

WestminsterResearch

http://www.wmin.ac.uk/westminsterresearch

Design of thick film microstrip lowpass filters.

Vesna Crnojevic-Bengin Djuradj Budimir

School of Informatics

Copyright © [2003] IEEE. Reprinted from the proceedings of the 6th International Conference on Telecommunications in Modern Satellite, Cable and Broadcasting Service, 2003. TELSIKS 2003, pp. 360-362.

This material is posted here with permission of the IEEE. Such permission of the IEEE does not in any way imply IEEE endorsement of any of the University of Westminster's products or services. Internal or personal use of this material is permitted. However, permission to reprint/republish this material for advertising or promotional purposes or for creating new collective works for resale or redistribution must be obtained from the IEEE by writing to pubs-permissions@ieee.org. By choosing to view this document, you agree to all provisions of the copyright laws protecting it.

The WestminsterResearch online digital archive at the University of Westminster aims to make the research output of the University available to a wider audience. Copyright and Moral Rights remain with the authors and/or copyright owners. Users are permitted to download and/or print one copy for non-commercial private study or research. Further distribution and any use of material from within this archive for profit-making enterprises or for commercial gain is strictly forbidden.

Whilst further distribution of specific materials from within this archive is forbidden, you may freely distribute the URL of the University of Westminster Eprints (<u>http://www.wmin.ac.uk/westminsterresearch</u>).

In case of abuse or copyright appearing without permission e-mail wattsn@wmin.ac.uk.

TELSIKS 2003

Design of Thick Film Microstrip Lowpass Filters

Vesna Crnojević-Bengin¹, Đurađ Budimir²

Abstract - This paper presents the CAD of RF and microwave filters such as shielded single layer thick film lowpass filters for wireless communication systems. The performances of the filter were investigated and the optimisation of filter elements was performed.

Key-Words - CAD, Thick Film Microstrip, Lowpass filters.

I. INTRODUCTION

The wireless communications market has experienced a rapid growth in the last several years. As a result, frequency usage and commercial wireless applications have continued to move toward the millimetre wave regime, bringing new demands for low-cost, miniaturized, high-volume packages and multi-chip modules. As the level of integration and the operating frequency increase, coupling between components and parasitic reactance within the package play a greater role in the package design, resulting in new technologies for the production of microwave and millimetre-wave integrated circuits (MICs).

Thick films are produced by screening patterns of conducting and insulating materials on ceramic substrates. The technique is used to produce only passive elements, such as resistors and capacitors. Thick-film manufacturing process can be divided into three stages: screen printing, firing and laser trimming and these stages are repeated as many times as needed.

Thick-film technology offers a high level of integration at low costs, and is very suitable for production of custom circuits. In addition to circuit size and weight reductions over standard PCB packaging, it simplifies assembly and offers improvements in circuit performances, achieved by shortened circuit paths and closer spacing that yield reduced noise pickup, enhanced thermal coupling, and improved stability.

In this paper a shielded single layer thick film lowpass filter (TF LPF) is presented. The filter is Chebyshev type, the 5th order. Stepped-impedance method is used in the design of the filter, where high and low impedance lines sections are

¹Vesna Crnojević-Bengin is with the Faculty of Engineering, University of Novi Sad, Trg D. Obradovića 6, 21000 Novi Sad, E-mail: bengin@uns.ns.ac.yu

²Durad Budimir is with the Wireless Communications Research Group. University of Westminster, 115 New Cavendish Street, London W1W 6UW, UK, E-mail: d.budimi@cmsa.wmin.ac.uk

cascaded together. Thick film parameters, such as dielectric thickness, metallization thickness and minimum line width are in accordance with those realizable with TF process available in Serbia and Montenegro.

Filter specifications are as follows:

- Cut-off frequency $f_c=2$ GHz at -3 dB,
- Insertion loss L₁=-20 dB at 3 GHz,
- Pass band ripple $\varepsilon < 0.2$,
- Characteristic impedance of the inductive line Z_{0L} =80 Ω ,
- Characteristic impedance of the capacitive line $Z_{0C}=20 \Omega$.

II. CONFIGURATION

The 5th order single layer TF LPF on 96% alumina substrate ($\epsilon r=9$, TanD=0.0006, roughness 20 µm) having height of 650 µm is considered. Filter is placed in a metal box, filled with air. The height of the air layer is 10 mm. Metallization layer is 10 µm thick. The cross-section of low (a) and high (b) impedance TF microstrip lines and 3D view of the filter are shown in Figs.1 and 2, respectively.



