LOW PASS BUTTRERWORTH USING BILINEAR

```
clear all;
wp=input('enter the the passband freq: ');
ws=input('enter the the stopband freq: ');
ap=input('enter the the passband gain: ');
as=input('enter the the stopband gain: ');
T=input( 'enter sampling interval: ');
Fs=1/T;
rp=-20*log10(ap);
disp('the passbad ripple of the filter ');rp
rs=-20*log10(as);
disp('the stopband ripple of the filter ');rs
omp=(2/T)*tan(wp/2);
disp('the analog passband freq of the filter '); omp
oms=(2/T)*tan(ws/2);
disp('the analog stopband freq of th filter ');oms
[N,wc]=buttord(omp,oms,rp,rs,'s');
disp('the order of th filter ');N
disp('the cuttoff freq of th filter ');wc
[bn,an]=butter(N,1,'s');
disp('the normalized transfer function');
HSn=tf(bn,an)
[b,a]=butter(N,wc,'s');
disp('the analog transfer function');
HS=tf(b,a)
[num,den]=bilinear(b,a,1/T);
disp('the digital transfer function');
HZ=tf(num,den,T)
w=0:pi/16:pi;
disp('the frequency response is');
HW=freqz(num,den,w)
HW=freqz(num,den,w);
disp('the magnitude response is');
HW_mag=abs(HW)
plot(w/pi,HW_mag,'k');grid
title('magnitude resp of butterworth 2nd order lowpass filter');
xlabel('normalized freq');
ylabel('magnitude');
```

ANSWER

the the passband gain: 0.6
enter the the passband freq: 0.35*pi
enter the the stopband freq: 0.7*pi
enter enter the the stopband gain: 0.1
enter sampling interval: 0.1
the passbad ripple of the filter rp = 4.4370
the stopband ripple of the filter rs = 20
the analog passband freq of the filter omp = 12.2560
the analog stopband freq of th filter oms = 39.2522

```
the order of th filter N =     2
the cuttoff freq of th filter wc =   12.4439

the normalized transfer function
 Transfer function:
       1
-----------------
s^2 + 1.414 s + 1


the analog transfer function
Transfer function:
      154.8
--------------------
s^2 + 17.6 s + 154.8

 the digital transfer function
 Transfer function:
0.1708 z^2 + 0.3415 z + 0.1708
-------------------------------
   z^2 - 0.5407 z + 0.2237

 Sampling time: 0.1

the frequency response is HW =
  Columns 1 through 6
   1.0000           0.9743 - 0.2237i   0.8885 - 0.4474i   0.7215 - 0.6526i   0.4654 - 0.7869i   0.1696 - 0.7865i
  Columns 7 through 12
  -0.0658 - 0.6518i  -0.1837 - 0.4632i  -0.2063 - 0.2962i  -0.1805 - 0.1763i  -0.1388 - 0.0987i  -0.0972 -
0.0514i
  Columns 13 through 17
  -0.0617 - 0.0241i  -0.0343 - 0.0095i  -0.0151 - 0.0027i  -0.0037 - 0.0003i  -0.0000 - 0.0000i

the magnitude response is HW_mag =
  Columns 1 through 12
    1.0000    0.9997    0.9948    0.9729    0.9142    0.8046    0.6551    0.4983    0.3610    0.2523    0.1703
0.1099
  Columns 13 through 17
    0.0663    0.0356    0.0153    0.0038    0.0000
```

HIGH PASS BUTTRERWORTH USING BILINEAR

```
Clc;
Close all;
clear all;
wp=input('enter the the passband freq: ');
ws=input('enter the the stopband freq: ');
ap=input('enter the the passband gain: ');
as=input('enter the the stopband gain: ');
T=input( 'enter sampling interval: ');
Fs=1/T;
rp=-20*log10(ap);
disp('the passbad ripple of the filter ');rp
rs=-20*log10(as);
disp('the stopband ripple of the filter ');rs
omp=(2/T)*tan(wp/2);
disp('the analog passband freq of the filter '); omp
oms=(2/T)*tan(ws/2);
disp('the analog stopband freq of the filter ');oms
[N,wc]=buttord(omp,oms,rp,rs,'s');
disp('the order of th filter ');N
disp('the cuttoff freq of th filter ');wc
[bn,an]=butter(N,1,'s');
disp('normalized transfer function is ');
HSn=tf(bn,an)
[b,a]=butter(N,wc,'high','s');
disp('the analog transfer function');
HS=tf(b,a)
[num,den]=bilinear(b,a,1/T);
disp('the digital transfer function');
HZ=tf(num,den,T)
w=0:pi/16:pi;
disp('the frequency response is');
HW=freqz(num,den,w)
disp('the magnitude response is');
HW_mag=abs(HW)
plot(w/pi,HW_mag,'k');grid
title('magnitude resp of butterworth 2nd order lowpass filter');
xlabel('normalized freq');
ylabel('magnitude');
```

