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Comparison Design of The Feeding Method of A 4x4 Microstrip Array Antenna.

Farohaji Kurniawan[1;2], Josaphat Tetuko Sri Sumantyo[1], Cahya Edi Santosa[2], Peberlin Parulian Sitompul[1;3], Pachrur Razi[1,4], Gunawan Setyo Prabowo[2], Agus Bayu Utama[2].

1Josaphat Microwave Remote Sensing Laboratory, Center for Environmental Remote Sensing
Graduate School Advanced Integration Science, Chiba University, Japan
2Center for Aeronautics Technology, National Institute of Aeronautics and Space, Bogor, Indonesia
3 Center for Space Science, National Institute of Aeronautics and Space, Bandung, Indonesia
[4] Physics department, Universitas Negeri Padang, padang, Sumatra, Indonesia

Abstract-The antenna design intended to develop at working frequencies 8.0 to 8.4 GHz. The array antenna designed in 4x4 array antenna with sequential phased feeding network. In this research, two feeding methods had been investigated and compared. That is microstrip feeding line and pin feeding line — this procedure aimed to find the most effective and its capability of feeding method. The circular shape is the main form of the patch design, then truncated by triangular shaped. And elliptical ring slot laid in the center of the patch antenna. The total size of the proposed antenna is 128 x 128 mm and printed on NPC-H220A which has a thickness of 1.6mm, dielectric constant 2.17 and losses tangen 0.005. The performances of the antenna design are satisfied. The maximum gain reached about 12 dBic for microstrip feeding line method then pin feeding method could be obtained up to 14dBic. Moreover, reflection coefficient, S11 of the pin feeding method attained of 9.7% (7.6 – 8.6 GHz), and at its center frequency obtained of -20 dB reflection coefficient. While microstrip feeding line could achieve dual band at 7.4-8.39 GHz and 8.69-9.47 GHz or 23. 3%. The main lobe direction of the array is at 0 degrees. The array design delivered excellent performance for satellite communication applications.

1. INTRODUCTION

It is well-known that antenna plays essential roles in modern devices such as communication [1-2], radar [3], image processing [4-5], etc. Some example of the antennas application for the communication system is implementing in Lapan-Chibasat/GAIA II project (X-band data communication and S-band telecommand). The working frequencies of the X-band antenna at 8.0-8.4 GHz. While working frequencies of the S-band antenna is at 2.2 – 2.3 GHz. This antenna design is purposed for the data communication system.

The proposed antenna designed at microstrip material, due to its superiority in term of low profile, easy to fabricate, compactness and cheap [6-8]. The antenna design is printed on NPC-H220A which has a thickness of 1.6mm, dielectric constant 2.17 and losses tangen 0.005.

The minimum requirement of the gain is up to 12 dBic, with a minimum bandwidth of 400 GHz of the reflection coefficient, S11, and axial ratio. The polarization of the antenna must be circularly polarized, then -10dB for the reflection coefficient. The beam direction of the proposed antenna set to be 0 degrees, it is to avoid misaligned between vehicles and ground station. For more detail, the complete minimum requirement of the antenna design shown in table.1.

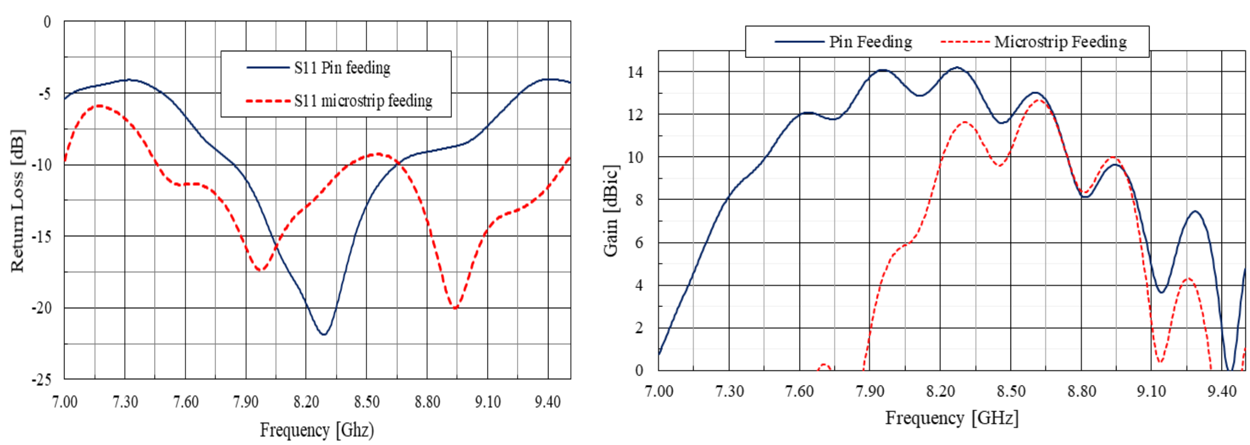
TABLE 1: Minimum requirement of the antenna.

