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Design and Analysis of Stepped Impedance Microstrip Low Pass Filter

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***Abstract:-* Most communication system contains an RF front end which performs signal processing with RF filters.Micro strip filters are a low cost means of doing this. This paper describes the design of low cost and low insertion loss microstrip stepped impedance low pass filter (LPF) by using microstrip layout which works at 0.4 GHz for permittivity 4.7 value with a substrate thickness 1.6 mm with pass band ripple 0.1dB. Microstrip technology is used for simplicity and ease of fabrication. The design and simulation are performed using 3D full wave electromagnetic simulator HFSS.**

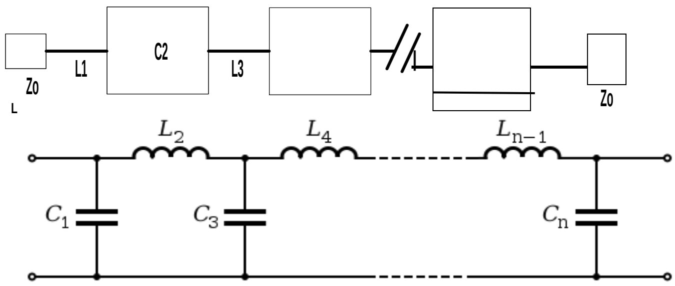
Key Words: Filter, Stepped Impedance filter, Low Pass Filter, HFSS.

INTRODUCTION

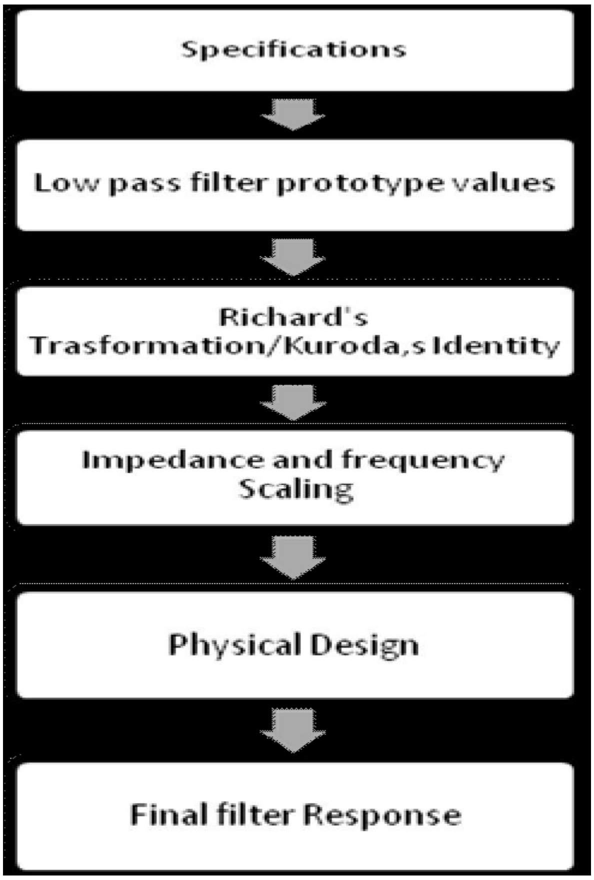
Stepped impedance low pass microstrip filters offer better stop band characteristics and are simpler to design. Such filters are formed, from the series connection of high and low impendence Microstrip transmission lines [1]-[2]. In the present work a conventional microstrip Chebyshev low pass filter has been designed and analyzed using HFSS software . To improve the performance of the filter, fractals design can be implemented.

