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PROCEEDING

THE INTERNATIONAL CONFERENCE ON MATHEMATICS, SCIENCE, EDUCATION AND TECHNOLOGY

ICOMSET 2015

Education, Mathematics, Science and Technology for Human and Natural Resources

October 22, 2015

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The International Conference on Mathematics, Science, Education and Technology

(ICOMSET 2015)

Education, Mathematics, Science and Technology for Human and Natural Resources

October 22, 2015

Inna Muara Hotel and Convention Center
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Organized by

Faculty of Mathematics and Science
State University of Padang
Padang, Indonesia

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Message

from the

Rector of State University of Padang

Ladies and Gentlemen,

It give me great happiness to extend my sincere and warm welcome to the participants of the International Conference on Mathematics, Science, Education and Technology (ICOMSET 2015). On behalf of Universitas Negeri Padang, let me welcome all of you to the conference in Padang, West Sumatra Province, Indonesia.

We believe that from this scientific meeting, all participants will have time to discuss and exchange ideas, findings, creating new networking as well as strengthen the existing collaboration in the respective fields of expertise. In the century in which the information is spreading in a tremendous speed and globalization ia a trend. Universitas Negeri Padang must prepare for the hard competition that lay a head. One way to succeed is by initiating and developing collaborative work with many partners from all over the world. Through the collaboration in this conference we can improve the quality of our researches as well as teaching and learning process in mathematics, science and technology.

I would like to express my sincere appreciation to FMIPA UNP and organizing committee who have organized this event. This is a great opportunity for us to be involved in an international community. I would also like to extend my appreciation and gratitude to keynote speakers and participants of this conference for their contribution to this event.

Finally, I wish all participants get a lot of benefits at the conference. I also wish all participants can enjoy the atmosphere of the city of Padang, West Sumatra.

Thank you very much

Prof. Dr. Phil. Yanuar Kiram
Rector

Message

from the

Dean of Faculty of Mathematics and Science
State University of Padang

Rector of State University of Padang
Vice-Dean of Faculty, Mathematics and Science
Head of Department in Faculty of Mathematics and Science
Distinguished Keynote Speakers
Organizers of this conference
Dear participants
Ladies and gentlemen

I am delighted and honored to have this opportunity to welcome you to ICOMSET 2015 - the International Conference on Mathematics, Science, Education and Technology, which is hosted by Faculty of Mathematics and Science, State University of Padang.

As the Dean of Faculty of Mathematics and Science, I wish to extend a warm welcome to colleagues from the various countries and provinces. We are especially honored this year by the presence of the eminent speaker, who has graciously accepted our invitation to be here as the Keynote Speaker. To all speakers and participants, I am greatly honored and pleased to welcome you to Padang. We are indeed honored to have you here with us.

The ICOMSET organization committee and also the scientific committee have done a great work preparing our first international conference and I would like to thank them for their energy, competence and professionalism during the organization process. For sure, the success I anticipate to this conference will certainly be the result of the effective collaboration between all those committees involved.

This conference is certainly a special occasion for those who work in education, mathematics, science, technology, and other related fields. It will be an occasion to meet, to listen, to discuss, to share information and to plan for the future. Indeed, a conference is an opportunity to provide an international platform for researchers, academicians as well as industrial professionals from all over the world to present their research results. This conference also provides opportunities for the delegates to exchange new ideas and application experiences, to establish research relations and to find partners for future collaboration. Hopefully, this conference will contribute for Human and Natural Resources.

I would like to take this opportunity to express my gratitude to all delegates and sponsors for their full support, cooperation and contribution to the ICOMSET 2015. I

also wish to express my gratitude to the Organizing Committee and the Scientific Committee for their diligence. The various sponsors are also thanked for their kind support.

In closing, I realize that you are fully dedicated to the sessions that will follow, but I do hope you will also take time to enjoy fascinating Padang, with its tropical setting, friendly people and multi-cultural cuisine.

I wish the participants a very fruitful and productive meeting and with that. Finally, we respectfully request the Rector of State University of Padang to open the ICOMSET 2015 officially.

