Design and Analysis of Microstrip Elliptical Low Pass Filter

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Abstract- **Design and analysis of a stepped impedance elliptical microstrip low pass filter has been described in this paper. To improve the frequency response, fractals have been proposed in the conventional design. Conventional geometry and fractalized geometry have been simulated and thus obtained results are reported and compared.**

Index terms- Elliptical, Filter, Fractal Microstrip, Stepped Impedance.

I. INTRODUCTION

The electromagnetic spectrum is limited, which has to be shared for many applications, and filters are used to select or confine the microwave signals within assigned spectral limits. Emerging applications such as wireless and satellite communications, etc. continue to challenge RF filters with ever more strict requirements like smaller size, lighter weight and higher performance [1-3].

The term fractal means fractional dimensions. These are simply broken or irregular fragments introduced to describe a family of complex shapes. Fractal posses an inherent self-similarity or self-affinity in their geometrical structure with dimensions that do not fall precisely into a whole number category. One property of a certain class of fractals is that it can have an infinite length while fitting in a finite volume [4]. A wide variety of applications for fractals continue to be found in many branches of science and engineering. Fractal techniques have shown the possibility toiniaturize filters and to improve input matching. In the present work a conventional microstrip elliptical low pass filter has been designed and analyzed [5].To improve the performance of the filter, fractal geometry has been applied to the conventional filter. The performance of the fractal filter has been compared with that obtained using conventional design.

II.FILTER DESIGN AND ANALYSIS

The most general prototype of elliptical low pass filters as shown in fig.1.The frequency response of an elliptical filter that has equal ripples, in both the pass band and the stop band as shown in fig.2.To obtain sharp cutoff for a given number of reactive elements, it is necessary to design filter structures having infinite attenuation at finite frequencies. Elliptical low pass filter which contains, series-resonant branches connected in shunt, used to short out transmission at their resonant frequencies as shown in Fig.3.

A.. Transfer functions

The transfer function of prototype elliptical low pass filter for even and odd as given below.

$$\left|S_{21}(j\Omega)\right|^2 = \frac{1}{1+\varepsilon^2 F_n^2(\Omega)} \qquad (1)$$

$$F_n(\Omega) = \begin{cases} M \dfrac{\prod_{i=1}^{n/2}\left(\Omega_i^2 - \Omega^2\right)}{\prod_{i=1}^{n/2}\left(\Omega_s^2 / \Omega_i^2 - \Omega^2\right)} & \text{for even} \\[2ex] N \dfrac{\Omega \prod_{i=1}^{(n-1)/2}\left(\Omega_i^2 - \Omega^2\right)}{\prod_{i=1}^{(n-1/2)}\left(\Omega_s^2 / \Omega_i^2 - \Omega^2\right)} & \text{for odd} \end{cases} \qquad (2)$$

where, Ω_i ($0 < \Omega_i < 1$) and $\Omega_s > 1$, represent critical frequencies, whereas M and N, are constants. F_n (Ω) will oscillate between ± 1 for $|\Omega| \le 1$, and $|F_n(\Omega = \pm 1)| = 1$.

B. Equations

The prototype low pass filter has a pass band ripple L_{Ar} = 0.18dB and minimum stop band attenuation,
L_{As} = 38.1 dB at Ω_s = 1.194 for the cutoff frequency Ω_c= 1.0 having element values as:

$$g_0 = g_5 = 1.000$$
$$g_{L1} = g_1 = 0.3714$$
$$g_{C2} = g_2^{'} = 1.0929$$
$$g_{L3} = g_3 = 1.1194$$

$$g_{C4} = g_4 = 0.9244$$

where g_{Li} and g_{Ci} denote, the inductive and capacitive elements respectively. The L-C element values, can be determined by

$$L_i = \frac{1}{2\pi f_c} Z_0 g_{Li} \qquad (3)$$

$$C_i = \frac{1}{2\pi f_c} \frac{1}{Z_0} g_{Ci} \qquad (4)$$

The step-impedance implementations of microstrip elliptical low pass filter as shown in fig.4. The series inductors in the low-pass prototype can be replaced with high-impedance line sections Z_H and the open capacitors can be replaced with low-impedance stub line section Z_L. Prototype filter elements are then scaled the impedance and frequency level and the physical length of the elements are obtained using the following relations:

$$\beta l = \mathrm{Sin}^{-1} (\omega L / Z_H) \approx \omega L / Z_H \qquad (5)$$

$$\beta l = \mathrm{Sin}^{-1} (\omega C Z_L) \approx \omega C Z_L \qquad (6)$$

The conventional elliptical low pass filter, designed using the above equations for the following parameters.

