Wearable Textile Microstrip Low Pass Filter using Jeans as Subtrate

Binal A. Patel
Electronics and Communication Department,
Chandubhai S. Patel Institute of Technology, Charotar University of Science and Technology, Anand, India

Falguni Raval
Electronics and Communication Department,
Chandubhai S. Patel Institute of Technology, Charotar university of science and Technology, Anand, India

***Abstract*— Low pass filter presented based on lumped-network and microstrip line structure suitable for wireless communication application. Chebyshev filter of order 3 and 0.1dB pass band ripple is designed using step-impedance method for 1GHz cut-off frequency. Then this Microstrip low pass filter designed as fabricated jeans Microstrip low pass filter using jeans as subtract and copper adhesive tape used as Microstrip line.**

Keywords—ANSOFT DESIGNER, ANSOFT HFSS,copper adhesive tape,jeans ,lumped-element network,Microstrip low pass filter, NETWORK ANALYSER

I. INTRODUCTION

Main purpose of filter is to take up frequencies in selected operated range and turn down all other. In this paper, the design, analysis, simulate and measure of the low pass filter is presented[1][2]. Ideal filter has no loss within pass band; above this frequency is what known as stop band the filter will reject all signals. In practical it not possible to achieve perfect filter. There are four main types for filter is possible like low pass filter, high pass filter, band pass filter, band stop filter. Each has different type of rejection and acceptance for signal in different ways. Low pass filter allows only frequencies below cut-off frequencies. High pass filter allows higher frequencies than cut-off frequencies. Band pass filter will allow frequencies within pass band and band stop filter will reject frequencies for certain band. A filter can allow frequencies called as pass band.

This filter used in microwave systems like as radars, measurement and test systems, satellite communication[7]. This Microstrip filter has advantages like low cost, higher selectivity and uncomplicated structure.

The design of Microstrip low pass filter is presented. Microstrip is kind of electrical transmission line. A low pass filter will pass frequencies below cut-off frequency and reduces amplitude of frequencies higher than cut-off frequency. This is revered of high pass filter. Low pass filters can be used in much different form such as electronic circuits, acoustic barriers, audio applications, blurring of images etc. low pass filter are used in many microwave systems to reject higher frequencies than cut-off frequency.

Microstrip line used to transport microwave signal. It compromise of a conducting strip apart on a ground plane dielectric layer known by subtract[6]. This Microstrip lines are much cheaper and lighter. Main disadvantage of Microstrip line is they have higher losses. The horizontal distance of the strip, the depth of subtract and the relative permittivity of subtract determine the characteristic impedance of the transmission line. Between 800MHz to 30 GHz we can use Microstrip RF filters[10]. In this project design of low pass filter and its implementation to Microstrip line is done. Joining of two Microstrip transmission lines with differ characteristic impedances give Microstrip low pass filter.

Wearable electronic devices are become more popular as body-centric communication becoming more important day by day in medical and military application [4]. RF devices like filters are weightily component in body-centric communication system. Wearable filter can be made by using textile material as subtract [5].

In this paper the design of Chebyshev filter is presented. Lumped parameter filter is simulated in ANSOFT DESIGNER. Then transformation methods are used to transform L and C into Microstrip design. We used stepped impedance method to design Microstrip low pass filter [3]. ANSOFT HFSS is used for microstrip design and analysis. Then filter is fabricated using jeans as subtract and copper adhesive tape for Microstrip lines. The fabricated filter is tested and verified.

II. DESIGN OF STEPPED IMPEDANCE LOW PASS FILTER

Microwave filter has micro stripe lines which are simulated from lumped elements of filter circuit. The similar lumped elements values of microwave components are themselves purpose of frequency.

The design of Microstrip low pass filter comprises two primary steps. The first step is to select suitable low pass prototype. The selection of type of response, including pass band ripple and scalar of reactive elements, will depend on required specifications. The element valuate of the low pass prototype filter, which are normalized to made a source impedance $g_0=1$ and a cutoff frequency $\Omega_c=1.0$, are then converted to the L-C elements for cut-off frequency and source impedance, which we usually take 50 ohms for Microstrip filter. Second main step for design of Microstrip low pass filter is to gain an appropriate Microstrip realization to the lumped element filter. There values for low pass prototype with Chebyshev response at pass band ripple 0.1 dB, source to load impedance Z_0=50 ohms, are taken from normalized values g_i i.e. $g_1,g_2,g_3,g_{34}\ldots g_n$. Then filter is fabricated on subtract of dielectric constant ε_r and angular thickness h mm. and angular cutoff frequency Ω_c using the element transformation.

