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DUAL-BAND BANDPASS FILTER BY USING SQUARE-LOOP DUAL-MODE RESONATOR

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ABSTRACT: *This paper presents a dual-band bandpass filter by introducing transmission zeroes in the passband of a broadband bandpass filter using square-loop dual-mode resonators. The transmission zeroes are achieved by using a dual-mode resonator. The dual-mode resonator is attached to two transmission lines of same length. These lines are coupled to similar transmission lines that are attached to the I/O ports. The filter has a compact size, low losses, and good rejection between the two bands.* © 2008 Wiley Periodicals, Inc. Microwave Opt Technol Lett 50: 1567–1570, 2008; Published online in Wiley InterScience (www.interscience.wiley.com). DOI 10.1002/mop.23427

Key words: *bandpass filter; dual-band filter; dual-mode filter; dual-mode resonator; filter*

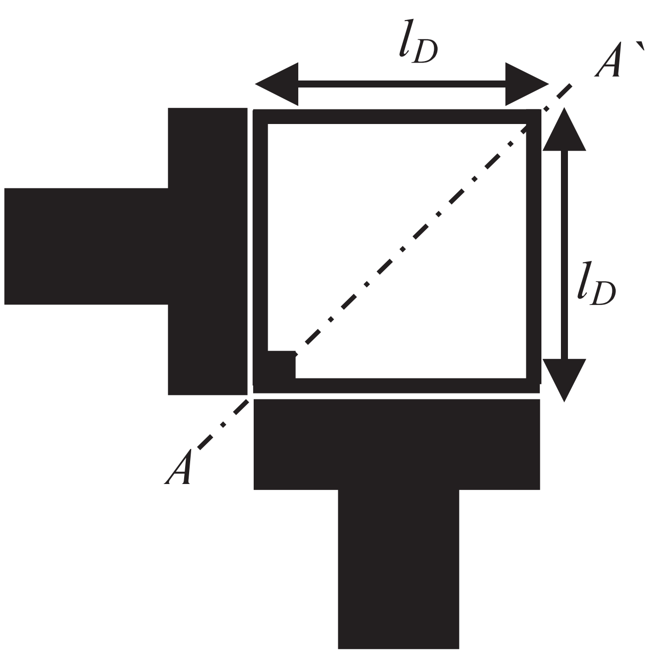

Figure 1 Layout of the bandpass filter using the microstrip dual-mode resonator

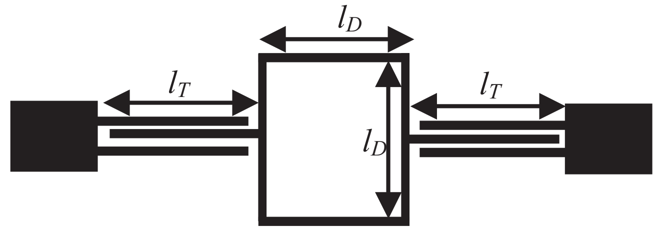

Figure 2 Layout of the bandpass filter using the microstrip dual-band structure

1. INTRODUCTION

The increasing scale of modern wireless communication applications and radar systems has boosted the demand for microwave filters, in particular dual-band filters, as they play an essential role in transmit-receive systems (e.g., [1–7]). The dual-band bandpass filters have been achieved in many different ways such as setting two different filters in parallel [1], using dual-band SIR resonators [2], using dual-band stubs [3], dual-mode resonators [5], using coupled resonator pairs [6], and combining quasi-lumped with open-loop bandpass filters (operating at different frequency bands) [7]. However, there is need for further work because the communications development requires low loss filters with compact size.

Dual-mode resonators are well known as excellent resonators for filter applications. They play a major role in reducing the size of the filter, because each of these resonators provides two return loss poles [7–12]. Figure 1 shows the layout of a bandpass filter designed using the square-loop dual-mode resonator, which has been proposed in [7]. The two modes are achieved by rotating one of the two ports by 90° and attaching a small square patch at the inner corner of the square loop [7]. The position of this patch is important for achieving either elliptic or quasi-chebyshev response. Keeping the symmetry of the structure with respect to the plane *A*–*A*[prime] (see Fig. 1) will lead to an elliptic response. On the other hand, breaking this symmetricity, a quasi-chebyshev response can be achieved [11, 12].

This paper demonstrates a dual-band bandpass filter using the square-loop dual-mode resonator connected to transmission lines of a length l_T coupled to the I/O ports by transmission lines of the same length l_T. The filter has been designed and fabricated on an RO4003c substrate, which has a thickness of 0.813 mm and a relative dielectric constant of 3.38. The filter has been optimized using the 2.5D MoM simulator SONNET.

