A Simple Dual-band Band-pass Microstrip Filter

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***Abstract* —Wireless communication has been gaining a lot of attention since this technology came into human lives with many successful military tools and popular commercial products. For the purpose of enhancing wireless communication performance, especially with dramatically increasing needs from industrial, scientific and medical (ISM) groups, this paper in particular concentrates on the development of a simple interdigital-hairpin-structured microstrip filter, with dual-band pass-bands located at specific frequencies of 2.4 GHz and 5.2 GHz.**

I. INTRODUCTION

As a result of dramatically rapid progress and growth of wireless communications recently, there has found many amazing applications such as telegraph, television (TV), mobile telephony, wireless local area networks (WLAN), and so on. The development of modern wireless systems cannot only satisfy the users' needs, but also necessary make wireless communications more reliable and safety. The design of a wireless communication system basically involves various core components, such as antenna, balun, amplifier, modulator, demodulator, oscillator and filter. In particular, for the purpose of enhancing the performance of wireless communication, this paper concentrates on the development of a simple dual-band band-pass filter [1,2].

Filtering technology is often used in signal processing, for restricting unwanted signals [3], i.e. noise, generated by communication system itself and/or other external sources. There have been many different techniques developed for combating the distortion due to inevitable noise, while the simple and efficient way is to allow specific frequency signals to be highlighted as well as attenuate the other frequency signals. Based on this frequency-based manner, our proposed filter was developed with dual pass-bands.

Filters can be fundamentally classified into two types: active and passive. Since active filters are usually more expensive and typically exhibit the operational inferiority at high frequencies, the passive framework was considered as our final design. General passive components, such as capacitors, resistors and inductors, can be typically composed in a specific manner to achieve the expected cutoff frequencies, bandwidths and frequency response characteristics. However, for the case that the electromagnetic wavelength does not dominates the circuit size, the distributed effectiveness of passive components will make the design more challenging. For simplicity and better consulting research findings from others, in addition for compact size with planar framework, our proposed filter was constructed by microstrip line structures.

With an increasing trend in the integration of different wireless communication technologies, the multi-band operational mode has become an important demand for wireless communication system, requiring the use of more than one frequency band. The conventional WLAN system is one example of which the integration of both IEEE 802.11b/g (2.4/2.45GHz) and IEEE 802.11a (5.2~5.8GHz) specifications is required. In particular, motivated by this dual-band purpose as the WLAN system, this paper concentrates on the development of a simple dual-band filter with pass-bands centered at specific frequencies of 2.4GHz and 5.2GHz.

There have been many different methods for designing a dual-band filter: inserting transmission zeros into an otherwise wide pass-band to realize two sub-bands [4–7], dual-mode stepped-impedance resonator (SIR) [8–10], stub line [11], folded waveguide [12], multilayer framework composed of two dual-mode resonators [13–15], two pairs of degenerate modes of the ring resonator [16–17], and so on. Since the accommodation of our filter design is designed to agree with the specifications of both IEEE 802.11b/g and IEEE 802.11a, with a wider bandwidth of the second pass-band than that of the first pass-band, we in particular choose the interdigital-hairpin microstrip structure [18–19] for developing filter framework, in order for high performance and compact size. While the profile of the interdigital-hairpin microstrip structure inherits the superiority of simplicity and compactness, it is more challenging to design the right coherence between all different size parameters for achieving the demanding pass-bands.

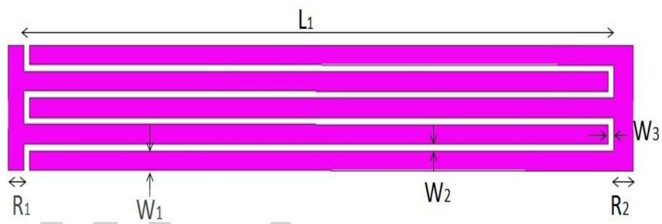

Fig. 1 Layout of our proposed dual-band band-pass microstrip filter.

The paper is organized as follows. Section 2 introduces

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the filter structure, from which the frequency responses associated with different size parameters can be observed. In Section 3 we demonstrate the tests by software simulations and experimental results.

II. Proposed Dual-band Band-pass Microstrip Filter

From the designing point of view, the profile of interdigital-hairpin microstrip structure inherits the superiority of simplicity and compactness, but it is more challenging to obtain the right coherence between all different size parameters for achieving the demanding pass-bands. In particular for achieving our demanding specification of both IEEE 802.11b/g and IEEE 802.11a, the right combination of hairpin's length and width should be chosen at the first step in accordance with two pass-bands centered at 2.4GHz and 5.2GHz, and then modifying other size parameters for better filtering performance.

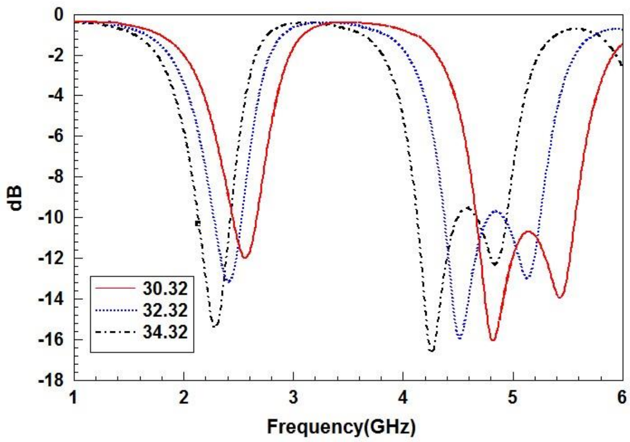

Fig. 2 Simulated S_{11} parameter under different values of L_1.