Thank you,

Faculty of Mathematics and Science
Prof. Dr. Lufri, M.S.

Message

from the

Chairman of Organizing Committee

Firstly, I would like to say welcome to Padang Indonesia. It is an honor for us to host this conference. We are very happy and proud because the participants of this conference come from many countries and many provinces in Indonesia.

Ladies and gentlemen, This conference facilitates researchers to present ideas and latest research findings that allows for discussion among fellow researchers. Events like this are very important for open collaborative research and create a wider network in conducting research.

In this conference, there are about 120 papers that will be discussed from various aspects of mathematics, science, technology, education and other related topics.

For all of us here, I would like to convey my sincere appreciation and gratitude for your participation in this conference.

Thank you very much

Drs. Hendra Syarifuddin, M.Si, Ph.D
Chairman

A SYNCHRONOUS SUB-ARRAY CIRCULARLY POLARIZED MICROSTRIP ANTENNA FOR BISAR ONBOARD UAV

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ABSTRACT

A circularly polarized microstrip antenna for bi-static SAR onboard UAV has been investigated. The both sense of the circular polarization left-hand circularly polarized (LHCP) and right-hand circularly polarized (RHCP) are can be achieved on experimental and simulation. The 2x2 sub array antenna operated in 1.176 (L-band) with novel proximity synchronous feed method has been designed, fabricated, and evaluated to show the characteristic of the antenna. The measured result give the axial ratio bandwidth (<3dB) of about 28 MHz (2%), which consistent with the simulated result of about 27 MHz (2%). These results satisfy the specification for our BiSAR system installed onboard UAV.

Keywords : Proximity synchronous feed, bi-static SAR, Circularly polarized antenna, UAV

1. INTRODUCTION

A bi-static synthetic aperture radar (BiSAR) has rapidly increased in the last years due to the ability operated in all-weather and both daytime and nighttime. Additional, the abilities in exploitation of extra reflective information of targets, reduced vulnerability for military application, forward-looking SAR imaging or increased radar cross section [1] has made BiSAR as a potential sensor in application. Recently, the signal from a Global Positioning System (GPS) can be used as a SAR sensor. A receiver collects both the reflected GPS signal from the ground surface and direct GPS signals on an airborne platform. Several measurements such as soil moisture measurement and determining of wind speed are succeeded done using this sensor [2, 3]. In application, some of the GPS receivers have been based on a linear polarization system. By receiving the signal in linearly polarized antenna produce loss caused by the polarization misalignment between the signal and receiving antenna and future will reduce the overall system efficiency and performance as well [4]. In order to transfer maximum power between transmit and receive antenna, both antennas must have the same spatial orientation, the same polarization sense, and the same axial ratio. It can be realize by receiving the reflected and direct signal from satellite at the same time using circularly polarized antenna (Fig. 1).

To realize a new model BiSAR system, research collaboration between microwave remote sensing laboratory Chiba University and Tokyo University is being done [5]. In this research, the signals are received by both of CP antennas Left-Hand Circular polarization (LHCP) and Right-Hand Circular

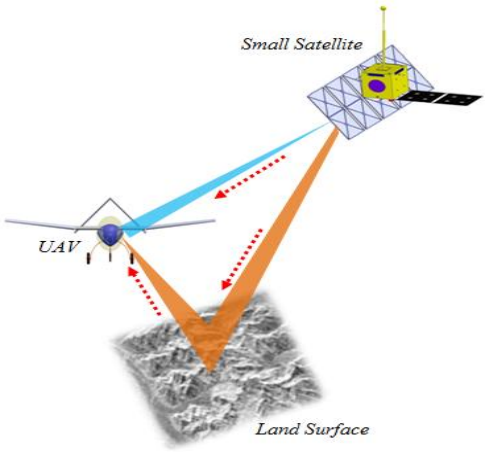

Figure 1. Illustration of the bi-static SAR

Polarization (RHCP) onboard unman aerial vehicle (UAV).

