is shown that by adding tuning stub, resonant frequency position can be arranged without redesign the antenna patch. With this tuning stub the axial ratio bandwidth of the antenna can be improved without arrange the antenna as an array. Hence the size of the antenna is not change. In addition, antenna with tuning stub then the minimum return loss is also improved.

B. Experimental Result

Input impedance of the measured antenna can be observed in Fig. 7. It can be seen that a dip at the frequency 2.602 GHz obtained near the 50Ω . This dip shows that two different orthogonal modes have been successfully generated.

Hence, circular polarization characteristic is achieved at this antenna.

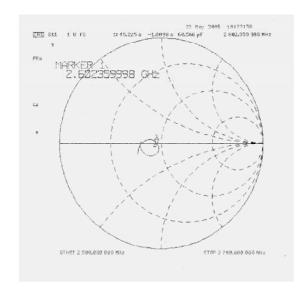


Fig. 7 Input impedance shows a dip at the frequency of 2.602 GHz measurement on smith-chart.

Furthermore, 3 dB axial ratio bandwidth for the antenna with tuning stub is 60 MHz. $(2.605~\mathrm{GHz}-2.66~\mathrm{GHz})$ which can be seen in Fig. 8.

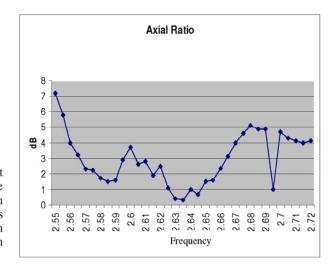


Fig. 8 Axial ratio bandwidth of 60 MHz obtained from the experiment.

Return loss characteristic for the antenna with tuning stub is 335 MHz. $(2.495~\mathrm{GHz}-2.83~\mathrm{GHz})$ which can be seen in Fig. 9.

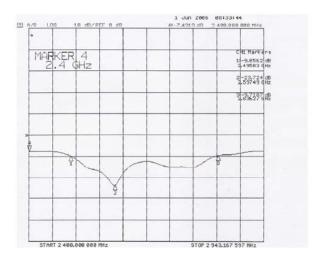


Fig. 9 Experiment result of return loss shows bandwidth of 340 MHz from 2.495 to 2.83 GHz

Following the axial ratio and impedance bandwidth measurement, the antenna gain is also measured. It is seen from Fig. 10 that the antenna gain varies from 5.95 dB to 6.4 dB within the desired frequency which is 2.605 to 2.630 GHz.

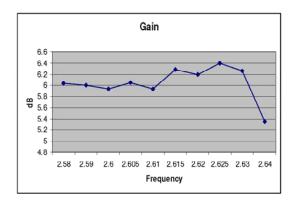


Fig. 10 Measured gain of fabricated antenna

In case of radiation pattern of the fabricated antenna, the circularly polarized radiation pattern is displayed in Fig. 10. It is shown that the pattern is almost symmetrical with 3 dB axial ratio is within 320° to 40° beam-width.

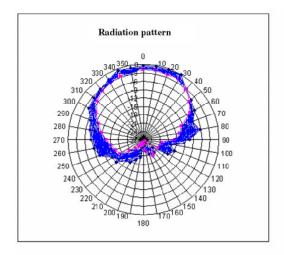


Fig.11 Radiation pattern of measured experimental antenna at the frequency of 2.62 GHz

IV. CONCLUSION

A modified hybrid fed equilateral triangular patch antenna has been successfully simulated and fabricated. The experiment result shows that circular polarization bandwidth 60 MHz is achieved which is slightly wider than simulated one. In addition, the antenna gain of about 6.0 dB is occurred within the desired frequency range. The 3 dB axial ratio beam-width of 80° shows a wide beam-width. Therefore, the proposed antenna can be used as a candidate for mobile satellite communication system in the eastern part of Indonesia.

Acknowledgement

The authors would like to thanks to the Ministry of National Educational of the Republic of Indonesia for partially funding this work under Hibah Pascasarjana scheme with contract No. 024/SPPP/PP/DP3M/2005.

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