Aperture 를 이용한 Microstrip Stepped-Impedance Hairpin 공진기 저역 통과 여파기

조주현, 윤태순, 김기병, 박정근, 이종철
광운대학교 RFIC 연구 및 교육센터
전화 : (02) 940-5203 / 팩스 : (02) 918-6381
E-mail : sigma-12@hanmail.net, jclee@kw.ac.kr

Microstrip Stepped-Impedance Hairpin Resonator Low-Pass Filter with Aperture

Ju-Hyun Cho, Tae-Soon Yun, Ki- Byoung Kim, Jung-Geun Park, and Jong-Chul Lee
RFIC Research and Education Center, Kwangwoon University
447-1 Wolgye-dong, Nowon-ku, Seoul 139-701, Korea

Abstract

A new microstrip stepped impedance hairpin resonator (SIR) low-pass filter (LPF) using aperture is proposed. This filter has the advantages of compact size, easy fabrication, and sharp cutoff frequency response. This filter provides a very sharp cutoff frequency response with low insertion loss and wide stopband characteristic. The filter is useful for many microwave system applications.

1. Introduction

Microstrip stepped-impedance hairpin resonators have many attractive features [1] and can be used in satellite, mobile phones, and other wireless communication system. The main advantages of the resonators are their compact size, easy fabrication, sharp cutoff frequency response, and wide stopband. Therefore, the resonators are widely used in the design of filters, oscillators, and mixers [2].

Small-size low-pass filters are frequently required in many communication systems to suppress harmonics and spurious signals [3]-[10]. The conventional stepped-impedance and Kuroda-identity-stub low-pass filters only provide Butterworth and Chebyshev characteristics with a gradual cutoff frequency response. This type of filter needs more sections and causes to increase the size of the filter and insertion loss. A compact semilumped low-pass filter has been also proposed. However, the structure using lumped elements increases difficulties in fabrication [11].

The microstrip Stepped-Impedance Resonator (SIR) low-pass filter using aperture shows the advantage of high performance, low cost, and easy fabrication [12]-[17].

In this paper, an equivalent-circuit model for the stepped-impedance hairpin resonator is described. The dimensions of the filter are optimized by electromagnetic (EM) simulation. Microstrip stepped impedance hairpin resonator low-pass filter using aperture is adopted to suppress the second harmonic component, to achieve a broad stopband bandwidth, and to improve the return loss.

2. Analysis of the Stepped-Impedance Hairpin Resonator

Fig. 1 shows the basic layout of the stepped-impedance hairpin resonator. The stepped-impedance hairpin resonator consists of the single transmission line l_s and coupled lines with a length of l_c. Z_h is the characteristic impedance of the single transmission line l_s. Z_{0e} and Z_{0o} are the even-mode and odd-mode impedance, respectively of symmetric capacitance-loaded parallel coupled lines with a length of l_c. By selecting $Z_h > \sqrt{Z_{0e}Z_{0o}}$, and employing aperture on the ground plane, the size of the stepped-impedance hairpin resonator becomes smaller than that of the conventional hairpin resonator, which is an elliptic-function low-pass filter using microstrip SIR hairpin resonator. Also, the effect of the loading capacitance shifts the spurious resonant frequencies of the resonator from integer multiples of the fundamental resonant frequency. Also it reduces interferences from high-order harmonics.

The resonator structure to be considered here is shown in Fig. 1 (a). The SIR is symmetrical and has two different characteristic impedance lines, Z_h and Z_l , of admittance Y_h and Y_l.

The admittance of the resonator from the open end, Y_i is given by

$$Y_i = jY_1 \frac{2(K\tan\theta_1 + \tan\theta_2)\cdot(K - \tan\theta_1 \cdot \tan\theta_2)}{K(1-\tan^2\theta_1)\cdot(1-\tan^2\theta_2) - 2(1+K^2)\cdot\tan\theta_1\cdot\tan\theta_2}. \quad (1)$$

Where K is the impedance ratio (=Z_l / Z_h). The resonance condition can be obtain from the following condition:

$$Y_i = 0. \quad (2)$$