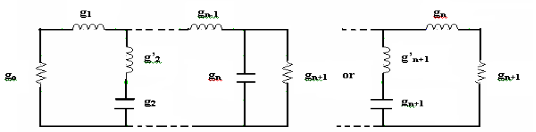
C. Design parameters

Order of filter,n=4
Cut-off frequency, $fc = 0.75$GHz
Dielectric constant, $\varepsilon_r = 4.7$
Substrate height, $h = 1.6$mm
Characteristic impedance and $Z_o = 50\Omega$

The frequency response of conventional design as shown in fig.5. The different sizes of fractals are proposed in the low impedance region of conventional filter as shown in fig.6, 8 and 10. These fractals are etched out in the low impedance regions of this filter. All filter designs are simulated using IE3D and the parameter S_{21} obtained as shown in fig.7, 9, and 11.

III. ELLIPTIC FUNCTION LOW PASS PROTOTYPE FILTERS

Commonly used network structure for elliptic function low pass prototype filters are shown in fig.1.The shunt branches of series-resonant circuits are used for implementing the finite-frequency transmission zeros, since they short out transmission at resonance.



(n even) (n odd)

Fig. 1. Low pass prototype filters for Elliptic response

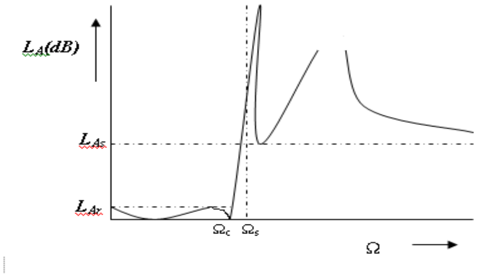


Fig.2.Elliptic low pass frequency response

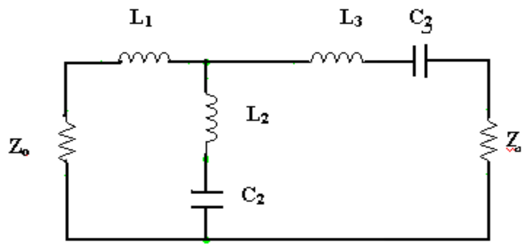


Fig.3.L-C circuit for four pole low pass Elliptical filter

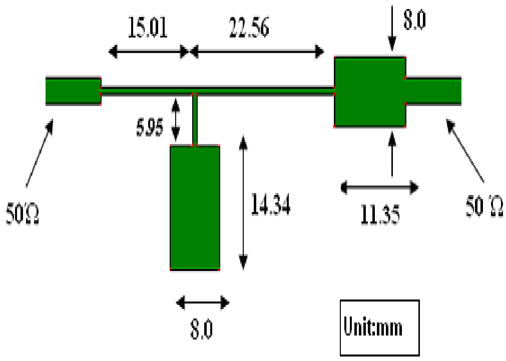


Fig.4. Microstrip Elliptical low pass filter

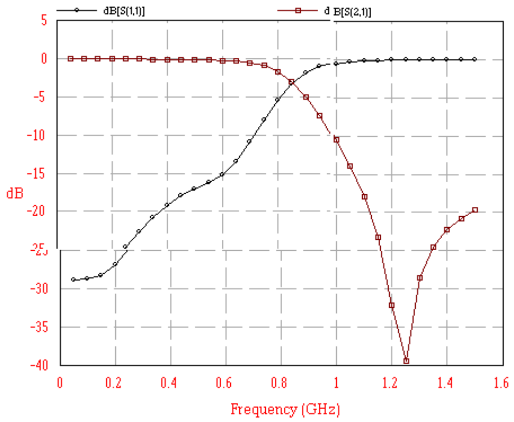


Fig5. Response of Elliptical low pass filter

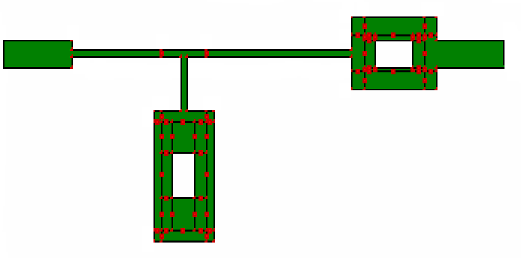


Fig.6. Fractal microstrip Elliptical low pass filter (fractal size 5x3)

