Design, Simulation and Construction a Low Pass Microwave Filters on the Micro Strip Transmission Line

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Abstract—**In this paper a low pass microwave filter has been designed. The filter has designed by step impedance method in which the alternative part characteristic linear impedance is too high or too low design. In this filter with changing every high or low impedance characteristics such as length or width desired characteristics can be rich and it has stimulated by using of HFSS software, and relying on full-wave analytical methods in three dimensional work page. Design with making by the micro strip technology, it becomes practical. This Filter has less complexity rather than other filters. Results of practical measure and simulation have been a fairly good agreement together.**

Index Terms—**Step impedance, microwave filter, micro strip**

I. Introduction

Micro strip filters in variety microwave Systems such as radars, measurement and test systems, satellite communications and electronic war to transfer energy in one or more pass band and to weaken the power in one or more cut band is used very high[1],[2]. They provide advantages include low price, low volume, high selectivity and simple structure. Extensive efforts of researchers in order to apply this benefit of the filters and minimize the disadvantages of it caused to build a wide variety of filters and also to create much analytically methods. These come in much forms such as: Champlain, Inter digital, coupled in parallel, and step impedance filters [3]. However, latter from electrical performance in comparison with other structures is placed in secondary step and it is further used to filter out unwanted signals outside the bandwidth. Generally, micro strip filters is designed using injection losses [4],[5]. Implementing design as its starting is done in low pass filter form in terms of normalized impedance and frequency [6]. Then the transformations we used to imply the pattern design and sample to impedance level and desired frequency band. The losses injection method for filter includes circuits with pressed elements. For applications such as microwave design it should be modified so that they use from the extensive elements includes transmission line sections [7]. Step impedance filters, through the sections with very high and very low micro strip lines characteristic impedance are produced and hence such filters generally is Known as high impedance and Low Impedance that common and zonal structure of this type of filters is shown in Fig. 1.

In Fig. 1, a serial inductor of a low-pass model can be replaced with high impedance transmission line sections and parallel capacitor, with low impedance transmission line sections. Also areas with low impedance, usually is in the form of very broad transmission lines that are opposing with generic densities of filters. Other hand, a destination with high impedance with small characteristic size maybe not suitable for made, and it depend to acceptable limiting processes.

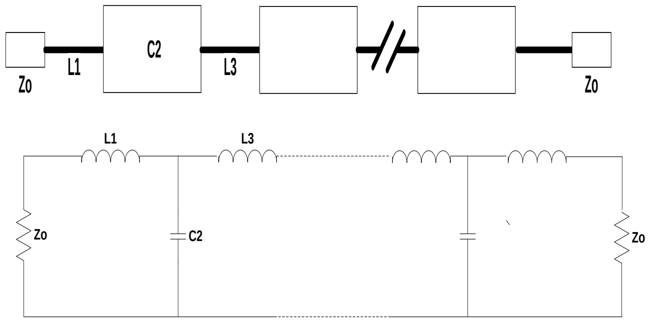

Fig. 1. Circuit structure of a low pass filter with step impedance.

In this paper a part that we will examine in the second part is response to this question that is which range, high or low impedance we can use or whether we can use any characteristic impedance to design that we wish it. In the third section the steps of simulation design and making step impedance low pass filter for off frequency 2.5GHz is described. In the fourth part also we design and simulate a low pass filter in that method for 1GHZ frequency and we explain the filter with changes in that method of reducing filter size and improving the frequency response of its sample. In Part fifth also presents results of the benefits of our offered topology and simulated data, which proves our claim.

