10. LPF – STEPPED IMPEDANCE METHOD

Aim : To design a microstrip low pass filter using stepped impedance method.

Equipment required: ANSYS HFSS

Filter specifications:

Filter type	-	Butterworth (or) Chebyshev
Cutoff frequency (f_c)	-	
Insertion loss &	-	
Frequency (*w*)	-	
Ripple factor (*δ*)	-	

Microstrip specifications:

Characteristic impedance	Z_0	=
Operating frequency	f	=
Substrate thickness	H	=
Dielectric constant	ε_r	=
Loss tangent	L	=

One easy way to implement low pass filter in microstrip form is to use alternating sections of very high and very low characteristic impedance lines. Such filters are usually referred to as *stepped impedance* or *hi-Z, low-Z* filters. These filters are popular because they are easier to design ad take up less space than a similar low pass filter using stubs. Because of the approximations involved, however, their electrical performance is not as good, so the use of such filters is usually limited to applications where a sharp cutoff is not required.

By using this method, the series inductors of a low pass prototype can be replaced with high impedance line section (Z_0=Z_h) and the shunt capacitors can be replaced with low impedance line sections (Z_0=Z_l). Stepped impedance filter implementation and its microstrip form is shown in figure 2. With these approximations the electrical lengths of the inductor and capacitor sections are calculated as follows

Inductor $\beta l = \dfrac{LR_0}{Z_h}$ and Capacitor $\beta l = \dfrac{CZ_l}{R_0}$

R_0 is the filter impedance; L, C are element values from the table.

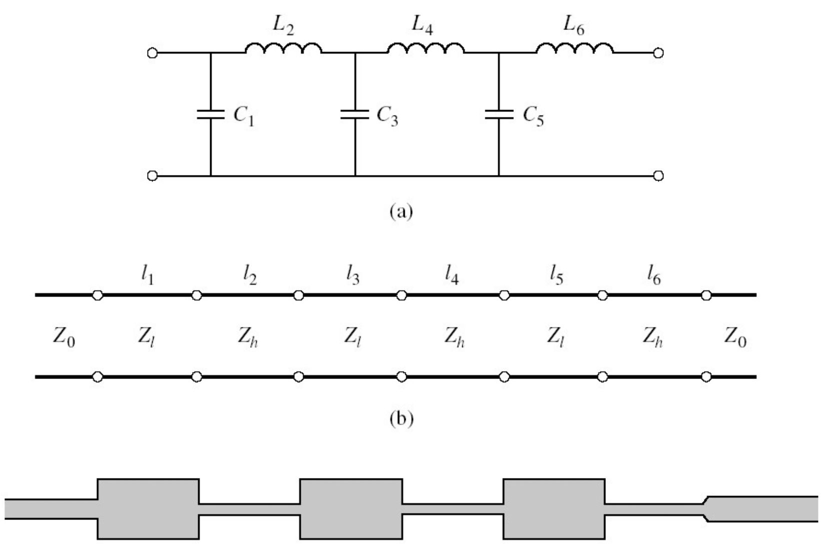

Figure 1

Sample Observations: Specifications for a maximally flat low pass filter are

Cut off frequency is 2.5 GHz; insertion loss at 4 GHz is 20 dB, highest practical line impedance is 120 Ω and the lowest is 20 Ω .

With the given specifications, number of elements required is 6.

$\boldsymbol{Z_0}$ = 50 Ω, $\boldsymbol{f}$ = 4 GHz , $\boldsymbol{H}$ = 1.58 mm, T = 0.0128 mm, $\boldsymbol{\varepsilon_r}$ = 4.2 , L = 0.02

