rod and ring resonators for obtaining the best mode separation, IEEE MTT-S Int Microwave Symp Dig, San Francisco, CA, (1984), 184–186.
13. S. W. Chen and K. A. Zaki, Dielectric ring resonators loaded in waveguide and on substrate, IEEE Trans Microwave Theory Tech MTT-39 (1991), 2069–2076.
14. K.V. Srivastava, V.V. Mishra, and A. Biswas, A modified ring dielectric resonator with improved mode separation and its tunability characteristics in MIC environment, IEEE Trans Microwave Theory Tech MTT-53 (2005), 1960–1967.
15. G.L. Matthaei, L. Young, and E.M.T. Jones, Microwave filters, impedance matching networks and coupling structures, Artech House, Norwood, MA, 1980.

LOW-LOSS DOUBLY METALLIZED CPW LOW-PASS FILTER WITH ADDITIONAL TRANSMISSION ZEROES

Atallah Balalem,[1] Jan Machac,[2] Wong Kim-Fai,[3] and Abbas Omar[1]
[1] Chair of Microwave and Communication Engineering, University of Magdeburg, 39016 Magdeburg, Germany; Corresponding author: atallah.balalem@ovgu.de
[2] Faculty of Electrical Engineering, Czech Technical University, 16627 Prague, Czech Republic
[3] Faculty of Engineering, University of Macao, Macao, China

Received 11 October 2007

ABSTRACT: *This article modifies the classical CPW low-pass filter to doubly metallized CPW, by implementing metallic patches at the backside of the substrate. Moreover, transmission zeroes are introduced by using single, dual, and tri-resonant stubs. These stubs are built on the rear side of the substrate. The filters are compact in distinction to the standard CPW low-pass filter and have a very low loss compared with some other structures.* © 2008 Wiley Periodicals, Inc. Microwave Opt Technol Lett 50: 1431–1433, 2008; Published online in Wiley InterScience (www.interscience.wiley.com). DOI 10.1002/mop.23386

Key words: *doubly metallized lines; CPW filter; low-pass filters; dual-resonant stub; tri-resonant stub*

1. INTRODUCTION

Doubly metallized lines have proven to be an excellent technology for filter applications [1-3]. Making use of both sides of a substrate, high capacitive coupling can be achieved [1, 3]. An ultra-wideband microstrip bandpass filter has been designed by using the broadside coupling between a multimode resonator and I/O microstrip ports [1]. Very compact quasi-lumped bandpass filters have been introduced for microstrip and CPW in Ref. [3]. Earlier, a microstrip low-pass filter has been designed using the same technology [2]. Figure 1 shows the cross section of the doubly metallized line, which has been presented in Ref. [3].