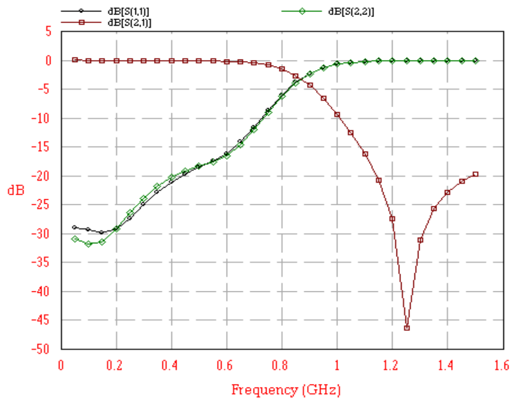


Fig.7. Response of fractal microstrip Elliptical low pass filter

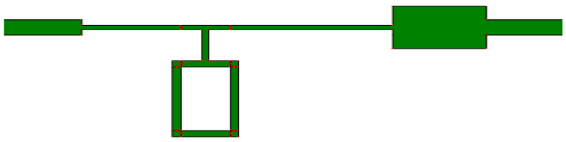


Fig.8. Fractal microstrip Elliptical low pass filter (fractal size 12x6)

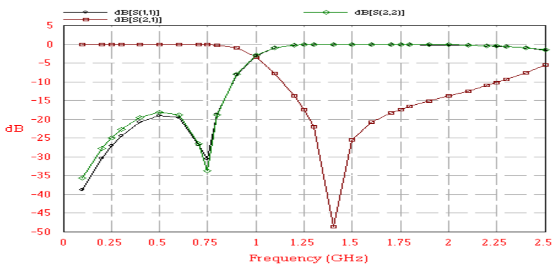


Fig.9. Response of Fractal microstrip Elliptical low pass filter

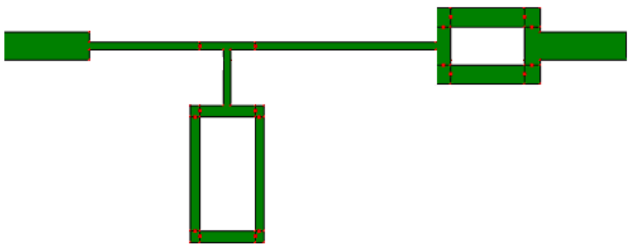


Fig.10. Fractal microstrip Elliptical low pass filter (fractal size 12x6 & 8x4)

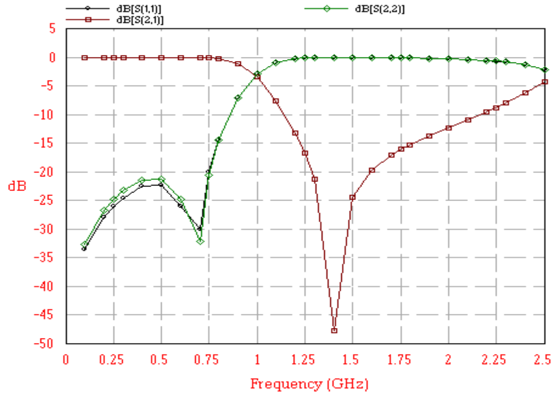


Fig.11. Response of fractal microstrip Elliptical low pass filter

CONCLUSION

The conventional geometry of the step impedance open circuited stub Elliptical low pass filter shown in Fig. 4. The simulated responses of the conventional geometry and on using the different sizes of fractal in conventional geometry with rectangular shape are shown in Fig. 5 and 7, 9 and 11 respectively. Simulated response of conventional and fractal filters are compared. On using the fractal filter, a significant improvement of 8dB in attenuation level is obtained and is shown in Fig.11. Therby, an overall considerable improvement in the frequency response of the filter has been obtained by fractalization.

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