Sidelobe Level Suppression Using Unequal Four-Way Power Divider for Proximity Coupled Microstrip Antenna

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***Abstract* — A four-way unequal power divider is developed to feed a linear array proximity coupled microstrip antenna. The unequal power divider excitation coefficients follow the chebyshev polynomial. The simulation result shows that the four element proximity coupled microstrip antenna array with unequal power divider has achieved a sidelobe level suppression of 18.7 dB with backlobe level suppression of 16.5 dB. Furthermore the antenna gain of 8.81 dB was also achieved. Measurement results of the antenna with unequal power divider show similar result with the simulation. Measurement results show sidelobe level suppression of 18.1 dB with backlobe level suppression of 19.4 dB.**

***Index Terms* — unequal power divider, proximity coupled, microstrip antenna, sidelobe suppression**

I. INTRODUCTION

Microstrip antennas have been used for many applications such as telecommunication, biomedical engineering, remote sensing and radar. Each application requires unique specification for the system. Sidelobe suppression is one special specification required for applications that requires high precision. In tracking radar, low sidelobe level is required to avoid interference from other detected target. Usually, a sidelobe level less than -14 dB is required and some applications up to -25 dB.

Several methodes to suppress sidelobe is using tapered excitation like dolph-chebyshev [1], chebyschev [2] and two-stage tournament-configuration of three Y-junctions [3]. The paper [1] applied the tapered power divider for aperture coupled microstrip antenna of total (8 x 32) 256 elements at the subarray of 8 x 4 elements and achieved sidelobe level suppression of 22 dB. Paper [2] designed the tapered power divider with 10 rectangular patches which works at C-band with sidelobe level suppression of 25 dB, while paper [3] uses Y-junctions for the four-line comb-line antenna with 4 x 14 elements that works at frequency 76.5 GHz. The sidelobe level suppression in paper [3] is 20 dB. The sidelobe level from paper [1] to [3] is below 20 dB by applying it to a complex antenna array structure.

This paper presents a simple structure of four element proximity coupled microstrip antenna with unequal power divider to suppress sidelobe level.

II. POWER DIVIDER DESIGN

In this section, equal and unequal power divider are designed using CST Microwave software. The simulation results between both power divider are compared to analyze the improvement of the side lobe suppression conducted by using the unequal power divider.

Basic configurations of equal power divider as well as the unequal power divider are shown in Fig. 1 and Fig.2. The equal power divider design is the uniform excitation from T-junction power divider, while the unequal power divider uses the tapered excitation with chebyshev polynomial. The power divider feeds four-array antenna, therefore it is designed with four ports which are port 2, port 3, port 4 and port 5.

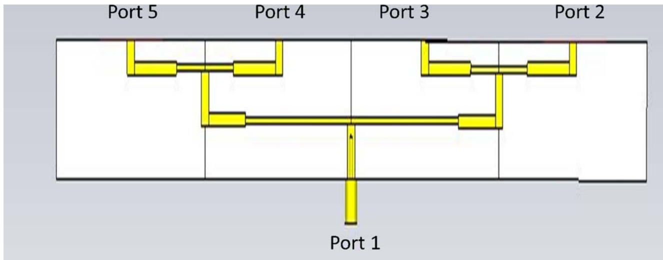

Fig 1. Equal 4-way power divider

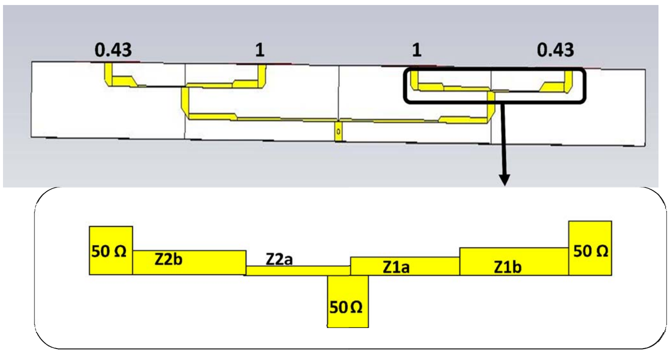

Fig 2. Unequal 4-way power divider

For the unequal power divider, the amplitude of the tapered excitation is designed with ratio as follow 0.43:1:1:0.43. To achieve impedance matching of 50 ohm, impedance matching

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using quarter-wavelength impedance transformers are applied to the dividers, where Z1a =166 Ω, Z1b = 91.1 Ω, Z2a =71.5 Ω and Z2b = 59.8 Ω.

