Miniaturized RF components employing π-type multiple coupled microstrip line structure

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Abstract: In this work, using a π-type multiple coupled microstrip line structure (MCMLS), we fabricated highly miniaturized Wilkinson power divider and branch-line coupler. The line length of the Wilkinson power divider and branch-line coupler were reduced to about λ/44 and λ/38, respectively, and their size were 11.2 % and 14.6 % of conventional ones, respectively. The miniaturized Wilkinson power divider and branch-line coupler showed good RF performances in C band.

1. Introduction

In RFIC device such as PA and Mixer[1], Wilkinson power divider and branch-line coupler are required for power coupling and splitting[1-12]. However, conventional Wilkinson power divider and branch-line coupler[13-25] employ quarter-wavelength line, which highly increases the circuit size and manufacturing cost. For a size reduction, we have proposed multiple coupled line [2]. In this work, in order to realize miniaturized Wilkinson power divider and branch-line coupler, we used π-type multiple coupled microstrip line structure (MCMLS). Concretely, the Wilkinson power divider and branch-line coupler were highly miniaturized by substituting quarter-wavelength line for π-type MCMLS. In the π-type MCMLS, the characteristic impedance of the line doesn't increase rapidly, though the line is shortened by shunt capacitors, which facilitated the fabrication of the miniaturized RF passive components.

2. A highly miniaturized Wilkinson power divider and branch-line coupler employing π-type MCMLS

Figure 1 shows a schematic circuit of the Wilkinson power divider employing π-type MCMLS [2]. Generally, λ/4 lines comprise conventional Wilkinson power divider and branch-line couplers, which has highly increased the circuit size of divider and couplers. However, λ/4 line was greatly shortened by using π-type MCMLS [2]. Figure 2 shows a photograph of the highly miniaturized Wilkinson power divider employing π-type MCMLS,

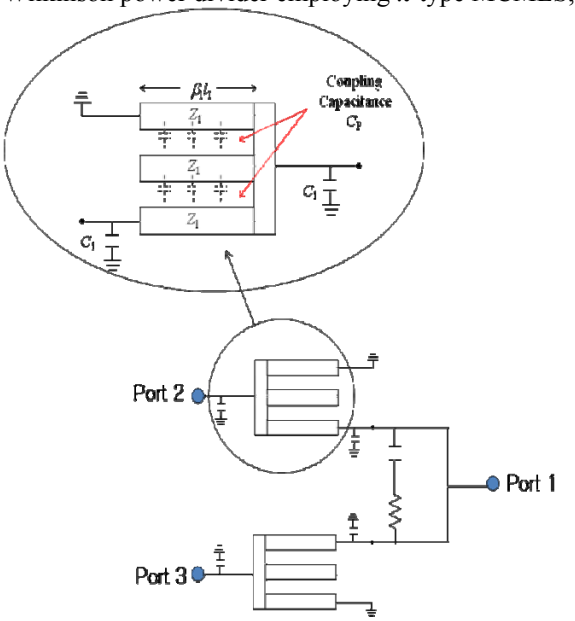

Figure 1. A schematic circuit of the Wilkinson power divider employing π-type MCMLS

which was fabricated on teflon substrate. The line width and spacing between lines are 1 and 0.4 mm and the resistance and shunt capacitor are 3.04 Ω and 1.83 pF.

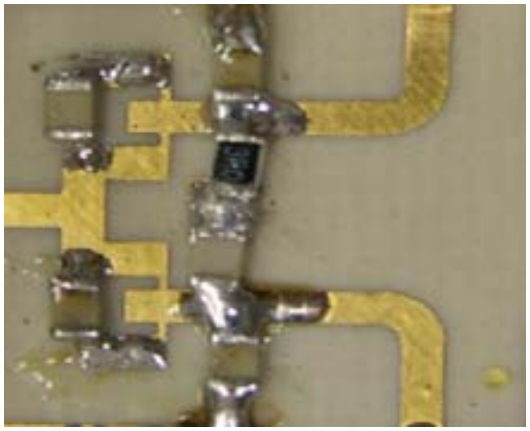

Figure 2. A photograph of the highly miniaturized Wilkinson power divider employing π-type MCMLS

Table 1. The size of the novel and conventional Wilkinson power divider

	Power divider size	Line length	Shunt C
π-type MCMLS	17 mm^2	1 mm	0.5pF
π-type SMLS	32 mm^2	8.2 mm	1pF
Quarter-wave line	45 mm^2	11.3 mm	

As shown in Figure 2, the Wilkinson power divider was highly miniaturized by substituting quarter-wavelength line for π-type MCMLS. As shown in the Table 1, the shunt capacitance of the π-type MCMLS and π-type SMLS is 0.5 and 1 pF. The line length was highly reduced to λ/44 by using the π-type MCMLS, and the circuit size of the power divider employing π-type MCMLS is 37% of the conventional one employing quarter-wave line.