MICROSTRIP LOWPASSFILTER :

In general, the design of microstrip lowpass filters involves two main steps. The first one is to select an appropriate lowpass prototype. The choice of the type of response, including passband ripple and the number of reactive elements, will depend on the required specifications. The element values of the lowpass prototype filter, which are usually normalized to make a source impedance *g*0 = 1 and a cutoff frequency f_c = 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. Having obtained a suitable lumped-element filter design, the next main step in the design of microstrip lowpass filters is to find an appropriate microstrip realization that approximates the lumpedelement filter. In this section, we concentrate on the second step. Several microstrip realizations will be described.
The stepped-impedance lowpass microstrip filters, which use a cascaded structure of alternating high- and lowimpedance transmission lines. These are much shorter than the associated guided-wavelength, so as to act as semilumped elements.The high-impedance lines act as series inductors and the low-impedance lines act as shunt capacitors.



Microstrip filter design Steps



Microstrip filter design steps

Filter Design Method:
1. Filter Specifications:
Figure 1 shows a low pass stepped impedance Microstrip filter, designed using the conventional technique [3-4].

Specification for conventional microstrip Chebyshev low pass filter of order n = 3 are given bellow

Cut-off frequency, $f_c = 0.4$ GHz

Dielectric constant, $\epsilon_r = 4.7$

Substrate height, h =1.6 mm

Characteristic impedance, $Z_o = 50\ \Omega$

Highest Line impedance $Z_H = Z_{oL} = 100\ \Omega$

Lowest Line impedance $Z_L = Z_{oC} = 20\ \Omega$

Loss tangent $\delta = 0.02$

Pass band ripple = 0.1dB

Normalized frequency $\Omega_c = 1$

2. We have taken the elements value for low pass filter for n = 3 ($g_1 = 1.0316$, $g_2 = 1.1474$, $g_3 = 1.0316$) [6]

3. Electrical length of inductor

$\beta l = L\ Z_o / Z_H$

Electrical length of capacitor

$\beta l = C\ Z_L / Z_o$

L and C are normalized elements values of low pass filter.

4. To calculate the width of capacitor & inductor, we use the following formula

For W/h < 2

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

Where $A = (Z_c / 60)\ \{(\epsilon_r+1)/2\}$ ^0.5 $+[(\epsilon_r + 1) / (\epsilon_r - 1)]\ \{0.23 + 0.11/ \epsilon_r\}$

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

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

For W/h > 2

$W/h = (2/\pi)[B - 1 - \ln(2B - 1) + ((\epsilon_r - 1)/2\ \epsilon_r))\ (\ln(B - 1) + 0.39 - 0.61/\epsilon_r)]$

Where $B = 377\pi / 2 Z_o \sqrt{\epsilon_r}$

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

$\epsilon_{re} = (\epsilon_r+1)/2 + [(\epsilon_r-1)/2]\ [(1+12\ h / W) - 0.5]$

6. Effective wavelength is also found as

$\lambda_{ge} = \lambda / \sqrt{\epsilon_{re}}$

7. Fractalization of original filter shape.

Filter Dimension & Simulation Result:

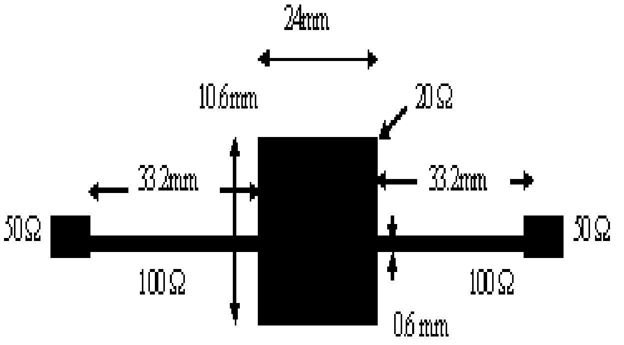


Fig 1: Layout of Microstrip Filter

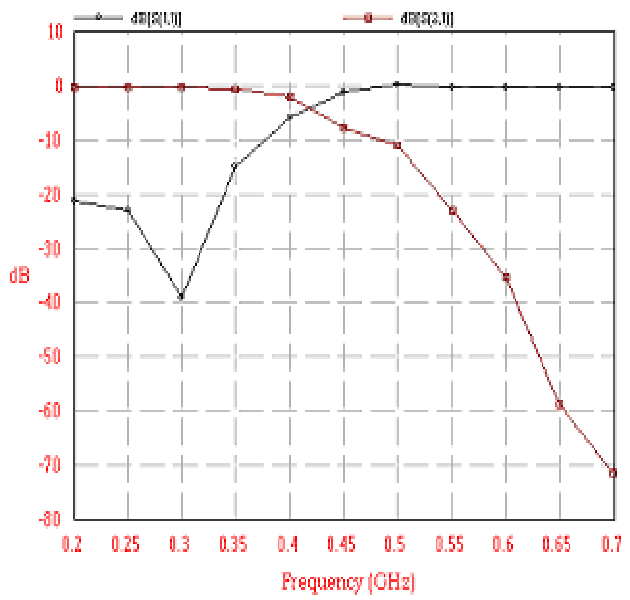
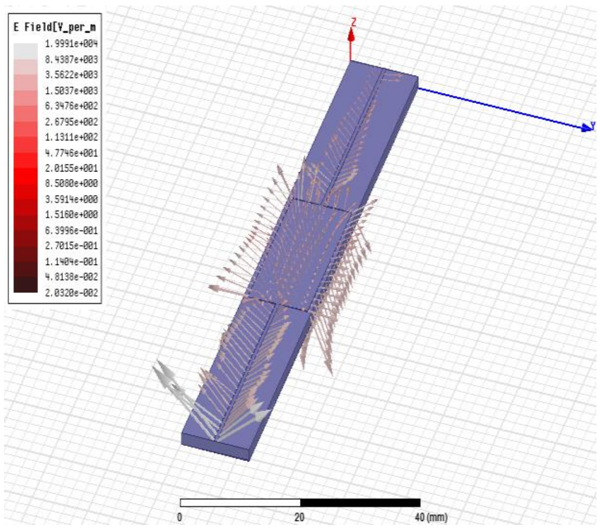
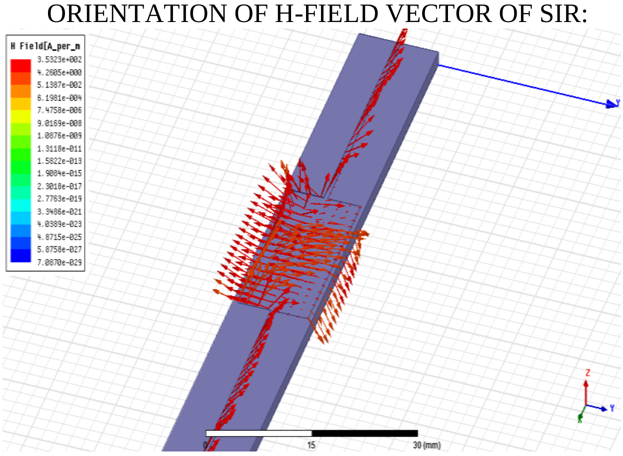


Fig 2: Simulated Result of low pass filter

ORIENTATION OF E-FIELD VECTOR OF SIR :



ORIENTATION OF H-FIELD VECTOR OF SIR:



Application of Microstrip Lowpassfilter:

Wi-Fi is a wireless LAN technology that enables laptop PC's, PDA's, and other devices to connect easily to the Internet. Technically known as IEEE 802.11 a/b/g/n. Wi-Fi is less expensive and nearing the speeds of standard Ethernet and other common wire-based LAN technologies. Several Wi-Fi hot spots have been popular over the past few years. Some business charge customers a monthly fee for service, while others have begun offering it or free in an effort to increase the sales of their goods.

CONCLUSION:

The response of Microstrip filter of fig.1 is not having sharp cut off and the attenuation peak is – 59.5dB, at 0.65GHz. To improve the frequency response, different types of fractals have been done in the designed filter. The fractal filter and their responses are more stable . All the filters are having the same dimension as the basic filter. Considerable improvements in the frequency response of the filters have been obtained by fractal.

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