A Compact 3D-Printed Broadband Coupler with Quadrature Phase

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Abstract

As is well known, hybrid couplers pose an indispensable component in various passive circuits, such as Butler Matrix (BM), one of the most widely used beamforming networks, for they have the capability of simultaneously generating a pair of signals with balanced amplitude and quadrature phase. Compact broadband couplers still face some challenges at high frequencies, despite the fact that numerous research on compact broadband coupler (CBC) has been reported at low frequency. The methods of loading slotlines [1], adding extra transmission line sections [2] [3], using parallel coupled-lines [4] and connecting varactors [5] are not able to adapt to millimetre-wave (mm-wave) applications, due to the significant transmission losses and tiny physical scale. Other mm-wave CBCs that utilize glass or silicon substrates are constricted by complex process and strict specification [6]. Tandem couplers with compact and wideband characteristics that use a simple stripline structure are formidable to fabricate by traditional PCB process because of the minute coupling distance in mm-wave. The traditional PCB process has limitations on the specification of substrate with a minimum substrate thickness of 0.1 mm. Compared to traditional PCB process, 3D printing process utilizing ink pixel printing technique has superior flexibility in the vertical axis with a 1.18 μm thickness accuracy.

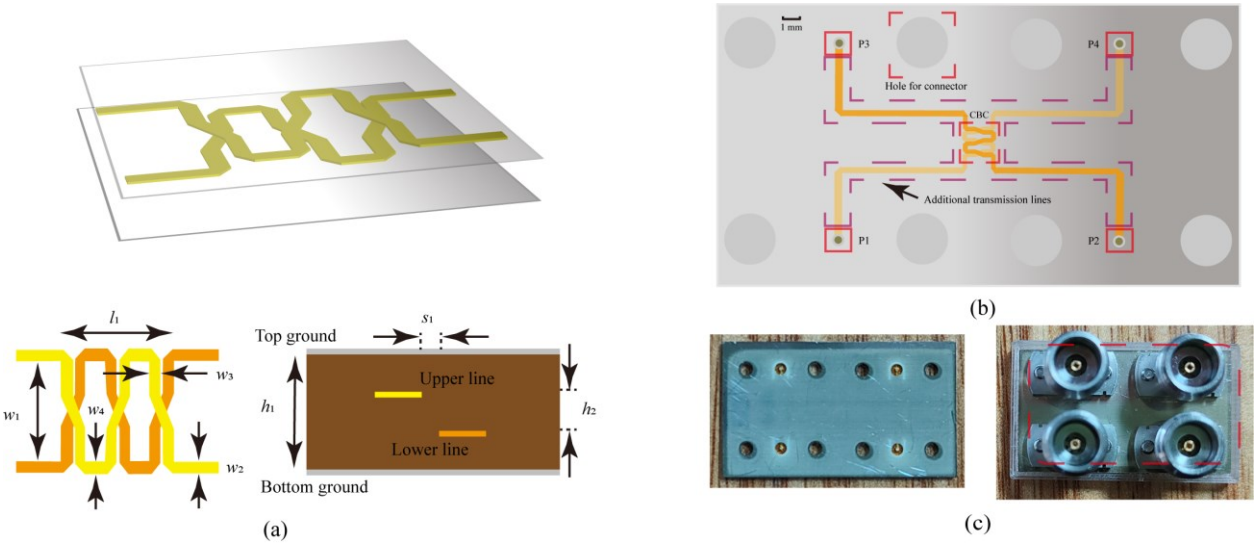

Fig. 1: (a) 3D diagram of the proposed CBC; (b) Proposed geometry of the CBC with ATL; (c) Fabricated sample of CBC with ATL (without and with connectors).

This paper proposes a compact 3D-printed broadband coupler with quadrature phase, which overcomes the challenges of designing and expanding a solution to implement CBC with coupling structures in mm-wave band. For verification, a 3D-printed prototype is conveniently fabricated and tested. The 3D diagram of the proposed CBC is shown in Fig. 1 (a). Meanwhile, another prototype of the additional transmission line (ATL) is realized to eliminate the extra interconnection loss from measurements. Fig. 1 (b) and Fig. 1 (c) illustrates the geometry and fabricated sample of CBC with ATL, respectively.

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