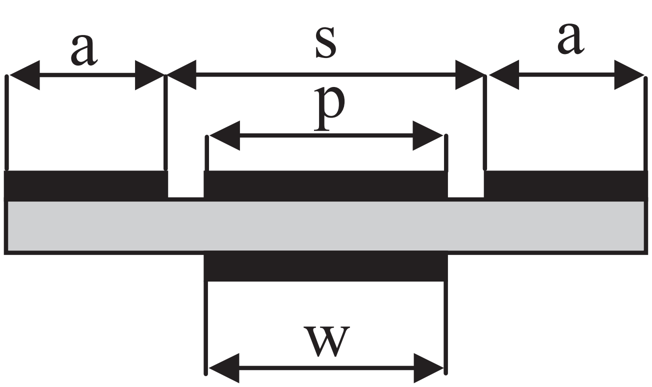

Figure 1 Cross section of the doubly metallized CPW

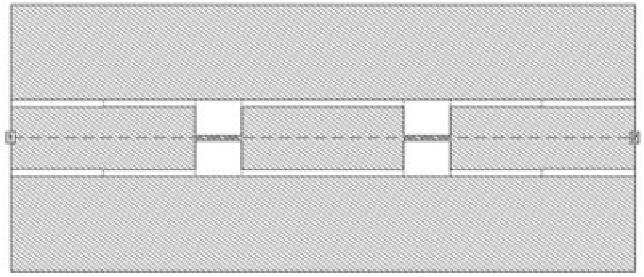

Figure 2 Layout of the classical CPW low-pass filter

A standard CPW low-pass filter is usually designed by cascading low-/high-impedance sections of transmission lines. The low-impedance transmission lines represent shunt capacitances. Although, the high-impedance transmission lines represent series inductances, the entire filter is built on one side of the substrate. Figure 2 shows the layout of such a filter. Moreover, introducing transmission zeros for the CPW low-pass filter increases the complexity of the filter and changes the overall filter structure. The losses are increased in majority of these structures as there are long narrow strips with high resistive impedance added to the filter [4].

This article modifies this low loss CPW low-pass filter for doubly metallized CPW. Moreover, two, four, and six transmission zeroes are introduced to the filter response by using single-, dual-, and tri-resonant stubs. The number of the transmission zeroes is increased without increasing the size or the complexity of the filter. All structures were simulated using the commercial MoM Simulator SONNET [5]. The filters were built on an AR600 substrate with thickness of 0.787 mm and relative dielectric constant of 6.

2. DOUBLY METALLIZED CPW LOW-PASS FILTER

This paragraph shows that the impedance of the low-impedance transmission line sections can be further reduced by implementing patches on the rear side of the substrate. These patches are built under the low-impedance transmission line stubs and are extended under the ground metallization. By this way, the shunt capacitance of the low-impedance transmission line is increased, which has main effect on reducing the filter length. Figure 3 shows the rear side of the substrate. Whereas the topside is shown in Figure 2. The filter has total length of about 18.7 mm and cut-off frequency

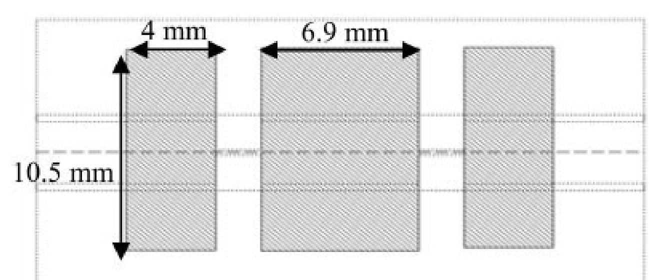

Figure 3 Rear side metallization of the low-pass filter with additional patches

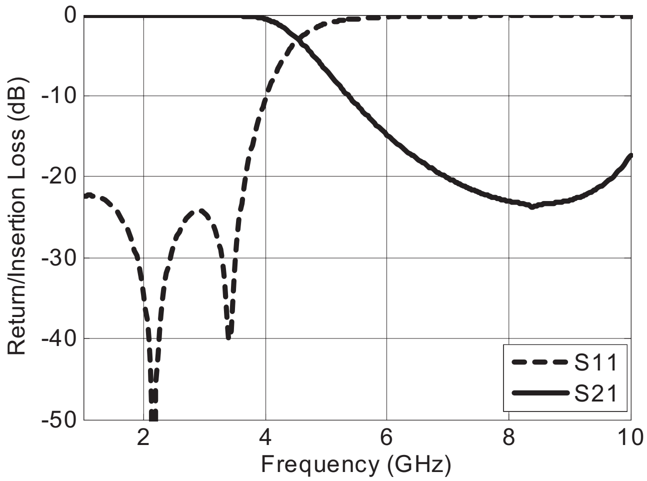

Figure 4 Simulated return and insertion loss of the doubly metallized CPW low-pass filter with additional patches at the back side of the substrate

of 4.5 GHz. The simulated return and insertion loss of the filter are demonstrated in Figure 4.

