Miniaturization Design of Horn Antenna Metal Rods Addition Technique for S-Band Applications

Fitri Yuli Zulkifli, Muhammad Ichsan, Basari, Eko Tjipto Rahardjo
Antenna Propagation and Microwave Research Group (AMRG),
Department of Electrical Engineering, Faculty of Engineering, Universitas Indonesia,
Kampus Baru UI Depok, 16424 Indonesia

Abstract—**Horn antenna offers essential benefits such as high gain, wide bandwidth, and ease of fabrication. One of the drawbacks of horn antenna is its relatively large dimension. Hence, this paper proposes a miniaturized design of a conventional horn antenna using metal rod addition technique. In order to reduce the dimension of the antenna, it utilizes two metal rods that are placed perpendicular to each other inside the antenna aperture. This antenna is numerically analyzed by using the Finite Integration Technique. The simulated results show that the proposed horn antenna can reduce the antenna dimension from the conventional horn by 35.72% without decreasing the antenna gain. In addition, the antenna operates in the frequency range 2.8 GHz – 3.1 GHz for S-band applications. The gain can be obtained by 12.2 dBi with 43.8o of the halfpower beamwidth and -18.6 dB of the side lobe level.**

Keywords-High gain, horn antenna, metal rod addition, miniaturization, S-band applications.

I. INTRODUCTION

Nowadays, the necessity for antennas that are low profile, with a relatively small size and light weight but still have a good performance is greatly increasing. However, the smaller size of the antenna usually excites lower gain. One of the antennas that has a high gain, wide bandwidth, high efficiency and high power handling is the horn antenna. However, it typically has bulky and huge dimension, especially if the antenna is designed to work at low frequency.

Due to the characteristics of high gain and wide bandwidth, horn antenna is widely used in several long-range communication applications such as satellite, radar and deep space communications [1]. Some of these aforementioned applications works at S-band (2.8-3.1 GHz), therefore many researches of antennas conducted at S-band uses other type of antenna to avoid large dimension for antenna like in [2] and [3]. In [4], a horn antenna is designed to work at S-band, however this antenna has a quite large dimension.

However, despite of horn antenna's drawback, in particular in terms of its quite large dimension, it still has high performances. Therefore, in order to utilize its high antenna performances with quite small dimension, it requires a special miniaturization technique.

The antenna gain is related to the area of the antenna's surface. If the dimension of the antenna is reduced, this will affect the operating frequency of the antenna and lower the antenna gain. In order to maintain the antenna gain, this requires a technique to miniaturize the antenna dimension without reducing the gain of the horn antenna. One of the techniques is to add two metal rods, which are placed perpendicular to each other inside the antenna aperture [5]. By using this technique, the gain will increase and the operating frequency of the horn antenna will decrease. In this paper, a parametric study of the perpendicular rods that is applied in the aperture is investigated to achieve higher gain for the horn antenna with smaller dimension.

II. DESIGN OF CONVENTIONAL HORN ANTENNA

One of the simplest and most widely used antennas is the horn antenna. Horn antenna is a microwave antenna that is widely used. These antennas are used in microwave telecommunication systems.

The Parameters of horn antenna that will be designed can be seen in Figure 1:

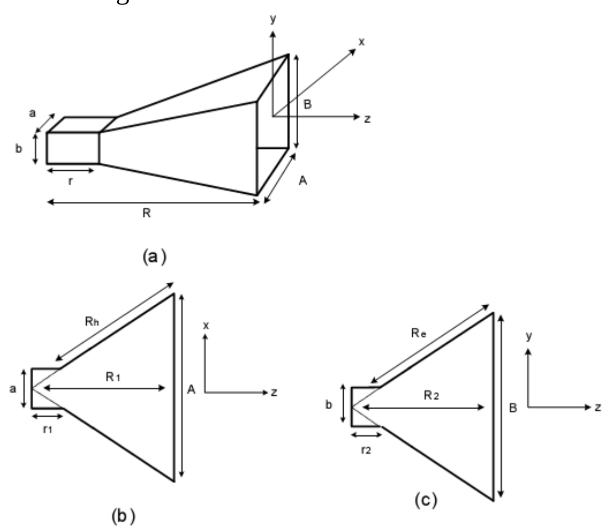

Figure 1. Parameters of conventional pyramidal horn antenna (a) 3D view (b) xz view (c) yz view [1]

Based on Figure 1, the parameters of the conventional horn antenna were obtained from calculation and iteration.

The dimensions are a =16.9 cm, b = 8.66 cm, r = 6.5 cm, Rh = Re = 10 cm, A = 20.43 cm and B = 15.58 cm.