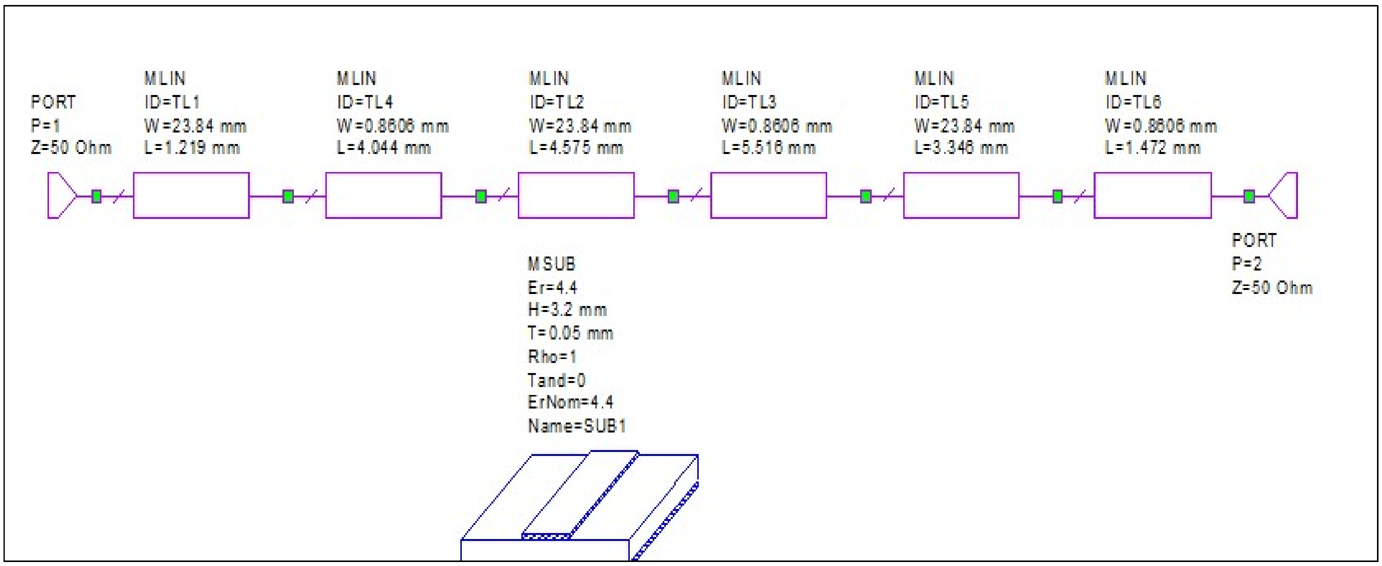

Fig. 1 : Design Stepped impedance filter

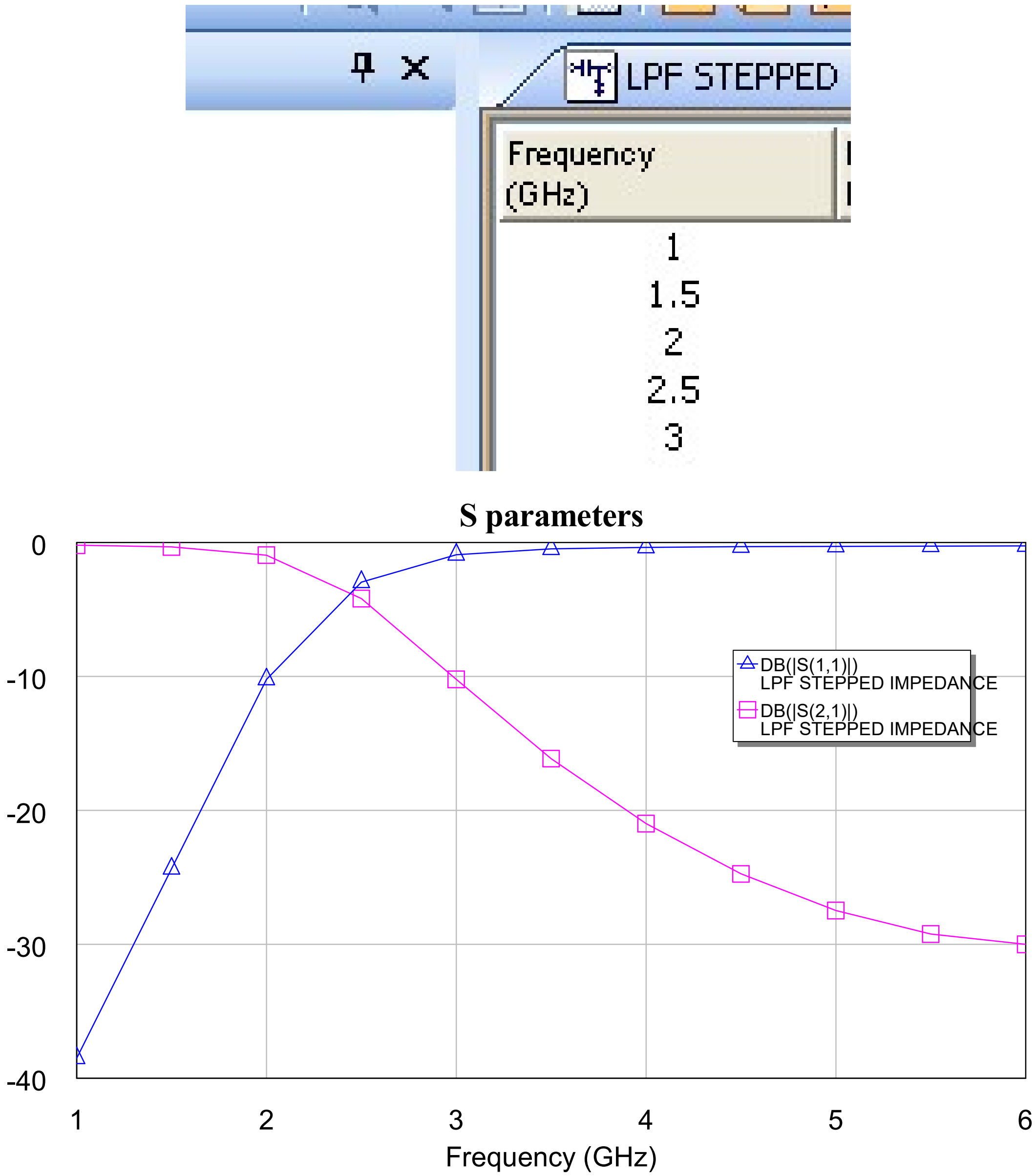

Fig. 2: Response and reading of stepped impedance filter.

Practical Observations:

Frequency	S_{11}	S_{21}

Conclusions: The Stepped filter is designed and studied.