Lumped Element Suspended Stripline Couplers

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Abstract— **Recently, very compact filters have been realized in suspended stripline using a lumped element approach. In this paper, a similar approach is used to realize very small 3 dB hybrid couplers. Two examples at 1.3 GHz and 6.8 GHz are presented, resulting in relative bandwidths of 5% to 10% (at -15 dB isolation) and quite low insertion loss. For the 1.3 GHz and 6.8 GHz range, these couplers are realized in a 20 mm × 20 mm and 10 mm × 10 mm mount, respectively.**

Keywords- Directional couplers, lumped elements, suspended stripline.

I. INTRODUCTION

Suspended stripline (SSL) has proven as an interesting transmission line medium mostly for filters due to its low loss performance. An increased cross section is responsible for reduced ohmic and dielectric losses. A shielding channel prevents radiation, and, if sufficiently small, the excitation of higher order modes. A large portion of the fields in air results in low dispersion of the SSL. Both transmission line filters as well as very compact quasi-lumped filters have been realized in this technique [1 – 3]. In some applications, it is of interest to combine filters with other types of circuits, maintaining a small size as it has been achieved for lumped element filters in [3]. This paper therefore describes first efforts towards lumped element 3 dB hybrid couplers.

II. COUPLER DESIGN AND REALIZATION

In [4, 5], general representations and the design of lumped element 3 dB hybrids and branchline couplers are reported. In principle, such approaches should be suitable for integration also in suspended stripline. The equivalent circuit selected for the investigations described in this contribution is shown in Fig. 1. It consists of inductances to ground at each port of the hybrid and four capacitances connecting the ports.

The general cross section of suspended stripline as used throughout this work is given in Fig. 2. It consists of a thin dielectric substrate suspended in a metal channel. Transmission line structures can be placed on top and bottom of the substrate, thus easily allowing broadside coupling or the realization of capacitances between two metal layers. On the other hand, thin lines to the edge of the mount can be used as inductances; their value may be increased by insets into the connecting metallization (Fig. 3). Due to the thin substrate, capacitances can be approximately calculated as parallel plate capacitors (including some edge effect). For the shunt inductances, a configuration as displayed in Fig. 3 (a) is simulated using a MoM simulator, e.g. [6], and compared to the results of the respective equivalent circuit [3].

For the design of the coupler, its equivalent circuit is determined according to [4], and these values then are transferred to a respective suspended stripline geometry. In a final step, a full wave simulation and optimization [6] is applied to find the dimensions for optimal performance of the coupler.

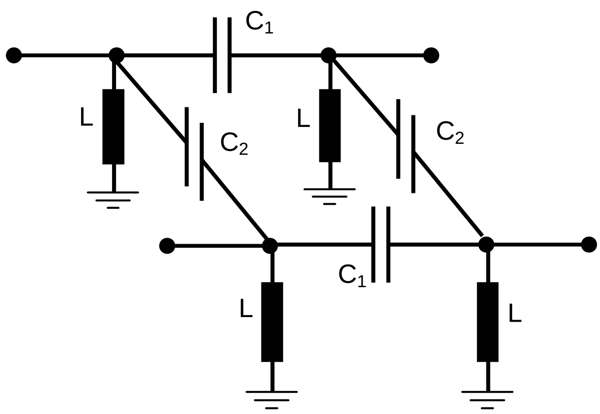

Figure 1: Equivalent circuit of a lumped element coupler according to [4].

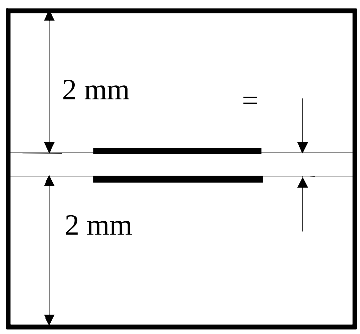

Figure 2: General cross section of suspended stripline as used in this work.

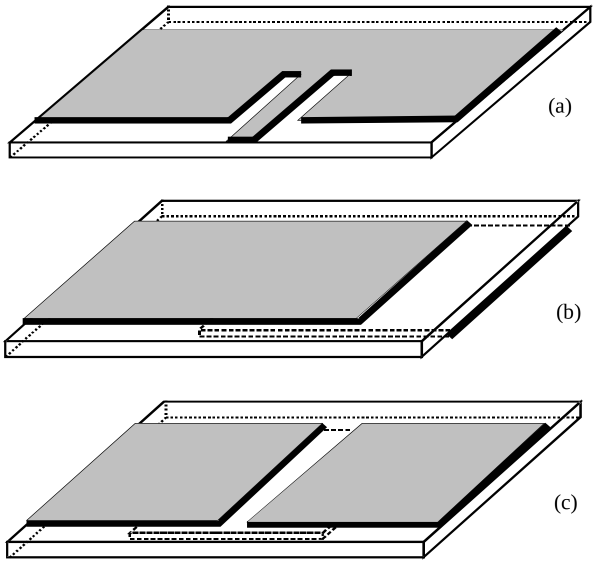

Figure 3: Principle structures of shunt inductance (a) and series capacitances (b, c) realized in suspended stripline. In this sketch, only the substrate with the respective metallization structures is shown; placed into the metal mount, front and back side are connected to the side wall of the channel (see cross section of Fig. 2).