The low pass filter is simulated using ANSOFT DESIGNER for lumped-element and ANSOFT HFSS software for Microstrip design.

Design a three-order low pass filter with 0.1 dB ripple and cut off frequency of 1 GHz. The source/load impedance of the filter is 50Ω.

For the low pass filter following parameter can be compromised.

Frequency response type: - Chebyshev response
Cutoff frequency=1 GHz
Source/load impedance=50Ω
Dielectric constant of subtract=1.6[8]
Subtract thickness=3.5mm
Pass band ripple=0.1dB
Design of Lumped-Element low pass filter is as follow:
For pass-band ripple characteristic having 0.1 dB ripple the element values for the filter is given in below table [1]

TABLE 1: Element values for low pass Chebyshev filter Prototypes (g_0=1, w_c=1 and 0.1 dB ripple)

m	g_1	g_2	g_3	g_4	g_5
1	0.3053	1.0000			
2	0.8431	0.6220	1.3554		
3	1.0316	1.1474	1.0316	1.000	
4	1.1088	1.3062	1.7704	0.8181	1.3554

From the table prototype element value are as follow
g_1=1.0316
g_2=1.1474
g_3=1.0316
Now inductor and capacitor value can be calculated by below formulas [9]

$$Li = \frac{z_0}{g_0} \times \frac{\Omega_c}{2\pi f_c} \times g_i \quad (1)$$

$$Ci = \frac{\Omega_c}{2\pi f_c} \times \frac{g_0}{z_0} \times g_i \quad (2)$$

Calculated values for lumped-element network from equation (1) and (2) are as given in below table

TABLE 2: Calculated lumped-element values

Prototype element value	corresponding L and C value
g_1=1.0316	L_1=8.2092nH
g_2=1.1474	C_2=3.6522pF
g_3=1.0316	L_3=8.2092nH

By this L and C values we design lumped-element type low pass filter in ANSOFT DESIGNER software as follow:

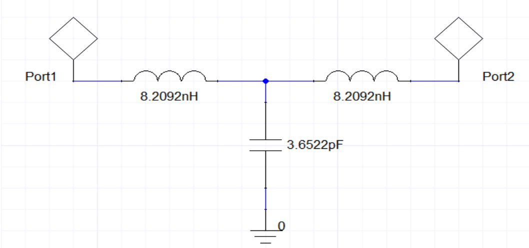

Figure 1: Lumped-element low pass filter design in ANSOFT DESIGNER software

Now we are going to assume high and low impedance values. Characteristic impedance of high impedance line value Z_{oL}=88Ω and characteristic impedance of low impedance line value Z_{oC}=30Ω. We are going to use JEANS as subtract. Which has 1.6 dielectric permittivity, thickness of subtract is h=3.5mm. Now we have to calculate width and length for Microstrip filter. We can calculate width of Microstrip line by equations. Equations for calculation of width and length are as given below [9].

If $\frac{w_0}{h} \le 2$,

$$\frac{w_0}{h} = \frac{8\exp(A)}{\exp(2A)-2} \quad (3)$$

Where $$A = \frac{z_0}{60}\sqrt{\frac{\varepsilon_r+1}{2}} + \frac{\varepsilon_r-1}{\varepsilon_r+1} \quad (4)$$

$$\text{Guided wavelength } (\lambda_{g0}) = \frac{300}{f(GHz)\sqrt{\varepsilon_{reff}}} \quad (5)$$

$$\varepsilon_{reff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left[1+12\frac{h}{w}\right]^{-1/2} \quad (6)$$

For calculation of physical line length we can use as given below [9]

$$l_L = \frac{\lambda_{gl}}{2\pi} \times \sin^{-1}\left(\frac{w_c L_i}{z_{0L}}\right) \quad (7)$$

$$l_C = \frac{\lambda_{gl}}{2\pi} \times \sin^{-1}\left(w_c C_i z_{0C}\right) \quad (8)$$

By using the formula (3), formula (4), formula (5), formula (6), formula (7), formula (8) we can have calculated width and length for Microstrip line are as below table

TABLE 3: Design parameter for Microstrip lines for stepped – impedance low pass filter

Characteristic impedance (Ω)	Z_{0C}=30	Z_0=50	Z_{0L}=88
Microstrip line width(mm)	W_C=25.66	W_0=12.87	W_L=5.131
Microstrip line length(mm)	l_C=29.6089	-	l_L=25.197

We can now make full structure of Microstrip low pass filter using ANSOFT HFSS for our calculating values. We have to assume length of the source impedance 10mm. We are getting 3D structure for Microstrip filter is as shown below.

