Novel Super Compact Dual-Band Branch-Line Couplers Using Folded Stepped-Impedance Resonators for GSM and WLAN systems

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Abstract— Two novel compact BLCs were developed and proposed with compact size and improve the performance of dual-band branch-line couplers (BLCs).

The developed model was reported to be a two-section stepped-impedance resonator which includes a high-impedance section accompanied by loaded double branches lines. The proposed model was shown to reduce the size of the dual-band BLC around 61% as well as a 4% enhancement in the bandwidth of such components. Based on the proposed topology, two different couplers were designed and simulated using EM simulator tool for both GSM and WLAN systems.

I. INTRODUCTION

Recently, dual-band components have attracted the interests of microwave designed and are now in demand as dual-band systems such as wireless local area network (WLAN) and global systems for GSM. The demand for low-cost, compact, portable as well as dual-band components persuades academic research groups to size miniaturization. Branch-line coupler (BLC) is one of the most popular hybrids widely employed in microwave and millimeter-wave applications.

In the recent years, many different models have been presented in several papers to design dual-band BLCs using simple microstrip transmission lines [1-6] or right/left-handed metamaterial transmission lines [7-8].

As presented in these investigations, the couples designed in [1-6] always have large circuit area size for example, the size of about 3λ/4×λ/4 and 4347 mm^2 for the BLCs presented in [1] and [3], respectively. Some efforts have been reported by many researchers to reduce the size of these components in different papers [5-6]; however, at the expense of deteriorating the performance of these BLCs, for example, in [5] a high level of size reduction has been achieved, though the central frequency of the second band is the odd harmonic of that of the first band. Besides, another effort has been carried out to reduce the size of such dual-band components using series open stubs, but the insertion loss and the return loss of the outputs have been achieved around $S_{31} \approx$ -8 dB and -10 dB, respectively [6].

Additionally, the BLCs analyzed by right/left-handed metamaterial transmission lines provide high losses caused by lumped elements. Note that these BLCs have also relatively complex configurations [7-8].

In 2010, K.S. Chin, and et al have designed a dual-band BLC with an excellent performance, but it has a large size of around 4347 mm^2 [3].

In this paper, two different BLCs were designed and simulated for GSM and WLAN systems using the developed two-section stepped-impedance resonator in whose layouts the stepped impedance lines were mirrored in the inner space of the BLC and a size reduction around 61% was achieved.

II. COMPACT DUAL-BAND BLC FOR GSM SYSTEMS

Fig.1 (a) shows the two-section stepped-impedance resonator and Fig. 1 (b) shows the developed dual-band branch-line coupler designing for GSM systems.

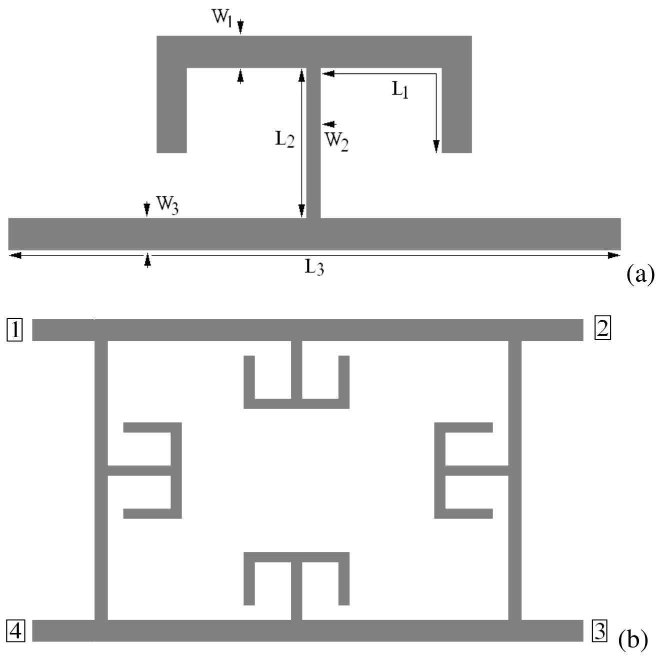


Fig.1 (a) The two-section loaded stepped-impedance resonator (b) The developed dual-band branch-line coupler for GSM systems

