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Compact Microstrip for Dual Bandpass Filter

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Abstract

A new configuration of Dual Bandpass Filter was proposed and developed on a basis of the Stepped Impedance Resonators(SIR) and the Parallel Coupled Microstrip Line (PCML). Spiral compact was used as the Stepped Impedance Resonators for tuning dual band resonators, and Hairpin comb structures was used as the coupling and matching network at input and output. Both were proposed to achieve dual band characteristics. The filter was designed to have the main center frequency at 800 MHz and second frequency at 1,700 MHz Measured characteristics of the filter indicated a reasonable agreement with simulated responses

Keywords : Microstrip, Bandpass Filter, Stepped Impedance Resonator**.**

Introduction

In communication systems, miniaturized and enhanced performance filters are always needed to support the growth in increasing coverage, multimedia services and many numbers of subscribers. Conventional filter are used in cellular phone base stations in reduced the cost and a low selectivity.

In this paper, Stepped Impedance Resonators has dual band property. (A.Gopinath, et al,1976) (M.Sagawa, et al,1997) It was used in tuning the harmonic frequency. The important in filter design is coupling coefficients.(M.Makimoto and S.Yamashita, 1979.) Parallel coupled transmission line is rather difficult for parameters to fit in with the specifications at dual band.(S.B.Cohn,1958) As examples, the filters are designed to have their dual band at 800 MHz with 1,700 MHz. The experiment results were verified by the responses simulated with IE3D.

Properties of Stepped Impedance Resonators

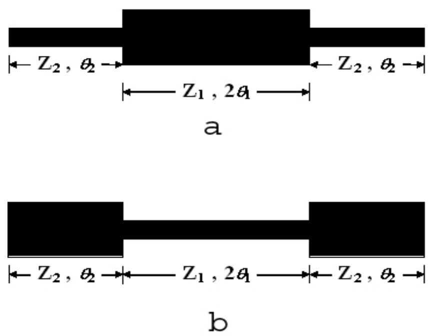


Fig. 1 Stepped Impedance Resonators
(a) $R_z > 1$ (b) $R_z < 1$

Fig.1 shows the basic structure of Stepped Impedance Resonators. Two resonant frequencies are denoted f_1 and f_2 respectively.(M.Makimoto and S.Yamashita, 1980.). Resonance conditions can be derived from fundamental transmission line section. The impedance from the open plane is given as following equation. (M.G.Banciu, et al.)

$$Y_i = jY_2 \frac{Y_2 \tan\theta_1 \times \tan\theta_2 - Y_1}{Y_2 \tan\theta_1 + Y_1 \tan\theta_2} \quad (1)$$

where

$$Y_1 = \frac{1}{Z_1}, Y_2 = \frac{1}{Z_2}$$

and impedance ratio is

$$R_z = \frac{Y_1}{Y_2} = \frac{Z_2}{Z_1}$$

From the analysis resonant conditions $Y_i = 0$ is given as follows

$$\tan\theta_1 \cdot \tan\theta_2 = R_z \qquad (2)$$

and

$$\cot\theta_1 \cdot \tan\theta_2 = -R_z \qquad (3)$$

Impedance ratio is given as follows to the ratio of the resonant frequency, f_2/f_1, and can be found as follows

$$\left.\begin{array}{lll} f_2/f_1 < 2 & \text{when} & R_z > 1 \\ f_2/f_1 = 2 & \text{when} & R_z = 1 \\ f_2/f_1 > 2 & \text{when} & R_z < 1 \end{array}\right\} \qquad (4)$$

There are conditions to be used to design the dual band filter with different frequencies ratio.

