Non-reflective band-pass filters based on two-wire and three-wire coupled lines

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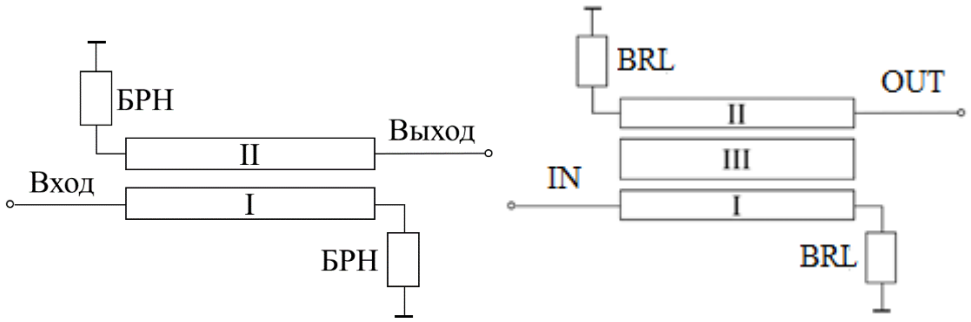
Abstract: This paper presents a comparison of the parameters of two non-reflective stripe filter designs, differing in the type of coupled lines used. The first design utilizes two-wire coupled lines, while the second utilizes three-wire coupled lines. The feasibility of implementing non-reflective filters using two- and three-wire coupled lines is demonstrated. A comparison of the frequency responses of non-reflective filters with different coupled line designs is provided.

Key words: directional coupler, three-connected lines, coupled lines, non-reflective filter, RLC circuits.

1. Introduction

The objective of this work is to simplify the manufacturing technology of non-reflective bandpass filters (NBPF) on coupled striplines (CSL). For this purpose, NBPFs with different types of coupled striplines were compared. The equivalent circuits of the compared filters are shown in Fig. 1, a, b. The first design (Fig. 1, a) includes two-wire coupled lines I and II, the diagonal arms of which are loaded with RLC circuits, forming buffer resonant loads (BRL) [1–3]. In this case, the coupled lines are located on two orthogonal substrates with different permittivity. This type of lines is called VIP [4]. The coupled strips are applied to both substrates and soldered to connect them, which complicates the installation of the substrates and, accordingly, the coupled strips. In addition, losses increase due to the presence of the soldered seam. The second design (Fig. 1, b) includes three-wire coupled lines, which allows the filter to be implemented on a multilayer printed circuit board.



a) b)

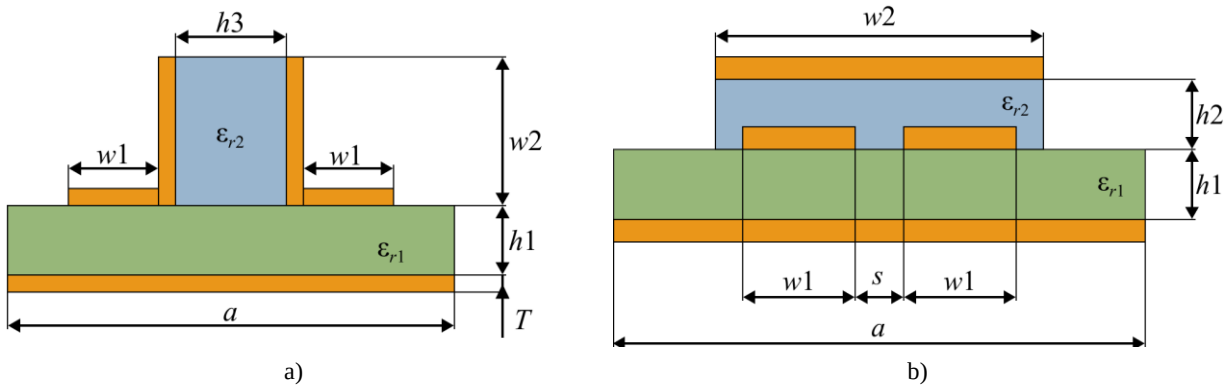
Fig. 1. Equivalent circuits of non-reflective strip filters: a) based on two-wire coupled lines; b) based on three-wire coupled lines

Three-wire coupled stripline designs are used primarily to provide strong electromagnetic coupling, such as in the design of phase shifters [5, 6] and transformers [5], or to maintain the frequency-selective properties of modal filters when signal conductors are spaced apart [7]. The paper [8] proposes using three-wire coupled striplines in printed circuit boards to enhance physical protection, eliminating the risk of simultaneous damage to the redundant and backup signal

conductors. A patent [9] describes a directional coupler (DC) with a third coupled stripline divided into three parts, which improves the technological efficiency of regulating the electrical parameters of the device.

