Design and Implementation of Coupled-Line Wilkinson Power Dividers Using Alumina Substrate

Taufiqqurrachman, Hana Arisesa, I Dewa Putu Hernida, Deni Permana[#1]

#*The First Reseacher, Research Center for Electronics and Telecomunication - Indonesian Institute of Sciences (PPET-LIPI),*
LIPI Campuss, Sangkuriang Street, Building 20 - 4th floors, Cisitu, Bandung - Indonesia

Abstract— **This paper presents design and implementation of coupled-line Wilkinson power dividers at frequency 2.4GHz using alumina substrate. This design using Wilkinson power dividers method where consist of two λ/4 impedance in the form of coupled lines on microstrip and one resistor is connected on the both of output ports. Design parameters used in the design of coupled lines dividers are input and output matching, insertion loss and isolation between the both output ports. The design parameters presented in graph on the simulation result from ADS2011.10 software simulation and the measurement result from vector network analyzer (VNA) R3770 from Advantest. The simulation and measurement results show almost the same results where the return loss is less than -15dB, insertion loss is about -3dB and isolation between the output ports is more than -12dB.**

Keywords— **Alumina, Coupled-Lines, Wilkinson Power Divider.**

I. INTRODUCTION

Power Divider is one of microwave component has commonly used in communication system. This component used for splitter power input into a several output with the same amplitude. The most common method used in the design of power divider is to use the method Wilkinson power dividers. The Wilkinson power dividers employing λ/4 impedance transformers with a characteristic impedance of $\sqrt{2}Z_0$ and a lumped isolation resistor of $2Z_0$ where good matching for all three ports and high isolation between the output ports can be achieved. For high frequency applications, chip resistors with small dimensions are usually chosen for the isolation resistors [1].

Research on 2-Way Wilkinson power dividers have been done before by various methods. Analysis and design of compact two-way Wilkinson power dividers using coupled lines and fabricated on duroid 5870 substrate has been presented in [1]. The coupled lines design has shown the measurement results better than the conventional design and more compact with a reduction in size of more than 50% compared to the conventional design. An equal split Wilkinson power divider with center frequency of 1.2GHz was designed, analysis and fabricated on duroid 5880 substrate [2]. In [3], 2-Way Wilkinson power dividers at frequency 2400MHz has been designed and realization on duroid 5880 substrates. The Wilkinson power dividers has designed use conventional design and good measurement result on insertion loss, return loss and isolation. In [4], a

unequal Wilkinson power divider based on asymmetrical coupled line section is presented in center frequency at 2GHz.

In this paper, two-way Wilkinson power dividers used coupled lines has been designed and fabricated on Alumina. The simulation and measurement result of insertion loss, return loss/VSWR, and isolation is provided.

II. DESIGN METHODOLOGY

In Figure 1 shown the proposed design of Wilkinson power divider using coupled lines layout. The two quarter-wavelength transformer are designed as the symmetrical coupled lines section**.**
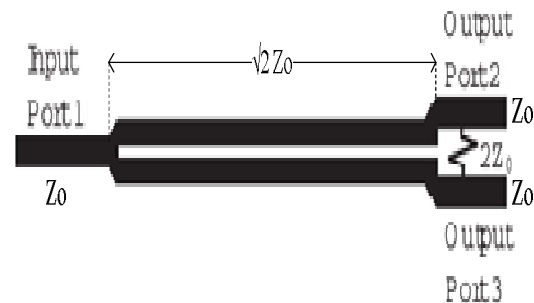

Fig 1. The proposed design of coupled lines layout.

The impedance of input and output ports are 50 ohm, denoted as Z_o. And the quarter-wavelength transformer influenced by the even and odd mode impedance (Z_{oe} and Z_{oo}) where the value is 70.71 ohm. The different of Z_{oe} and Z_{oo} will be varying the widths of and spacing between of the coupled lines. To obtain a perfect input matching, we must select Z_{oe} to be $\sqrt{2}Z_0$ and three S-parameters (S_{11}, S_{21} and S_{31}) are fixed. While Z_{oo} influences the output ports matching and isolation [1].

III. SIMULATION AND MEASUREMENT RESULT

The coupled lines Wilkinson power divider has designed at 2.4GHz center frequencies and used alumina (Er=9.6, H=0.508mm) as the substrate. Figure 2 shows the schematic diagram of the proposed design where physical dimension of the proposed design depicted in Figure 3.

In ADS 2011.10 Software, the physical dimension or layout of the proposed design has simulated in electromagnetic simulation using Method of Moments (MoM). Afterwards, the physical dimension of the proposed design is

combined with the resistor isolation as about 100 ohm in schematic window to simulate the power divider performance.
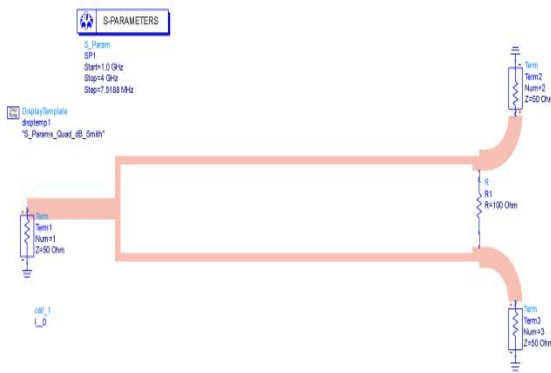

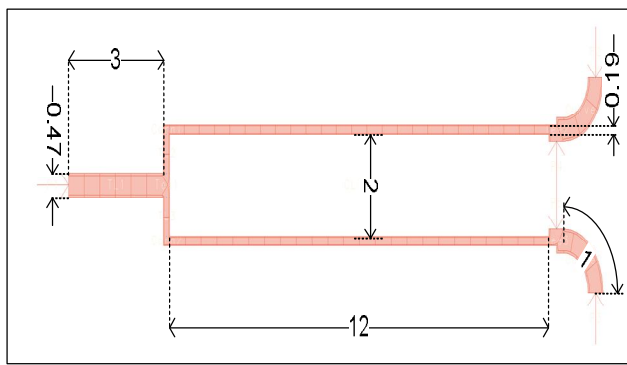Fig 2. Schematic diagram of the proposed design.