Figure 3 shows the inner ports 3 and 4 (S_{31} and S_{41}) with power of -6.1 dB while outer ports 2 and 5 (S_{21} and S_{51}) shows -9.6 dB. Therefore this power divider has unequal excitation. Furthermore, this power divider is designed for antenna that resonates at frequency 2.8 GHz – 3.1 GHz and therefore is achieved and shown from the S_{11} result.

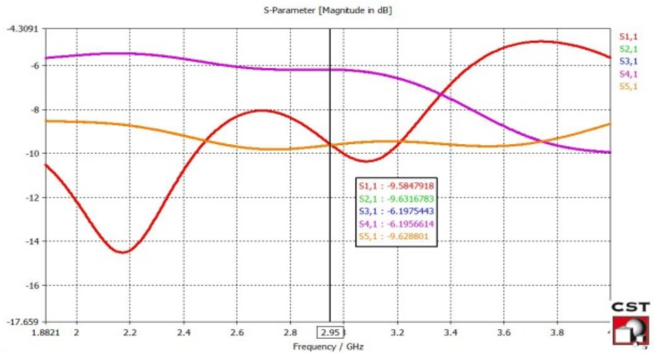
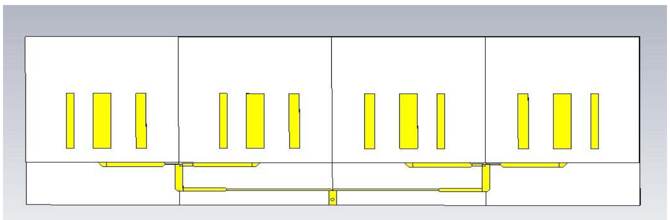


Fig 3. S-paramater simulation of unequal 4-way power divider

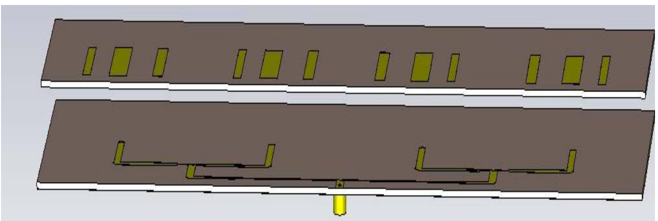
III. ANTENNA ARRAY DESIGN USING POWER DIVIDER

The proximity coupled microstrip antenna used for the array antenna is from [4]. Both antenna and feed with power divider uses substrate FR4 with dielectric constant of 4 and thickness of 1.6 mm. The single element antenna consists of side parasitic patch to achieve wide bandwidth from 2.8 GHz to 3.1 GHz.

The array antenna design is shown in Fig.4. The antenna consists of two layer substrates. The first layer is the side parasitic patch while the second layer is the feed with the 4-way power divider. Fig. 4(a) shows the top view of the antenna while Fig. 4(b) shows the exploded view of the antenna.



(a)



(b)

Fig 4. Antenna Design (a) top view (b) exploded view

The antenna with the feed type of equal and unequal power divider was compared and the radiation pattern at phi = 0 is shown in Fig. 6. The antenna with equal power divider has a side lobe level of -15.1 dB while the antenna with unequal power divider has a sidelobe level of -18.7 dB. Moreover, the backlobe level is -14.9 dB and -16.5 dB respectively. Therefore a sidelobe level suppression of 3.6 dB and backlobe level suppression of 1.6 dB was improved by using the unequal power divider. In adittion, an increase of antenna gain to 0.56 dB was also achieved from 8.25 dB of the equal power divider to 8.81 dB from the unequal power divider.

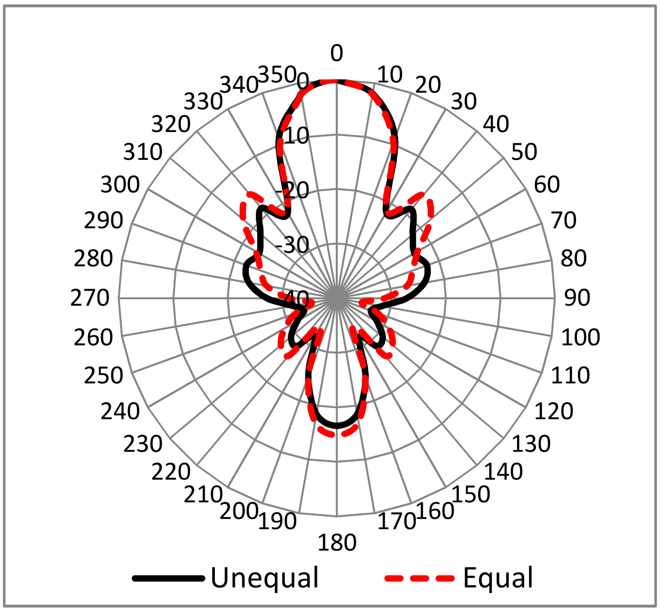


Fig 5. Radiation pattern at phi = 0

IV. SIMULATION AND MEASUREMENT RESULT

The proximity coupled microstrip array antenna with unequal power divider was fabricated and shown in Fig.6.