2. Equivalent circuit and design NBPF

When replacing the design of the connected strip lines, relative to [1] (Fig. 2, a), the NBPF will have a cross-section shown in Fig. 2, b.

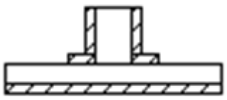
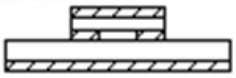


a) b)

Fig. 2. Cross-section of strip lines: a) two-wire; b) three-wire

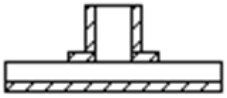
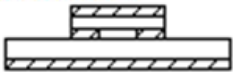
The topological features of the designs of the coupled lines for comparing frequency characteristics are made close to each other, as shown in Table 1.

Table 1. Technological features of connected line designs.

Parameter for comparison (Fig. 2)		
w1, mm	0,6	0,6
w2, mm	2	2
h3 (fig. 2, a) or s (fig. 2, b), mm	0,635	0,1
h1, mm	1,5	1,5
h2, mm	–	0,2
ε_{r1}	4,5	4,5
ε_{r2}	3	3
length of a section of connected lines, mm	28,5	28,5

When calculating the filters, the same values of the RLC circuit elements were included: R = 50 Ohm; L = 23 nH; C = 1.2 pF, forming the BRL. The calculated dependences of the transmission and reflection coefficients are shown in Fig. 3 and 4, their comparison is given in Table 2.

Table 2. Comparison of frequency parameters of filters with different designs of coupled striplines.

Parameter for comparison		
f_0, GHz	0,95	0,95
Δf, MHz	161,3	160,1

$S_{21}(f_0)$, dB	– 0,15	-0,49
$S_{11}(f_0)$, dB	– 29,62	-19,67

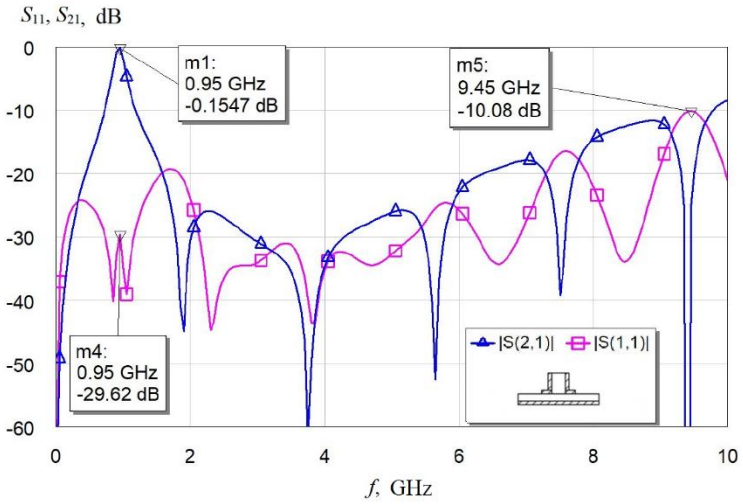


Fig. 3. Frequency dependences of the NBPF based on two-wire coupled lines

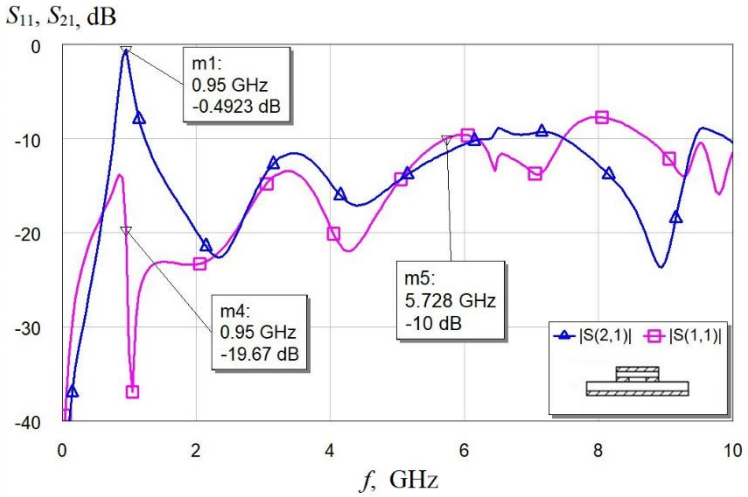


Fig. 4. Frequency dependences of the NBPF based on three-wire coupled lines

Conclusion

In the frequency range up to 10 GHz, the frequency characteristics of a bandpass filter based on three-wire coupled lines and two-wire lines are comparable in all frequency parameters. However, the second type of filter, based on three-wire lines, is more rationally used in a narrower operating frequency range.

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