Miniaturized RF components employing $\pi$-type multiple coupled microstrip line structure

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Abstract: In this work, using a $\pi$-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 $\lambda/44$ and $\lambda/38$, 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 $\pi$-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 $\pi$-type MCMLS. In the $\pi$-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 $\pi$-type MCMLS

Figure 1 shows a schematic circuit of the Wilkinson power divider employing $\pi$-type MCMLS [2]. Generally, $\lambda/4$ lines comprise conventional Wilkinson power divider and branch-line couplers, which has highly increased the circuit size of divider and couplers. However, $\lambda/4$ line was greatly shortened by using $\pi$-type MCMLS [2]. Figure 2 shows a photograph of the highly miniaturized Wilkinson power divider employing $\pi$-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 $\Omega$ and 1.83 pF.
Table 1. The size of the novel and conventional Wilkinson power divider

<table>
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<tr>
<th>Power divider size</th>
<th>Line length</th>
<th>Shunt C</th>
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<tbody>
<tr>
<td>π-type MCMLS</td>
<td>17 mm²</td>
<td>1 mm</td>
</tr>
<tr>
<td>π-type SMLS</td>
<td>32 mm²</td>
<td>8.2 mm</td>
</tr>
<tr>
<td>Quarter-wave line</td>
<td>45 mm²</td>
<td>11.3 mm</td>
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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 S21 and S31 of the Wilkinson power divider

Figure 4. Measured isolation S32 of the Wilkinson power divider

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>
<thead>
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<th>Table 2. The RF performances of branch-line coupler employing π-type MCMLS</th>
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<tr>
<td>Bandwidth</td>
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<tr>
<td>Power division</td>
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<td>Isolation</td>
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<td>Phase division</td>
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Figure 8. Measured result for power division S21 and S31

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.

Acknowledgment

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References

[17] R. K. Gupta, and W. J. Getsinger, "Quasi-