3. DOUBLY METALYED CPW LOW-PASS FILTER WITH TOW TRANSMISSION ZEROES

As it has been shown in Figure 4, the filter transmission characteristic decreases very slowly above the cut-off. Therefore, transmission zeroes are needed to improve the filter response. To achieve this, the side patches were loaded by two half-wavelength stubs. These stubs are coupled capacitively to the topside ground metallization. Each of these additional stubs introduces a transmission zero to the filter response at the defined frequency. Figure 5 shows the top and the rear side layout of the doubly metallized CPW low-pass filter with two additional stubs. Figure 6 shows the return and insertion loss of this filter.

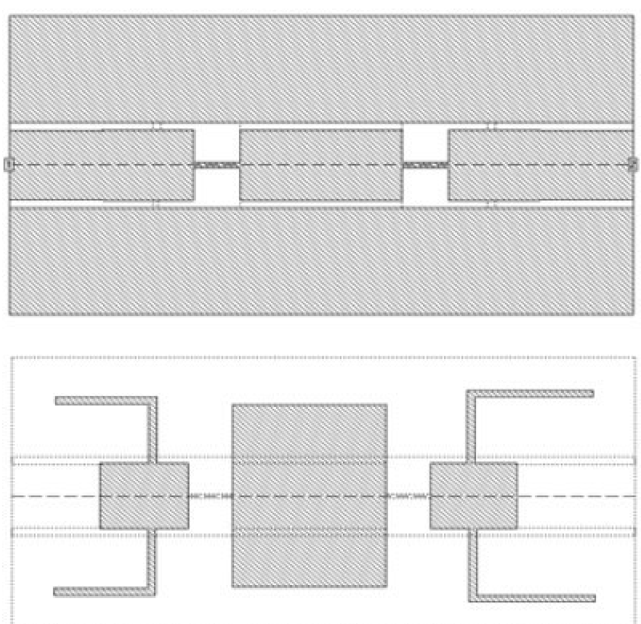

Figure 5 Top (up) and bottom (down) layout of the doubly metallized CPW low-pass filter with single-resonant stubs

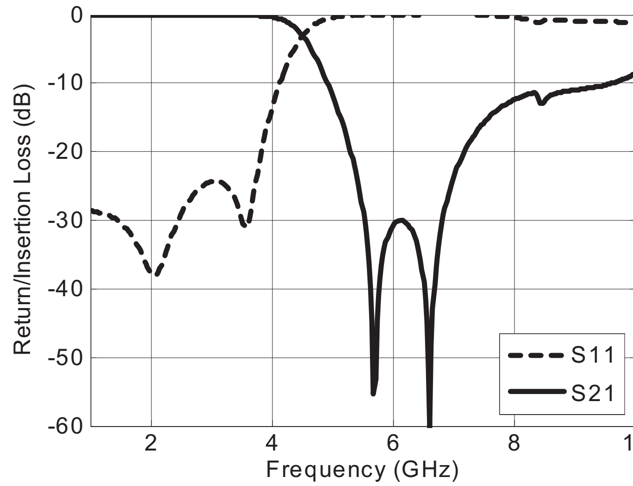

Figure 6 Simulated return and insertion loss of the doubly metallized CPW low-pass filter with two additional transmission zeroes shown in Figure 5

4. DOULBY METALLIZED CPW LOW-PASS FILTER WITH FOUR TRANSMIAAION ZEROES

By adding an additional arm to the half wavelength stub (Fig. 7), we get a dual-resonant stubs and an additional resonance is generated. The mutual coupling of these two resonances is very weak. This structure suppresses better the filter transmission in the stopband just by replacing only the side metallic patches by two dual-resonance stabs and keeping central one as it was. Figure 7 shows the top and bottom layout of the filter, whereas Figure 8 shows its return and insertion loss. This filter has 3 dB cut-off at bout 4.3 GHz, and four transmission zeroes are generated at about 5.7, 6,2, 6.8, and 7.6 GHz, respectively. The insertion loss at the passband is 0.2 dB. The filter works well up to 8 GHz. A very good agreement between the simulated and the measured data is achieved except small shift in the transmission zeroes, which is most probably caused by some fabrication errors.