2. METHOD OF DESIGN

Figure 2 shows the layout of a broadband bandpass filter. It basically consists of the above described square-loop dual-mode resonator attached to two transmission lines of same length l_T. These lines are coupled to similar ones that are attached to the I/O ports. Figure 3 shows the insertion loss of the broadband bandpass filter.

On rotating the I/O ports by 90°, transmission zeros will be generated which are responsible for this dual band behavior. Figure 4 shows the layout of the of this dual-band bandpass filter.

3. DUAL-BAND BANDPASS FILTER AND CENTER FREQUENCY CONTROL

Figure 5 demonstrates the relation of the insertion loss of the filter by choosing $l_T = l_D = 5$, 10, and 15 mm, while keeping the dimensions of the perturbation patch at $p = 0.5$ mm, and the width of the attached transmission line and the arms of square-loop resonator at 0.3 mm fixed.

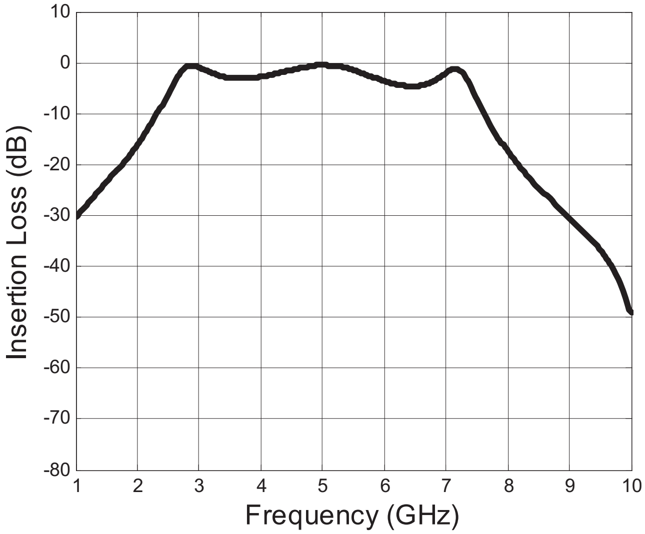

Figure 3 Simulated return loss of a dual-band bandpass filter with $l_T = l_D = 10$ mm

The relation between the length of the transmission lines l_T, the length of dual-mode arms l_D sharing the same width $w_1 = w_2$, and the center frequency of the filter as it is observed from Figure 5 is given by

$$f_0 \approx \frac{c_o}{(2l_T + 4l_D)\sqrt{\varepsilon_{eff}}} \approx \frac{f_{02}}{2}, \quad (1)$$

where f_{01}, f_{02} are the center frequencies of the first and second bands, respectively, c_0 is the speed of the light in free space, ε_{eff} is the effective dielectric constant, l_T, l_D are the length of the additional transmission lines, and the length of the dual-mode resonator arms, respectively.