II. Filter Characteristics Impedance Range

We know that whatever line impedance is lower, the fine bar is become wider and the line get capacitor property and it will close more to properties of the pressed capacitor parameter used in filter and vice versa, also whatever line impedance is higher, the fine bar is become thinner and the line get inductor property and it will close more to properties of the pressed inductor parameter used in filter [8]. Also know that whatever the ratio of the line impedance is more top-down, the filter frequency response is improved [9]. Then we result of this design method that we should use the highest and lowest characteristic impedance that is possible. In various references characteristic impedance range for micro strip structure can be between 20 to 125 ohm [10], [11]. However, in the low or moderate frequency can hit to characteristic impedance below 10 ohms or characteristic impedance close to 150ohm also. This impedance range resulting from where as much width of

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line conductor become wider, it can cause making transverse resonance and how much conductor line width become more narrower, flowing is survived and making it is harder and manufacturing tolerances become more. In continue in this part with doing a computations that we have brought it's results in graphs that with it's help we can make do a stuffs to determine a impedance range suitable for optimum design.

In Fig. 2 effects of the line characteristic impedance on the width of two micro strip lines with dielectric coefficient 9.4 mm and the thickness 1.58 and 0.79 mm has been shown. The horizontal axis represents different impedance characteristics and vertical axis represents the line width. From a comparison which in This chart has been done we conclude that in places where we want to reduce the line width it is better we use lines with less thickness because so that we view in graph 2, the line width of each impedance in the thickness 0.79 mm, almost is half of the line width in thickness 1.58 mm that shows its effect on the more below impedances.

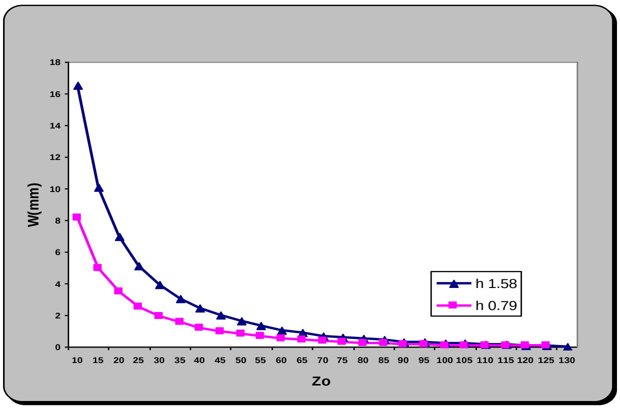

Fig. 2. The effects of line characteristic impedance.

In Fig. 3 the effects of the dielectric coefficients on the micro strip line conductor width for characteristic impedance over 120 ohms for 0.79 mm and 1.58 mm thickness is shown. The horizontal axis is the different dielectric coefficients and vertical axis is line conductor width. A result we get from this chart is that whatever choice dielectric coefficient for the design on the micro strip line be lower and line thickness is greater, width of the line conductor is more that is more appropriate for the characteristic impedance relatively over 120 ohms.

In Fig. 4 the effects of the dielectric coefficients on micro strip line conductor width for characteristic impedance below 20 ohms for both thickness 1.58mm and 0.79 mm is shown. The horizontal axis is the different dielectric coefficients and vertical axis is line conductor width. A result we get from this chart is that whatever choice dielectric coefficient for the design on the micro strip line be greater and line thickness is lower, width of the line conductor is less, that is more appropriate for the characteristic impedance relatively below 20 ohms. We can by a comparison between the 2 and 3 diagrams and we get a help from them that, choose the limitation contracts and processes which acceptable for a suitable micro strip transmission line structure for filter design.

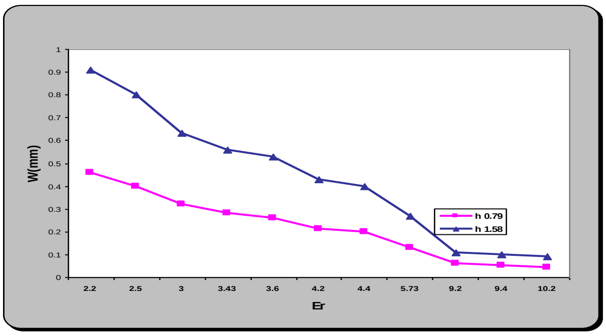

Fig. 3. The effects of dielectric coefficients on micro strip lines.