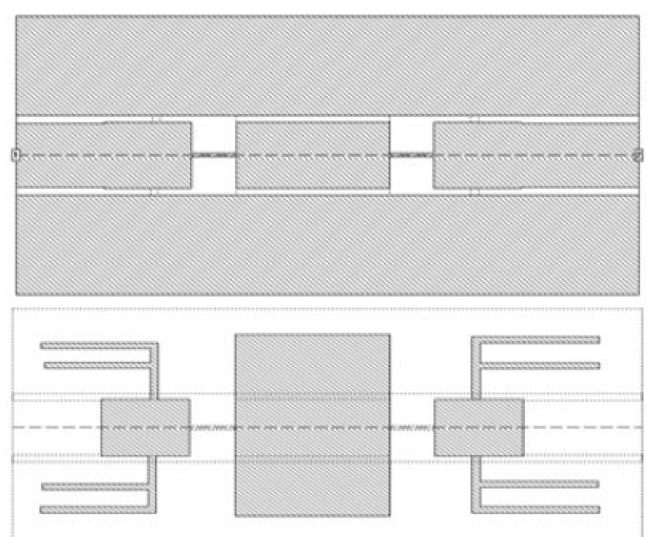

Figure 7 Top (up) and bottom (down) layout of the doubly metallized CPW low-pass filter with dual-resonant stubs

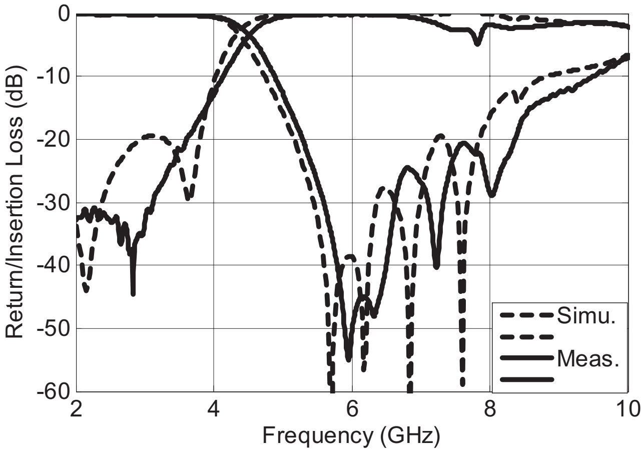

Figure 8 Return and insertion loss of the doubly metallized CPW low-pass filter with four additional transmission zeroes

5. DOULBY METALLIZED CPW LOW-PASS FILTER WITH SIX TRANSMIAAION ZEROES

Adding the third arm to the dual-resonant stub (Fig. 9) would increase the number of transmission zeroes by one. These resonances are only weakly coupled to each other, therefore, in our design we kept the central patch unchanged, and we replaced the side patches bye the tri- resonant stubs. Moreover, the lengths of the arms were not varied too much. Figure 9 shows the top and bottom layouts of the filter. Figure 10 shows the measured and simulated insertion and return loss of the filter. A good agreement was achieved except a shift in the transmission zeroes position, which occurs because of some fabrication errors.

6. CONCLUSION

A very compact low-loss CPW low-pass filter using a doubly metallized CPW was introduced by implementing patches on the rear side of the substrate under the low-impedance transmission line sections. Moreover, transmission zeroes were introduced to the filter resonance by loading some on the patches by single-, dual-, and tri-resonant stubs. A good agreement between the measured and simulated results was achieved. These transmission zeros improve the rate of decrease of the filter transmission at its cut-off.

