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Research Article

LOW PASS FILTER FOR L-BAND APPLICATION USING STEPPED-IMPEDANCE MICROSTRIP LINES

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ABSTRACT

There is an increasing demand for newer microwave and millimeter-wave systems to meet the emerging telecommunication challenges with respect to size, performance and cost. This paper presents a low cost and low insertion loss L-band lowpass filter (LPF) based on high-resistivity silicon substrate.Microstrip technology is used for simplicity and ease of fabrication. The design and simulation are performed using 3D full wave electromagnetic simulator IE3D. The simulated filter achieved an insertion loss of less than 1.0dB in the passband. The filter has a center fiequency of 1.5GHz with covering the frequency range from 0.5 GHz to 1.55 GHz.

KEYWORDS Low pass Filter, Dielectric Constant, Microstrip filter, Millimeter wave filter

I. INTRODUCTION

Microwave communication systems are expanding rapidly to higher frequency such as L-band since they can provide many advantages over conventional wireless links, for example the larger bandwidth and smaller device size. Waveguide components are widely used at these frequencies and offer very good performance but the result in high production costs and bulky systems. Conventional planar filter structures suffer from radiation from the resonators into the substrate and from high ohmic loss, and therefore give high insertion loss and poor filter rejection However, there is still a challenge in lowering the cost of the commercial RF micromachined device since the devices are fabricated in semiconductor- like process. The filters are one of the primary and necessary components of a microwave system.Microstrip line is a good candidate for filter design due to its advantages of low cost, copact size, light weight, planar structure and easy integration with other components on a single circuit board. Conventional filter structures like equal ripple and butterworth low pass filters are requirement of special fabrication methods. Conventional low frequency techniques for fabrication does not fit at these frequencies due to the very high losses associated. Although microstrip is not the highest performance filter technology, still it is the preferred choice in many thin-film on ceramic and printed circuit board applications. RF pre-selector filters, image rejection filters, local oscillator (LO) filters and intermediate frequency (IF) filters can all be realized in microstrip. The recent advance of novel materials and fabrication technologies, including monolithic microwave integrated circuit (MMIC), microelectromechanic system (MEMS), micromachining, high-temperature Superconductor (HTS), and low-temperature co fired ceramics (LTCC), has simulated the rapid development of new microstrip and other filters. In this paper, low pass filter is optimized for high performance and an efficient. Microstrip technology is used for simplicity and ease of fabrication.The design and simulation are performed using 3D full wave electromagnetic simulator IE3D. This filter is widely used today in radar,satellite and terrestrial communication applications.

II. DESIGN AND ANALYSIS OF MICROSTRIP FILTER

The design of low pass filters involves two main steps. The first one is to select an appropriate low pass prototype. The choice of the type of response, including Pass band ripple and the number of reactive elements will depend on the required specifications. The element values of the low pass prototype filters, which are usually normalized to make a source impedance go = 1 and a cutoff frequency Ωc = 1.0, are then transformed to the L-C elements for the desired cutoff frequency and the desired source impedance, which is normally 50 ohms for microstrip filters. The next main step in the design of microstrip low pass filters [1] is to find an appropriate micro strip realization that approximates the lumped element filter. The element values for the low pass prototype with Chebyshev response at pass band ripple factor L_{AR} = 0.1 dB, characteristic impedance source/load Zo = 50 ohms, are taken from normalized values g_i i.e. g_1, g_2, g_3, $g_{4......}$, g_n. The filter is assumed to be fabricated on a substrate of dielectric constant ε_r and of thickness h mm. for Angular (normalized) cutoff frequency Ω_c, using the element transformation [1].

The filter design steps are as follows:

1. Determine the number of sections from the specification characteristics for microstrip parameters.

Filter Specifications:

Relative Dielectric Constant, $\epsilon_r = 4.4$
Height of substrate, h = 1.6 mm
The substrate used –
The loss tangent tanδ = 0.02
Z_o=50 Ω
$\Omega_c = 1$

2. Determine the values of the prototype elements to realize the specifications. Also we have taken the element value for low pass filters from table 3.2 [1] for n=3