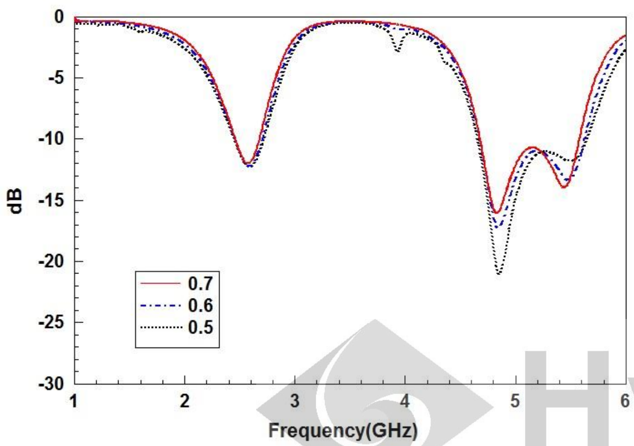

Fig. 3 Simulated S_{11} parameter under different values of W_1.

The layout of our proposed dual-band band-pass microstrip filter is shown in Fig. 1. The design of this filter takes the interdigital hairpin structur and fabricate it by using the microstrip plate, with Roger FR-4 substrate material of dielectric constant 4.4 and of thickness 0.4 mm. Scale parameters regarding the structure size are given by: R_1=0.8mm, L_1=30.2mm, R_2=1mm, W_1=0.7mm, W_2=0.25mm and W_3=0.3mm.

The schematic analyses regarding the S_{11} parameter under different choice of scale parameters are represented in Fig. 2, Fig. 3 and Fig. 4: the change of L_1 essentially shift the central positions of two pass-bands as well as affect their gain characteristics; different choice of W_1 will principally change the frequency response at frequencies beyond 3.6Ghz; the main effectiveness of W_2 is the gain characteristics at frequencies over two pass-bands.

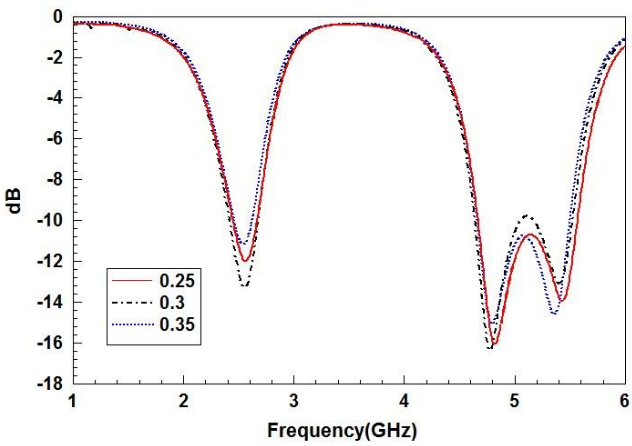

Fig. 4 Simulated S_{11} parameter under different values of W_2.

III. Simulations And Experimental Results

To test our research findings under more realistic condition, we simulated the proposed filter design by using Ansoft High Frequency Structure Simulator (HFSS) computer software, and also measured the realistic operation performance of an experimental model, as shown in Fig. 6. As illustrated in Fig. 5, over the frequency range of 1~6 GHz, the measured and simulated results of our proposed dual-band band-pass microstrip filter can be clearly analyzed and compared to each other. The measured central frequencies for both pass-bands are located at 2.48 GHz and 5.2 GHz respectively. The pass-band insertion losses are approximately 1.73 dB and 2.21 dB at the first and second pass-bands respectively. The size of the proposed filter only occupies the area as small as 32.3 mm × 4.5 mm. Moreover, the high-frequency pass-band of this proposed filter has a wide bandwidth of 4.2~5.9 GHz.

IV. CONCLUSIONS

We had successfully developed an interdigital-hairpin-structured microstrip filter, with dual-band pass-bands centered at specific frequencies of 2.4GHz and 5.2GHz. This proposed simply-structured filter is compact, and essentially accommodate the dual-band specification of the conventional WLAN communications. It remains a topic for future research, to explore some modifications in structure and material for improving the performance quality.

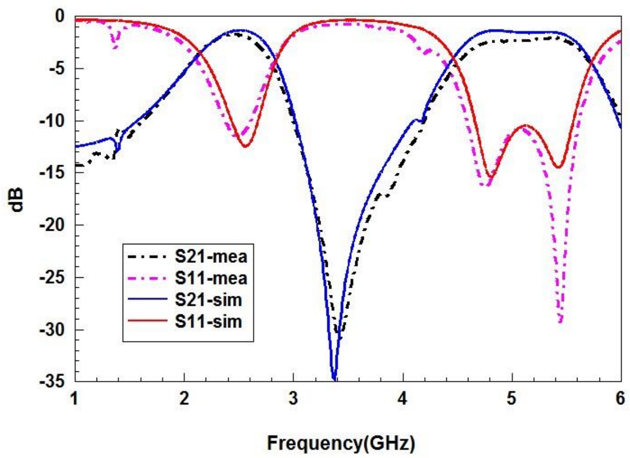

Fig. 5 Simulated and measured results of our proposed filter.

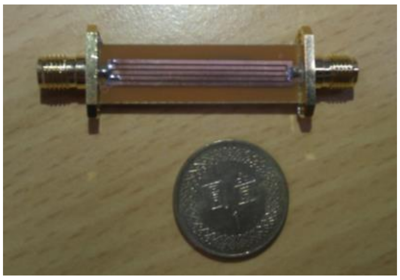

Fig. 6 Photograph of the proposed dual-band filter.

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