The recorded signals from the both antennas will be used to reconstruct the target reflectivity function using the match filtering. The high quality and efficiency are required in development the BiSAR system. The microstrip antenna is selected in antenna development due to its advantages such as a compact size, light weight, conformability to surfaces of substrates, low cost, and easier integration with other circuits and versatility [6]. Additional, other of the advantages of the microstrip antenna is ease to generate circular polarization (CP). This feature is one reason why microstrip patch antennas have been utilized for space borne communication antenna and

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satellites [7, 8]. However, as well known, a microstrip antenna can attain a narrow frequency bandwidth, especially axial ratio bandwidth generally in order of one-half percent at the expense of a low gain [9,10]. Some previous work has reported the enhancement of the axial ratio bandwidth of microstrip antenna [11]. By implementing many hybrids and power divider in the design, the antenna would be more complex geometry, heavier, high loss, and larger size [7]. One of the promising ways to produce the wider axial ratio bandwidth of CP antenna is sequential rotation technique on sub-array linearly polarized elements.

In this research, a novel synchronous sub-array model to generate circular polarization using sequential rotation technique is presented. Different from previous models [12], the synchronous sub-array is designed with circular series feed method without using a power divider. The advantages of this feed method are the compactness and simplicity of the structure and easy to fabricate. In addition, by using a simple model can reduce the size of antenna and high loss in feeding network. This sub array antenna with novel proximity feeding model can be applied and satisfy for BiSAR onboard UAV requirement. On the next section, the specifications and target of the proposed antenna are introduced. The discussion about circularly polarized antenna will be given in Sec. 3, and the antenna configuration in Sec. 4. The parametric study and performance of the proposed antenna will be explained in Sec. 5 and Sec. 6, respectively. Finally, the conclusion about this research is pointed out on the Sec. 7.

2. SPECIFICATION AND TARGET

In this research, the sub-array antenna is operated on frequency center 1.176 GHz (L-band). The input impedance should be fixed match by resulting in the return loss smaller than 10 dB in the working frequency range. To ensure the radiation is circularly polarized, the maximum axial ratio (AR) is 3 dB in the targeted direction (Azimuth angle 5-90 and elevation angle 360). The antenna also should be keep smaller and light weight to satisfy the UAV payload. The targeted minimum gain of the antenna is set to 16 dBic at the center working frequency. The detail specifications and target of the antenna for BiSAR onboard UAV is sown in the Table 1.

Tabel 1. Specifications and Target

Parameters	Specifications
Frequency center (GHz)	1.176
Pulse Bandwidth (MHz)	24
VSWR	1.5 Typical at 1.176
Axial Ratio (dB)	≤ 3
Antenna Gain (dBic)	≥ 16
Azimuth angle coverage	5-90 degree
Elevation angle coverage	360 degree
Antenna Size (m)	1.5 x 0.25
Polarization	LHCP and RHCP

3. CIRCULARLY POLARIZED ANTENNAS

Generally, the polarization of an electromagnetic wave is defined as the orientation of its electric field vector. If the vector appears to rotate with time, then the wave is elliptically polarized. The ellipse so described may vary in ellipticity from a circle to a straight line, or from linearly to circularly polarize. Hence, the Circular polarization is a limiting case of the more general condition of elliptical polarization. In a circularly polarized, the plane of polarization rotates in a circle making one complete revolution during one period of the wave and can be obtained by combining two orthogonal linearly polarized radiating elements. The other special case is the easier to understand linear polarization. A linear polarized antenna radiates wholly in one plane containing the direction of propagation.

A circularly polarized element can also be generated by implementing a single feed with some perturbation on the radiator element.