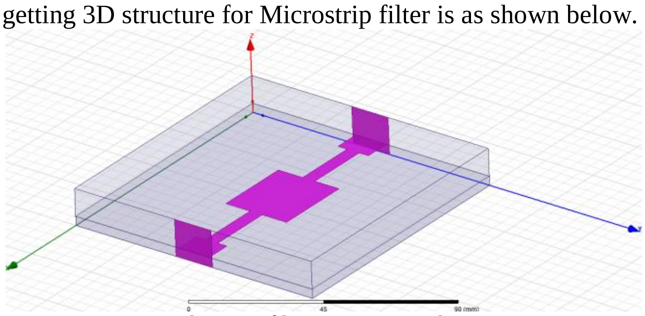

Figure 2: Microstrip low pass filter 3D geometry design in ANSOFT HFSS software

III. FABRICATED WEARABLE MICROSTRIP LOW PASS FILTER

Figure 3: top view of jeans low pass filter

Figure 4:back view of jeans low pass filter

Fabricate model for wearable low pass filter is shown in Fig 3 and Fig 4. Here we use jeans as subtract and copper adhesive tape for our Microstrip line structure and ground surface. For required thickness for subtract we have to first measure single layer of jeans material. It is done by use of thickness gauge. Thickness we getting is 0.6mm for this single layer. For our total required 3.5mm we have to stack jeans as per our dimensions and sew it at the edges. As per our microstrip line dimensions self-adhesive copper tape is cut using blade. Then using this self-adhesive copper tape ground plane was cut and stick on other side of subtract. Then we solder SMA connectors with normal soldering technique. There are chances of burning the jeans material so care is during soldering and wire is used.

IV. RESULT AND DISCUSSION

Simulation result for lumped-element low pass filter design using ANSOFT DESIGNER software is as shown in Fig 5.The filter allows all frequencies below 1 GHz to pass.

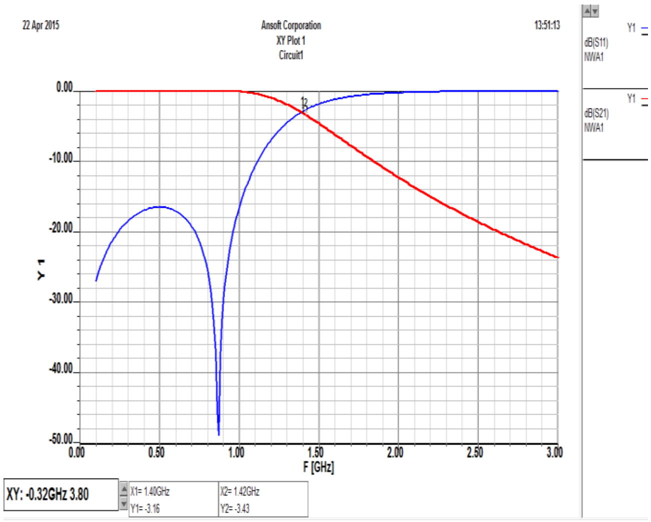

Figure 5: simulated result of ANSOFT DESIGNER for lumped-element low pass filter

Figure 6 show result for microstrip low pass filter that ANSOFT HFSS software. The insertion loss is -3.1dB at 1.16GHz as shown in figure 6.

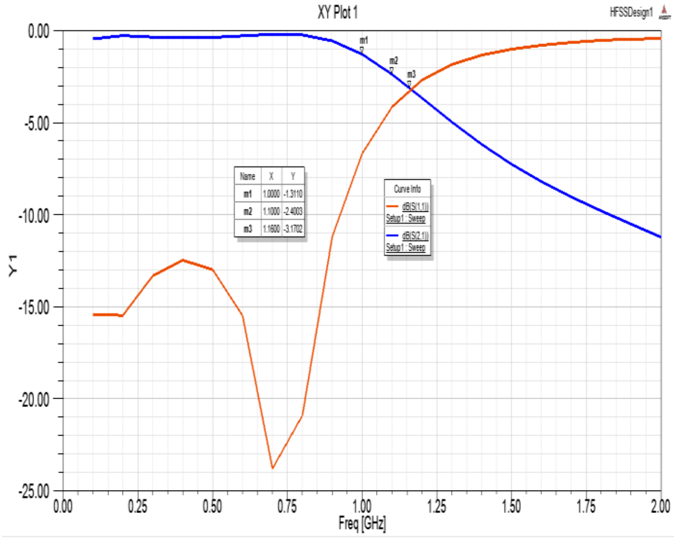

Figure 6: simulation result of ANSOF HFSS for Microstrip low pass filter

For fabricated jeans low pass filter using NETWORK ANALYSER. Fig 7 shows the measured result of fabricated filter. The insertion loss is -4.3dB insertion loss at 1.035GHz for this fabricated filter. 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 subtract and Microstrip lines.