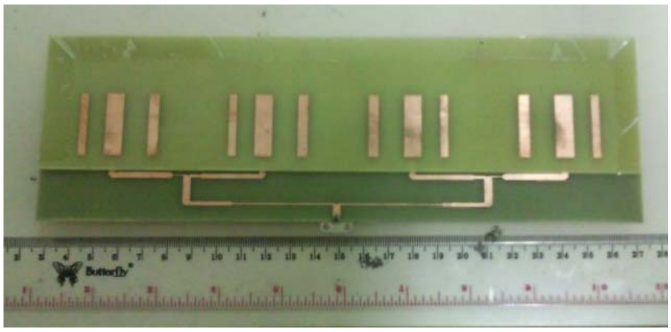


Fig 6. Photo of the fabricated antenna

After fabricated, the antenna was measured in anechoic chamber at the Electrical Engineering Departement, Faculty of Engineering, Universitas Indonesia.

The measurement results were compared to the simulation results and shown in Fig. 7 and Fig. 8. Fig. 7 shows the comparison of the S_{11} parameter. The figure shows that the antenna works at frequency 2.8 GHz -3.1GHz (VSWR ≤ 1.5).

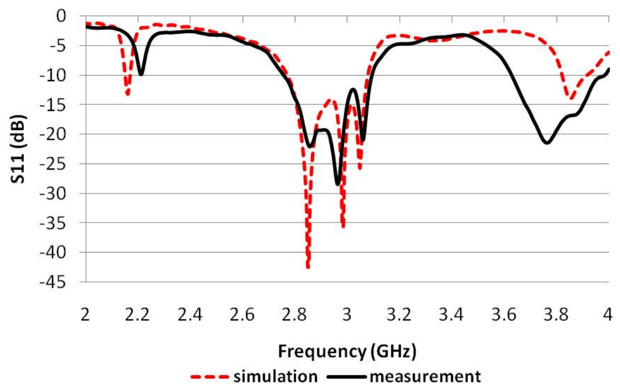


Fig 7. S_{11} parameter of the antenna

Fig. 8 shows the comparison of the simulated and measured radiation pattern at phi=0 with frequency 2.9 GHz. The measured sidelobe level is -18.1 dB with backlobe level of -19.4 dB. The first sidelobe shows similar result compared to the simulation, while the front to back ratio are better than simulation result.

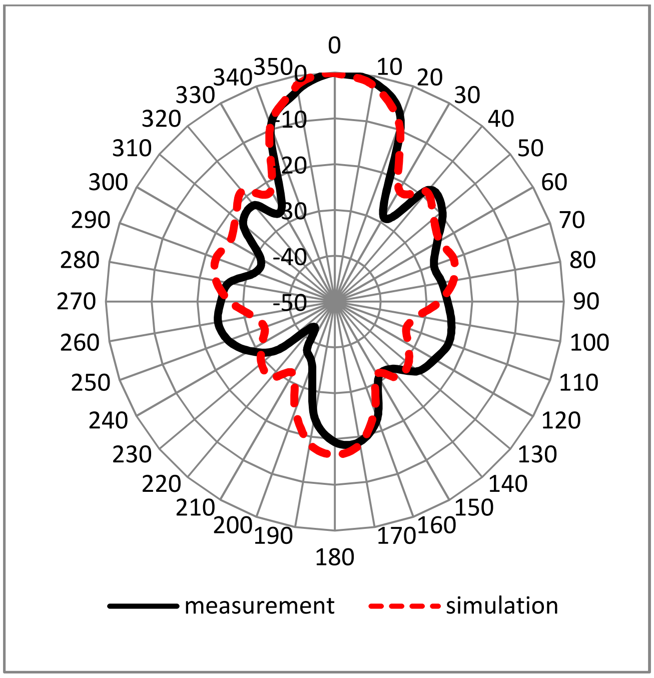


Fig 5. Radiation pattern of the antenna with unequal power divider at phi = 0

VI. Conclusion

An unequal four-way power divider for a proximity coupled microstrip array antenna was designed, fabricated and measured. The simulation result shows that by comparing the equal power divider with the unequal power divider, a sidelobe level suppression of 3.6 dB and backlobe level suppression of 1.6 dB occurred with an increase of antenna gain 0.56 dB was also achieved. Measurement results of the unequal power divider show similar result with the simulation. Measurement results show sidelobe suppression of 18.1 dB with backlobe suppression of 19.4 dB.

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