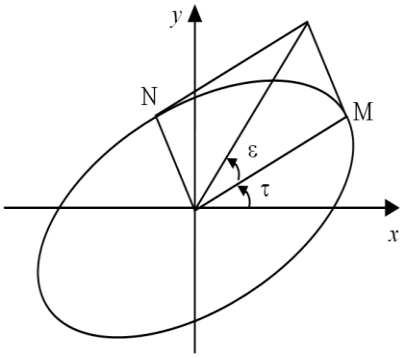

Figure 2. Polarization Parameters

The axial ratio (AR) is a very important characteristic for circularly polarized antennas. Generally, the polarization of an electromagnetic wave can be categorized by using AR parameter. Axial ratio is the ratio of the major axis to the minor axis of the polarization ellipse which commonly stated in units of dB. Based on Figure 2, the ellipticity as a function of AR is defined as.

$$\varepsilon = \cot^{-1}(R) \qquad (1)$$

Here, ε is ellipticity angle ($-45° \leq \varepsilon \leq 45°$) and R is the value of axial ratio. The value of axial ratio can be formulated as [5]

$$R = \frac{major\ axis\ length}{minor\ axis\ length} = \frac{E_{\max}}{E_{\min}} = \frac{OM}{ON} \qquad (2)$$

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Where OM (Emax) and ON (Emin) are the maximum and minimum of the electric field amplitude, respectively. The R is equal to 1 for perfect circular polarization and infinite for linear polarization. In the between of 1 and infinite, electromagnetic wave is classified as elliptical polarization. The axial ratio for pure linear polarization is infinite, because the orthogonal components of the field are zero.

The circular polarization sense can be right-hand and left-hand depends on the vector is turning clockwise (CW) or counter clockwise (CCW) in relation to the time. In term of polarization sense, the sign of R is positive for RHCP and negative for LHCP.

4. ANTENNA CONFIGURATION

The configuration of the antenna and its parameter's design are shown in Figure 3. The antennas consist of four circular patches (2 x 2) with radius r and fabricated on two layers substrate. The top layer substrate is for radiator element and the bottom substrate is for the synchronous feed. Each substrate having thickness (h) 1.6 mm, conductor thickness tc ≈ 35 μm, dielectric constant εr = 2.17 and loss tangent 0.0005. Each patch is fed by a proximity feed located at *(Xi Yi,) from its center*. Thus, the bandwidth of a proximity-coupled patch is inherently greater than the direct contact feed patch. Spacing between the patch (S) for both horizontal and vertical of 0 03Lamda, was chosen and overall size (W x L) of the antenna was 20x20 cm2. The method of moment (IE3D simulation software) with a finite ground plane model was employed to achieve the optimum parameters of the antenna design. The detailed optimum parameters of the antenna are r =5 mm, R=11 mm, r=4 mm, w=5 mm, w1= 2 mm, w2= 2 mm w3= 2 mm and w4= 2 mm. A SMA connector is used to feed the microstrip line on the edge of the substrate.

Several types of the previous sub array with synchronous feed are reported. However, the feed method is complex and need more junction and power divider. By implementing many junctions and power dividers make the size of the antenna become larger and heavy. Therefore, by implementing a compact synchronous feed method as sown in Figure 4, the design and fabrication of the antenna are made easier and smaller.

In order to design the antenna in LHCP the feed is started from the right element of the radiator and continue to next element in a form of circular