ANS

enter the the passband freq: 0.35*pi
enter the the stopband freq: 0.7*pi
enter the the passband gain: 0.6
enter the the stopband gain: 0.1
enter sampling interval: 0.1
the passbad ripple of the filter rp = 4.4370

the stopband ripple of the filter rs = 20
the analog passband freq of the filter omp = 12.2560
the analog stopband freq of the filter oms = 39.2522
the order of th filter N = 2

the cuttoff freq of th filter wc = 12.4439

normalized transfer function is
Transfer function:
        1
----
s^2 + 1.414 s + 1

the analog transfer function
 Transfer function:
        s^2
----
s^2 + 17.6 s + 154.8

the digital transfer function
 Transfer function:
0.4411 z^2 - 0.8822 z + 0.4411
----
  z^2 - 0.5407 z + 0.2237

Sampling time: 0.1

the frequency response is HW =
  Columns 1 through 6
   0.0000   -0.0244 + 0.0056i -0.0908 + 0.0457i -0.1715 + 0.1551i -0.2063 + 0.3488i -0.1252 + 0.5805i
  Columns 7 through 12
   0.0759 + 0.7517i   0.3196 + 0.8059i   0.5330 + 0.7652i   0.6922 + 0.6762i   0.8032 + 0.5709i   0.8786 + 0.4646i
  Columns 13 through 17
   0.9295 + 0.3629i   0.9632 + 0.2666i   0.9845 + 0.1750i   0.9962 + 0.0867i   1.0000 + 0.0000i

the magnitude response is HW_mag =
  Columns 1 through 12
    0.0000   0.0251   0.1017   0.2313   0.4052   0.5938   0.7555   0.8670   0.9326   0.9676   0.9854   0.9939
  Columns 13 through 17
    0.9978   0.9994   0.9999   1.0000   1.0000

BANDPASS BUTTRERWORTH USING BILINEAR

```
clc;
close all;
clear all;
wp=input('enter the the passband freq in rad : ');
ws=input('enter the the stopband freq in rad : ');
rp=input('enter the the passband ripple: ');
rs=input('enter the the stopband ripple: ');
fs=input( 'enter sampling frequency : ');
T=1/fs;
omp=(2/T)*tan(wp/2);
disp('the analog passband freq of the filter '); omp
oms=(2/T)*tan(ws/2);
disp('the analog stopband freq of the filter ');oms
[N,wc]=buttord(omp,oms,rp,rs,'s');
disp('the order of th filter ');N
disp('the cuttoff freq of th filter ');wc
[bn,an]=butter(N,1,'s');
disp('normalized transfer function is ');
HSn=tf(bn,an)
[b,a]=butter(N,wc,'bandpass','s');
disp('the analog transfer function');
HS=tf(b,a)
[num,den]=bilinear(b,a,1/T);
disp('the digital transfer function');
HZ=tf(num,den,T)
w=0:pi/16:pi;
disp('the frequency response is');
HW=freqz(num,den,w)
disp('the magnitude response is');
HW_mag=abs(HW)
plot(w/pi,HW_mag,'k');grid
title('magnitude resp of butterworth 2nd order lowpass filter');
xlabel('normalized freq');
ylabel('magnitude');
```

ANS

enter the the passband freq in rad : [0.4*pi 0.6*pi]
enter the the stopband freq in rad : [0.1*pi 0.8*pi]
enter the the passband ripple: 1
enter the the stopband ripple: 20
enter sampling frequency : 1000
the analog passband freq of the filter omp = 1.0e+003 * 1.4531 2.7528
the analog stopband freq of the filter oms = 1.0e+003 * 0.3168 6.1554

the order of the filter N = 3

the cuttoff freq of the filter wc = 1.0e+003 * 1.0946 3.6543

normalized transfer function is

Transfer function:
```
        1
--------------------
s^3 + 2 s^2 + 2 s + 1
```

the analog transfer function

Transfer function:
```
                          1.677e010 s^3
-------------------------------------------------------------------------------
s^6 + 5119 s^5 + 2.51e007 s^4 + 5.773e010 s^3 + 1.004e014 s^2 + 8.191e016 s + 6.4e019
```

the digital transfer function

Transfer function:
```
0.07797 z^6 - 2.46e-015 z^5 - 0.2339 z^4 - 1.725e-015 z^3 + 0.2339 z^2 + 1.98e-016 z - 0.07797
-----------------------------------------------------------------------------------------------
  z^6 - 4.025e-016 z^5 + 0.7958 z^4 - 3.189e-016 z^3 + 0.502 z^2 - 3.352e-016 z + 0.08245
```

Sampling time: 0.001

the frequency response is HW =
```
  Columns 1 through 6
  -0.0000           -0.0005 - 0.0020i  -0.0095 - 0.0160i  -0.0604 - 0.0493i  -0.2496 - 0.0444i  -0.5142 +
0.4138i
  Columns 7 through 12
   0.1510 + 0.9533i   0.8060 + 0.5911i   1.0000 + 0.0000i   0.8060 - 0.5911i   0.1510 - 0.9533i  -0.5142 -
0.4138i
  Columns 13 through 17
  -0.2496 + 0.0444i  -0.0604 + 0.0493i  -0.0095 + 0.0160i  -0.0005 + 0.0020i   0.0000 + 0.0000i
```

the magnitude response is HW_mag =

```
  Columns 1 through 12
    0.0000    0.0021    0.0186    0.0779    0.2535    0.6600    0.9651    0.9995    1.0000    0.9995    0.9651
0.6600
  Columns 13 through 17
    0.2535    0.0779    0.0186    0.0021    0.0000
```