The significant parameters of resonator structure

Y_i = characteristic admittance
Z_i = characteristic impedance
θ_i = electrical length
R_z = impedance ratio
f_i = resonant frequency

Properties of Hairpin comb structures

A hairpin structure is a resonance effect occurs in the vicinity of the coupling region between resonators, and this creates a pole of attenuation adjacent to the passband. If the hairpin structure is in a homogeneous dielectric this pole will occur above the passband. In this case of conventional microstrip using a dielectric substrate, the even-mode and odd-mode wave velocities for pairs of coupled lines are different, and it turns out that the pole of attenuation typically occurs below the passband. The position of this pole of attenuation can be controlled to some extent by the addition of capacitive coupling between the open ends of adjacent resonators. It is found that as small amounts of capacitance C are added as near resonator, the pole of attenuation moves upwards in frequency and causes the passband to be further narrowed. At some point the pole will move into the passband and kill the passband completely. Adding still more capacitance C will cause the pole to move up above the passband. This control of the pole position is a potentially useful feature of hairpin structures. In this case of the hairpin-comb structures about to be discussed there are more degrees of freedom present, and the pole position for the case of C = 0 can be on either side of the passband depending on the design of the comb structure.(G.L.Matthaei, 2000.)

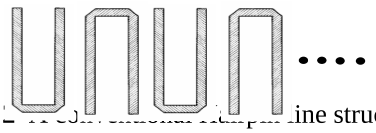


Fig. 2 A conventional Hairpin line structure

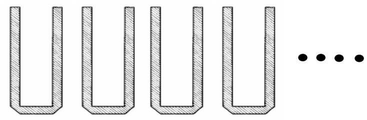


Fig. 3 A conventional Hairpin comb structure

Fig.2 shows a common configuration of Hairpin line. As is discussed in (E.G.Cristal and S.Frankel,1972) The orientation of the hairpin resonator alternating the electric and magnetic coupling to tend to add, result of maximum coupling depends on the space between resonators. (G.L.Matthaei, 2000.) The Hairpin comb referred in Fig.3, the orientation of all resonators alternating the electric and magnetic coupling to tend to reduce.(M.Sagawa, et al.) This type of structure result in the bandwidth which is narrow and very small space between the resonator.(G.L.Matthaei, et al.) This method is included in this paper.

Dual-Band Microstrip Bandpass Filter

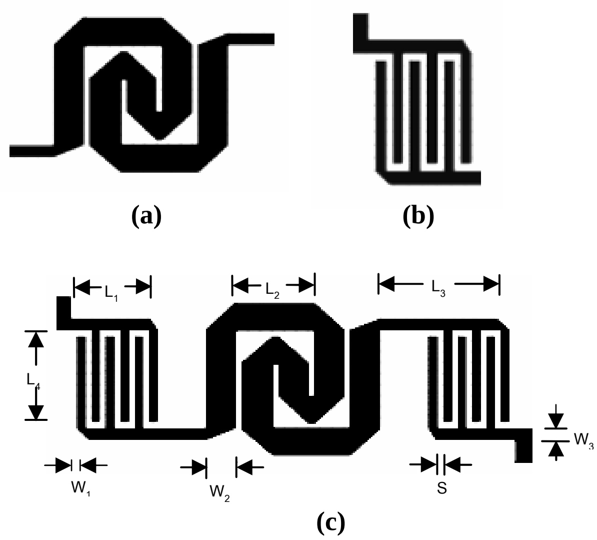


Fig.4 Stepped Impedance Resonators
(a) Spiral (b) Hairpin comb
(c) Topology network

In this section, practical resonator structure and couple line of SIR's are demonstrated. Application of SIR's of dual band filters for communication have been investigated due to excellent electrical performances of SIR's shown in Fig.4. In Fig.4(a) shows Spiral structure for R_z = 1 can be calculated from(1)-(4). In Fig.4(b)shows Hairpin comb.(G.L. Matthaei,2000) Hairpin comb are used as a coupling at input and output of network shown in Fig.4(c) Topology network L_1= 118 mil, L_2=113 mil, L_3=604 mil, L_4=165 mil, W_1=11.8 mil, W_2=50.5 mil, W_3=19.7 mil, S=0.8 mil. which is composed of transmission line with impedance ratio R_z and has two different resonance frequencies f_1 and f_2. The coupling coefficients between the resonators control the bandwidth of a filter.(G.L.Matthaei,2002) Spiral and Hairpin comb are designed coupling coefficients at f_1 for input and at f_2 for output.(G.L.Matthaei, et al.)