Parameter	Specification	Units
Frequency	8.0 to 8.4	GHz
VSWR	≤ 2	
Polarization (T_x/R_x)	Left-handed circular polarization	
Axial ratio (AR)	≤ 3	dB
Return loss	≥ 10	dB
Gain	≥ 10	dBic
Weight	< 0.4	kg
Thickness	< 10	mm
Temperature (ºC)	–50 to +55	
Operating altitude	550–800	km
Vibration	14	g rms

This antenna is designing in circular polarization]. It was due to its advantages; more resistant to the Faraday rotation, Immune to the signal degradation cause of atmospheric environment, less of a risk of being misaligned and higher link reliability [9-10]. In this design, Triangular truncation implemented to generate circular polarization properties. A sequential rotation also implemented in this antenna network feeding. This method aimed to strengthen the circularly polarized characteristics and their gain. The antenna design could be obtained maximum gain reached about 12 dBic for microstrip feeding line method then pin feeding method could be obtained up to 14 dBic. Moreover, reflection coefficient, S11 of the pin feeding method attained of 9.7% (7.6 – 8.6 GHz), and at its center frequency obtained of -20 dB reflection coefficient. While microstrip feeding line could obtain dual band at 7.4-8.39 GHz and 8.69-9.47 GHz or 23. 3%.

2. ANTENNA DESIGN AND PARAMETERS

In this antenna research, comparison of the feeding design is investigated to understanding their advantages. Figure 1 depicts influences of the feeding type to the reflection coefficient, S11 and to the gain.



(a) (b)

Figure 1. Comparison design of feeding method: a) Reflection coefficient, b) Gain.

Figure 1. a, shows the comparison result of the reflection coefficient, S11 from two feeding line methods. It is shown that the reflection coefficient, S11 by pin feeding method could be release power of the antenna stronger than reflection coefficient, S11 by microstrip feeding line method. It can be proved by the depth of the reflection coefficient, S11 curve. The Deepest point of the reflection coefficient, S11 of the pin feeding is at 8. 29 GHz and obtained -21 dB of the reflection coefficient and its total bandwidth is 9.7% (7.6 – 8.6 GHz). On the other side, the feeding line method could be provided dual-band frequencies, that are at the 7.4-8.39 GHz and 8.69-9.47 GHz. The deepest point from this method is at 8.9 GHz of -19 dB reflection coefficient, S11. Nevertheless, these working frequencies were out of desired frequencies.

The comparison result of the gain shown in figure 1.b. Pin feeding method could provide more high and more broadband of the gain. Average value of the gain of pin feeding method at the working frequencies (8.0 – 8.4 GHz) is about 14 dBic. While the average value of the gain of microstrip feeding line at the working frequencies is about 11dBic, for the pin feeding method, its center frequency (8.2 GHz) could be reached 13.6 dBic. On the other side, Microstrip feeding line method could be obtained nothing but 9.8 dBic. For more detail of the comparison result shown in table 2.