Fig 3. Physical dimension of the proposed design

The simulation result of the proposed design depicted of S-Parameter about insertion loss (denoted as S_{12} or S_{21}), return loss/VSWR (denoted as S_{11}, S_{22} and S_{33}) and isolation (denoted as S_{32} or S_{23}) shown in Figure 4. Return loss of the proposed design is shown a good matching between input and output ports where input ports matching (S_{11}) is about -34.7dB and output ports matching (S_{22} and S_{33}) is about -39.9dB.

The power division of the proposed design (denoted as S_{12} or S_{21}) was very good because insertion loss at the center frequency is equal -3.03dB which close to ideal -3.01dB. And the isolation result (denoted as S_{23}) between the both output ports is better than -35.76dB.
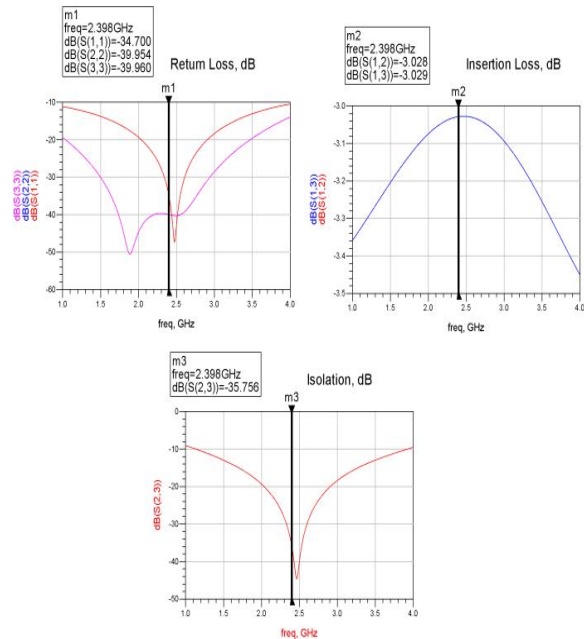

Fig 4. Simulation result of the proposed design

The photograph of fabricated of the proposed design on Alumina substrate is shown in Figure 5. The area of the coupled line dividers and the all areas of the proposed design are 1.2 cm^2 and 2.3 cm2, respectively.

Fig 5. Fabricated of the proposed design

The measurement result of the proposed design from VNA Advantest R3770 was shown in Figure 6-8.

(a).

(b).

(c).

Fig 6. Measurement result of VSWR
(a). S_{11} (b). S_{22} (c). S_{33}

In Figure 6, measurement result of VSWR for the proposed design where input port matching (S11) is about 1.04 (or return loss about -34.15dB) and output port matching (S22 and S33) is about 1.494 and 1.404 (or return loss are about -14.06dB and -15.49dB), respectively.

Fig 7. Measurement result of insertion loss (S_{12})

Figure 7 shows measurement result of insertion loss of the proposed design where the power division result was fairly good at the center frequency about -3.084dB. This indicates that the distribution of power in the both output ports are at around -3dB from input power and occurs only a very small loss on each output ports.

Fig 8. Measurement result of isolation (S_{32})

Measurement result of isolation between the both output ports is shown in Figure 8. The isolation at the center frequency is around -12.157 dB where its more different with simulation results. This caused by the final fabrication of the proposed design fared slightly worse where the physical dimensions of the microstrip line not smooth so causes changes in the value of the impedance as well. Overall the performance of the coupled-lines Wilkinson power divider is fairly good can be applied to supporting our RADAR research.

IV. CONCLUSIONS

The coupled-lines Wilkinson power divider has been designed, simulated and fabricated on Alumina substrate. Simulations and measurements show comparable results for the coupled-lines Wilkinson power divider. Insertion loss for the coupled-lines design was achieved -3.084dB, return loss is around -34dB (for input ports matching) and -15.56dB (for output ports matching), and isolation between the both output ports is better than -12dB.

REFERENCES

[1] Tang Xinyi, Koen Mouthaan, "Analysis and Design of Compact Two-Way Wilkinson Power Dividers Using Coupled Lines", **Microwave Conference - APMC 2009** pages 1319-1322.

[2]. Bobba Bajee, Labanowski Dominic, Zajdel Tom, Zeeb Cameron, "Design and Analysis of an Equal Split Wilkinson Power Divider', **Proposal Design** on Jan 11, 2010.

[3]. Taufiqqurrachman, Deni Permana Kurniadi, "Design and Realization Wilkinson Power Divider at Frequency 2400MHz for Radar S-band", **IOSR Journal of Electronics and Communication Engineering (IOSR-JECE)**, Vol. X, Issue X (Nov-Dec 2012).

[4]. Y. Wu and Y. Liu, "A Unequal Coupled-Line Wilkinson Power Divider For Arbitrary Terminated Impedances", **Progress In Electromagnetics Research**, Vol. 117, page 181-194, 2011.