A Design of Cascaded Trisection Bandpass Filter Using The Meander line Embedded in SIR

YUSEON KIM, HUN NAM*, GEONCHEON LEE,
HYEONSIK NA, KYOUNGKEUN KIM, YEONGSEOG LIM
Dept. of Electronics Engineering
Chonnam Nat. University, LG-Nortel*
500-757, Yongbong, Bukgu, Gwang-ju
Republic of South Korea

Abstract: The embedded meander line in stepped-impedance resonator (SIR) is proposed to design narrow bandpass filter with a good stopband characteristics. The design differs from the general SIR configuration in that the microstrip lines are bent at the location of the maximum magnetic field density. As a result, the resonators have high external quality factors by themselves, since the factor is closely concerned with electric component of the resonator. Moreover, the SIR filter size is heavily reduced by electric coupling between the meander section and the side with open gap. The main application of the proposed structure is in realizing miniaturization in the wibro transceiver band. Sizes of resonators are 7.3 mm×4.95 mm×0.635 mm, 8.6 mm×5.5 mm×0.635 mm, respectively. Measured data of the CT filter indicate 2.8 dB of insertion loss at 2.32 GHz, as well as 18 dB of attenuations at refraction frequencies of 2.37 GHz, respectively.

Key-Words: Microstrip line, SIR, Bandpass filter, Meander line, Miniaturization circuits

1 Introduction

In modern wireless communication systems, the market pressure is the most important to configure system. These trends demand for the mass production and many functions. As a result, the size reduction in limited space plays a part role in the integrated modules which include microwave front end part and IF(intermediate frequency) circuits and systems.

The future market pressure will be proceeding for the integrated digital circuits and analog circuits. For an example, Intel mobile processors are comprised in wireless LAN (Local Area Network), as well as conventional computer structures. Wibro (Wireless Broadband Internet) systems have a similar concept as states. The main concept of Wibro is providing communication network with high speed data transfer rate using mobile phone. The assigned bands of Wibro service are 2.3~2.33GHz/Tx and 2.37GHz~2.40GHz /Rx, respectively. In this paper, the narrow bandpass filters are designed for the using Tx band of Wibro.

The microwave bandpass filters that control the frequency response are an absolute necessity in wireless system[1-6]. The major roles of filters are suppressing unwanted other band signals and image signal except passband signals. Good characteristics of filters are enhancing the whole system performance. For an example, The SNR (Signal-to-Noise Ratio) of the transmission signal is decreased by increasing the signal loss or noise. The signal loss can be reduced by improving pass band characteristics of the filter response. The noise (another band transmission signal, image signal, white noise) can be reduced by shaping frequency responses between pass band and stop band. The improvement of SNR leads to reduction BER (Bit Error Rate) in digital communication system since a decision boundary can be widen by increasing SNR.

Since the late 1950's, the filter design on the microstrip using like a parallel coupled transmission line resonator has been developed by various approaches. The design of the bandpass filter using the SIR can be easily configured to arrange the resonator [3]. Moreover, the spurious responses can be controlled by characteristic impedance ratio and self electromagnetic coupling in the resonator [1].

Fig.1 shows the proposed CT filter using the SIR with the embedded meander line. The structure can be easily realized the prototype element by controlling the self mutual electromagnetic coupling path [2]. Moreover, the values of self inductance and self capacitance are fitted by changing the meander line gap [2,4]. The proposed resonators are optimized to suitable wibro frequency band.

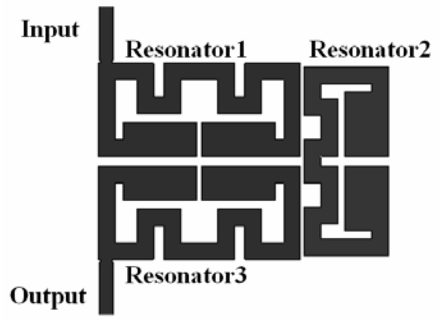


Fig.1 The configuration of the proposed CT Filter.