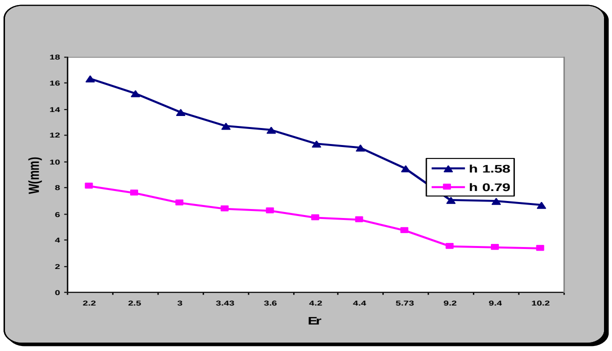

Fig. 4. The effects of dielectric coefficients on micro strip lines.

III. Design, Simulation and Construction of Low Pass Micro Strip Filter With Step Impedance

Low pass filters with step impedance can be designed with replies in form of max flat or response with equal Ripple. Design is based on normalized g values. These values should convert to inductors and capacitors. We do here the design for a microwave low pass filter with 2.5GHZ cutting frequency and the flat maximum response with inserting losses more than 20dB in frequency 4GHZ and filter characteristic impedance 50ohm. The normalized value of it's parameters is according to low pass pattern with flat maximum response for cutting frequency $W_c = 1$ and impedance $Z_0 = 1$ is described as follows[12]:

$$g_1 = 0.517 = c_1 \quad g_2 = 1.414 = l_2$$

$$g_3 = 1.932 = c_3 \quad g_4 = 1.932 = l_4$$

$$g_5 = 1.414 = c_5 \quad g_6 = 0.517 = l_6$$

The actual or demoralized amount of inductors L_i and capacitors C_i is calculated by equation 1 and 2.

$$l_i = \frac{Z_\circ}{Z\pi f_c} g_i \qquad (1)$$

$$c_i = \frac{g_i}{Z_\circ z_\pi f_c} g_i \qquad (2)$$

The make-up implementation of the micro strip low pass filter with step impedance is done on substrate FR4 with dielectric coefficient 4.2 and thickness 1.58 mm with copper conductor with 0.5 mm that we assume highest practical characteristic impedance 120 ohm and lowest 15 ohm of the line. The width of high impedance line assuming $\frac{w}{h} \le 2$ and the width of low impedance line assuming $\frac{w}{h} \ge 2$ are calculated as equation3 and 4 [13], [14].

$$\frac{w}{h} \le 2 \Rightarrow \frac{w}{h} = \frac{8\exp(A)}{\exp(2A)-2} \quad (3)$$

$$A = \frac{Z_\circ}{60}\left\{\frac{\varepsilon_r + 1}{2}\right\}^{.5} + \left(\frac{\varepsilon_r - 1}{\varepsilon_r + 1}\right)\left\{0.23 + \frac{.11}{\varepsilon_r}\right\}$$

$$\frac{w}{h} \ge 2 \Rightarrow \frac{w}{h} = \frac{2}{M}\{(B-1) - \ln(2B-1)\} \quad (4)$$

$$+\frac{\varepsilon_r - 1}{2\varepsilon_r}\left[\ln(B-1) + 0.39 - \frac{.61}{\varepsilon_r}\right]$$

$$B = \frac{60\pi^2}{z_\circ\sqrt{\varepsilon_r}}$$

Inductive and capacitive physical length in micro strip line for desired filter are shown in summarized form in Fig. 4. Accuracy of presented relationship to calculate the width of the high line impedance and low impedance in the equation 3 is more than one percent, so what better accuracy is needed, we can use optimization processes [15]. Accurate and optimized values of line width and w_i and lines length l_i is given in table I. After obtaining measurements of design we examine designed filter by microwave soft ware's and in order to executive it so if the results of the simulation was desirable we make the advised filter on micro strip transmission line. Here we analysis the designed filter by HFSS software [16], [17]. This emulator is relying on the full wave analysis methods and using comparative feedback loop and by providing three-dimensional work environment and tools and various ideal microwave instruments, provide desirable and ideal environment for design, as noted and we observed in Fig. 5, view of the software model, since the range resolution of a issue in this software should be limited and specific, we placed the view of the model in a metal or radiation container cause the mesh model range of model structure be limited and determined [18], [19].