$L_i = (Z_o/g_o)\ (\Omega_c/2\pi f_c)\ g_i$

$C_i\ \ = (g_o/Z_o)\ (\Omega_c/2\pi f_c)\ g_i$

$l_L = \lambda_{gl}\ /2\pi\ \mathrm{Sin}^{-1}\ (\omega_c\, L_i\ /\ Z_{OL})$

$l_C = \lambda_{gc}\ /2\pi\ \mathrm{Sin}^{-1}\ (\omega_c\, C_i\ Zoc)$

3. To calculate the width of capacitor and inductor we use the following formula

$W/h = 8\ \exp\ (A)/\exp(2A)\text{-}2$

$A= Zc\ /\ 60\ \{\varepsilon r+1\}\text{^}0.5+\ \varepsilon r+1/\ \varepsilon r\text{-}1\{0.23+0.11/\ \varepsilon r\}$

$Zc = \eta\ /\ 2\ \pi\ \sqrt{}\ \varepsilon re\ [\ln\ (8h/w+\ 0.25\ w/h)]$

$\eta = 120\ \pi$ ohms is the wave impedance in free space.

4. The effective dielectric constant can be found by the following formula

$\varepsilon_{re} = (\varepsilon_r+1)/2+(\varepsilon_r\text{-}1)/2\ [(1+12h/W)^{-0.5}]$

5. Effective wavelength is also found as

$\lambda_{ge}=300/(6\sqrt{}\varepsilon_{ree})$

TABLE I: DIMENSIONS FOR A STEPPED-IMPEDANCE LOW PASS FILTERS (FOR N=3)

Dimension	Value
Microstrip line width in mm	W_C=11.10,W_O=3.059,W_L=2.22
Characteristic impedance in ohm	Z_{OC} = 20,Z_O = 50, Z_{OL} = 60
Effective dielectric constant	$(\varepsilon re)_C$ = 3.788, $(\varepsilon re)_O$ = 3. 381, $(\varepsilon re)_L$ = 3.294

III.SIMULATION RESULTS

In order to verify the validity of the above expressions in millimeter wave regime, a simulation study was performed using IE3D. To get the exact response for our purpose, an optimization was performed using software. The dimensions of the filters are given in the above table.

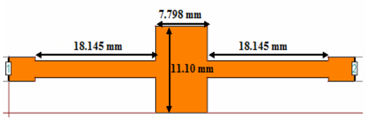

Fig.1. Layout of a 3-pole, stepped-impedance Microstrip low pass filter on a substrate with εr= 4.4 and h = 1.6 mm at 1.5 GHz frequency.

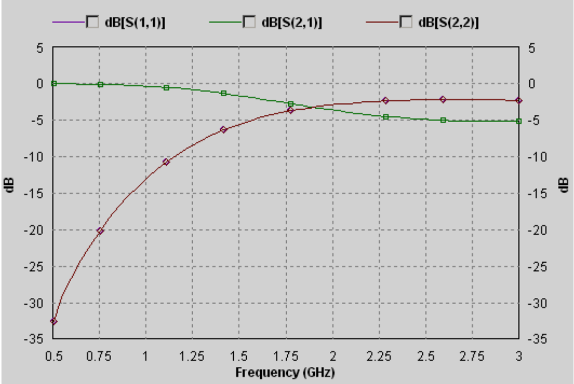

Fig.2. Full-wave EM simulated performance of the stepped-impedance low pass filter for n = 3 at 1.5GHz.

IV. RESULTS & ANALYSIS

The simulated filter as shown in Figure 1and 2, predicts the geometry & response of low pass filters for n=3.The graph is plotted by taking gain (dB) on the Y-axis and frequency in GHz on the X-axis. From the graph it is clear that the cut-off frequency is found to be 1.5GHz for stepped-impedance low pass filter. Hence stepped-impedance low pass filter is capable of passing the frequency less than 1.5GHz & reject the frequency after 1.5GHz for the thickness of the substrate 1.6 mm and relative dielectric constant 4.4.

V. CONCLUSION

A 1.5GHz filter has been successfully demonstrated using microstrip technology. The simulated LPF achieved an insertion loss of less than 1.0dB with a 3dB bandwidth about 33% which is smaller in size and larger bandwidth than previous microstrip fiters of this type. The filter is designed on high- resistivitysilicon substrate which is compatiable with the new SiGe Process In general, the transmission characteristic (S21) of the filter is very well except for an additional loss of less than 1.0dB in the low frequency of the pass band. This could be due to radiation loss, or the relatively thin metal used This filter is widely used today in radar, satellite and terrestrial communications, and electronic counter measure applications, both militarily and commercially.

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