Design of Compact Coupled Resonators Bandpass Filter with Defected Ground Structure

Tang-yao Xie* · Young-bea Park* · Gi-rae Kim*
*Silla University
E-mail : grkim@silla.ac.kr

결함접지면 구조를 갖는 소형 결합 공진기 대역통과 여파기의 설계

사당요*, 박영배, 김기래
신라대학교 전자공학과

ABSTRACT

In this paper a four-pole elliptic function bandpass filter is designed with two ground slots. A research of microstrip bandpass filters (BPF) using defected ground structures (DGS) is presented. DGS technique allows designs of tight couplings without the necessity of using very narrow coupling gaps. The simulator Sonnet is used to design the resonator and to calculate the coupling coefficient of the basic coupling structure. Compared to similar microstrip filters without defected ground structure, the simulated performances of these novel structures indicate some technological advantages.

키워드

Compact coupled resonators, bandpass filer (BPF), Defected ground structure(DGS).

Ⅰ. INTRODUCTION

In wireless communication systems, small size and high performance filters are needed to reduce the cost and improve the system performance. They can be designed in many different ways. However, further miniaturization becomes more difficult for this filter. Planar filters provide good miniaturization ability [1-4]. Therefore, there has been much research conducted on planar filters and their components. Since microstrip resonators are the basic components of a planar filter design, it is necessary to select proper resonator types used in a filter design. A conventional haft-wavelength open-line microstrip resonator is too large to be used in the modern communication system such as 900 MHz, 1800 MHz for personal communication systems (PCS). The hairpin filters [1, 5 7] were folded from the open line wavelength microstrip resonator to become U-shaped resonators and make progress in circuit size reduction from the parallel-coupled line structure. Ground slots have many applications in microwave techniques. Slot antennas and slot coupled antennas [8] have been continuously developed and are widely used in communications. The slot coupling is a convenient way to couple microstrip lines in multilayer circuits [9].

In this paper are presented investigations on the effects of ground slots on the couplings between hairpin resonators. Ground slots in the ground plane can enhance the electric coupling, or the electric part of a mixed coupling between two adjacent resonators. The results of these investigations were used in the design of some four-pole cross coupled planar microwave bandpass Filters with a pair of attenuation poles at imposed finite frequencies. The Filters were designed with two ground slots.

Ⅱ. COUPLING CONFIGURATIONS

The microstrip circuit was designed on a Teflon dielectric substrate, with a thickness of 0.7874 mm, a dielectric constant ε_r of 2.17. In order to develop applications for the 1.8 GHz frequency band, the sizes of microstrip hairpin resonators were confirmed. The hairpin resonators size is: W=5.5mm, L=23.7mm, S=18mm. The ground slots are all rectangular, with different lengths l_{slot} and widths w_{slot}. The geometries of the main coupling configurations are shown in Figs. 1. Fig. 2 shows the coupling coefficient of the structures.