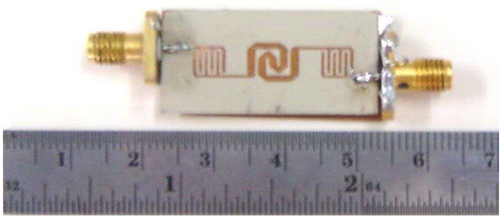
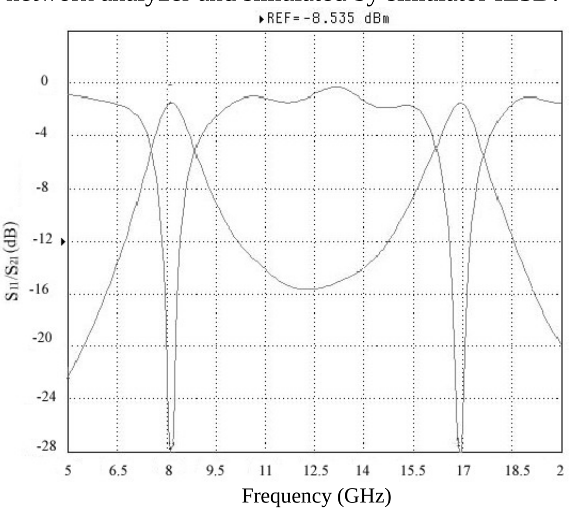


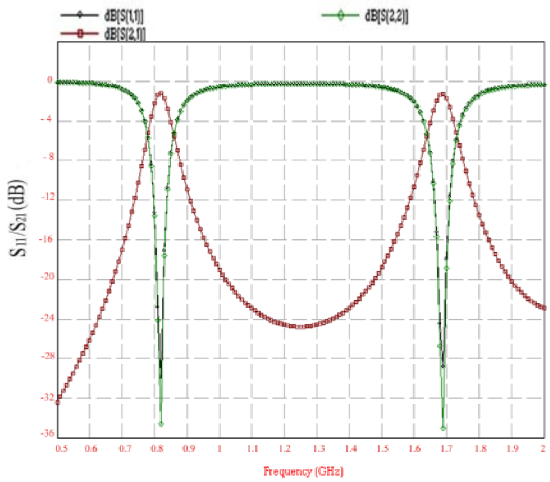
Fig. 5 Photographs of Dual band Microstrip Bandpass filter

Fig.5 shows the Photograph of Dual band Microstrip Bandpass filter. It is constructed by two types of resonators. One is the stepped impedance resonator with Spiral structure and the other is the Hairpin comb resonators. This process is to reduce the filter size for frequency at the main center 800 MHz and second at 1,700 MHz.

A Dual band Microstrip Bandpass filter was implemented using the Roger RT6010L substrate a thickness(h) of 1.27 mm., a relative dielectric constant(ε_r) of = 10.5 and a loss tangent (δ) of 0.0023. The photographs and the simulated, measured results of the filters are shown in fig.6. The filter was measured using an Anritsu 37317C network analyzer and simulated by simulator IE3D.



a



b

Fig. 6 Result (a) from Anritsu 37317C , (b) from Zeland IE3D

Fig.6 shows the results of Dual band Microstrip Bandpass filter form the experiments and simulates at 800 MHz with 1,700 MHz.

The dualband center frequency 800 MHz and 1,700 MHz insertion loss are -28 dB , -28 dB return loss -5 dBm, -8.5 dBm respectively. The bandwidths of dual band center frequency have 70 MHz at – 3 dB. The design methods and theories were verified by the measured results.

Conclusion

The stepped impedance resonators have been used for dual band filter design. A new

configuration of dual band is proposed. The tuning of the coupling coefficients is added. Besides, the matching networks are also given to achieve the dualband in mobile communication. Finally, this topology has been designed and experimentally verified.

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