According to the developed two-section loaded stepped-impedance resonator, the developed dual-band branch-line coupler was designed for GSM systems. The parameters of the dual-band BLC were tuned using ADS software by full-wave method. Table I gives the optimized parameters for the designed dual-band branch-line coupler designed for GSM systems

Table I: the optimized parameters for the designed dual-band branch-line coupler designed for GSM systems

Parameters	L_1	W_1	L_2	W_2	L_3	W_3
35-Ohm Branch	16.9 mm	0.5 mm	18.2 mm	0.3 mm	64 mm	3.8 mm
50-Ohm Branch	16.9 mm	0.5 mm	18.2 mm	0.3 mm	64 mm	2.7 mm

Based on the optimized parameters for the designed dual-band branch-line coupler given in Table I, the frequency response of the coupler was simulated which has been shown in Fig.2 (a) and (b) for the S parameters and phases of the two outputs.

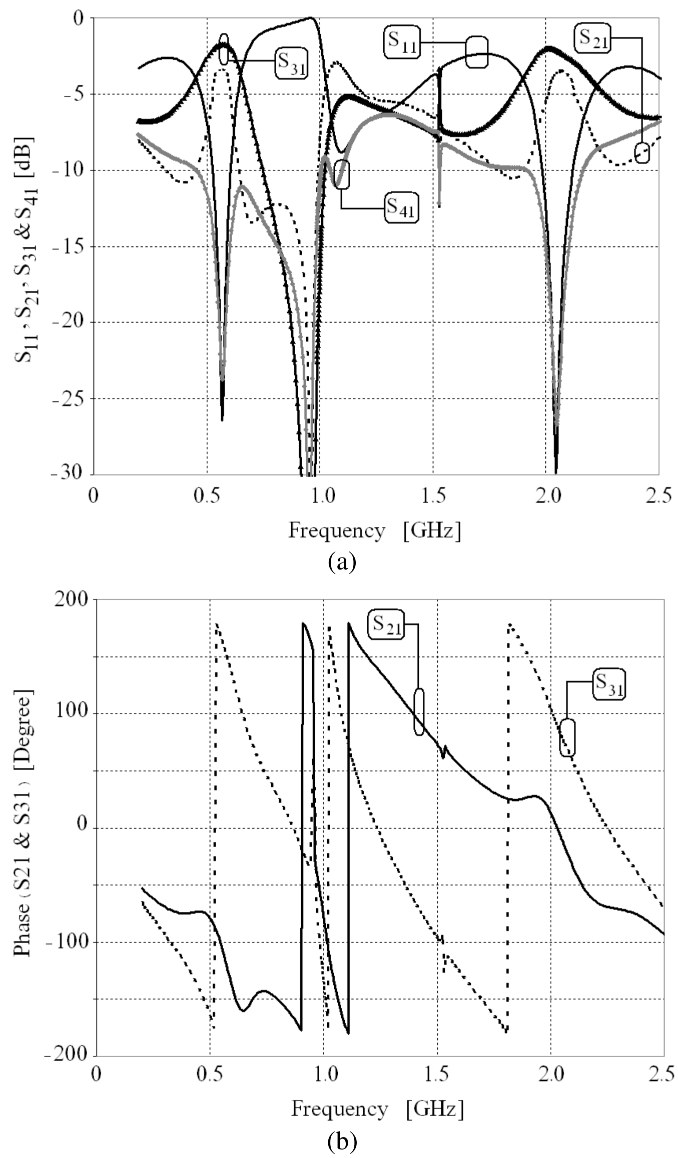


Fig.2, (a) Simulated frequency response of the dual-band coupler for GSM systems (b) the phases of two outputs

Simulated results show that the insertion losses of the through and coupled ports are -3.1 and -3.9 dB with the phase difference of +91° at 0.6 GH and -2.6 and – 3.85 dB with the phase difference of +272° (-88°) at 2.5 GHz