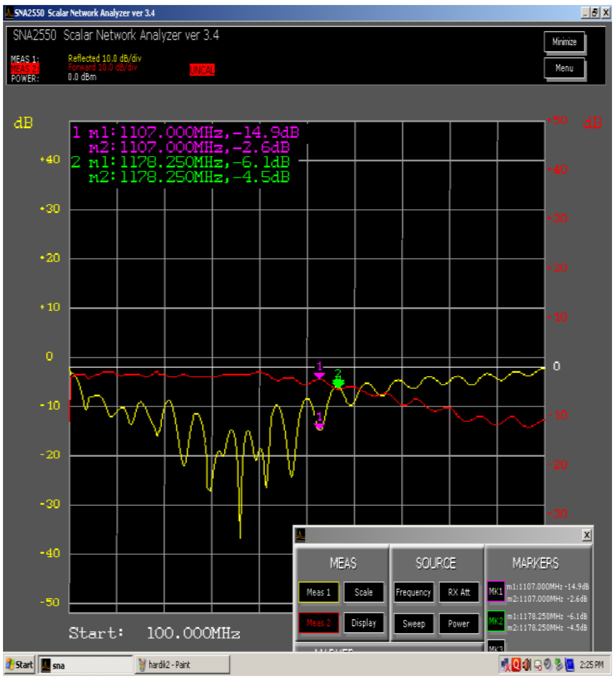

Figure 7: simulated result of NETWORK ANALISER for fabricated jeans low pass filter

V. CONCLUSION

In this letter, wearable jeans stepped impedance micro strip low pass filter is designed. This letter shows calculation steps and result analysis of lumped network low pass filter using ANSOFT DESIGNER, micro strip low pass filter using jeans as subtract in ANSOFT HFSS and fabricated jeans micro strip low pass filter analysis in NETWORK ANALYSER software.. We get -3.00dB insertion loss at 1.39 GHz for lumped-network low pass filter design and -3.1592dB insertion loss at 1.16GHz for micro strip low pass filter design, which is showing good result. But due to fabrication related error in fabricated jeans micro strip low pass insertion loss is -4.3dB at 1.035 GHz frequency.

REFERENCES

[1] Devendra k. misrea, "radio-frequency and microwave communication circutits, analysis and design",student edition, A wiley-interscience publication

[2] Ian C. Hunter, L. Billonet, B. Jarry, and P. Guillon,"Microwave filters-application and tecchnology",IEEE transaction on vol.50, issue 3,march 2002.

[3] A. S. Mohra and M.A. Alkanhal, "small size stepped impedance low pss filters" microw. Optical Tech. Ltt, vol.49, oct. 2007

[4] M. Billinghurst and T. starner, "wearavle devices: new ways to manage informance"computer, vol. 32, no. 1, pp.57-64, jan. 1999.

[5] S. Gao, S. Xiao, B. wang and X. Xu, "wideband antenna and wideband bandpass filter for wearable system", p.p 871-874, May 2010

[6] P. singh, "Analysis of multilayer Microstrip line of finite conducter thickness using Quasi_static Spectral domain analysis and single layer reduction metod ", IEEE, p.p 1-4,Dev. 2011

[7] O. Borazjani, A. Reazaee, "Design , simulation and construction a low pass microwave filters on the Microstrip transmission line", International Jouranal of computer theory and Engineering, vol. 4, no. 5, october 2012

[8] S. Sankaralingam, B. Gupta, "Determination of dieelectric constant of fabric material and their use as subtract and development of antennas for wearable applications", IEEE, vol. 59 , Dec. 2010

[9] V. Kushwah, G. Tomar, S. Bhadauria,"Design stepped impedance Microstrip low pass filters using artificial neural network at 1.8 GHz ", 2013 International Conference on communication systems and Network Technologies

[10] K. Rajasekaran, J. Jayalakshmi, T. Jayashankar, "Design and analysis of stepped impedance Microstrip low pass filter using ADS simulation tool for wireless application" , International journal of scientific and research publication, Vol. 3, Aug. 2013