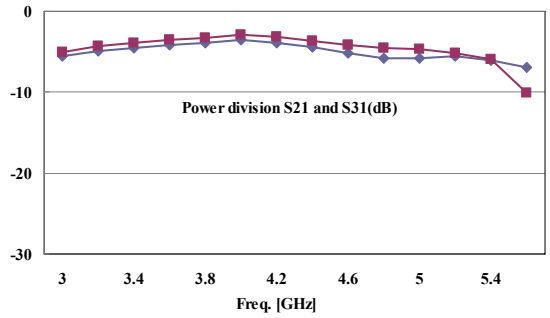

Figure 3. Measured result for power division S_{21} and S_{31} of the Wilkinson power divider

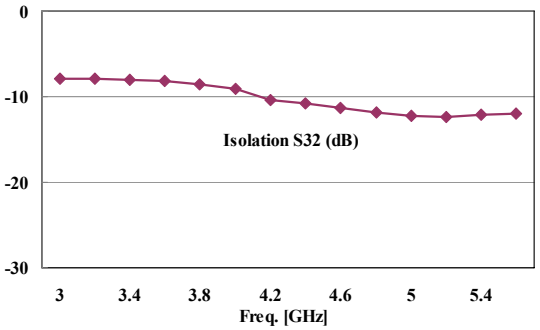

Figure 4. Measured isolation S32 of the Wilkinson power divider

Figure 3 and 4 show measured power division and isolation characteristics for the miniaturized Wilkinson power divider employing π-type MCMLS, respectively. From 3 to 5.5GHz, we can observe equal power and phase characteristics. Concretely, we can observe power division higher than –5.5dB, and isolation better than –9 dB. We also fabricated highly miniaturized branch-line coupler employing π-type MCMLS.

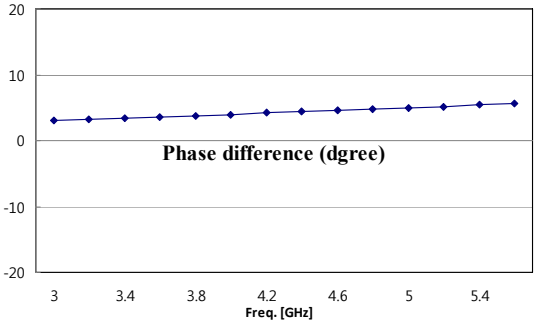

Figure 5. Measured result for Phase difference S21 and S31

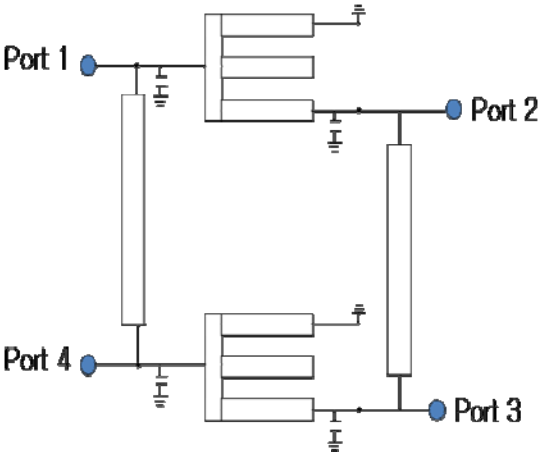

Figure 6. A schematic circuit of the highly miniaturized branch-line coupler employing π-type MCMLS

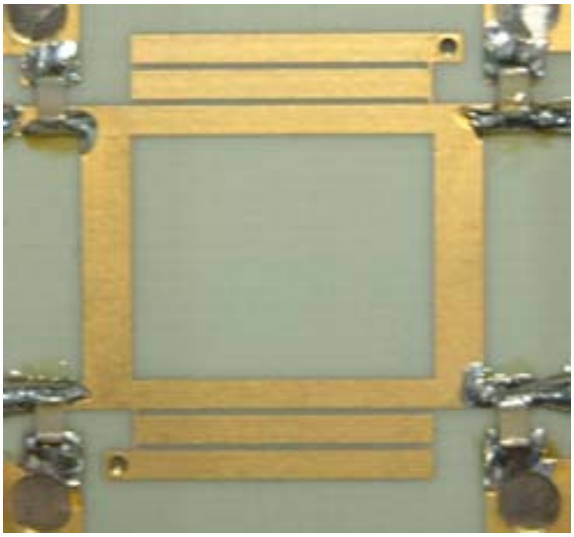

Figure 7. A photograph of the highly miniaturized branch-line coupler employing MCMLS

Figure 6 shows a schematic circuit of the highly miniaturized branch-line coupler employing π-type

MCMLS, and Figure 7 shows its photograph, which was fabricated on teflon substrate. The size of the branch-line coupler was 60% of conventional one [2, 3]. RF performances of the branch-line coupler were summarized in Table 2. Figure 8 shows measured power division for the miniaturized branch-line coupler employing π-type MCMLS. We can observe good RF performances from 1.4 ‐ 1.9 GHz.

Table 2. The RF performances of branch-line coupler employing π-type MCMLS

Bandwidth	1.4 ~ 1.9 GHz
Power division	- 4.5 ± 0.5 dB
Isolation	≤ -16.5 dB
Phase division	90° ± 4.5°

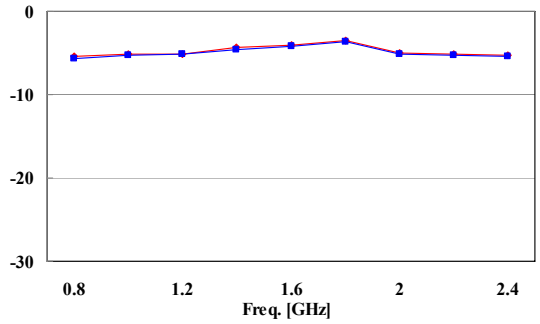

Figure 8. Measured result for power division S_{21} and S_{31}

3. Conclusion

In this work, using the π-type MCMLS, we fabricated highly miniaturized Wilkinson power divider and branch-line coupler on teflon substrate, and their size was 37 % and 60 % of conventional ones employing quarter-wave line, respectively. The miniaturized Wilkinson power divider and branch-line coupler exhibited good RF performances in the C band .

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