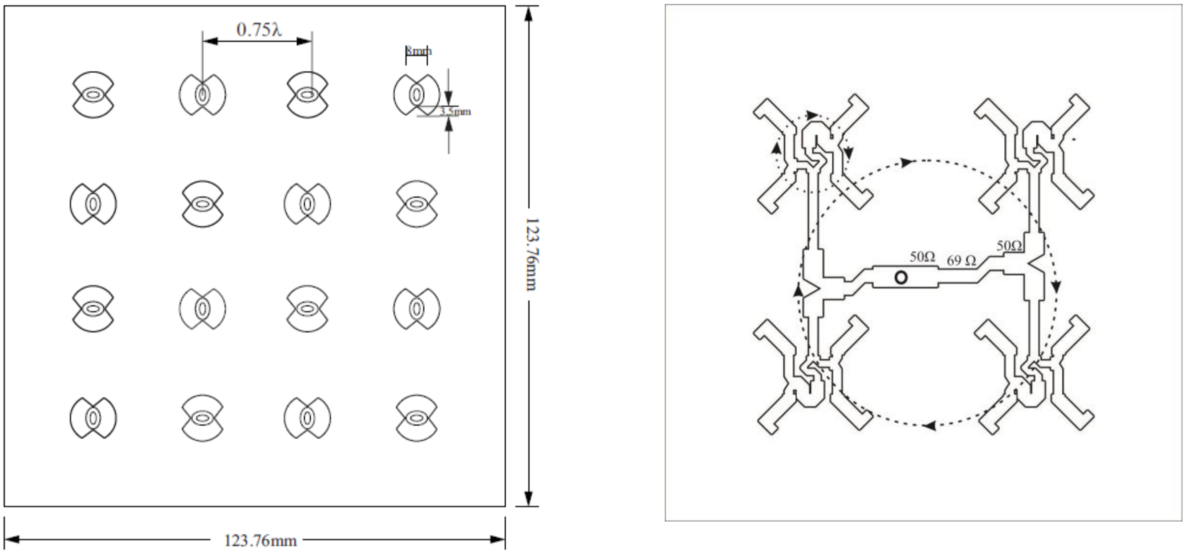
Table 2. Simulation result of the reflection coefficient, S11 of the feeding methods variation

Type of Feeding	**Desired frequencies (GHz)**	**At the center frequency /8.2 GHz (dB)**	**Working frequencies (GHz)**	**Deepest value (GHz)**
Microstrip feeding line	8.0 – 8.4	-12.5	7.4-8.39 and 8.69-9.47	8.9 GHz of -19 dB
Pin feeding	8.0 – 8.4	-19.8	7.6 – 8.6	8.29GHz; -21dB

Table 3. Simulation result of the gain of feeding methods variation

Type of Feeding	Desired frequencies (GHz)	At the center frequency /8.2 GHz (dBic)	The average value (dBic)	Highest value (GH)
Microstrip feeding line	8.0 – 8.4	9.8	8.3	8.28GHz; 14.18dBic
Pin feeding	8.0 – 8.4	13.6	13.5	8.62GHz; 12.6dBic

Evidently, that Pin feeding method has a better impact on reflection coefficient, S11, and Gain. Thus, The final design of the proposed antenna used pin feeding method. The configuration of the final design of the proposed antenna shown in figure 2.



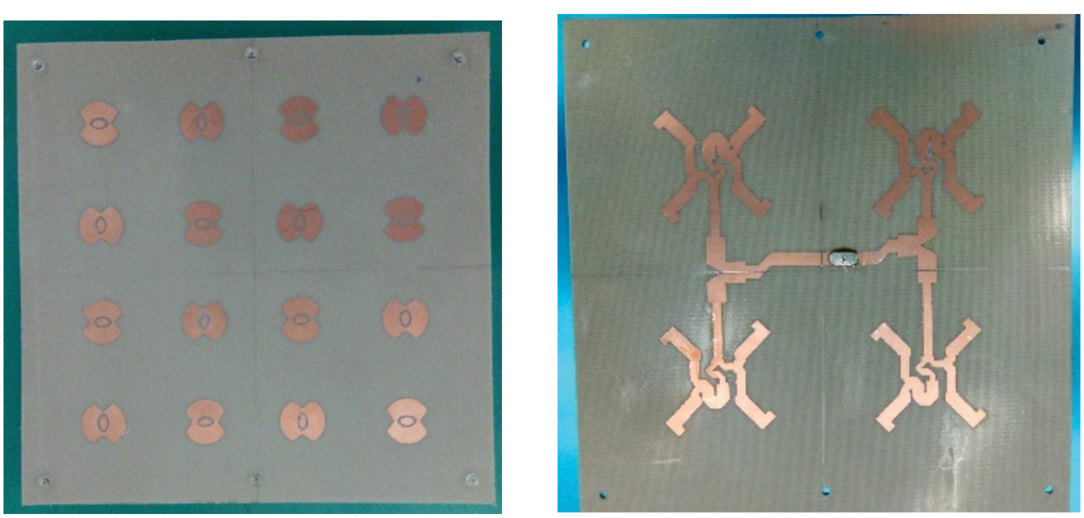
(a) (b)

Figure 2. The configuration of 4 x 4 array antenna.