2 Equivalent Circuits and Analysis

Fig. 2 show the equivalent circuit of the CT filter and the result of the circuit analysis where the C_i and L_i are self capacitance and self inductance, and M_{ij} are Mutual coupling capacitances between the resonators, and Q_{e1}, Q_{e3} are external quality factors input and output. The equivalent circuit of Fig. 2(b) can be expressed in terms of even and odd mode parameters as[3]

$$S_{11} = S_{22} = \frac{S_{11even} + S_{11odd}}{2} \quad (1)$$

$$S_{12} = S_{21} = \frac{S_{11even} - S_{11odd}}{2} \quad (2)$$

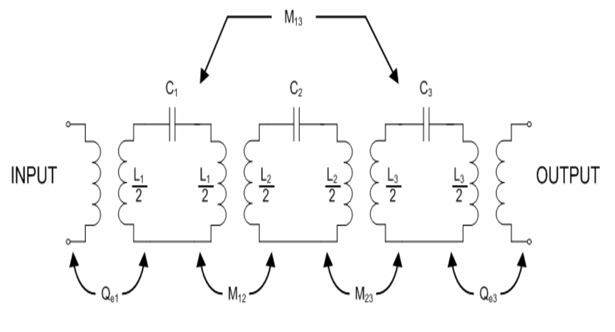
$$S_{11\,even} = \frac{1 - \left(jg_1\omega_S + jB_1 - jJ_{13} + \dfrac{2J_{12}}{jg_2\omega_S + jB_2} \right)}{1 + \left(jg_1\omega_S + jB_1 - jJ_{13} + \dfrac{2J_{12}}{jg_2\omega_S + jB_2} \right)} \quad (3)$$

$$S_{11\,odd} = \frac{1 - (jg_1\omega_S + jB_1 + jJ_{13})}{1 + (jg_1\omega_S + jB_1 + jJ_{13})} \quad (4)$$

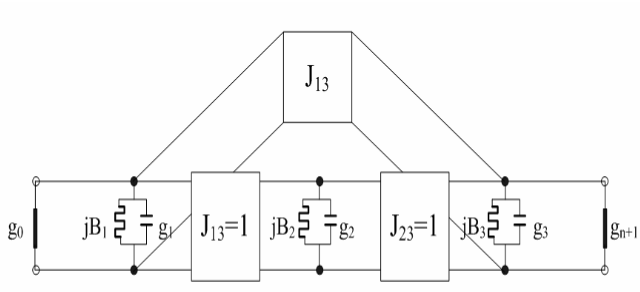
where the ω_S is the frequency variable of the lowpass prototype filter. The relations of the components b e t - ween Fig.2 (a) and Fig.2 (b) are easily extracted by using the lowpass to bandpass frequency transformation. The external quality factor Q_n and mutual coefficient M_{ij} can be presented as

$$Q_n = \frac{\omega_{0n}}{\omega_0 g_{n+1}} \cdot \left(\frac{g_n}{\Delta} + \frac{B_n}{2} \right) \quad (5)$$

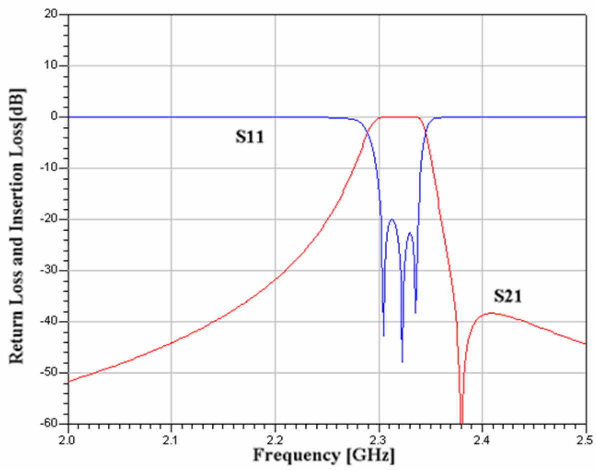
$$M_{ij} = \frac{\omega_0}{\sqrt{\omega_{0i}\omega_{0j}}} \cdot \left(\frac{\Delta \cdot J_{ij}}{\sqrt{g_i + \Delta \cdot B_i / 2} \cdot \sqrt{g_j + \Delta \cdot B_j / 2}} \right) \quad (6)$$



