Design of Reduced-size Branch-line Couplers with Series Capacitors

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Branch-line couplers are widely used in microwave and milimeter-wave circuit systems such as balanced mixers, balanced amplifiers, phase shifters, and etc. Since conventional couplers designed based on the distributed circuit theory tend to waste chip area in MICs or MMICs, especially at low frequencies, thus many research efforts have been devoted to reduce the size of couplers. Here, we treat branch-line couplers with series capacitors at each input/output port as shown in Fig. 1(a) and design reduced-size couplers based on the equivalent admittance approach. Fig. 1(b) exhibits the theoretical scattering parameters for the compact coupler that the electrical length of branchlines is 60°. As shown in this figure, the fractional bandwidth is about 10% for -20 dB return loss. This value is comparable to that of the conventional branch-line coupler. The validity of this design technique is demonstrated by electromagnetic simulator (Sonnet em) assuming that the glass substrate with dielectric constant of 4.8 and thickness of 0.5 mm, respectively. Fig. 2 shows the circuit pattern of simulation for the proposed coupler designed at center frequency of 3 GHz. In this circuit, input/output ports and branch-lines are constructed of coplanar waveguides (CPWs). Metal- Insulate-Metal (MIM) capacitor is constructed with the air gap ($Gap = 3\,\mu m, area = 0.3\,mm^2$) under the CPW center conductor near each port junction. In order to avoid the parasitic slot-line mode, air bridges are added near the junctions. Simulation results given by plots in Fig. 1(b) generally agree with the theoretical results. We demonstrate that the size reduction of about 50% can be achieved with maintaining the property comparable to that of the conventional couplers. Experiment verifications will be our feature works.

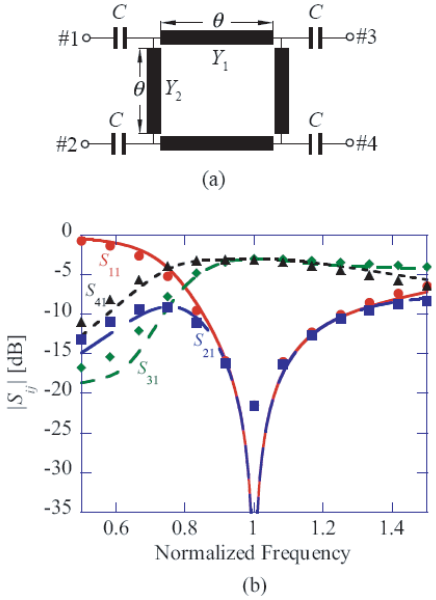

Figure 1: (a) Circuit construction and (b) frequency characteristics of scattering parameters of branch-line coupler with series capacitors ($Y_1 = 0.50, Y_2 = 0.35, C = 0.83, \theta = 60°$).

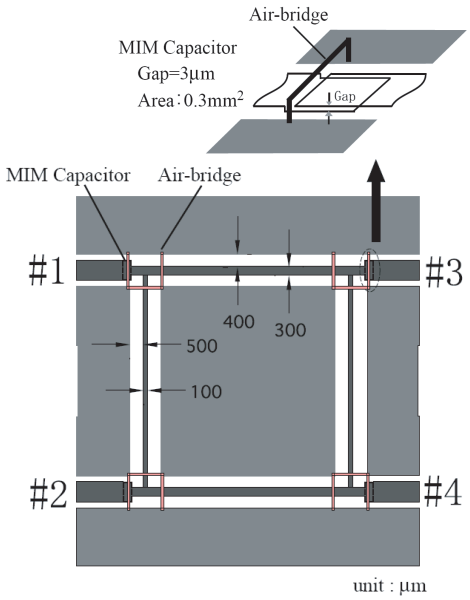

Figure 2: Circuit pattern of a proposed coupler.