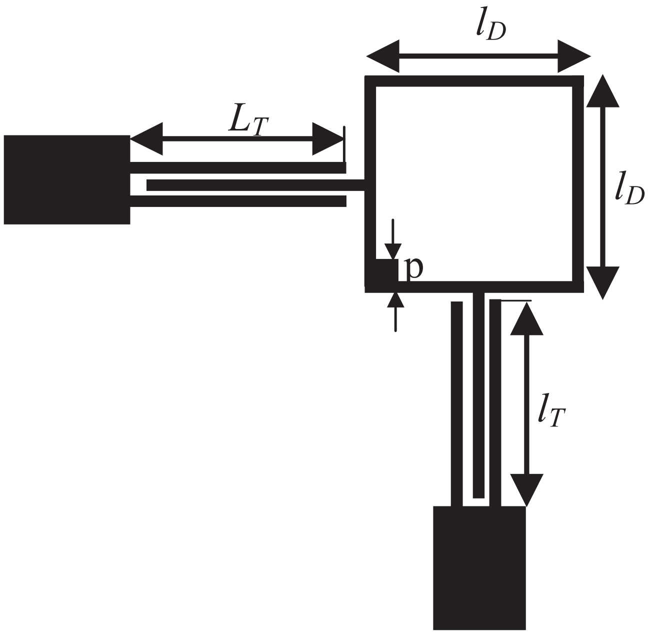

Figure 4 Layout of a dual-band bandpass filter using dual-mode resonator

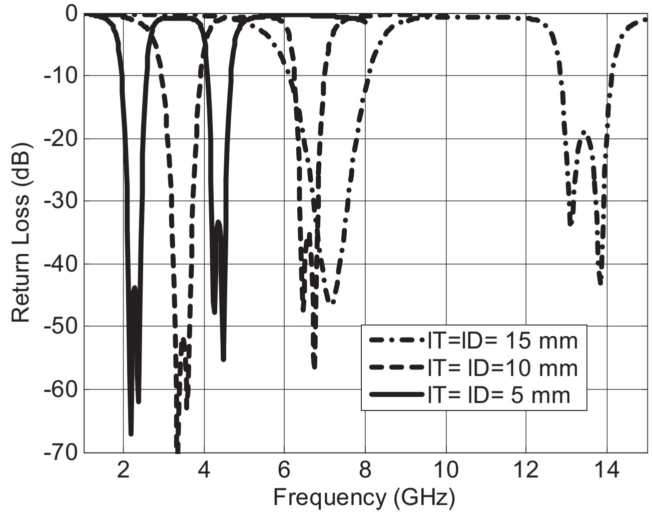

Figure 5 Simulated return loss of a dual-band bandpass filter with $l_T = l_D = 5$, 10, 15 mm

4. DUAL-BAND BANDPASS FILTER WITH BANDWIDTH CONTROL

One of the main advantages of this filter is that the bandwidths of both bands can be controlled, which is shown in the following.

4.1. Bandwidth Control by Adjusting the Length of the Attached Transmission Lines l_T

Changing the length of the attached transmission lines only (which will lead to changing the center frequency of both bands) will affect the bandwidth of both bands. So by choosing l_T longer than the l_D, the bandwidth of the first band increases and that of the second band decreases.

The opposite applies too, i.e., choosing the length of the attached transmission line smaller than the length of arms of the dual-mode resonator decreases the bandwidth of the lower band and increases that of the higher band. This basically occurs because of the transmission zeroes that remain fixed. This can be

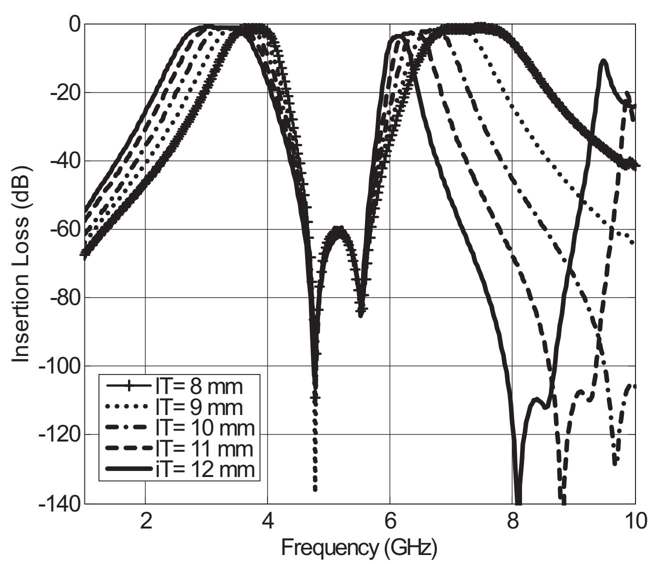

Figure 6 Simulated insertion loss of the dual-band bandpass filter with different l_T values

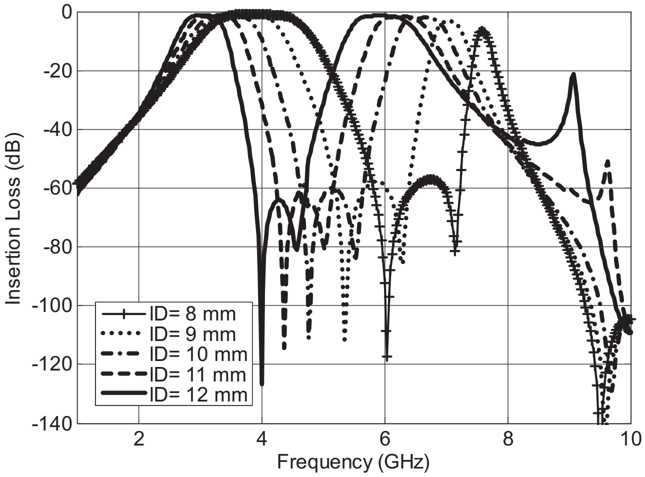

Figure 7 Simulated insertion loss of the dual-band bandpass filter with different l_D values

clearly seen in Figure 6, which shows the simulated insertion loss of the filter for different transmission lines lengths.