(a) Equivalent Circuit



(b) Lowpass prototype filter



(c) The circuit analysis result

Fig. 2 The equivalent circuit and result using the lowpass prototype.

where ω_0 is angular frequency in center frequency, and ω_{0i} is angular resonance frequency of i th resonator, and Δ is the frequency bandwidth versus center frequency. The lowpass prototypes are extracted from (1)-(6) for the desired specification that the center frequency and bandwidth are 3.22 GHz, 62 MHz,

Table 1. The lowpass prototype values and extracted parameters

The prototype	The element values	The obtained values
g1 = g3	0.97	$f_{01} = f_{03} =$ 2.305GHz
g2	1.4	$f_{02} =$ 2.319GHz
B1 = B3	0.62	$Q_{e1} = Q_{e3} =$ 26.612
B2	0.4288	$M_{12} = M_{23} =$ 0.031
J12=J23	1	$M_{13} =$ -0.01
J13	-0.247	FBW=0.036

respectively. The values of lowpass prototype parameters are shown Table 1. The circuit analysis result is shown in Fig 2.(c).

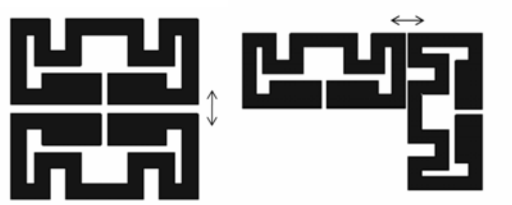
3 The CT Filter Design

Fig.3 shows the process of the extract mutual coefficient and the result. The wanted mutual coefficient values can be extracted by the distance between resonances frequencies of the resonator. The coupling coefficient M_{ij} for resonators i and j can be calculate as [3]

$$M_{ij} = \pm \frac{f_b^2 - f_a^2}{f_b^2 + f_a^2} \qquad (7)$$

where f_a is the lower of the two resonant frequencies, and f_b is the higher one. The upper sign (+) applies to M12 , while the lower sign (-) applies to M13.

Fig.4 and Fig.5 show the results of the simulation and measurement. The simulation is carried out with the assistant of the full wave electromagnetic (EM) simulator HFSS9.1 from Ansoft Inc. The simulations perform the substrate of Rogers6010. Their dielectric constant, loss tangent, and the material of conductor are 10.2, 0.0023, and copper with 0.02 mm thickness, respectively. The miniaturized bandpass filters are designed on one layer with the sheet of 0.63 mm. These overall sizes are only 12 mm×13mm×0.63 mm. The center frequency moves 20 MHz toward lower band. The small mismatch could be generated by processing etching. However, the Rx band of wibro is isolated and the desired bandwidth 2.30~2.33 GHz is satisfied since the bandwidth also increases about 20MHz. The Insertion losses are 2.87 dB at the center frequency due to conductor loss and dielectric loss as shown in Fig.5. The picture of the fabricated bandpass filter is shown in Fig.6.



(a) M13 (b) M12

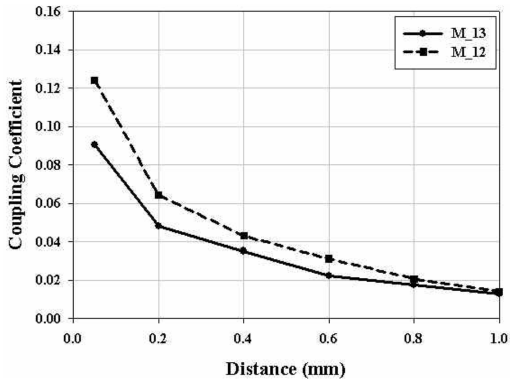
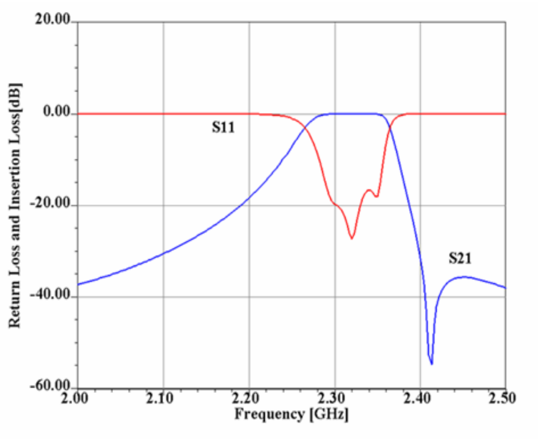
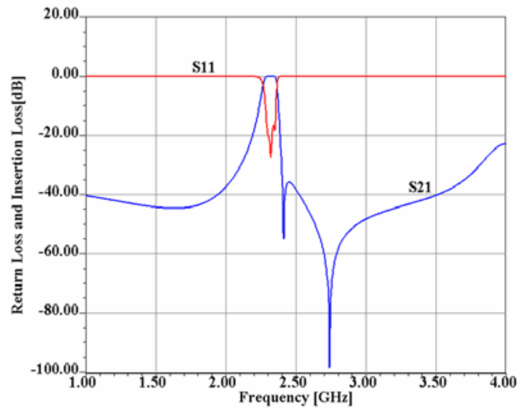