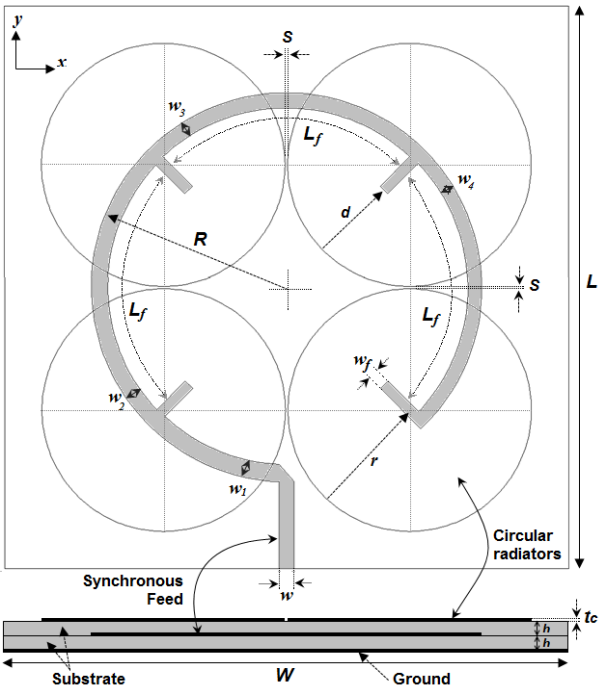

Figure 3. Configuration of sub array circular synchronous feed

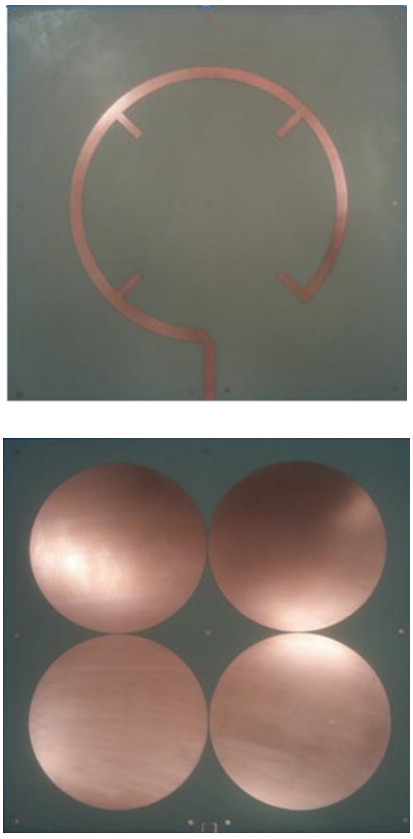

Figure 4. Photograph of fabricated proposed antenna: (a) synchronous feed, and (b) 2x2 circular radiators.

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5. PARAMETRIC STUDY OF THE ANTENNA

Results of the parametric study are reported in this section. The characteristics of the antenna in this sub array configuration are investigated in terms of the influence of the elements spacing, the length of feed, and width ratio of the feed. Other parameters are control to make sure the simulated result only effect by particular parameter.

a. Effect of Elements Spacing (S)

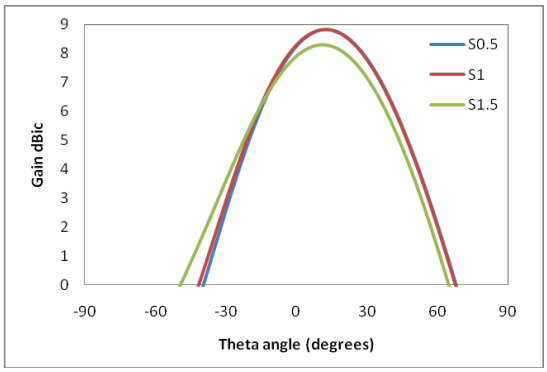

Figure 5. Simulation results showing the radiation pattern of the proposed antenna for various values of elements spacing (S)

b. Effect of the Feed Length (Lf)

The first parameter is the radius of the circular feed (R). Figure 6 shows the simulated result of return loss and axial ratio.

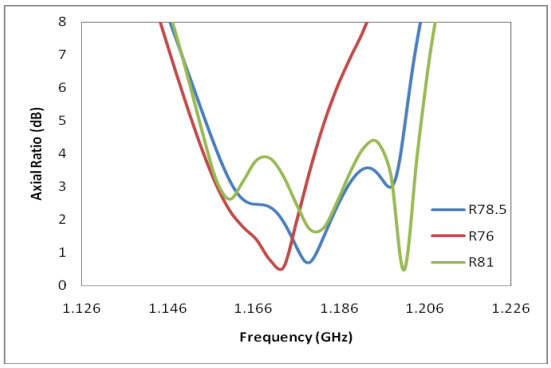

Figure 6. Simulation results showing the frequency dependence of the axial ratio (AR) of the proposed antenna for various values of feed length (Lf).

c. Effect of the Width Ratio of Feed (w_i)

