Reduced-length tandem directional couplers designed in microstrip technique for use in balanced amplifiers

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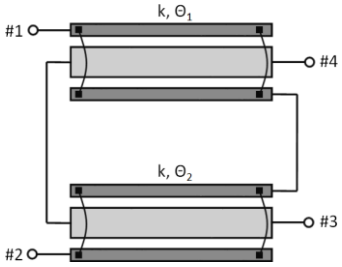
Abstract

A reduced-length broadband tandem directional coupler realized in microstrip technique is presented. The proposed structure is designed as a tandem connection of two coupled-line sections having different electrical lengths and the same value of coupling coefficient. Such approach can be used to reduce overall size of the component, what is more attractive in comparison to the classic tandem hybrid topology. Furthermore, to verify possibility of implementation in conjunction with active devices, the proposed directional coupler have been implemented in two balanced amplifiers utilized in PCB and MMIC technologies operating at 1 GHz and 20 GHz, respectively.

Reduced-Length Microstrip Tandem Coupler



The proposed reduced-length tandem coupler composed of two three-coupled-line sections

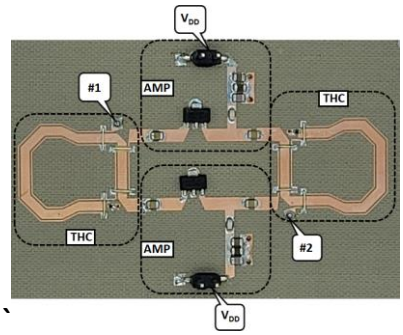
The tandem coupler can be defined by pair of following formulas:

$$\frac{k\sqrt{1-k^2}(\sin\Theta_1+\sin\Theta_2)}{1-k^2-k^2\sin\Theta_1\sin\Theta_2}=\frac{k_{nom}}{\sqrt{1-k_{nom}^2}}$$

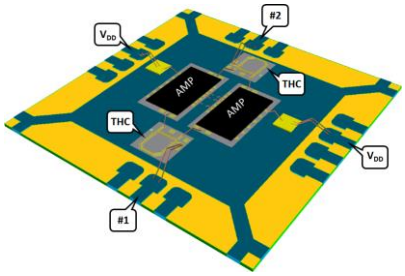
$$\Theta_1\cos\Theta_1(1-k^2\cos\Theta_2)+\Theta_2\cos\Theta_2(1-k^2\cos\Theta_1)=0\ .$$

The factor k_{nom}, define the required coupling of the entire tandem coupler. It can be noticed that the nominal coupling k_{nom} at the center frequency is achieved by properly chosen electrical parameters of the coupled-line sections i.e., available coupling coefficient k and electrical lengths Θ_1, Θ_2. Hence, the proposed design method features great flexibility.

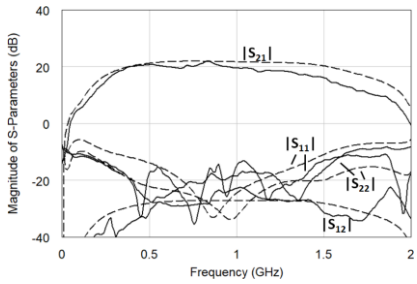
Implementation in balanced amplifiers and results



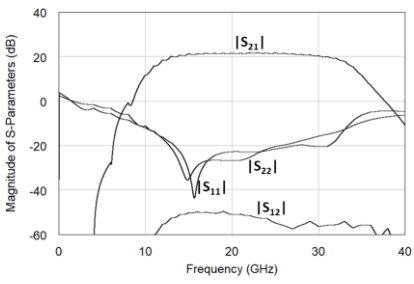
Picture of manufactured balanced amplifier consisting of proposed microstrip tandem couplers (THC) and ADL5611 amplifiers (AMP).



3D view of the designed balanced amplifier consisting of the proposed reduced-length tandem couplers designed on GaN substrate (THC) and amplifying stages (AMP) based on UMS CHA2069.



Results of simulations (dashed lines) and measurements (solid lines) of the balanced amplifier composed of the proposed tandem hybrid couplers



Simulation results obtained for the Hybrid Monolithic Integrated Circuit (HMIC) balanced amplifier consisting of the proposed couplers.

Conclusions

The paper shown, that the considered tandem topology can be realized in microstrip technique, which is more suitable for simple applications and processes having limited achievable coupling between lines. Moreover, in both designs the occupied area has been reduced. The designed amplifiers feature good electrical performance.

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