4.2. Bandwidth Control by Adjusting the Length of the Arms of the Square-Loop Resonator l_D

Changing the length of the dual-mode resonator arms will influence basically the position of the transmission zeroes. This in turn affects the bandwidth of both bands. Increasing the length l_D shifts the transmission zeroes to a lower band, which leads to having a narrower bandwidth of the lower band and wider bandwidth of the higher band. Shortening the arms shifts the transmission zeroes to a higher frequency band, which increases the bandwidth of the lower band and decreases that of the higher band. Figure 7 shows the corresponding insertion loss.

4.3. Bandwidth Control by Changing the Dimensions of the Small Patch p

Splitting the transmission zeroes can be easily done by increasing the dimensions of the square patch (*p*) attached to the inner side of the square-loop dual-mode resonator. Figure 8 shows the effect of the square patch dimensions and the simulated insertion loss of the

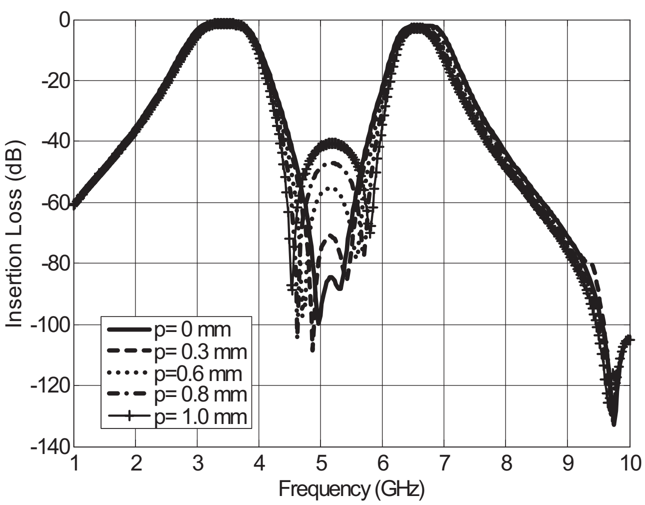

Figure 8 Simulated insertion loss of the dual-band bandpass filter with different (*p*) values

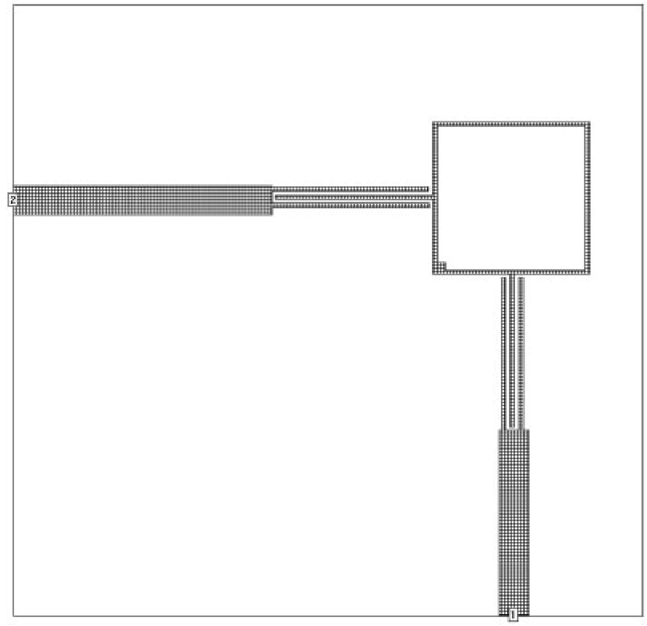

Figure 9 Layout of the measured dual-band bandpass filter

dual-band bandpass filter. It is clear from Figure 6 that the longer the patch dimensions (*p*), the more the transmission zeroes are splitted. This may affect the bandwidths of both bands. By splitting the zeroes, the bandwidths may become narrower.

4. EXPERIMENTAL RESULT

A dual-band bandpass filter has been designed, fabricated, and measured. The width of the attached transmission line and the arms of the dual-mode resonator were chosen to be each 0.3 mm, the lengths $l_T = l_D = 10$ mm, and the dimension $p = 0.5$ mm. Additional transmission lines have been attached to the I/O ports and coupled to the original transmission lines to increase the coupling. Figure 9 shows the layout of the microstrip dual-band bandpass filter, while Figure 10 shows the simulated and measured return and insertion loss of the filter. The filter has center frequencies of 3.45 and 6.65 GHz, and bandwidths of 0.5 and 0.55 GHz.

