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# Design of textile based microstrip low pass filter

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***Abstract*— The design of textile microstrip low pass filter is discussed in this paper. The filter is designed at 1GHz frequency. The lumped circuit model is simulated in student version of ansoft designer. The transmission line model of the filter is simulated in high frequency structure simulator. Jeans is used as dielectric substrate and copper adhesive tape is used to make conductive parts. The filter is fabricated and tested in network analyzer. There is little change in simulated and measured results that may be due to fabrication errors.**

*Keywords*—***lumped-element network, Microstrip low pass filter, Jeans, , High frequency structure simulator.***

## I. INTRODUCTION

Recently lot of research work is going on wearable electronic devices. This application has led to the necessity of electronic devices to be integrated with cloths, for which they have to be low profile and flexible. It is big challenge to make them flexible, its parameters have to be at acceptable levels in normal condition and environment. In [4-9], the microstrip filters are designed using dielectric material substrate like FR4 [5,7]. The design of microstrip filters using wearable substrate such as jeans are discussed in [1,2].

In this paper chebyshev low pass filter is designed using Jeans as substrate. The filter is fabricated and tested.

## II. DESIGN OF MICROSTRIP LOW PASS FILTER

The design of low pass filter at 1 GHz is presented in this paper. The filter is designed using third ordered chebyshev approximation. The lumped circuit model is designed and simulated using ansoft designer. The lumped parameters are converted into microstrip line using richard transformation method [10]. The designed microstrip line model is simulated in high frequency structure simulator.

Third order low pass filter have been designed in microstrip configuration with the following specification.

Dielectric constant =1.6 (Jeans)[3]

Pass band Ripple = 1dB

Cut off frequency = 1 GHz

Substrate thickness, h =2.4 mm

Lowest Line impedance = 20 Ω

Characteristic impedance = 50 Ω

Highest Line impedance = 86 Ω

Design of Lumped-Element low pass filter

For pass-band ripple characteristic having 1 dB ripple the element values for the third ordered filter are given below [10].

$g1=2.0237, g2=0.9941, g3=2.0237$

Lumped elements like inductor and capacitor value can be calculated by below formula[10].

$$L_i = \frac{z_0}{g_0} \times \frac{\Omega_C}{2\Pi f_C} \times g_i \text{..........................................(1)}$$

$$C_i = \frac{\Omega_C}{2\Pi f_C} \times \frac{g_0}{Z_0} \times g_i \text{........................................(2)}$$

Calculated values for lumped-element network from equation (1) and (2) are as given in Table 1. The lumped model of filter is shown in Fig 1.

**Table 1: Lumped parameter values**

| Prototype element value | Correspond L and C value |
|---|---|
| g1=2.0237 | L1=16.1 nH |
| g2=0.9941 | C1=3.164 pF |
| g3=2.0237 | L2=16.1 nH |

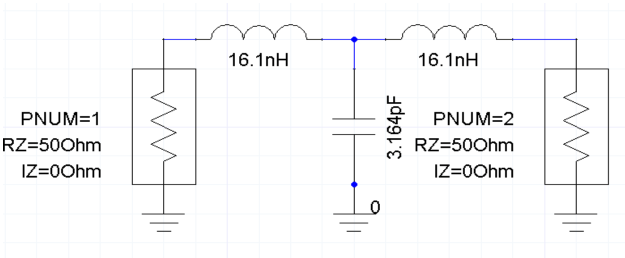



**Figure 1- Lumped model of filter**

Design of equivalent microstrip low pass filter

In order to convert L and C in to microstrip line the low impedance value and high impedance values are assumed. Characteristic impedance of high impedance line value ZoL =86 Ω and characteristic impedance of low impedance line value ZoC =20 Ω. The fabric jeans is used as substrate having 1.6[3] dielectric permittivity.

The length and width of microstrip lines are calculated by equations (3), (4) and (5)[10]. The equations for calculation of width and length are as given below which gives result in radians so they need to be converted it into degrees.

$$(\beta d)_l = \frac{R_o L}{Zh} \text{rad....................................................(3)}$$

$$(\beta d)_c = \frac{Z_m C}{R_o} \text{rad..................................................(4)}$$

$$W_h = \left( \frac{377}{Z_{0L}\sqrt{\varepsilon_r}} + 1.57 \right) h \text{......................................(5)}$$

Where $W_h$ is the width of microstrip line

By using the above formulas the dimensions of filter are calculated. The calculated width and length for microstrip line are shown Table 2.

