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Signal Processing Lab

Subject- Digital Signal Processing

EXPERIMENT NO. 7

Aim: To design Butterworth filter using Scilab:

To compute the order and the poles of Butterworth low pass filter using Bilinear transformation (ASSUME T=1SEC).

- Attenuation in passband =1.93dB
- Attenuation in stopband =13.97dB
- Passband edge frequency =0.2
- Stopbandband edge frequency =0.6

Software Used: Scilab software.

Code:

```
clc;
clear;
s = poly(0,"s")
T = 1;

Ap = 1.93; //in dB
As = 13.97; //in dB
wp = 0.2*(%pi)
ws = 0.6*(%pi)
ohmp = 2/T*(tan(wp/2))
ohms = 2/T*(tan(ws/2))

//ORDER CALCULATION
N = (0.5)*(log((((10^(0.1*As))-1)/((10^(0.1*Ap))-
1))))/(log(ohms/ohmp))

Nr = int(N)
x = N-int(N)
if(x>0)
   Nr = Nr+1
```

```
ohmc = (ohmp/(10^(0.1*Ap)-1)^(1/(2*Nr)))

//Calculation of Poles
i = 0:1:Nr-1;
pi_plus = ohmc*exp(%i*(Nr+2*i+1)*(%pi)/(2*Nr))
pi_minus = -ohmc*exp(%i*(Nr+2.*i+1)*(%pi)/(2*Nr))
disp(wp, 'wp = ')
disp(ws, 'ws = ')
disp(ohmp, 'ohmp = ')
disp(ohms, 'ohms = ')
disp(N, 'N = ')
disp(Nr, 'Roundoff value of N now denoted as Nr = ')
disp(ohmc, 'Cutoff frequency : ohmc = ')
disp('Displaying the poles')
disp(pi_plus, 'pi_plus = ')
disp(pi_minus, 'pi_minus = ')
h2 = zeros(1,2)
h = ohmc/(s-(-0.53-0.53*%i))
h1 = ohmc/(s-(-0.53+0.53*%i))
h2 = h*h1;
disp(h,h1, 'Now the analog transfer function H(s) is the multiplication of
the following two terms: ');
disp(h2, 'After multiplication, H(s) = ')
g = numer(h2);
disp(g, 'Numerator of the analog transfer function = ')
//Obtaining H(z) using Bilinear Transformation Method:
z = poly(0, "z")
s = (2/T)*((z-1)/(z+1)); //Bilinear Transformation Method
disp('Type resume in console')
pause
a = 0.5618 + 1.06*s + s^2;
b = (1/a)
c = 0.5645360*b;
disp(c, 'The digital transfer function H(z) = ')
end
```

Output:


Scilab 6.0.2 Console
wp =
0.6283185
ws =
1.8849556
ohmp =
0.6498394
ohms =
2.7527638
N =
1.3010268
Roundoff value of N now denoted as Nr =
2.
Cutoff frequency : ohmc =
0.7513561
Displaying the poles
pi_plus =
-0.531289 + 0.531289i -0.531289 - 0.531289i
pi_minus =
0.531289 - 0.531289i 0.531289 + 0.531289i

```
 Now the analog transfer function H(s) is the multiplication of the following two ter
 ms:

       0.7513561
   ------------------

   (0.53-i*0.53) + s


       0.7513561
   ------------------

   (0.53+i*0.53) + s

 After multiplication, H(s) =


        0.564536
   -------------------
                     2
   0.5618 + 1.06s + s
WARNING: Feature numer is obsolete.
WARNING: Please use the r.num rational attribute instead.
WARNING: This feature will be permanently removed in Scilab 6.1.0

 Numerator of the analog transfer function =


   0.564536

 Type resume in console

Type 'resume' or 'abort' to return to standard level prompt.

-1->
```

```
-1-> resume
 The digital transfer function H(z) =

                                      2
   0.564536 + 1.129072z + 0.564536z
   ---------------------------------
                                   2
      2.4418 - 6.8764z + 6.6818z

-->
```

Conclusion:

In this experiment we designed a Butterworth Filter using minimum readymade scilab functions. Bilinear Transformation method was used to design the Butterworth Low Pass Filter. This method also helps in mapping from Analog S Plane to Digital Z Plane.