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자기유도 결합 LC 공진기를 이용한 초소형 평형신호 여파기

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Micro Balanced Filter in Magnetically Coupled LC Resonators

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Abstract - In this paper, a micro balanced filter in magnetically coupled LC resonators is proposed, designed, simulated by using FR-4 PCB substrate for low cost, small volume IEEE 802. 11a wireless LAN application. Two pair of coupled LC resonators using magnetic coupling of embedded inductors are applied to obtain bandpass transmission response and improve their phase and magnitude imbalance characteristics. In addition, high dielectric composite film is applied to fabricate the high Q MIM capacitors with small size and high capacitance density. It has an insertion loss of 1.4 dB, a return loss of 10 dB, a phase imbalance of 0.25 degree, and magnitude imbalance of 0.17 dB at frequency bandwidth of 200 MHz ranged from 5.15 GHz to 5.35 GHz, respectively. The proposed balanced filter has a small volume of 1.1mm×1.3mm×0.6mm (height).

1. Introduction

Balanced transmission lines have more resistant to common mode noise and other interference than conventional single-ended lines. Therefore, many commercial RFICs, such as Wireless LAN and Bluetooth chipsets, adopt balanced inputs and outputs. However, in a general RF front-end circuit and most components, such as antennas, duplexers, switches and filters still have single-ended inputs and outputs. Recently, a compact balun with high performance becomes the most necessary component as an interface between a single-ended and a balanced device, such as between the front-end filter and a balanced LNA for miniaturized RF transceiver [1-5].

Fig. 1 shows a system block diagram of wireless LAN module. Generally, baluns which are known planar-type configurations, a number of multi-layered structure using low temperature co-fired ceramic (LTCC) technology, have small size and good performance [1]. However, they do not have transmission characteristic within the interesting frequency bandwidth over any frequency. As shown in Fig. 1, the cascade configuration of filter and balun is most conventional [2]. However, it is not optimal for miniaturized RF front-end. In order to reduce the size, the balanced filter which has a bandpass-type of transmission response has been presented using LTCC technology [3-5]. They showed that coupled-resonators is powerful method in design of balanced filters.

In this paper, a micro balanced filter is proposed, designed, simulated, and embedded into 8-layerd FR-4 PCB substrate for small size, low cost and high performance IEEE 802. 11a wireless LAN application. It consists of two pair of coupled resonators with magnetic coupling by using three embedded LC resonators. These coupled resonators are applied to obtain bandpass transmission response and improve their phase and magnitude imbalance characteristics. In addition, high dielectric composite film is applied to fabricate the high Q MIM capacitors with small size and high capacitance density.

2. Design and Simulation

2.1 Design

As shown in Fig. 2, proposed balanced filter is comprised of two pairs of coupled LC resonators that are coupled magnetically due to their mutual inductance (M). These coupled resonators share one LC resonator with the other. It's assumed that two resonators has same resonant frequency, their self resonant frequencies are given as

$$\omega_o = \frac{1}{\sqrt{(L_P C_P)}} = \frac{1}{\sqrt{(L_S C_S)}} \tag{1}$$

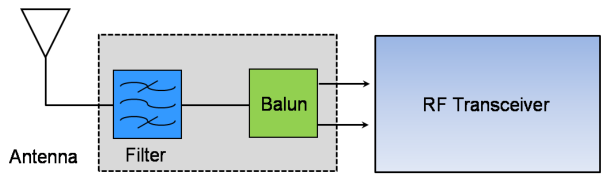
The resonant frequencies of the balun circuit shown in Fig. 2 are

$$\omega_{h,l} = \frac{1}{\sqrt{(L \mp M)C}} \tag{2}$$

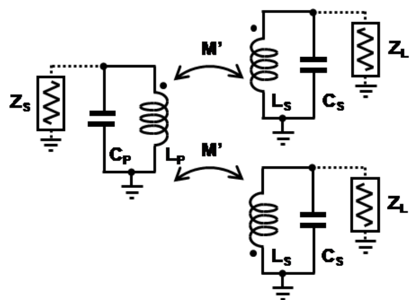
$$k_m = \frac{\omega_h^2 - \omega_l^2}{\omega_h^2 + \omega_l^2} = \frac{M}{\sqrt{L_P L_S}} \tag{3}$$

where ω_h and ω_l are higher and lower resonant frequencies separated by coupling factor (k_m). The coupling coefficient is a quantity used to determine of the bandwidth of the filter. Thus, the knowledge of M, L_P, and L_S is sufficient.

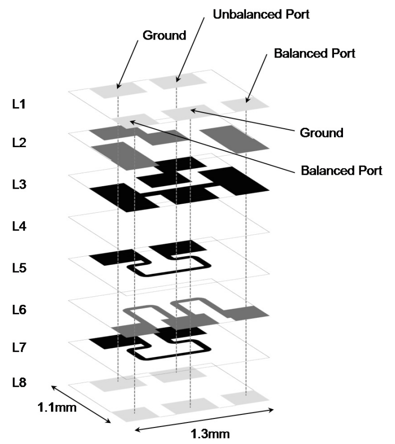
The proposed balanced filter are fully embedded into the 8-layered FR-4 substrate. As shown in Fig.3 and Fig. 4, it is comprised of a prepreg, high DK resin coated copper film, and copper clad laminate. The second and third layers are utilized for making MIM capacitors with high capacitance density. And three embedded inductors are formed onto the fifth to seventh layer. These geometry parameters are optimized by using 3D EM simulator. In particular, the space of three inductors and the electrode size of the capacitor are carefully optimized and interconnected, since the proposed filter is the most sensitive to their geometry. And also, the symmetric structure should be kept. The proposed balanced filter has a size of 1.1mm×1.3mm×0.6mm (height).



