3D Print X-band Horn Antenna for Ground-based SAR Application

Yohandri[1], **Rahmad Arif Syafrindo**[1], **Josaphat Tetuko Sri Sumantyo**[2], **Cahya Edi Santosa**[2], **and Achmad Munir**[3]

[1]Physics Department, Faculty of Mathematics and Natural Science, Universitas Negeri Padang, Indonesia
[2]Josaphat Microwave Remote Sensing Laboratory, Center for Environmental Remote Sensing
Graduate School Advanced Integration Science, Chiba University, Japan
[3]Radio Telecommunication and Microwave Laboratory, School of Electrical Engineering and Informatics
Institut Teknologi Bandung, Indonesia

Abstract— The Ground-Based Synthetic Aperture Radar (GB-SAR) system is developed in our research. The system which is proposed for landslide monitoring operates in X-band frequency with the center frequency 10 GHz. In this paper, the light pyramidal X-band horn antenna implemented for the system is presented. The optimization of antenna design is carried out using CST software. Based on the optimum design, the proposed pyramidal X-band horn antenna is fabricated using a high resolution 3D printer with a polylactic acid (PLA) applied as 3D printing filaments. The printed antenna is then coated using polyurethane on its surface. From the characterization result, it shows that the working bandwidth of proposed pyramidal X-band horn antenna is about 2.9 GHz with reflection coefficient of −69 dB and −16 dB for simulation and measurement, respectively. A good agreement has been achieved between the simulated and measured results indicating that the proposed antenna has satisfied for our GB-SAR system.

1. INTRODUCTION

As is well-known, the terrene in Indonesia comprises of many mountains and hills. Due to its geographic location in the tropical area, Indonesia has a high level of rainfall which causes many of areas are prone to landslides. Therefore, to prevent the damage and victim of landslides, it is very important to monitor the landslide movement especially in the suspected area. There are several methods for monitoring movements of landslide surface, some of them are using geographic information system (GIS) and wireless sensor network [1, 2]. Although it is effective to obtain the data accurately, however the method is hard to be implemented since some of network devices should be installed directly on the surface of landslide.

Other approaches have been proposed by many researchers involved in geology activities by utilizing radar remote sensing systems [3–7]. The change of ground surface after landslides has been detected by using SAR interferometry [3–5]. The method is developed based on phase difference between two SAR images which reflects geometrical change along the line of sight of radar system. Due to the drawback of SAR interferometry in producing low resolution of image, hence some extensions of the method have been performed using GB-SAR system [6, 7].

In order to maintain monitoring process of landslide movement, the GB-SAR with high gain and wide bandwidth antenna is required. Several antennas intended for air vehicle communications as well as for SAR application have been designed and realized [8–11]. However, the antennas were designed for rocket communication and SAR onboard unmanned aerial vehicle (UAV) systems and could not be operated continuously in the potential areas of landslides. Therefore, a development of horm antenna for GB-SAR application is proposed in this paper. The proposed antenna is intended to work at X-band frequency and realized using a high resolution 3D printer.

2. DESIGN AND REALIZATION OF X-BAND HORN ANTENNA

The GB-SAR system consists of two antennas which operate as transmitter antenna and receiver antenna as illustrated in Figure 1. In this work, a pyramidal horn antenna developed in a 3D printed antenna is proposed for the GB-SAR system operates at X-band frequency. Parameters of the antenna is calculated based on the required working frequency of GB-SAR system. Figure 2 shows essential parameters of pyramidal X-band horn antenna consisting of waveguide and aperture with material thickness (h). Meanwhile, geometrical design of the antenna is optimized using CST Studio Suite where the optimum parameters are summarized in Table 1.

The optimum parameter of antenna obtained from the simulation is exported and used as dimension parameter in 3D printing. Figure 3 shows the fabrication process of antenna using a 3D printer. Whilst photographs of printed pyramidal X-band horn antenna before and after being coated using polyurethane are visualized in Figure 4.

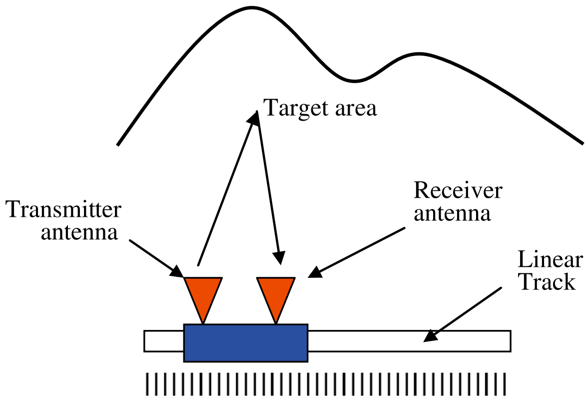

Figure 1: Illustration of GB-SAR system.

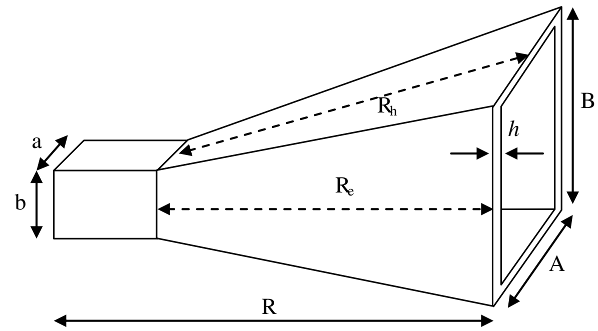

Figure 2: Geometry of pyramidal horn antenna.

Table 1: Parameters of pyramidal X-band horn antenna.