Fig.1. Cross section of low (a) and high (b) impedance TF microstrip lines



Fig.2. TF LPF, 3D view

Microstrip line widths are 200 μ m for inductive and 2.9 mm for capacitive line. Microstrip line lengths were obtained by Akello's relationships for alumina substrates, [2] :

0-7803-7963-2/03/\$17.00 ©2003 IEEE

L'=7.82·10⁻³·Z₀ + 0.03 [nH/mm], if $20 \le Z_0 \le 110 \Omega$ (1) C'= 88.9·10⁻³·w/h + 0.08 [pF/mm], for $0.5 \le w/h \le 6$ (2)

Filter components values were obtained from the 5^{th} order Chebyshev LPF parameters. The corresponding widths and lengths of the metallization pattern of the TF LPF are shown in Table 1.

TABLE 1. PARAMETER VALUES FOR THE TF LPF

Filter comp.	Comp. value	Line impedance, [Ω]	Width	Length	Length value, [mm]
C1	1.1 pF	20	2.9 mm	P1	2.53
L2	7.3 nH	80	200 µm	P2	11.88
C3	3.5 pF	20	2.9 mm	P3	8.05
L4	7.3 nH	80	200 µm	P2	11.85
C5	1.1 pF	20	2.9 mm	P1	2.53

Software package Sonnet 8.51-Lite was used for the electromagnetic simulations of the filter. The corresponding s_{11} and s_{21} responses of the proposed filter are shown in Fig.3. It can be seen that the filter does not meet the specifications and, therefore, optimisation is required.



Fig.3. TF LPF response prior to optimisation

III. SIMULATED RESULTS

Ansoft's software package Serenade SV 8.5 was used for the optimisation of the filter, as well as Agilent's Advanced Design System. Frequency range used in simulations was set to [0MHz, 3.5GHz], step size 10MHz. In optimisation procedure lengths of elements P1, P2 and P3 were varied, while widths values were fixed. Initial lengths were set to values obtained by Akkelo's relations, Table 1.

Optimisation goals are shown in Table 2.

Method of optimisation was *random* and optimisation goals were reached after approx. 500 iterations. Obtained microstrip line lengths are shown in Table 3.

TABLE 2. Optimization goals

Frequency range, [GHz]	Goal	
0.5 GHz - 2 GHz	$s_{21} > -3 \text{ dB}$	
3 GHz	$s_{21} = -20 \text{ dB}$	
3.1 GHz - 3.5 GHz	$s_{21} > -20 \text{ dB}$	

TABLE 3. Optimization results

Length	Length value, [mm]
Pl	4.9
P2	8.8
P3	7.4

The corresponding s_{11} and s_{21} responses of the optimised filter are shown in Fig.4. The filter meets the specifications, exhibiting attenuation of -3 dB at 2 GHz and -20 dB at 3 GHz.



Fig. 4. TF LPF response after optimisation

The enlarged detail shown in Fig. 5, illustrates low pass band ripple factor (less than 0.16dB).

IV. CONCLUSION

In this paper a single layer thick film microstrip lowpass filter has been presented. The performances of the filter were investigated with electromagnetic simulations and the optimisation of microstrip lines lengths was performed. The resulting filter conforms to the required specifications. All parameters related to thick film process, such as dielectric



Fig. 5. TF LPF response after optimisation, detail

thickness, metallization thickness and minimum line width were in accordance with those realizable in Serbia and Montenegro.

.

REFERENCES

- [1] K.C. Gupta, A. Sihgh, Microwave Integrated Circuits, Wiley Eastern Private Limited, India, 1974
- [2] M. Haskard, K. Pitt, Thick-Film Technology and Applications, Electrochemical Publications LTD, UK, 1997.
- [3] D. Budimir, RF and Microwave Filters for Mobile and Fixed Wireless Communications, *INFOTEH*, Jahorina, Yugoslavia, 2002.
- [4] D. Budimir, RF and Microwave Systems, *Lecture Notes*, London, UK, 2002.
- [5] E.C. Niehenke, R.A. Pucel, Microwave and Millimeter-Wave Integrated Circuits, *IEEE Trans. on MTT*, Vol.50, No.3, March 2002
- [6] Sonnet 8.51-Lite, Users Manual, Sonnet Software Inc., USA 2002
- [7] Serenade SV 8.5, Users Manual, Ansoft, USA, 2002
- [8] Advanced Design System, Users Manual, Agilent, USA, 2002