3.3 - 3.7 GHz 180^0 Hybrid Coupler Design

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Abstract

This paper presents a novel wide band microstrip coupler, composed of two parts. The first one is a compensated Wilkinson power divider which provides a good separation between the two output ports. The second is a passive phase shifter composed of two filters consisting of 3 dB 180^0 hybrid couplers, the coupled and transmitted port being short circuited or open circuited on the bottom and top surfaces of printed circuit board. The results of the theoretical analysis are presented. The simulation results presented below are valid over the 3.3-3.7 GHz band and contain the coupling between input and output ports as well as phase shift isolation 3.3 dB and 178 degree and 20 dB.

1. Introduction

In broadband power HEMT amplifiers, severe bandwidth limitations result from the low input and output impedance level of the device. The balanced configuration overcomes this handicap by increasing input and output impedances. Compared with a single device having the same gate width, a balanced structure therefore gives improved gain, wider bandwidth, has a better efficiency and in addition, even harmonics are suppressed [1]. However the balanced operation requires balanced to unbalanced transformers. The proposed coupler is composed of two parts. The first one is a compensated Wilkinson power divider which provides a good power separation between the two output ports over 3-4 GHz. The second is a passive phase shifter composed of two filters, consisting of 3 dB 180^0 hybrid couplers [2,3].

2. Theoretical Analysis

Design considerations power divider consists of a Wilkinson power divider compensated by the use of an in line quarter wave transformer. In figure 1, general structure of the coupler is presented.

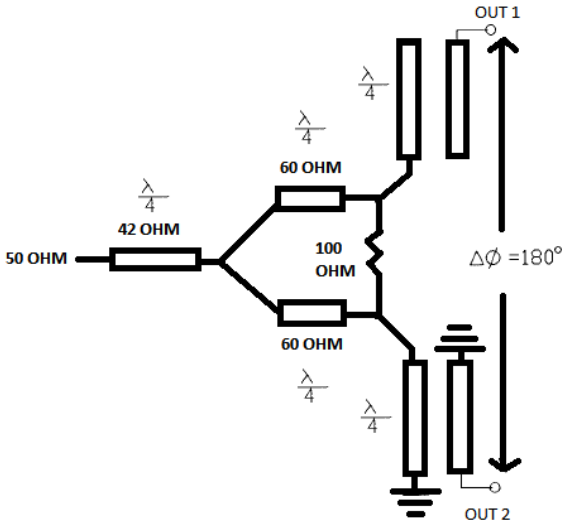

Figure 1: 180^0 3 dB Hybrid Coupler

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The property of coupled lines are completely defined by their even and odd mode impedances Z_{oe} and Z_{oo}. The characteristic impedances presented by the open and short circuited phase shifters and phase shift are given equations (1), (2), (3) and (4). We can see therefore that the image phase shift of the short circuited filter is always 180 degrees greater than open circuited filter.

$$Z_{co} = \frac{[(Z_{oe} - Z_{oo})^2 - (Z_{oe} + Z_{oo})^2 \cos^2\theta]^{\frac{1}{2}}}{2\sin\theta} \tag{1}$$

$$\cos\beta_{co} = [\frac{\frac{Z_{oe}}{Z_{oo}} + 1}{\frac{Z_{oe}}{Z_{oo}} - 1}]\cos\theta \tag{2}$$

$$Z_{cc} = \frac{2Z_{oe}Z_{oo}\sin\theta}{[(Z_{oe} - Z_{oo})^2 - (Z_{oe} + Z_{oo})^2 \cos^2\theta]^{\frac{1}{2}}} \tag{3}$$

$$\cos\beta_{cc} = [\frac{\frac{Z_{oe}}{Z_{oo}} + 1}{\frac{Z_{oe}}{Z_{oo}} - 1}]\cos\theta \tag{4}$$

In figure 2, lengths of microstrip lines belongs to Wilkinson divider are calculated. These are 15.57 mm length and 3.06 mm width for 42 ohm line, 15.82 mm length and 1.82 mm width for 60 ohm.