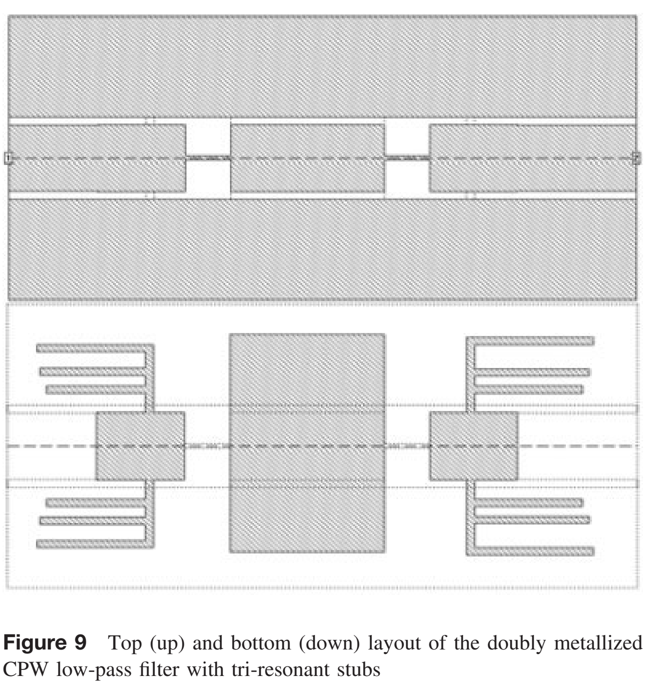

Figure 9 Top (up) and bottom (down) layout of the doubly metallized CPW low-pass filter with tri-resonant stubs

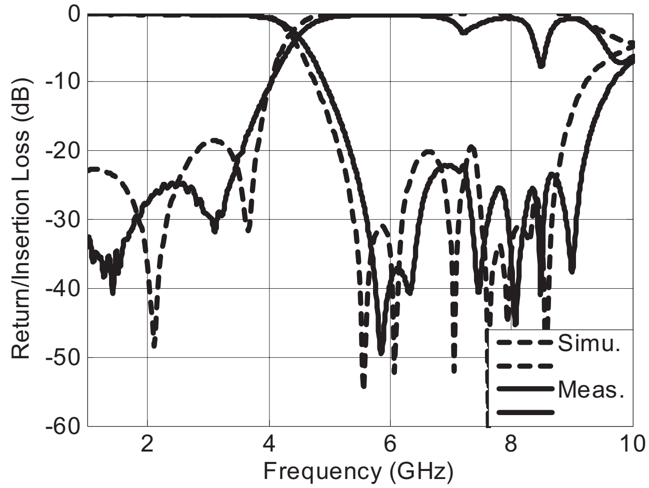

Figure 10 Return and insertion loss of the doubly metallized CPW low-pass filter with six additional transmission zeroes

REFERENCES

1. H. Wang, L. Zhu, and W. Menzel, Ultra-wideband bandpass filter with hybrid microstrip/CPW structure, IEEE Microwave Wireless Comp Lett 15 (2005), 844–846.
2. L. Zhu, H. Bu, K. Wu, and M. Stubbs, Unified CAD model of microstrip line with rear side aperture for multilayer integrated circuits, 2000 IEEE MTT-S International Microwave Symposium Digest, Boston, USA, June 2000, pp. 981–984.
3. S. Sun and L. Zhu, Compact dual-band microstrip bandpass filter without external feeds, IEEE Microwave Theory Tech 15 (2005), 644–646.
4. J. Sor, Y. Qian, and T. Itoh, Miniature low-loss slow-wave CPW periodic structure for filter applications, IEEE MTT Trans 49 (2001), 2336–2341.
5. SONNET, Version 10.52, Sonnet Software Inc.

ENHANCED GMRES METHOD COMBINED WITH MLFMA FOR SOLVING ELECTROMAGNETIC WAVE SCATTERING PROBLEMS

P. L. Rui and R. S. Chen
Department of Communication Engineering, Nanjing University of Science and Technology, Nanjing 210094, China; Corresponding author: rpldantirui@hotmail.com

Received 11 October 2007

ABSTRACT: *For efficiently solving large dense complex linear systems that arise in the electric field integral equation (EFIE) formulation of electromagnetic wave scattering problems, the multilevel fast multipole algorithm (MLFMA) is used to speed up the matrix vector product operations, and the sparse approximate inverse (SAI) preconditioning technique is employed to accelerate the convergence rate of the generalized minimal residual (GMRES) iterative method. We show that the convergence rate can be greatly improved by augmenting to the*