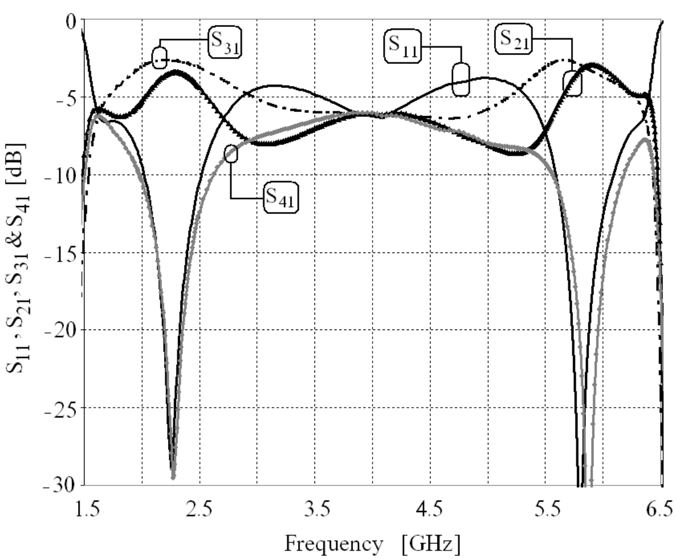
III. COMPACT DUAL-BAND BLC FOR WLAN SYSTEMS

Similar to the previous case, another dual-band BLC was designed and analyzed for WLAN systems. Based on two-section loaded stepped-impedance resonator, shown in Fig. 1 (a), the parameters of the dual-band BLC were similarly tuned using ADS software by full-wave method. Table II gives the optimized parameters for the designed dual-band branch-line coupler designed for WLAN systems

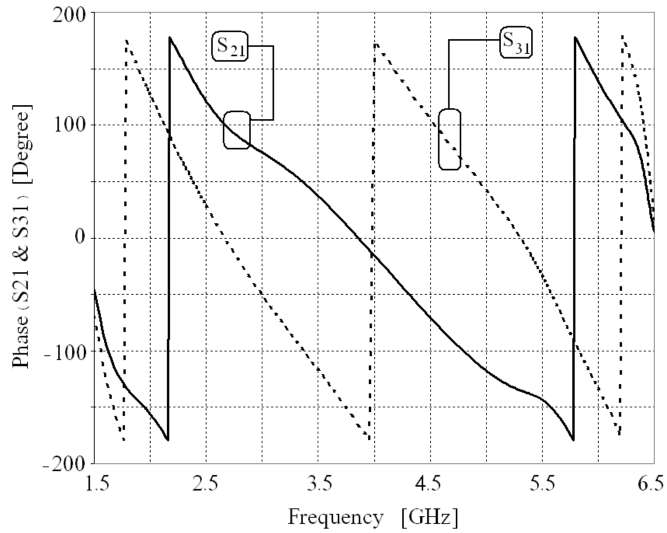
Table II: the optimized parameters for the designed dual-band branch-line coupler designed for WLAN systems

Parameters	L_1	W_1	L_2	W_2	L_3	W_3
35- Ohm Branch	12.9 mm	0.5 mm	10.2 mm	0.15 mm	20.15 mm	3.8 mm
50 - Ohm Branch	12.9 mm	0.5 mm	10.2 mm	0.15 mm	20.15 mm	2.7 mm

Similar to the BLC presented for GSM systems and according to the optimized parameters for the designed dual-band branch-line coupler given in Table II, the frequency response of the coupler was simulated observed in Fig.3 (a) and (b) for the S parameters and phases of the two outputs.



(a)



(b)

Fig.3, (a) Simulated frequency response of the dual-band coupler for WLAN systems (b) the phases of two outputs

According to the graphs indicated in Fig.3 (a) and (b), the simulated bandwidth of dual bands was obtained 15% and 8%,.

The simulated insertion-loss at the coupler's output ports relative to the input port were obtained as $|S_{21}| = 3.1$ dB, $|S_{31}| = 3.4$ dB at 2.41 GHz. The corresponding phase difference was achieved 91.8 degree. At 5.7 GHz, the $|S_{21}|$ and $|S_{31}|$ were simulated to be 3.9 dB and 3.3 dB, respectively, with a phase difference of -91 degree.

4. CONCLUSION

Two super compact dual-band branch-line couplers have been designed, analyzed and simulated for GSM and WLAN systems. The modified layout comprises of a loaded two-section stepped-impedance resonator. The proposed model has been shown to reduce the size of the dual-band BLC around 61% as well as a 4% enhancement in the bandwidth of such components.

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