Fig. 3 The mutual coefficient

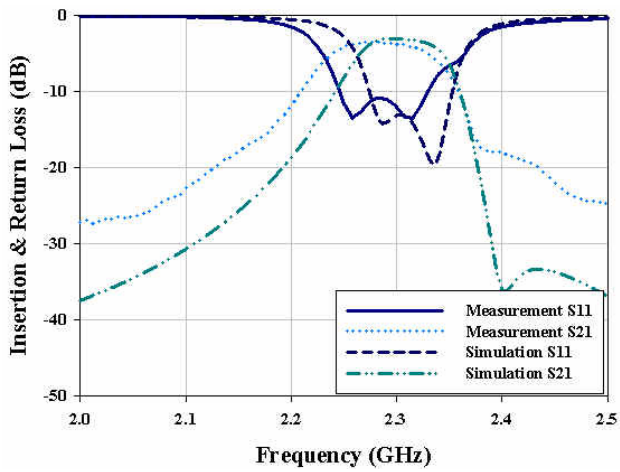


(a) 2.0~2.5GHz

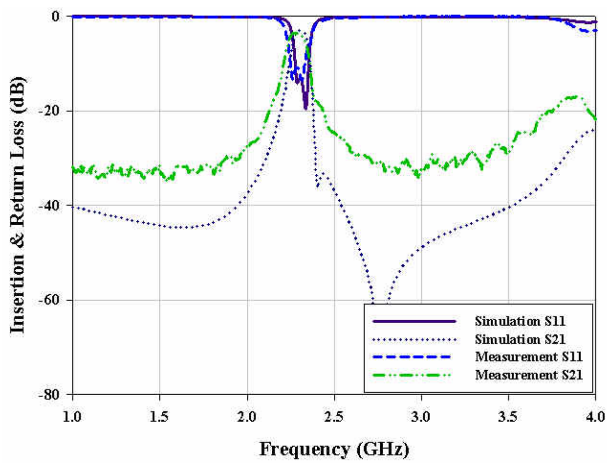


(b) Wide band

Fig. 4 The EM simulation result(Lossless)



(a) EM Simulation and Mesurement(2.0~2.5 GHz)



(b) EM Simulation and Mesurement(1.0~4.0 GHz)

Fig. 5 The EM simulation result(Loss media) and Mesurement

4 Conclusion

In this paper, we design and fabrication the miniaturized bandpass filter using the meander line embedded in SIR. The proposed filter structure has merits which are including sharp frequency response and the narrow gap between the resonators from the realized high external quality factor. Moreover, it can be easily applied to the miniaturized filter design technologies, such as LTCC and MMIC (Microwave Monolithic Integrated Circuit).

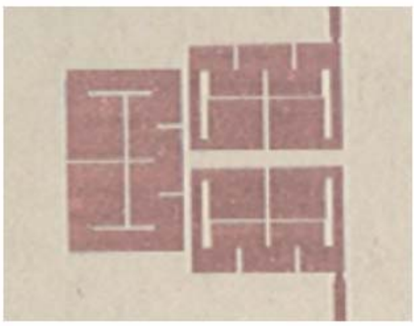


Fig. 6 The Wibro Tx bandpass filter

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