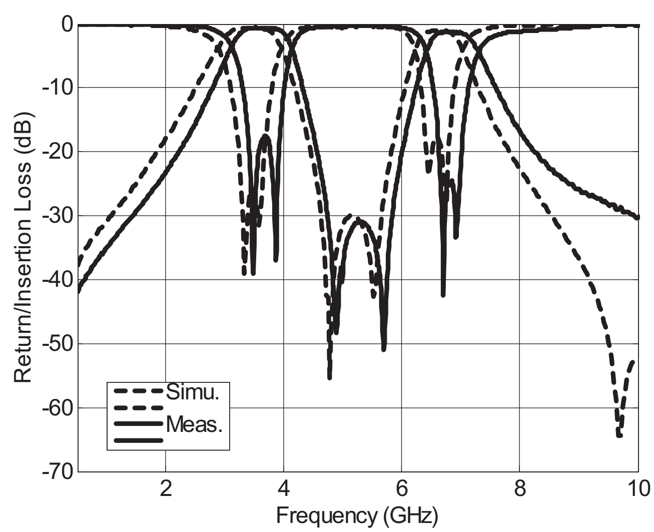

Figure 10 Simulated and measured return and insertion loss of a dual-band bandpass filter

The insertion loss within the passbands is better than 0.7 dB for the first band, and better than 1.2 dB for the second band.

5. CONCLUSION

A dual-band bandpass filter designed by introducing transmission zeroes in the passband of broadband bandpass filter using square-loop dual-mode resonator has been presented in this paper. The filter is relatively compact.

Controlling the bandwidths and the center frequency of both bands can be easily done. Very good agreement between theoretical and experimental data has been achieved.

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MEMS BASED RECONFIGURABLE DUAL BAND ANTENNA

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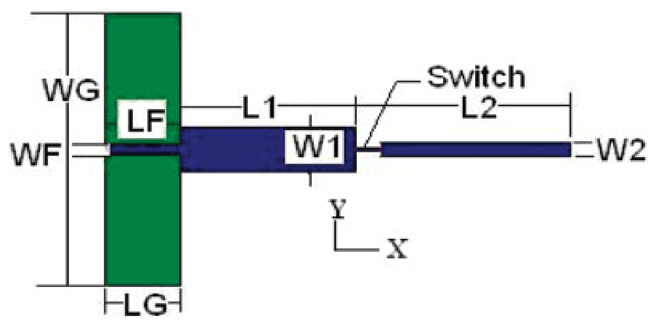
ABSTRACT: *In this study, a novel MEMS technology based reconfigurable dual band monopole antenna implementing RF-MEMS switch is proposed for satellite communications applications. The prototyped Dual band antenna is designed, fabricated, and tested. The proposed antenna is fabricated on Quartz and high receptivity silicon (HRS) using an ideal MEMS switch. The antenna structure consists of two elements—one element couples weakly to other element in OFF state while in ON state it couples strongly. This electromagnetic coupling, through a MEMS switch, gives rise to reconfigurable dual band antenna. The measured VSWR [lt] 2 at 3.7–4.2 GHz frequency band when the switch is OFF, while in the ON state's VSWR [lt]2 at 5.9–6.4 GHz frequency band. The measured VSWR and radiation patterns indicate the suitability of this antenna for satellite applications. The fabricated switch exhibits an isolation of more than 40 dB while its insertion loss is [lt]0.3 dB in the frequency range of interest.* © 2008 Wiley Periodicals, Inc. Microwave Opt Technol Lett 50: 1570–1575, 2008; Published online in Wiley InterScience (www.interscience.wiley.com). DOI 10.1002/mop.23426

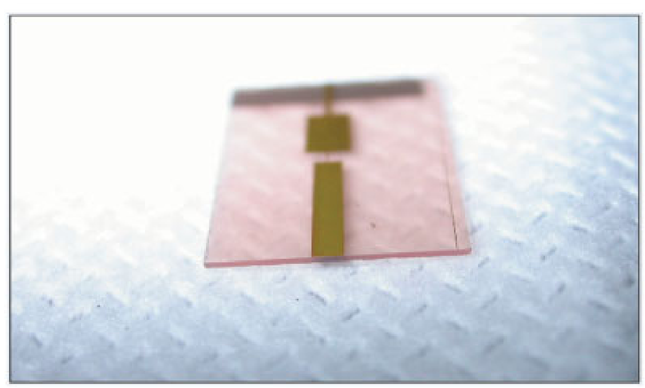
Key words: *dual band; MEMS; reconfigurable; monopole antenna; planar antenna; MEMS switch; satellite communication*

1. INTRODUCTION

Dual and multi-frequency band operation of antennas has increasingly become common, mainly because of the tremendous



(a)



(b)

Figure 1 (a) Geometry of the proposed DBMA antenna (b) Picture of Fabricated antenna. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com]