**Table 2: Dimensions of microstrip line**

| Impedance (ohm) | Width (mm) | Length (mm) |
|---|---|---|
| 50 | 10.53 | 10 |
| 86 | 3.73 | 47.28 |
| 20 | 29.3 | 15.36 |
| 86 | 3.73 | 47.28 |
| 50 | 10.53 | 10 |

The microstrip low pass filter model is shown in Fig 2.

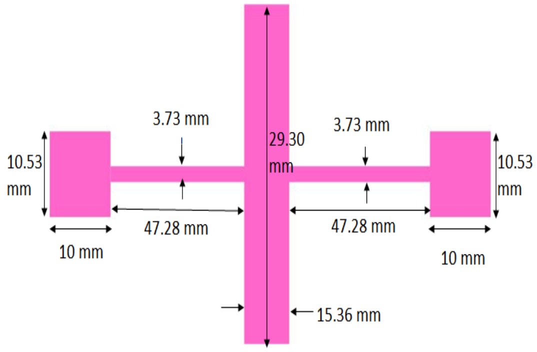



Figure 2. Microstrip low pass filter model

## 3. FABRICATION OF TEXTILE MICROSTRIP LOW PASS FILTER

The fabricated prototype of filter is shown in Fig 3 and Fig 4. Fig 3 shows top view of the filter and Fig 4 shows bottom view of filter. The jean is used as substrate and copper adhesive tape is used for making microstrip line structure and ground. The thickness of single layer is measured using thickness gauge and it is found 0.8 mm. So, for required thickness of 2.4 mm, jeans layer are stacked and sewed at the edges. The copper adhesive tape is used to make conductive parts. Microstrip line structure and ground plane fixed on opposite side of jeans substrate. The soldering of SMA connector is done by normal soldering technique. There are chances of burning the jeans material, so care is taken during stitching of layers and also during soldering of connectors.

Figure 3- Top view of textile based microstrip low pass filter

**Figure 4- Bottom view of textile based microstrip filter**

## 4. RESULT AND DISCUSSION

The simulation results for lumped-element low pass filter design using ansoft designer software are shown in Fig 5. The filter allows all frequencies below 1 GHz to pass. The simulated S21 and S12 is -3.05 dB at 1.10 GHz for lumped model as shown in Fig 5. The microstrip line model of filter is simulated in high frequency structure simulator. Fig 6 shows comparison plot of measured and simulated results (hfss) of S11, S22, S12 and S21. The simulated S21 and S12 is -3.07 dB at 1.005GHz. The fabricated low pass filter is tested using network analyzer. The measured S21 is -4.64dB and S12 is -4.46 dB at 1.005 GHz for this fabricated filter as shown in Fig 6. There is small difference between simulated and measured is observed which is due to fabrication related errors like while cutting and fabricating of material for substrate and microstrip lines. The flexibility test of filter is carried out by fixing the prototype filter on cylinders of different radius. Fig 7 shows flexibility measurement setup. Fig 8 shows measured S21 of prototype filter while it is fixed on different cylinders. The measured S21 is -3.24dB at 0.90GHz frequency when filter is kept flat. The measured S21 is -3.20dB, -3.14dB and -3.41dB at 0.90GHz frequency when filter is fixed on cylinders having radius 9cm, 10cm and 11cm, respectively as shown in Fig 8. The measured results are little shifted towards lower side for various curved condition.