The results of the conventional horn antenna are gain of 12 dB and operating frequency with VSWR ≤1.5 is from 2,8 GHz to 3,1 GHz.

III. Proposed Antenna

In this study, metal rods addition technique is used to increase antenna gain and to decrease the operating frequency of the antenna. Therefore, to maintain the operating frequency of the antenna, the dimensions of the horn antenna must be reduced. The design of the modified horn antenna can be seen in Figure 2 below with dimensions a =11.2 cm, b = 6.2 cm, r = 6.5 cm, Rh = Re = 10 cm, A = 14.4 cm, B = 11.9 cm, h = v = 0 cm, j = 3.25 cm and t = 2 cm. The simulated results show that the proposed horn antenna can reduce the antenna dimension from the conventional horn by 35.72%.

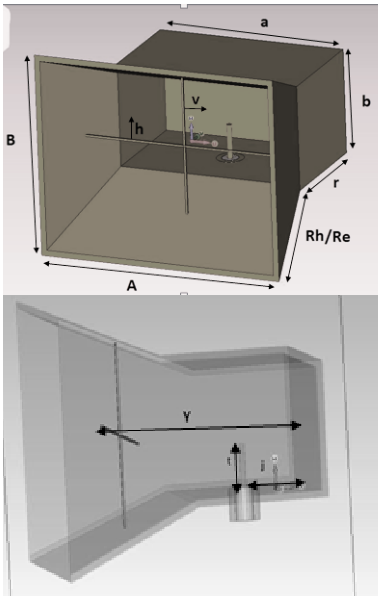

Figure 2. Parameters of the modified horn antenna

To achieve the aforementioned dimensions of the modified horn antenna, the location of the metal rod in vertical and horizontal plane plays an important role. The location of the vertical rod starts from the center (v = 0 cm) and shifted to v = 3 cm. The influence of the location of the vertical rod towards the S11 parameter is shown in Figure 3.

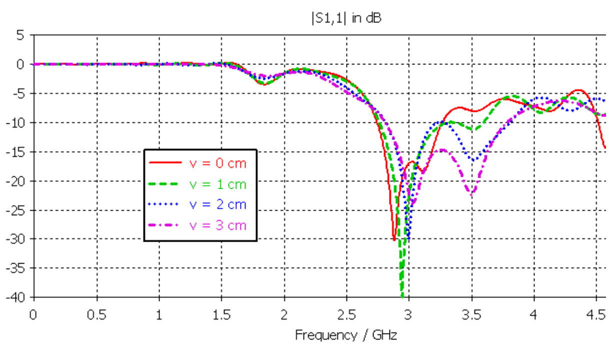

Figure 3. Influence of the metal rod in the vertical plane towards S11 parameter

The location of metal rods in the vertical plane affects the frequency of the antenna, the farther the location of metal rod from center, the frequency of the antenna increases. This same influence occurs also toward the next parameter which is the location of the metal rod in horizontal plane as depicted in Figure 4.

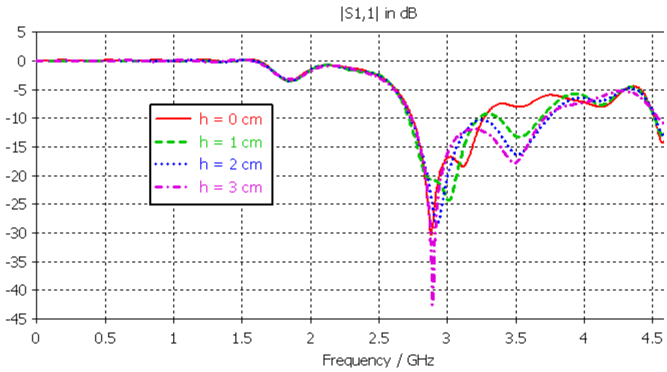

Figure 4. Influence of the metal rod in the horizontal plane towards S11 parameter

The simulation result of the proposed antenna shows that the operating frequency is at 2.8 GHz - 3.1 GHz with gain of 12.2 dBi.

IV. Simulated and Measured Results

Based on the design and dimensions of the modified horn antenna, Figure 5 and Figure 6 shows the simulated result of S_{11}, radiation pattern and antenna gain.