III. EXAMPLES OF LUMPED ELEMENT SUSPENDED STRIPLINE COUPLERS

Based on this procedure, two couplers were designed, one for a frequency around 1.3 GHz, the other one around 7 GHz.

The first coupler is based on simple overlapping metallizations for the capacitances and four narrow strips to ground as inductances, integrated into a mount of 20 mm × 20 mm, see Fig. 4. This leads to a very compact setup of only 0.0075 ^{2}, although some possible disadvantage was found that the ports were on different sides of the substrate. The results of this coupler are plotted in Fig. 5, showing a very good agreement between simulation and experiment. Relative bandwidth at -15 dB isolation (S41) is about 10%, in-band insertion loss amounts to 0.3 dB.

The second coupler was designed for a frequency around 7 GHz and uses a modified configuration for the series capacitances according to Fig. 3 (c). As the capacitances of this type consist of two separate capacitors in series, they occupy more space, but all ports are on the same side of the substrate. As the structure at this frequency was too small (10 mm × 10 mm) to connect the ports directly to SMA connectors, some feeding lines had to be added for measurement (Fig. 6). In principle, this coupler can be made smaller, but then its dimensions are even smaller than the lateral dimension of the connecting suspended striplines.

Simulated and experimental results are presented in Fig. 7. Due to the feed structure and the transitions to coaxial line, some reflections occurred at the port, leading to slight deteriorations of return loss and isolation, and the center frequency is shifted by 100 MHz, possible based on some fabrication errors. Bandwidth is around 5%, and in-band insertion loss amounts to 0.5 dB including the feed structure and the transitions to the connectors.

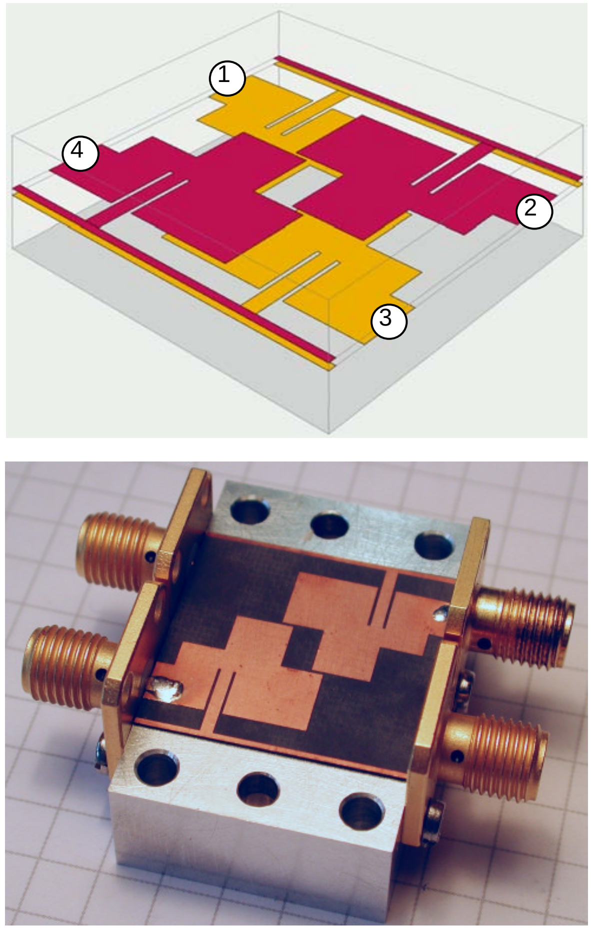

Figure 4: Structure with port designations (top) and photograph of the 1.3 GHz suspended stripline coupler (bottom, top part of the mount removed).

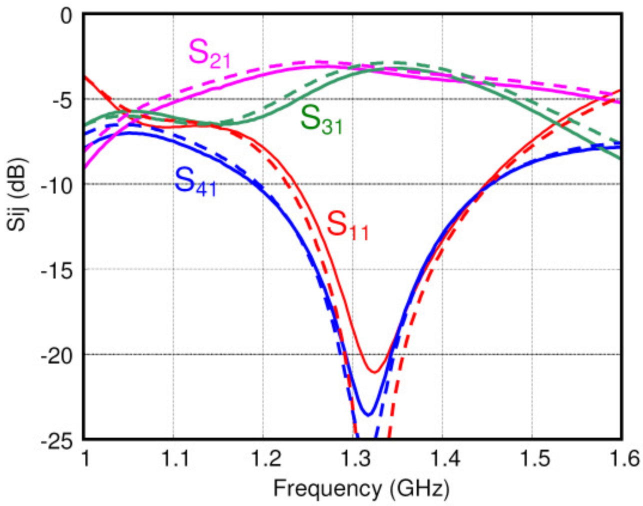

Figure 5: Simulated S-parameters (dashed lines) and experimental results (solid lines) of the 6.8 GHz suspended stripline coupler.