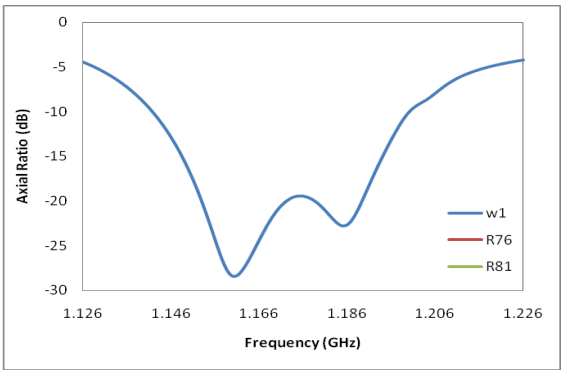

Figure 7. Simulation results showing the return loss (S_{11}) of the proposed antenna for various values of width feed ratio (w_i).

6. RESULT AND DISCUSSION

The novel synchronous feed sub-array antenna has been fabricated to verify the simulated result. The reflection coefficient (S11) is measured by a vector network analyzer (VNA K0022). The antenna's characteristics such as axial ratio, gain and radiation pattern are measured in the anechoic chamber in MRSL, CEReS, Chiba University. The schematic of measurement system and photograph antenna under test (AUT) can be seen as Figure 8. The antenna performance in simulated and measured result is plotted as presented in Fig. 9-11.

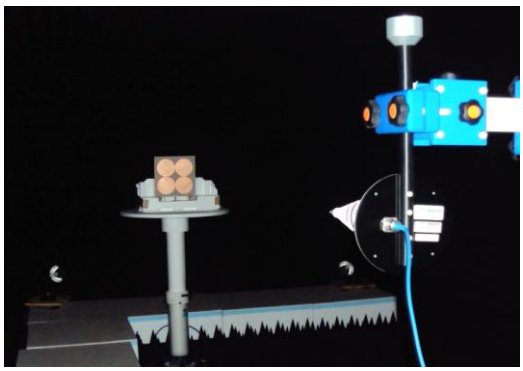

Figure 8. The schematic of measurement system

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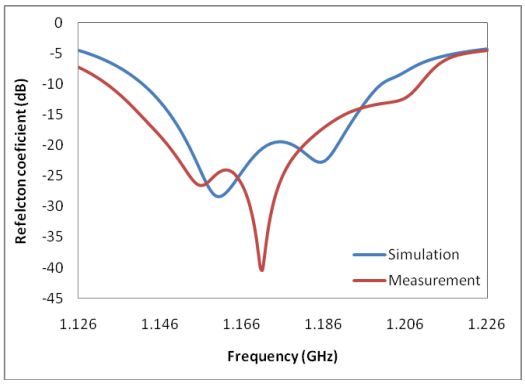

Figure 9. Simulated and measured reflection coefficient vs. frequency

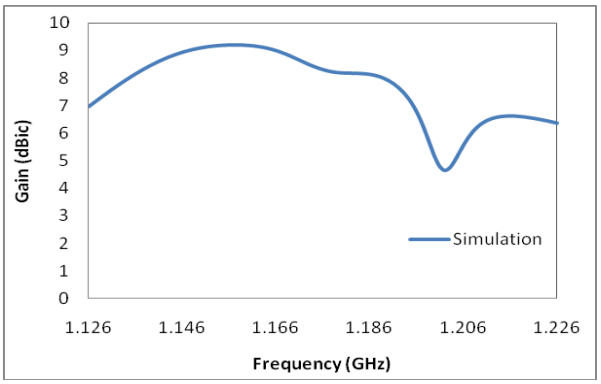

Figure 12. Simulated and measured gain (G) vs. frequency at $\theta = 0^{o}$.

