Chapter 3

Investigating Single- to Dual-Band Bandpass Filter Transformation for Wireless Communication Systems

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ABSTRACT

A simple technique for transforming a single-band bandpass filter (BPF) into a dual-band BPF is presented in this chapter. The method starts with a 2nd-order single-band BPF design, giving rise to a 4th-order dual-band BPF after the proposed transformation. Both filters are implemented using compact U-shaped microstrip resonator for improved device miniaturization. The proposed work features a centre frequency of 1.4 GHz for the single-band BPF, with a 3.4% fractional bandwidth. The dual-band BPF operates at 1.35 and 1.45 GHz for the first and second bands, respectively. The design implementation employs the commercially available Rogers RT/Duroid 6010LM substrate, having a dissipation factor of 0.0023, dielectric constant of 10.7, and thickness of 1.27 mm. The practical responses of the prototype dual-band BPF indicate a good return loss of better than 18 dB across both bands, and an insertion loss of better than 0.1 dB. The design prototype achieved physical size of 0.23 x 0.18 λg. λg is the guided wavelength for the microstrip line impedance at the centre frequency of the filter.

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1. INTRODUCTION

In the rapidly evolving landscape of communication technology, the demand for smaller and more efficient devices has become increasingly prevalent. This necessity has spurred research and development efforts towards enhancing the performance of primary devices, particularly filters, which play a critical role in signal transmission and reception. Filters are passive components designed to selectively transmit or receive signals within specified frequency bands (Li et al., 2023; Nwajana, 2021; Yan J. et al., 2023; Nwajana et al., 2021; Mu et al., 2023; Nwajana et al., 2017). They find applications across a myriad of wireless communication systems. One remarkable advancement in this domain is the exploration of dual-band BPF as a single component in communication systems (Wei et al., 2023; Alazemi, 2023; Kumar et al., 2021; Li, & Xiao, 2023). This cutting-edge approach aimed at achieving compactness and reduced losses in the system. Dual-band BPFs, realised by employing dual- and multi-mode resonators (Liu Q. et al., 2023), have gained attention for their ability to significantly reduce the physical size of the filter device while enhancing overall performance. Resonators play a pivotal role in the investigation of BPF design techniques. Diverse resonator structures including hairpin (Nwajana, 2020; Shankar et al., 2023; Liu H. et al. 2023), quarter-wavelength (Ma et al., 2022), open-loop ring (Pradhan et al., 2023; Liu et al., 2020), waveguide (Xiong et al., 2023), substrate integrated waveguide (Nwajana & Obi, 2022), and folded-arms square open-loop (Nwajana, & Paul, 2024), have been employed by researchers to successfully achieve BPF components.

In this chapter, a simple technique for transforming a single-band BPF into a dual-band BPF is presented. Microstrip U-shaped resonator structure (Mahadevaswamy et al. 2024) is employed in the implementation of the proposed filter due to its simplicity and relative compact size, when compared to many other popular microstrip resonator structures. The proposed method can be extended to the design of any multi-band BPF and implemented using any resonator of choice. To realise the microstrip U-shaped resonator structure, the conventional microstrip half-wavelength resonator structure shown in Figure 1 (a) is folded into a U-shape structure with dimensions relative to the standard guided wavelength as shown in Figure 1 (b).

The rest of the chapter is organized by firstly reviewing related works in section 2. The theoretical configuration of the proposed dual-band BPF is covered in section 3 while the practical implementation is the focus of section 4. In section 5, the results and discussion are presented while the conclusion is drawn in section 6.