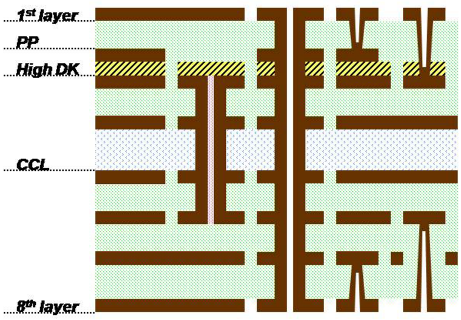
<Fig 1> Block diagram for wireless LAN system module.



<Fig 2> A Schematic drawing of proposed balanced filter.



(a)



(b)

<Fig 3> Physical layout of proposed balanced filter (a) andcross-sectional view of 8-layered organic packaging substrate (b).

2.2 Simulation Results

The proposed balanced filter have been simulated and characterized by using 3D EM simulation. The simulated frequencies are ranged from 0.1GHz to 10 GHz for commercial RF applications.

Figures 4 and 5 show 3D EM simulated results of micro balanced filter in magnetically coupled LC resonators. As shown in these figures, it has low insertion loss, phase imbalance, and magnitude imbalance characteristics. The simulated insertion and return losses are approximately 1.4 dB and 10dB at the operating frequency band, respectively. The simulated amplitude and phase difference are within 0.17 dB and 0.25 degree, respectively.

3. Conclusion

A balanced filter with magnetically coupled LC resonators has been optimally designed and simulated for IEEE 802. 11a wireless LAN applications by using conventional FR-4 PCB substrate. The designed balanced filter consists of two pair of coupled LC resonators to obtain bandpass transmission responses. In order to reduce a size of the embedded capacitor, high dielectric film has been applied into the multi-layered organic packaging substrate. Table 1 shows that it has a competitive performance with smallest size which has ever been reported before. Thus, it might be promising for low cost, small size/volume and high performance wireless LAN front-end modules.

4. Acknowledgment

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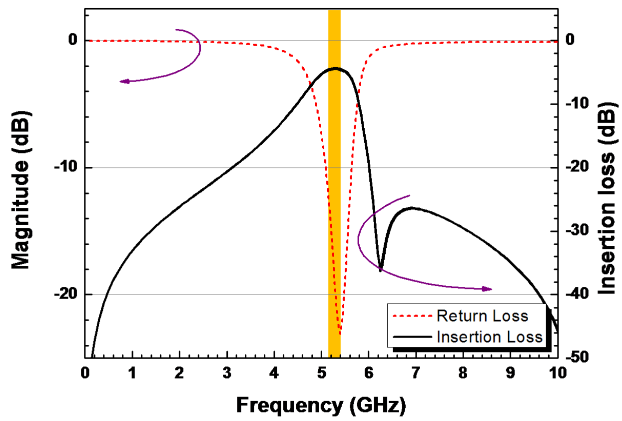
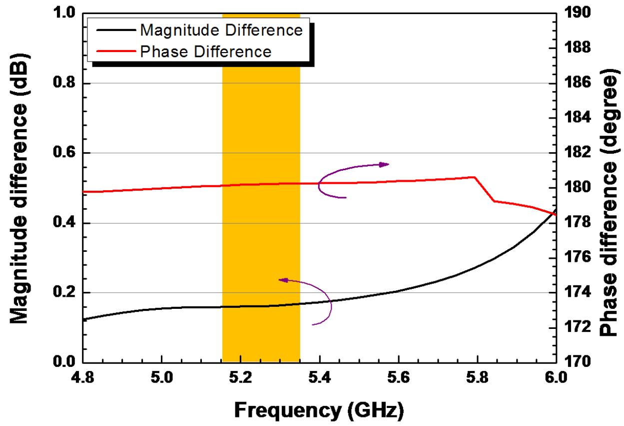


<Fig 4> Simulated transmission and reflection responses.



<Fig 5> Simulated phase and magnitude Imbalance characteristic.

<Table 1> Comparison of this work with previous works

Ref.	Tech.	Insertion Loss (Max)	Mag. Diff. (Max)	Phase Err. (Max)	Stopband Rejection (Min)	CMR (Min)	Size (mm^2)
[3]	LTCC	2 dB	-	-	30 dB (@2.7GHz)	30 dB	2.0×2.0
[4]	LTCC	2 dB	0.3 dB	4 °	20 dB (@2.5GHz)	-	1.4×1.0
This	*PCB*	*1.4 dB*	*0.17 dB*	*0.25 °*	*23 dB (@2.5GHz)*	*42 dB*	*1.1×1.3*

[참 고 문 헌]

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