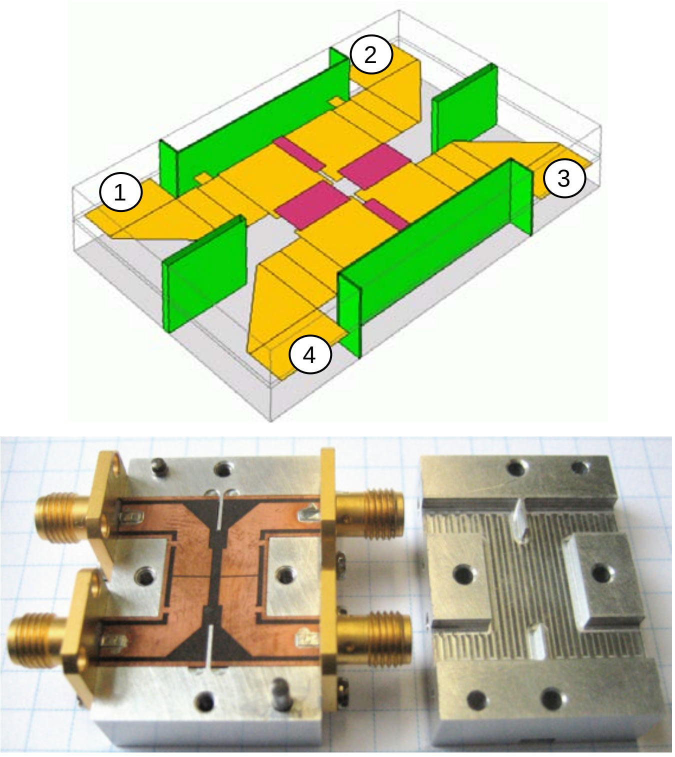

Figure 6: Structure with port designations (top) and photograph of the opened 6.8 GHz suspended stripline coupler (bottom).

IV. CONCLUSION

Two examples of very compact suspended stripline lumped element couplers at 1.3 GHz and 6.8 GHz have been presented, resulting in relative bandwidths of 5% to 10% (at -15 dB isolation) and quite low insertion loss. Improvements in bandwidth are possible using concepts of lumped element branchline couplers as described in [5]

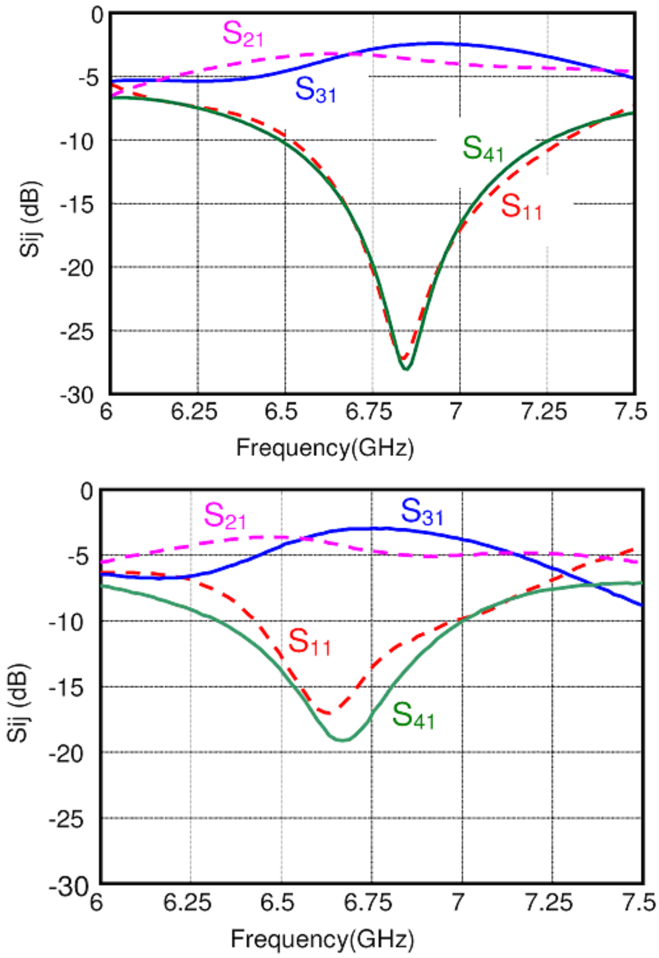

Figure 7: Simulated S-parameters (top) and experimental results (bottom) of the 6.8 GHz suspended stripline coupler

V. REFERENCES

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