Compact Broadband Absorptive Bandstop Filter Based on Microstrip

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Abstract. A compact broadband absorptive band rejection filter (ABSF) based on microstrip line is proposed. The filter consists of a pair of coupled wires and is loaded with a resistor. The coupling line of the filter has an open stub. The transmission zero point can be adjusted by adjusting the width of the coupling line. The center frequency can be adjusted by changing the length of the intermediate coupling line. Absorption performance can be achieved through loaded resistors. In this way, the signal not input in the filter will be dissipated in the filter and will not be reflected. When $f_0=3.8$ GHz, 26% of the 20 dB bandwidth covers 3.15 GHz-4.2 GHz, the rejection depth of the stopband is less than -40 dB, and the in-band absorption is less than -10 dB.

1. Introduction

In recent years, the design of non-reflection/absorptive microwave filters has attracted widespread attention. Contrary to the signals that are not transmitted to the output port in the channel of the traditional filter are reflected back to the input port, the signals that are not transmitted to the output port in the absorptive filter will be dissipated in the filter channel, so that the entire RF transmission chain causes adverse effects. As a result, poor power reflections that may reduce the operation of sensitive RF modules in the microwave front-end chain and reduce the overall linearity and efficiency of the transceiver are suppressed.

At present, most of the non reflective filter designs are based on bandpass filters. A general method for designing an absorptive bandpass filter is presented[1]. Two different all pass filters are combined, and the selectivity comes from phase cancellation. In [2] and [3], in order to achieve high power matching level in stopband or out of band frequency range, several π type lumped elements and hybrid transmission line / lumped element circuit networks are used to analyze the prototype of nonreflective bandpass filter. In [4], the symmetrical quasi nonreflection behavior can be obtained at two entrances of two channels by combining microstrip resonators with lumped element resonators. In [5], it is possible to use transmission lines instead of lumped elements to construct a prototype of non reflective filter. The motivation for using transmission lines is to allow filters to be used at significantly higher frequencies. Lumped element resonators can be replaced by open stub with quarter and half wavelength. In [6], split multi band bandpass filters with no input reflection function are introduced. In the case of multi band BPF, they are composed of a duplex network. In [7], a multiband filter based on coupled multline elements is introduced, which allows generation of multiband responses at transmission zeros on both sides of all passbands without cross coupling between resonant nodes. Of course, many designs of absorptive bandstop filters are also proposed. In [8], an absorptive bandstop filter that can operate in the microwave state (C band) is proposed, and its attenuation is achieved by a resonator composed of
petroleum printed circuit components and surface mount components. In [9], a novel design of absorbing bandstop filter is proposed, which is realized by introducing a lossy resonator into the traditional narrow-band coupling line bandstop filter. [10] A planar bidirectional absorptive bandstop filter with wide absorptive bandwidth and compact circuit size is proposed in this paper. The proposed absorptive bandstop filter is developed from the absorptive coupling line. [11] proposed an absorptive bandstop filter and combined it with the specified negative group delay and negative group delay bandwidth. It is realized by a resistance-loaded coupled line structure. The article [12] first proposed a balanced octave band adjustable absorptive bandstop filter, which is based on a hybrid coupling absorption-type bandstop filter topology, which can achieve high rejection rate in a wide tuning range.

This paper proposes a compact broadband absorptive bandstop filter based on microstrip line on the basis of the traditional band stop filter in literature [13]. The absorptive performance is achieved by loading resistors. The basic principles of design are given in the article. Compared with other non-reflective band rejection filter designs, this design method can obtain a wider bandwidth while maintaining a higher suppression depth.

2. Filter design
The so-called non-reflection/absorption principle is: if the input signal in the filter stopband is reflected, the reflected signal may produce a bad response in the system using the filter and cause signal interference to the performance of other components in the line. Therefore, adding absorption elements in the circuit makes most of the energy of the stopband or out-of-band input signal consumed instead of being reflected back to the source end, thereby improving the overall performance of the filter. Therefore, according to this principle, on the basis of the traditional bandstop filter, the layout of the proposed absorptive bandstop filter is shown in Figure 1 below. The figure shows a pair of coupled lines with open stubs. They are connected by a T-shaped transmission line, loaded with a resistor at the end of the first branch near the input port, and grounded through a through hole. By adjusting the width of the coupling line, the transmission zero point can be adjusted, and the center frequency can be adjusted by changing the length of the intermediate coupling line and the length of the open stub. The signal that cannot be transmitted to the output port in the entire filter channel is absorbed by the load resistor in the filter and will not be reflected back to the input port. By adjusting the resistance value, the in-band absorptive rate is lower than -10 dB, and finally R=220Ω. Through simulation and optimization, the size of the absorptive band rejection filter is shown in Table 1. The filter is designed on the Rogers 4350 substrate, the substrate thickness is 0.508 mm, the dielectric constant is 3.66, and the through hole is a metal circle with a diameter of 0.4 mm.

![Figure 1. The layout of the proposed absorptive bandstop filter.](image-url)
Table 1. Design dimensions of the proposed absorptive bandstop filter.

| Name | Value (mm) | Name | Value (mm) |
|------|------------|------|------------|
| L1   | 1.2        | W3   | 0.5        |
| L2   | 5          | W4   | 0.6        |
| L3   | 12         | g1   | 0.37       |
| L4   | 11         | H    | 0.508      |
| W1   | 0.7        | d    | 0.4        |
| W2   | 0.7        |      |            |

The simulated response is shown in Figure 2. It can be seen from the figure that the 26% 20 dB fractional bandwidth can cover 3.15 GHz-4.2 GHz, the rejection depth of the stopband is less than -40 dB, and the in-band absorption rate is less than -10 dB.

As shown in Table 2 below, in order to test whether the proposed absorptive bandstop filter is practical and whether there is an advantage in performance, the performance of the proposed absorptive bandstop filter is compared with the existing ones that have been proposed. The performance of the band stop filter is compared with some performances, such as the depth of stop band rejection, in-band absorptive, size, etc. It can be seen from the table below that the proposed absorptive bandstop filter has deep stopband suppression, is relatively small in size, and has a relatively wide absorption fractional bandwidth, achieving the purpose of a compact high suppression broadband absorptive bandstop filter.
3. Conclusion
A small broadband absorptive bandstop filter based on microstrip line is proposed. The principle of absorptive filter is given in this paper. Therefore, it is easy to realize the design of absorptive filter on the basis of traditional bandstop filter. Through simulation and optimization, the filter has a suppression depth of ~ 40 dB and a bandwidth of 26%. At the same time, the size of the filter is only 20.8 * 12.8 mm. It can absorb the UN transmitted signal in the frequency band and not be reflected back to the input, so it has a wide application prospect.

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Table 2: Comparison of the proposed absorptive bandstop filter with the reported design.

| Ref. | $f_0$ (GHz) | Size ($\lambda_g \times \lambda_g$) | Absorptive FBW | Attenuation (dB) |
|------|------------|----------------------------------|----------------|-----------------|
| [8]  | 2          | 1.23*0.17                        | 0.9%@RL=20dB   | 34.8            |
| [9]  | 3          | 0.56*0.19                        | 18.7%@RL=20dB  | 30              |
| [10] | 1.99       | 0.76*0.16                        | 6.5%@RL=20dB   | 20              |
| This work | 3.8       | 0.52*0.32                        | 26%@RL=12dB    | 45              |
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