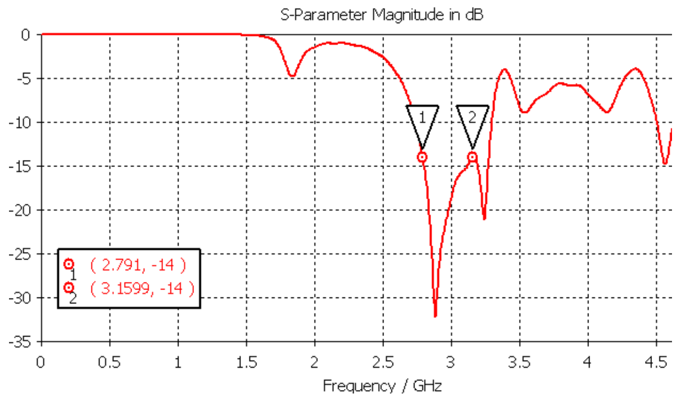

Figure 5. Simulation result of proposed modified horn antenna

From Figure 5 above, the simulation result shows that at return loss of -14 dB the proposed antenna works at frequency 2.79 GHz to 3.15 GHz. The radiation pattern depicted in Figure 6 shows the half power beamwidth of 43.8^o and the side lobe level is -18.6 dB. In addition, the antenna gain is 12.2 dB. From these simulation results, the modified horn antenna has better performance compared to the conventional horn antenna. The modified horn antenna has improved the antenna gain of 0.2 dB despite the reduction of size of 35.72%.

Figure 6. E-plan radiation pattern and gain simulation result of proposed antenna

Afterwards, the antenna is fabricated and measured in anechoic chamber. The measurement result of the antenna is shown in Figure 7 and Figure 8.

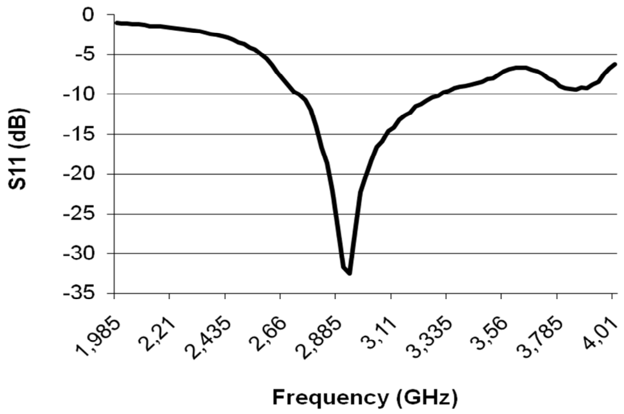

Figure 7. Simulation result of proposed modified horn antenna

The measurement result shows that at return loss of -14 dB the proposed antenna works at frequency 2.79 GHz to 3.32 GHz. The measured impedance bandwidth result shows a slight broader band of 17 MHz compared to the simulated result. However the results show good agreement.

The measured radiation pattern depicted in Figure 8 shows the half power beamwidth of 40^o and the side lobe level is -18.69 dB. The measured antenna gain is 12.4 dB, which is slightly higher than the simulated gain of 12.2 dB.

Overall, the simulated and measured results of the modified horn antenna are in good agreement. The slight difference between simulated and measured results are due to imperfect fabrication of the antenna.

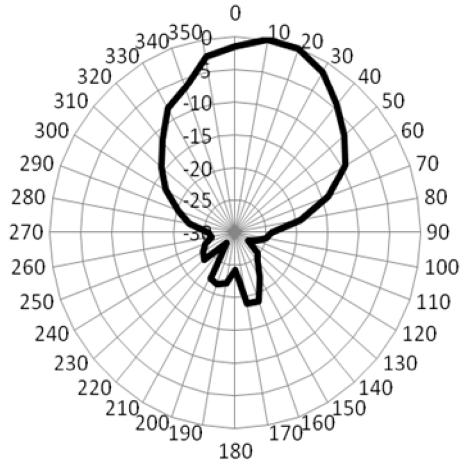

Figure 8. E-plan radiation pattern and gain simulation result of proposed antenna

V. Conclusion

The modified horn antenna design using metal rods addition technique can reduce the dimensions of the conventional horn antenna to 35.72% and increase the antenna gain to 0.2 dB. In addition, the antenna operates in the frequency range 2.8 GHz – 3.1 GHz for S-band applications. The half power beamwidth is 43.8^o and the side lobe level is -18.6 dB.

Acknowledgement

1) The authors would like to thank for the partially support of this work under Hibah SINAS, Radar Consorsium, Ministry of Research and Technology Republic of Indonesia.

References

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DISSCUSSION

Prof. Dr. Wolfgang-Martin Boerner: Dual polarize antenna or wideband antenna?
Fitri Yuli Zulkifli: SBand dual polarize Antenna
Letkol Arief Meidyanto (BAKORKAMLA): How to reduce the angle beamwitdh an antenna? Because to reduce angle beamwidth it can made the dimension more wide?
Fitri Yuli Zulkifli: it can cover with reflect array antenna
Laksono Widyo (PT. LEN): What main secret of compact antenna with high gain?
Fitri Yuli Zulkifli: modify and optimization in substrate antenna and reflector