

Design a IIR bandpass digital Filter

Filter specification

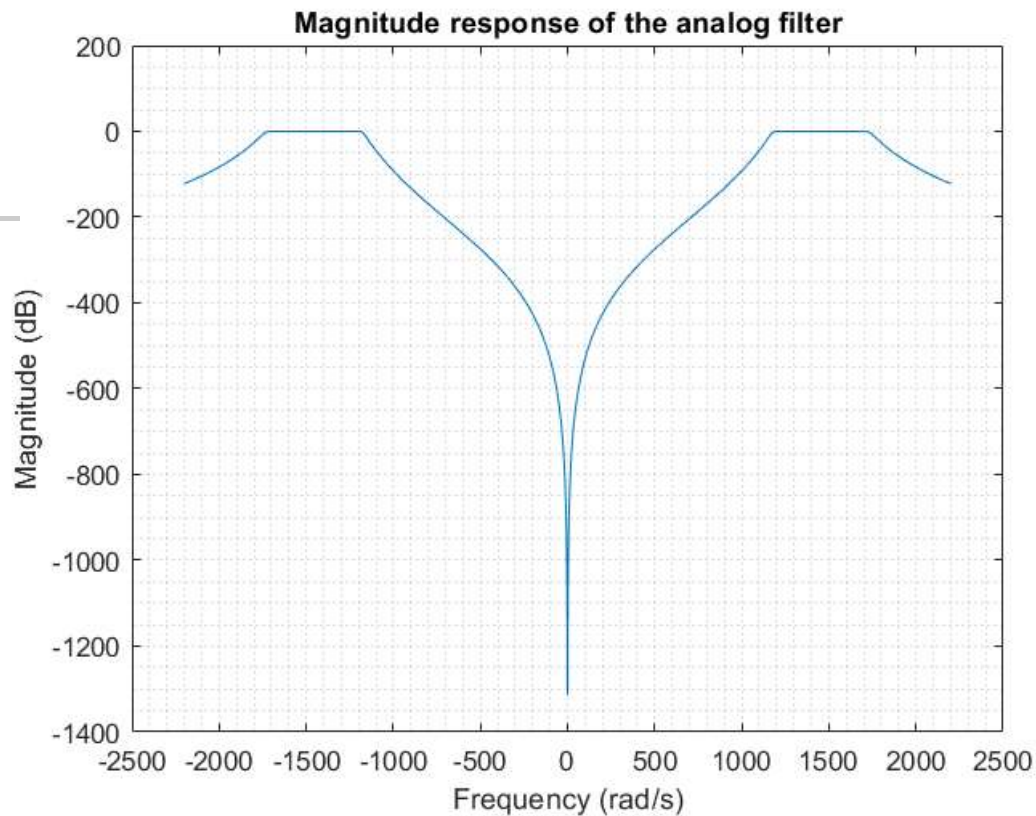
```
wp = [1200 1700];  
ws = [900 1900];  
Rp = 0.14;  
Rs = 58;
```

Designing the analog filter

```
[n,wn] = buttord(wp,ws,Rp,Rs,"s");  
[b,a] = butter(n,wn,"s");  
filter = tf(b,a);  
w_sam = 4600;  
t_sam = 2*pi/w_sam;  
f_sam = 1/t_sam;
```

Analog filter magnitude response

```
w = linspace(-2200,2200,4400);  
h = freqs(b, a, w);  
mag = abs(h);  
  
figure(1)  
plot(w,mag2db(mag))  
title("Magnitude response of the analog filter")  
xlabel("Frequency (rad/s)")  
ylabel("Magnitude (dB)")  
grid minor
```



Prewrapping frequencies

```
wp(1) = 2/t_sam*tan(wp(1)*t_sam/2);
wp(2) = 2/t_sam*tan(wp(2)*t_sam/2);
ws(1) = 2/t_sam*tan(ws(1)*t_sam/2);
ws(2) = 2/t_sam*tan(ws(2)*t_sam/2);
```

Frequency Normalizing

```
wp = [wp(1)/(w_sam/2) wp(2)/(w_sam/2)];
ws = [ws(1)/(w_sam/2) ws(2)/(w_sam/2)];
```