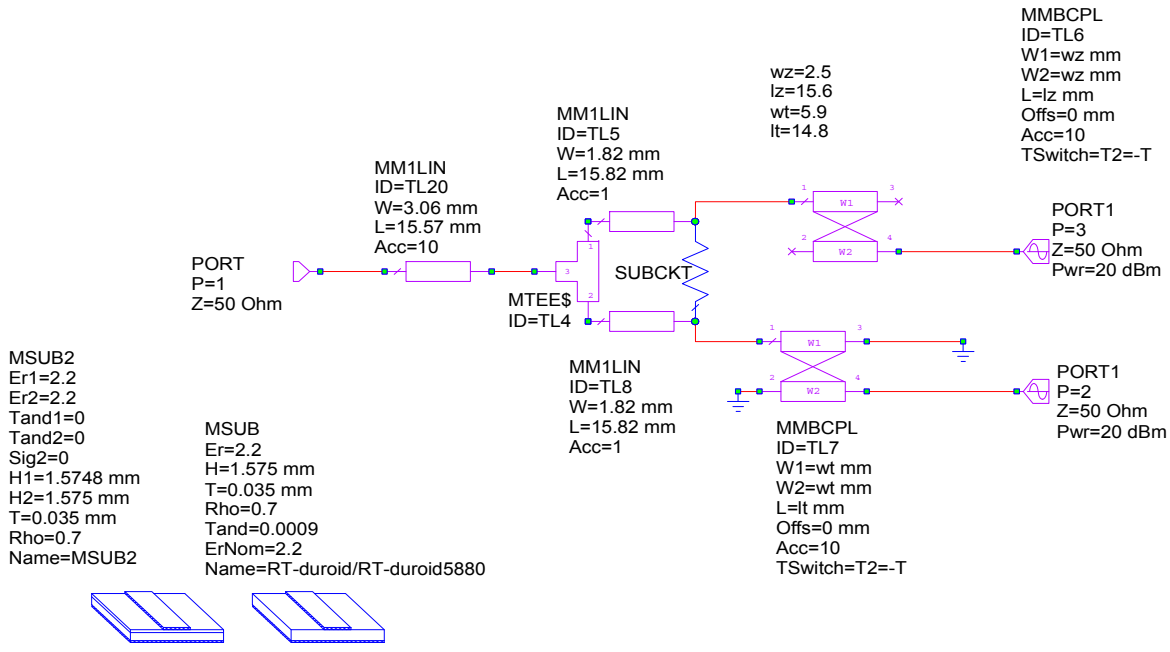

Figure 2: 180^0 Hybrid Coupler Design

3. Simulation Results

The 3dB 180^0 hybrid coupler was designed by using Rogers RT5880 substrate. Phase difference between out1 and out2 branches is approximately 180 degree. In figure 3, phase difference between ports is presented over 3-4 GHz band. In figure 4, s-parameters s11, s21 and s31 are presented. At 3.5 GHz s21 and s31 parameters of branches are -3.348 dB, at 3.3 GHz -3.504dB and 3.7 GHz -3.496 dB.

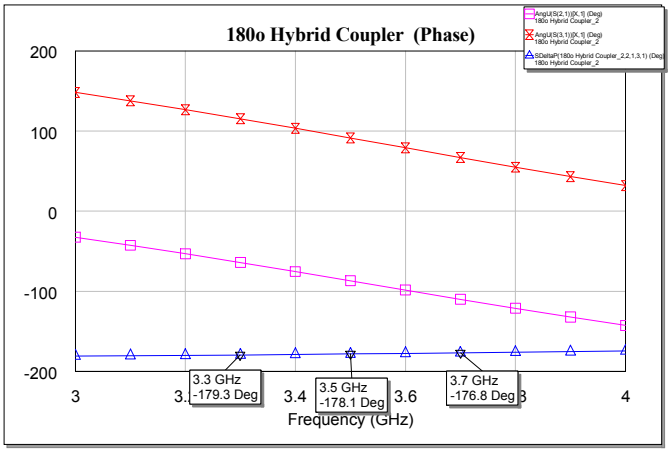

Figure 3: Phase Difference of Branches

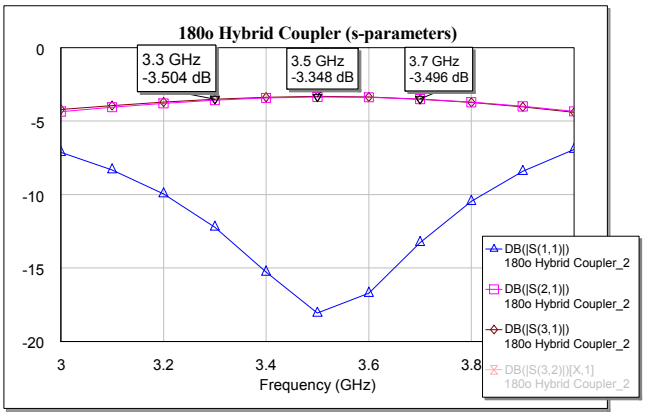

Figure 4: S11, S21, S31 Parameters

4. Conclusion

A hybrid coupler with useful performances has been designed and simulated. The agreement with the theoretical predictions is fair and operation over the 3.3-3.7 GHz band has been simulated. Using doubled sided printed circuit board is a solution of small microstrip line gap problem of the coplanar couplers. The simulation results presented below are valid over the 3.3-3.7 GHz band and contain the coupling between input and output ports as well as phase shift isolation 3.3 dB and 178 degree and 20 dB.

5. References

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