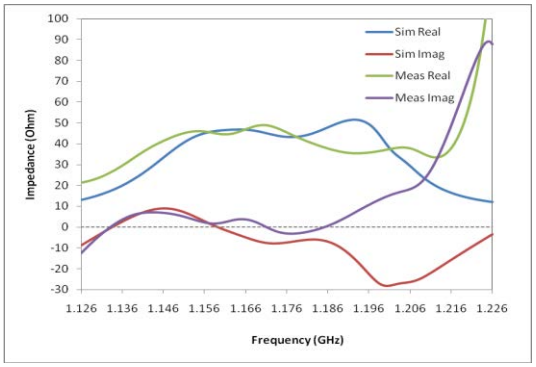

Figure 10. Simulated and measured input impedance (Z_{in}) plotted as a function of frequency.

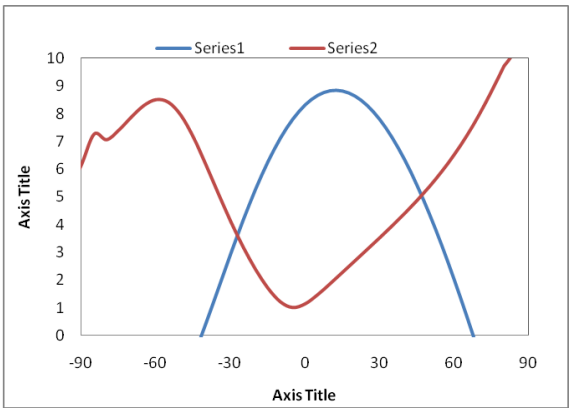

Figure 13. Array antenna characteristics in the theta plane (x-z plane) at $f = 1.27$ GHz: (a) gain versus theta angle, and (b) axial ratio versus theta angle.

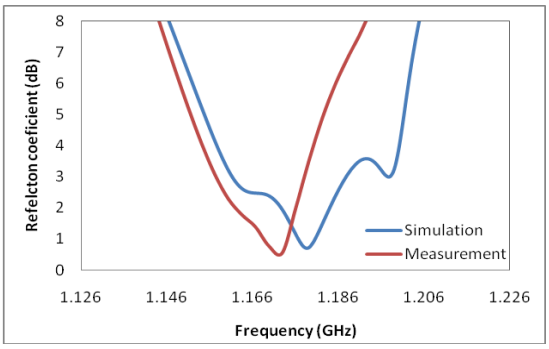

Figure 11. Simulated and measured axial ratio (AR) vs. frequency at $\theta = 0^{o}$.

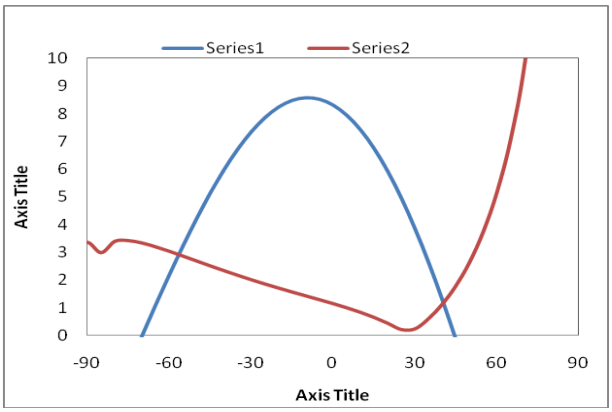

Figure 14. Array antenna characteristics in the theta plane (y-z plane) at f = 1.27 GHz: (a) gain vs. theta angle, and (b) axial ratio vs. theta angle.

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7. CONCLUSION

A novel compact synchronous feed has been described for the generation of circular polarization (CP) radiation. The simulation has done to achieve the optimum performance in studying the proposed antenna. The measured impedance bandwidth (<-10dB) and 3-dB axial ratio bandwidth has been attained around 60 MHz, and 28 MHz, respectively. The maximum measured gain is fairly high of about 7.11 dBic in the operating band (1.176 GHz). In general, numerical analyses using the method of moment can lead to a good agreement with experimental results. The slight differences of antenna performance between the simulation and measurement are probably due to imperfection during the fabrication and measurement processes. With its good performance, this novel antenna design will be useful to be applied on L-band BISAR system onboard UAV.

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