Transforming to a Digital filter

```
[n,wc] = buttord(wp,ws,Rp,Rs,'s');
[z,p,k] = buttap(n);
[A,B,C,D] = zp2ss(z,p,k);
[At,Bt,Ct,Dt] = lp2bp(A,B,C,D,sqrt(wp(1)*wp(2)),wp(2)-wp(1));

w=linspace(-2200/(w_sam/2),2200/(w_sam/2),4400);
[Ad,Bd,Cd,Dd] = bilinear(At,Bt,Ct,Dt,1/pi); % Bilinear Transformation here
filter = ss2sos(Ad,Bd,Cd,Dd);
[b,a] = sos2tf(filter);

filter = tf(b,a); % Coefficients of the transfer function
[num,den] = tfdata(filter);
num
```

```
num = 1x1 cell array
      {[9.7337e-07 -7.0003e-17 -1.0707e-05 -7.8852e-16 5.3535e-05 -3.1071e-15 -1.6061e-04 -5.9745
```

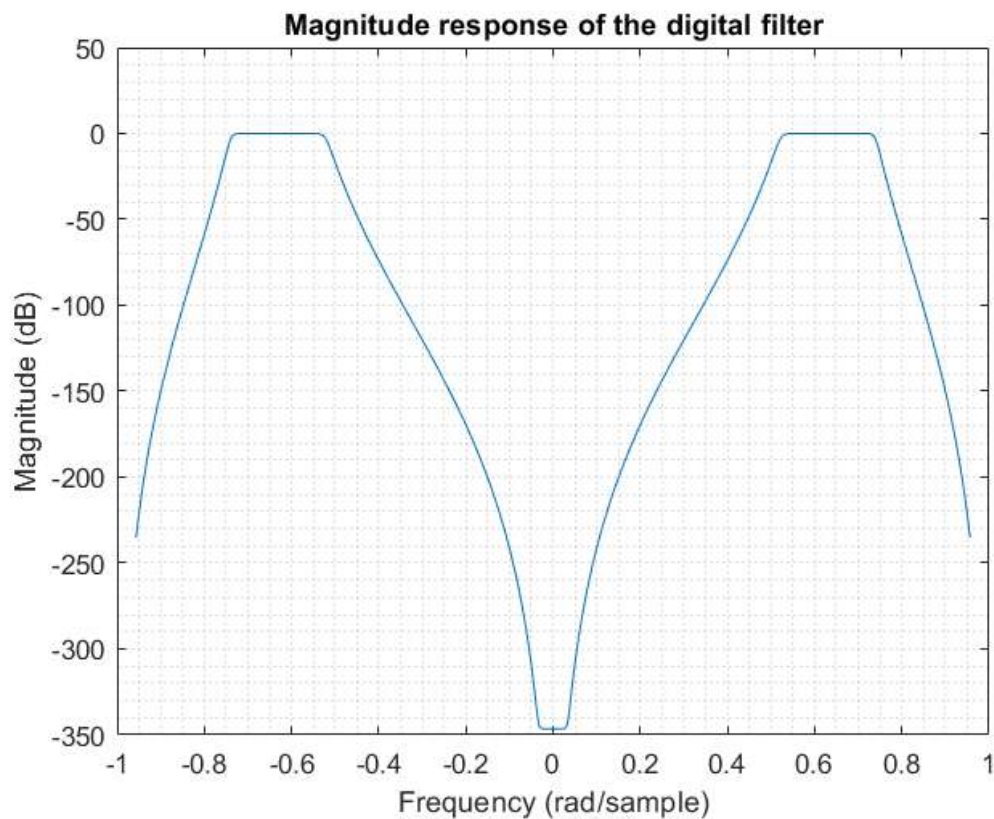
```
den
```

```
den = 1x1 cell array  
      {[1 7.2748 30.3821 90.0473 209.2506 399.5753 646.5323 902.9116 1.1027e+03 1.1874e+03 1.1336
```

```
[hd,f] = freqz(b,a,w,2);
```

Digital filter magnitude response

```
magn = abs(hd);  
wp=[1200/(w_sam/2) 1700/(w_sam/2)];  
ws=[900/(w_sam/2) 1900/(w_sam/2)];  
figure(2)  
  
plot(w,mag2db(magn))  
title("Magnitude response of the digital filter")  
xlabel("Frequency (rad/sample)")  
ylabel("Magnitude (dB)")  
grid minor
```



Magnitude response of the passband

```
figure(3)  
plot(w,mag2db(magn))  
axis ([ 0.5 , 0.8 , -0.1 , 0.1]);  
title("Magnitude response of the passband")  
xlabel("Frequency (rad/sample)")  
ylabel("Magnitude (dB)")  
grid("minor")
```

