COMPARISON OF ELECTROMAGNETIC BAND GAP AND SPLIT-RING RESONATOR MICROSTRIP LINES AS STOP BAND STRUCTURES

J. García-García,[1] J. Bonache,[1] I. Gil,[1] F. Martín,[2] R. Marqués,[2] F. Falcone,[3] T. Lopetegi,[3] M.A.G. Laso,[3] and M. Sorolla[3]
[1] Department d'Enginyeria Electrònica
Universitat Autònoma de Barcelona
08193 Bellaterra (Barcelona), Spain
[2] Departamento de Electrónica y Electromagnetismo
Facultad de Física
Universidad de Sevilla
Av. Reina Mercedes s/n
41012 Sevilla, Spain
[3] Departamento de Ingeniería Eléctrica y Electrónica
Universidad Pública de Navarra
31006 Pamplona (Navarra), Spain

Received 29 July 2004

ABSTRACT: *In this paper, microstrip lines magnetically coupled to split-ring resonators (SRRs) are compared to electromagnetic bandgap (EBG) microstrip lines in terms of their stop-band performance and dimensions. In both types of transmission lines, signal propagation is inhibited in a certain frequency band. For EBG microstrip lines, the central frequency of such a forbidden band is determined by the period of the structure, whereas in SRR-based microstrip lines the position of the frequency gap depends on the quasi-static resonant frequency of the rings. The main relevant contribution of this paper is to provide a tuning procedure to control the gap width in SRR microstrip lines, and to show that by using SRRs, device dimensions are much smaller than those required by EBGs in order to obtain similar stop-band performance. This has been demonstrated by full-wave electromagnetic simulations and experimentally verified from the characterization of two fabricated microstrip lines: one with rectangular SRRs etched on the upper substrate side, and the other with a periodic perturbation of strip width. For similar rejection and 1-GHz gap width centered at 4.5 GHz, it has been found that the SRR microstrip line is five times shorter. In addition, no ripple is appreciable in the allowed band for the SRR-based structure, whereas due to dispersion, certain mismatch is expected in the EBG prototype. Due to the high-frequency selectivity, controllable gap width, and small dimensions, it is believed that SRR coupled to planar transmission lines can have an actual impact on the design of stop-band filters compatible with planar technology, and can be an alternative to present solutions based on distributed approaches or EBG.* Microwave Opt Technol Lett 44: 376–379, 2005; Published online in Wiley InterScience (www.interscience.wiley.com). DOI 10.1002/mop.20640

Key words: *split ring resonators (SRRs); electromagnetic bandgaps (EBGs); microstrip lines; metamaterials*

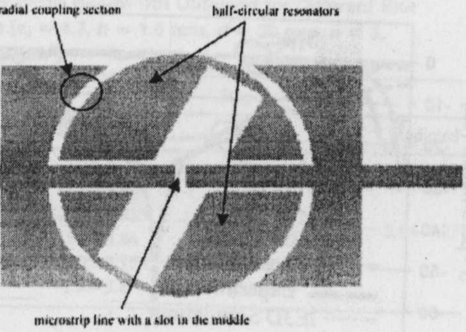

Figure 1 Schematic layout of the proposed BPF

The size of this filter is $12.8 \times 8.8\ mm^2$. The substrate used here has a relative dielectric constant of 9.6 and a thickness of 0.8 mm.

3. SIMULATED AND MEASURED RESULTS

The simulation was accomplished using Ensemble, which is an electromagnetic-wave simulator based on the method of moments (MoM). The measurement was carried out on an HP8510C network analyzer. Figure 3 shows the simulated and measured results, which are in good agreement. As can be seen from Figure 3, two transmission zeros on both sides of the passband can be clearly observed with attenuations of about 46.8 and 59.7 dB at frequencies of 5.62 and 7.11 GHz, respectively. Additionally, the attenuation of the third transmission zero is more than 43 dB at a frequency of 5.31 GHz. The minimum passband insertion loss is 2.1 dB at 6.0 GHz and the 3-dB fractional bandwidth is approximately 1.5%. And the simulated results show that the minimum passband insertion loss is 0.3 dB at 6.0 GHz, that is, lower than the measured results. The discrepancy between them mainly results from the conductor loss and the two microstrip-to-coaxial-line transitions.

4. CONCLUSION

A new type of microstrip narrowband BPF with a multipath coupling structure has been presented. Its performance has been confirmed by simulation and measurement. Two transmission zeros, located at 5.62 and 7.11 GHz with rejection levels of about 46.8 and 59.7 dB, respectively, have been implemented. The fabricated filter has a 1.5% 3-dB bandwidth and the simulated minimum passband insertion loss is 0.3 dB. The new filter is compact and easy to fabricate with good accuracy.

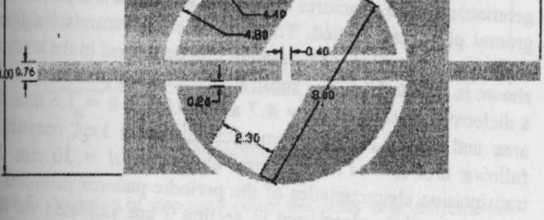

Figure 2 Dimensional layout of the BPF (unit: mm)

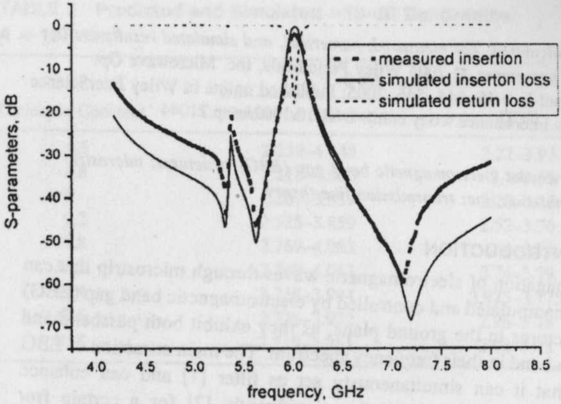

Figure 3 Simulated and measured results of the BPF

ACKNOWLEDGMENTS

This work was supported by the Specialized Research Fund for the Doctoral Program of Higher Education (no. 20010614003) and by the Key Project of Chinese Ministry of Education (no. 104166).

REFERENCES

1. K.T. Jokela, Narrow-band stripline or microstrip filters with transmission zeros at real or imaginary frequencies, IEEE Trans Microwave Theory Tech 28 (1980), 542–547.
2. G.L. Matthael, Narrow-band, fixed-tuned and tunable bandpass filters with zig-zag hairpin-comb resonators, IEEE Trans Microw Theory Tech 51 (2003), 1214–1219.
3. J.S. Hong and M.J. Lancaster, Design of highly selective microstrip bandpass filters with a single pair of attenuation poles at finite frequencies, IEEE Trans Microwave Theory Tech 48 (2000), 1098–1107.
4. J.-T. Kuo, M.-J. Maa, and P.-H. Lu, A microstrip elliptic function filter with compact miniaturized hairpin resonators, IEEE Microwave Guided Wave Lett 10 (2000), 94–95.
5. S.-Y. Lee and C.-M. Tsai, New cross-coupled filter design using improved hairpin resonators, IEEE Trans Microwave Theory Tech 48 (2000), 2482–2490.