TABLE I: DESIGN PARAMETERS OF A IMPLEMENTED LOW PASS MICRO STRIP FILTER

row	$l_i(mm)$	$w_i(mm)$	z_l or $z_i = z_h$
1	2.05	11.3	20
2	6.63	0.428	120
3	7.69	11.3	20
4	9.04	0.428	120
5	5.63	11.3	20
6	2.41	0.428	120

If the simulated response in the software has little difference with the desired response of the designer, we can with it's settings section achieve to the designer desired parameters [20]. After simulation, the desired filter has been run on micro strip transmission line that making steps of this example of micro strip filters in [10] is explained. Fig. 6 is an image from the constructed low pass filter.

Fig. 7 is a comparison between simulated run and measured of the filter made by the network analyzer, simulation and fabrication results are shown respectively by red line and blue one. we observed a good compromise between the results of simulation and construction. It's clear that the results are much closed to each other.

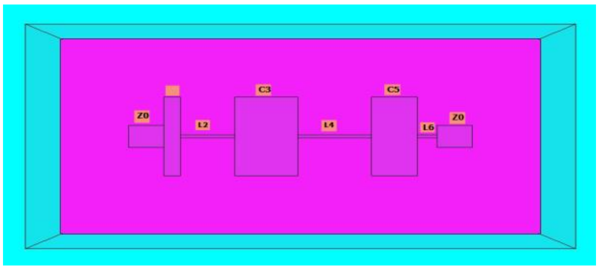

Fig. 5. Designed filter in three-dimensional environment, and full-wave hfss software on a below substrate with dielectric constant 4.2 and thickness1.58 mm .

Fig. 6. Photo of micro strip filter built on the substrate with a dielectric constant 4.2 and thickness 1.58 mm.

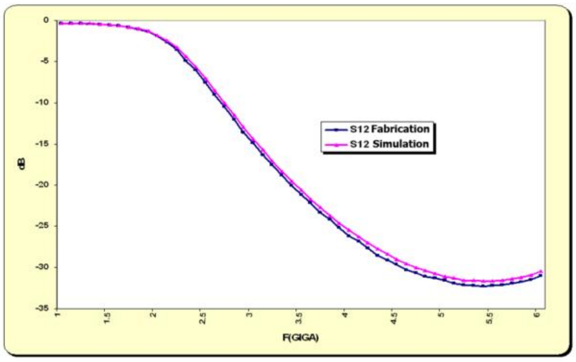

Fig. 7. Comparison between frequency of built filter and simulation

IV. CONCLUSIONS

In this paper a Low pass microwave filters with step impedance by micro strip lines with high impedance characteristic and low impedance characteristic has been designed. Although the standard implementations, has the relatively low limitations we define from high to low impedance when the back surface of the filter is in cutting band. Also depending on the substrate because these are advanced filters and there are restrictions on the small size by being compact and dense throughout it. This research work review being an executive steps of micro strip filter with method of a step impedance from design to build, by design method with helping computer and demonstrating ways which by them helping we can improve the size of a micro strip filter with helping our micro strip technology and frequency response and improve power return losses.

In overall in this design method, increasing the ratio of high characteristic impedance to low is caused to improve frequency response that to achieve this purpose and resolve problems such as increased manufacturing tolerances, width revival and preventing of cross flow, we point to methods to increase the coefficient dielectric, reducing substrate thickness and maintaining constant the widths by help increasing the coefficient of dielectric. All these methods cause to reduce the filter size. It should be mentioned, we can extend the provided methods in this paper to reduce the size and improve the frequency response for many microwave filters in order to various applications on micro strip transmission lines.

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