Parameters	Value (mm)
λ	30
λ_g	23
a	31
b	16.5
R_h	60
R_e	60
R	60
h	1.1

3. RESULT AND DISCUSSION

Based on the result of antenna characterization, reflection coefficient, voltage standing wave ratio (VSWR), efficiency, and radiation pattern are depicted in Figures 5–8, respectively. From Figure 5,

Figure 3: Fabrication of pyramidal X-band horn antenna using 3D printer.

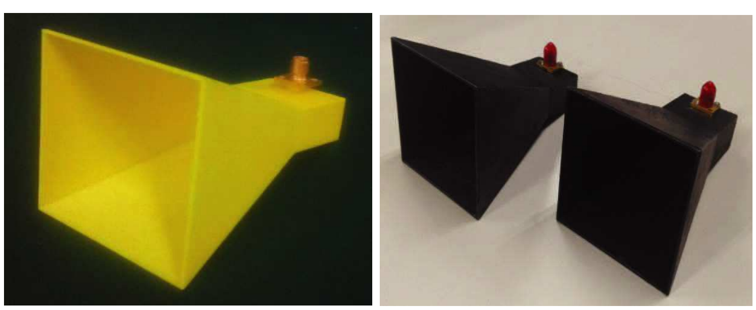

Figure 4: Photographs of printed X-band horn antenna; left is horn antenna before being coated; right is horn antenna after being coated using polyurethane.

good agreements in term of bandwidth of working frequency are achieved between the simulated and measured results. It shown that the achievement of working bandwidth is about 2.9 GHz with reflection coefficient of −69 dB and −16 dB for simulation and measurement, respectively. The discrepancy which occurs between simulation and measurement is probably evoked by the material setting during simulation.

Furthermore, the simulated and measured VSWR in Figure 6 shows that the measured value at working frequency of 10 GHz is 1.11 bit higher than the simulated one of about 1.02. Whereas from the graphs of efficiency and radiation pattern plotted in Figures 7 and 8, respectively, the characterization results show that the proposed pyramidal X-band horn antenna has satisfied requirements for the GB-SAR system.

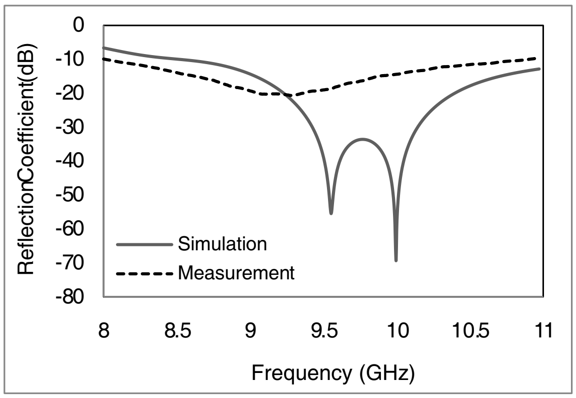

Figure 5: Simulated and measured reflection coefficient of pyramidal X-band horn antenna.

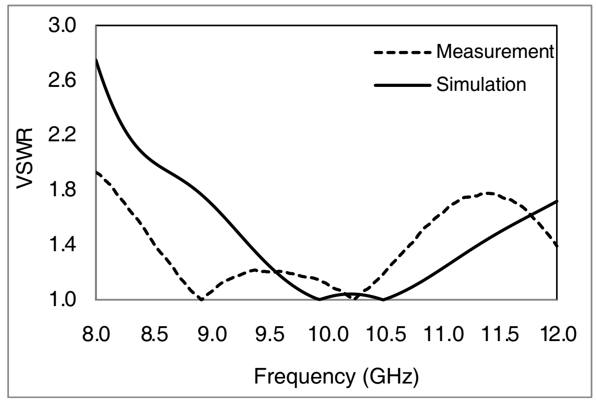

Figure 6: Simulated and measured VSWR of pyramidal X-band horn antenna.

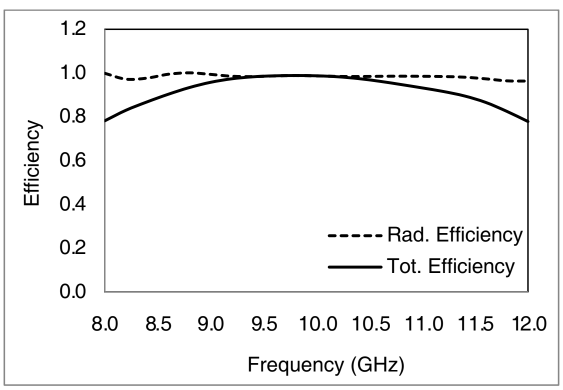

Figure 7: Efficiency of pyramidal X-band horn antenna.

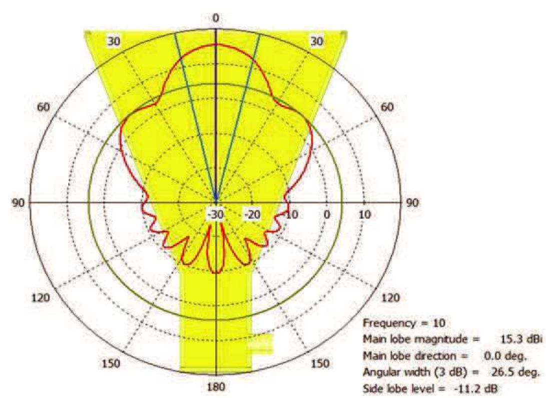

Figure 8: Radiation pattern of pyramidal X-band horn antenna.

4. CONCLUSION

The development of 3D print X-band horn antenna for GB-SAR application has been successfully demonstrated. The printed antenna has shown adequate performances in terms of return loss, VSWR, efficiency and radiation pattern. A good agreement has been obtained between the simulated and measured results indicating that the antenna properties have mostly satisfied the requirements for the GB-SAR system. In the future work, the performance of proposed pyramidal X-band horn antenna will be enhanced and implemented on the GB-SAR system.

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