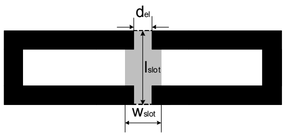

Fig. 1(a). Electric coupling configuration

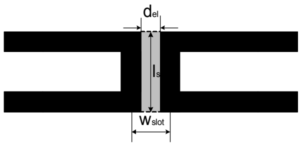

Fig. 1(b). Magnetic coupling configuration

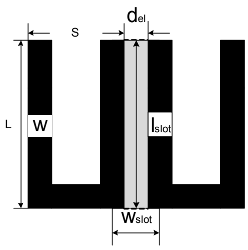

Fig.1(c). Mixed coupling configuration

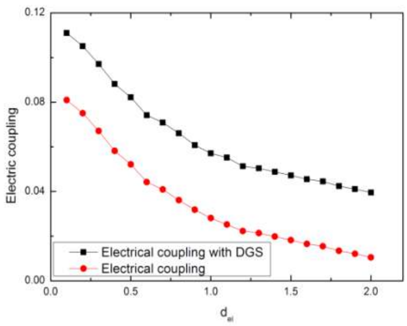

Fig. 2(a) Electric coupling coefficient

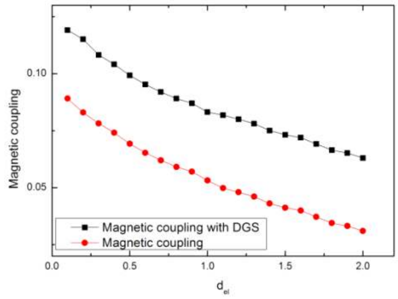

Fig. 2(b) Magnetic coupling coefficient

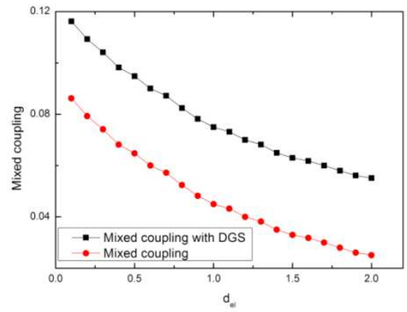

Fig. 2(c) Mixed coupling coefficient

Ⅲ. FILTERS DESIGN AND SIMULATION

A four-pole elliptical bandpass filter response can be implemented using the cross coupling between nonadjacent resonators. The cross-couplings give the input signal two paths from the input port to the output. The magnitude and phase of the signal are changed differently though different paths. As mentioned above, the multipath effect may cause attenuation poles at finite frequencies if the couplings among the resonators are properly designed. Fig. 3 shows the four-pole elliptic function bandpass filter with using miniaturized hairpin resonators. In the configuration, significant couplings exist between any two neighboring miniaturized hairpin resonators. The structure can be extended to form cross-coupled filters of higher orders. Cross-coupled bandpass filters with using compact hairpin resonators are designed to have a fractional bandwidth of 100MHz at a mid-band frequency fo 1.8 GHz. The filter was fabricated on Teflon substrate. The relationships between the bandpass design parameters and coupling coefficient are as follows [14]: K_{12} =0.0322, K_{23} =0.0393, K_{34} =0.03173 and K_{41} = 0.030. The spacing designated in the cross-coupled filter is as follows: w_1=1.1mm, w_2=2.4mm, w_3= 5.8mm, w_4=1.9mm, w_5=1.2mm and w_6=0.6mm. The effects on the center frequency and bandwidth are negligible as long as the gap tuning is small. The measured passband insertion loss is -3 dB, good agreement with the simulation. Fig. 4 shows the simulated and measured characteristics of the filters. Both filters exhibit a good rejection at second harmonic as predicted. Fig. 5 shows the prototype of bandpass filter.

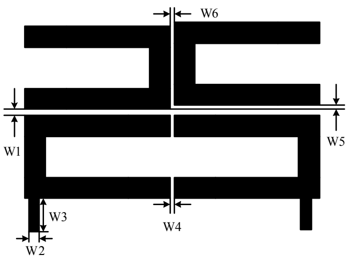

Fig. 3 Layout of the microstrip four-pole elliptic function compact filer

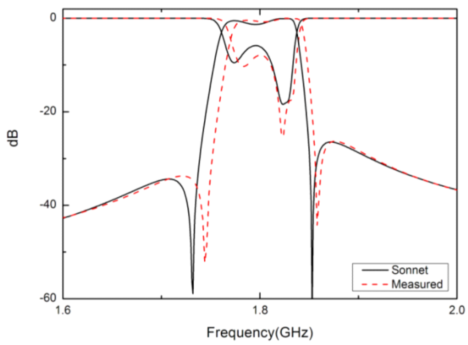

Fig. 4 Simulation and measured results of BPF

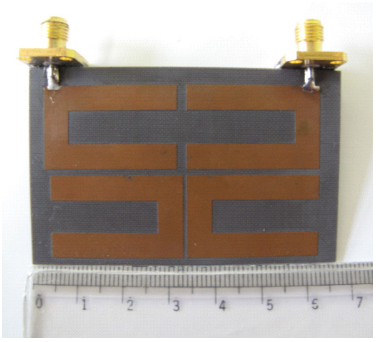

Fig. 5 Fabricated prototype

Ⅳ. BANDPASS FILTERS WITH DGS DESIGN AND SIMULATION

Based on the above results, some 4-pole cross-coupled planar microwave BPFs with a single or with two ground slots were designed. The slots are chosen in the center of ground plane (9mm×3mm). Fig. 6 shows the layout of the microstrip four-pole elliptic function compact filer with DGS. Fig. 7 shows the simulated and measured characteristics of the filters. Fig. 8 shows the ground plane of proposed structure. Both filters exhibit a good rejection at second harmonic as predicted. But the spacing is changed. The spacing is as follows: W_1 = 1.2 mm, W_2 = 2.4 mm, W_3 = 5.8 mm, W_4 = 1.9 mm, W_5=1.2mm and W_6=1.2 mm. Fig. 10 shows the prototype of bandpass filter with DGS.

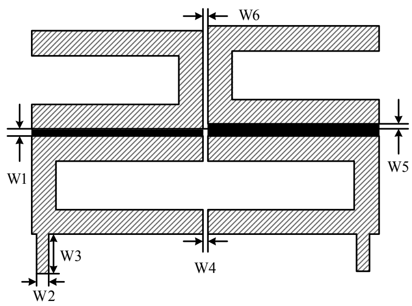

Fig. 6 Layout of the microstrip four-pole elliptic function compact filer with DGS

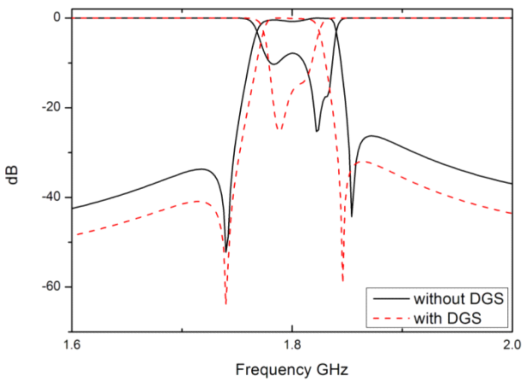

Fig. 7 Compare of simulation results of BPF

Ⅴ. CONCLUSIONS

The main advantage of the BPF with ground slots stays in the possibility of using larger gaps between resonators. This solution is especially convenient when tight couplings are needed. The filters' layouts were designed after a study of the coupling coefficients versus gaps, based on EM-field simulation.

The designed filters with ground slots under the mixed coupling were fabricated and tested. The measured frequency responses of these proposed filter structures demonstrated the validity of the design and of the EM-field simulations. The DGS design can be also applied to many other types of bandpass filters, allowing a relaxation of the fabrication tolerances. If better performances are required, lower loss substrates should be used.

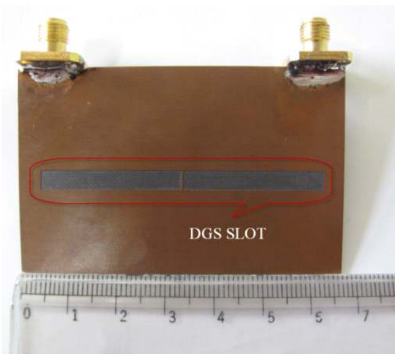

Fig. 8 Fabricated prototype of bandpass filer with DGS

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