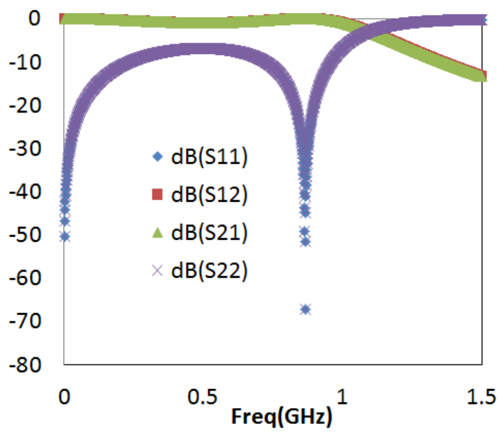



**Figure 5- Simulated result of lumped-element low pass filter simulated in ansoft designer**

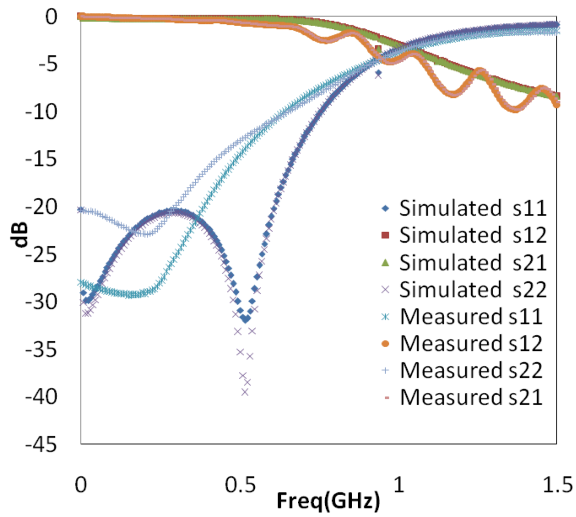
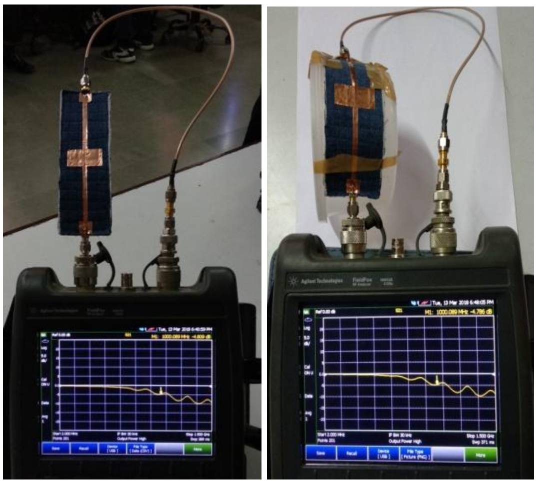



**Figure 6- Comparison of simulated and measured results**



(a) flat condition (b) curved condition

**Figure 7- Flexibility test measurement setup**

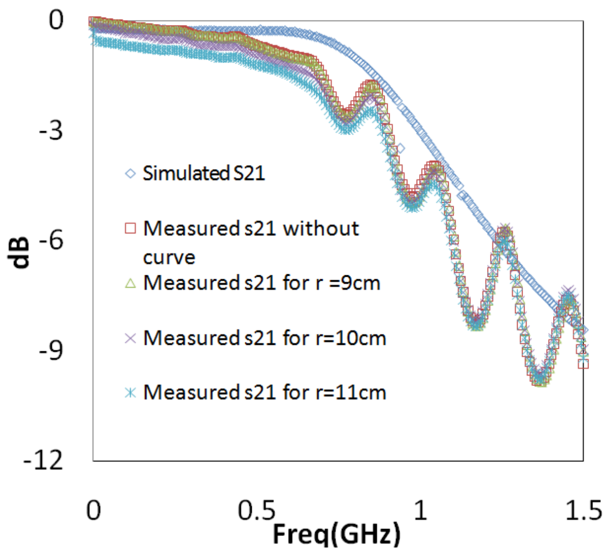



**Figure 8- Measured S21 of fabricated filter for different curved conditions**

## 5. CONCLUSION

In this paper, microstrip low pass filter is designed. This paper shows calculation steps and result analysis of lumped network low pass filter. The designed filter is simulated and tested. The simulated S21 and S12 is -3.05dB at 1.10 GHz for lumped-network low pass filter design and - 3.07 dB at 1.005 GHz for micro strip low pass filter design. The measured S21 is -4.64dB and S12 is -4.46 dB at 1.005 GHz for this fabricated filter. There is little variation in measured and simulated result which may be because of fabrication related error. The flexibility test of filter is carried out and it is observed that results are shifted towards lower side.

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