Figure 2.(a), depicts the front layer of the antenna design, every patch of the proposed antenna separated by 0.75λ. Then figure 2.(b) depicts the feeding line using sequential rotation method by relative phase of 0^o, 90^o, 180^o, and 270^o.

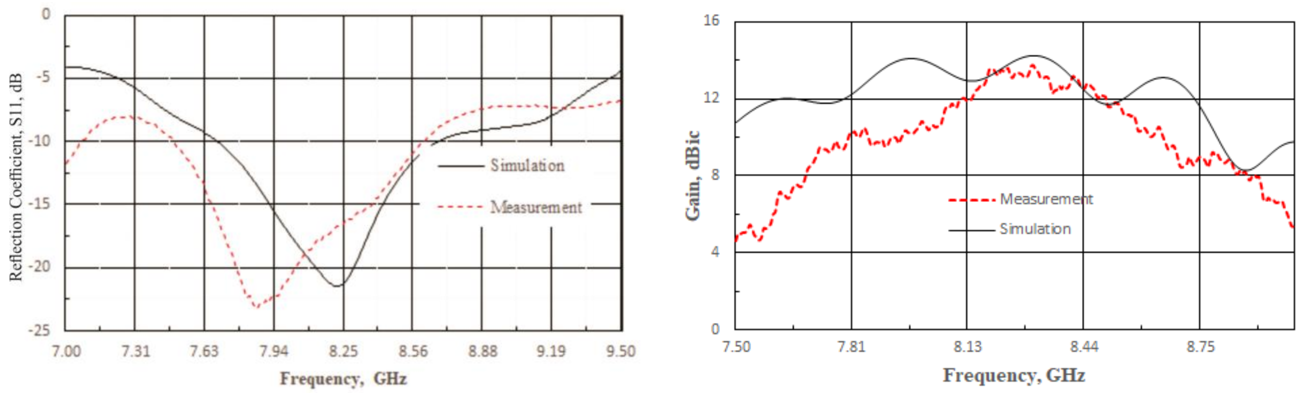
3. RESULT AND DISCUSSION

Fabrication antenna is shown in figure 3. The 4x4 array antenna etched on NPC-H220A material, its dielectric constant 2.17 and this material has a thickness of 1.6mm. The total dimension of the proposed antenna is about 128 x 128 mm. The comparison between measurement result and the simulation result shown in figure 4.



(a) (b)

Figure 3. Fabricated the 4 x 4 array antenna.



(a) (b)

Figure 4. The comparison result of the simulation and measurement of; (a) Reflection coefficient, S11, (b) Gain.

The measurement result of the antenna design, shown that the fabricated antenna fulfill the minimum requirement and its measured result met the agreement with the simulated result. Figure 4. (a) highlight that the reflection coefficient result, S11 of the measured antenna achieved a deeper curve compare to the simulated one, it is about -23.4 dB at the frequency 7.83 GHz. Then, measured one obtained -16.8 dB at the center frequency (8.2 GHz). And also it has a bandwidth of 14% (7.48 – 8.65 GHz). Compare to the simulated result, the fabricated antenna produced wider bandwidth but its result shifted to the lower frequency.

Figure 4. (b) depicts the comparison result of the measurement and simulation of the gain. The measured gain shows the suitability with simulated gain. Its result obtained 13.3 dBic in the center frequency (8.2 GHz). Overall, the average values of the measured result of the gain reached up to 12 dBic. It can be concluded that the fabricated antenna could produce decent gain at the working frequencies (8.0 – 8.4 GHz).

CONCLUSION

The antenna design has decent performances both simulation and measurement. The measurement result of the proposed antenna was shifted to the lower frequencies. However, its result could fulfill the minimum requirement. The simulated result reached 9.7% (7.6 – 8.6 GHz) reflection coefficient, S11, then the measured result obtained of 14% (7.48 – 8.65 GHz) reflection coefficient, S11. Both measured and simulated gain reached up to 12 dBic at the desired frequencies. The decreasing and shifting of the measured result due to imperfect in the fabrication process or error during measurement activities.

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