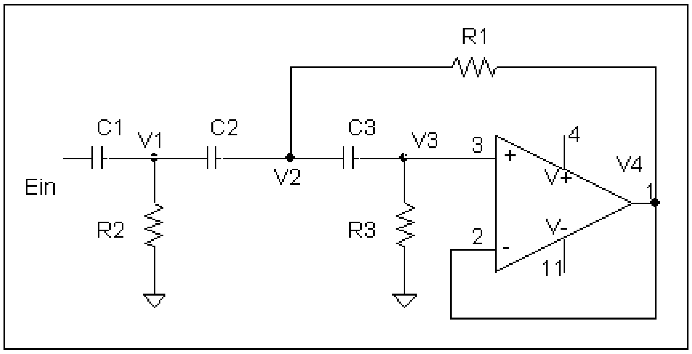
2/10/2007

Reduced Algebra Method With the G Array

Third Order Bessel High-Pass Filter



Desire circuit equations in the form f(eL,iC) = g(Ein,iL,vC) (1)

$$iC1 = iC2 + \frac{V1}{R2}, \quad V1 = Ein - vC1, \quad (iC1 - iC2)R2 = Ein - vC1 \quad (2)$$

The last equation is in the form (1).

$$iC2 = iC3 + \frac{V2 - V4}{R1} = iC3 + \frac{V2 - V3}{R1}, \quad V3 = V4$$

$$iC3 = iC2 + \frac{V3 - V2}{R1}, \quad vC2 = V1 - V2 = Ein - vC1 - V2, \quad V2 = Ein - vC1 - vC2$$

$$V3 = V4 = Vo = iC3 \cdot R3, \quad iC3 - iC2 = \frac{V3}{R1} - \frac{V2}{R1}, \quad (iC3 - iC2)R1 = V3 - V2 \quad (2a)$$

$$(iC3 - iC2)R1 = iC3 \cdot R3 + vC1 + vC2 - Ein$$

$$iC3(R3 - R1) + iC2 \cdot R1 = Ein - vC1 - vC2 \quad (3)$$

$$vC3 = V2 - V3 = Ein - vC1 - vC2 - iC3 \cdot R3$$

$$iC2 \cdot R3 = Ein - vC1 - vC2 - vC3 \quad (4)$$

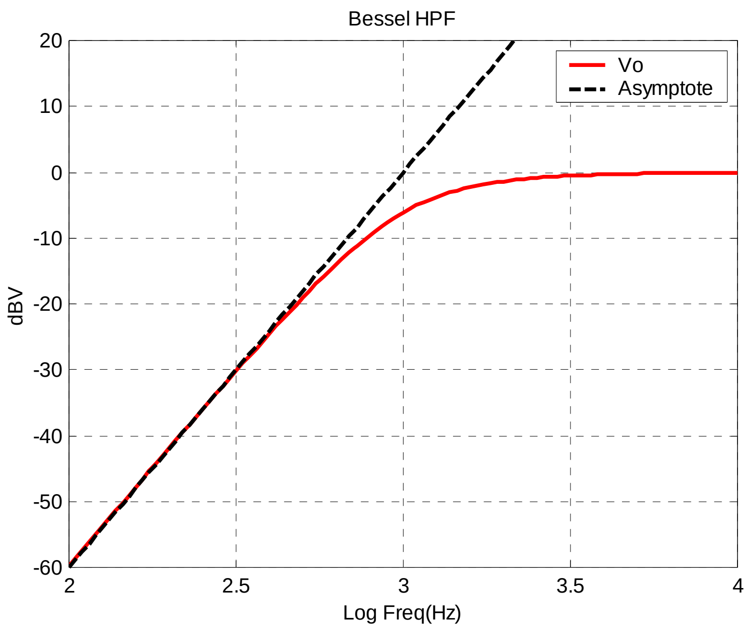
Forming W, Q, & S from (2), (3), & (4)

$$W=\begin{bmatrix} R2 & -R2 & 0 \\ 0 & R1 & R3-R1 \\ 0 & 0 & R3 \end{bmatrix},\quad Q=-\begin{bmatrix} 1 & 0 & 0 \\ 1 & 1 & 0 \\ 1 & 1 & 1 \end{bmatrix},\quad S=Ein\begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix}$$

$$P=\begin{bmatrix} C1 & 0 & 0 \\ 0 & C2 & 0 \\ 0 & 0 & C3 \end{bmatrix}$$

From (2a), $V3=V4=Vo=iC3\cdot R3$, $F=\begin{bmatrix} 0 & 0 & R3 \end{bmatrix}$, $G=FP$

$D=\begin{bmatrix} 0 & 0 & 0 \end{bmatrix}$, $E=0$



```
% Frequency response 3rd Order Bessel HPF
%  and G array.
% File:  c:\M_files\short_updates\UsingGarray2.m
% 02/10/07
% See Word file UsingGarray2.doc for schemtic and equations.
clear;clc;
% unit suffixes
u=1e-6;K=1e3;m=1e-3;u=1e-6;n=1e-9;p=1e-12;
% component values
R1=52*K;R2=75*K;R3=287*K;
C1=1.55*n;C2=C1;C3=C1;
Ein=1; % Unity input for (normalized) transfer function
N=3; % Number of capacitors = order of circuit
%
% Form W, Q, S, and P arrays:
%
W=[R2 -R2 0;0 R1 R3-R1;0 0 R3];
Q=-[1 0 0;1 1 0;1 1 1];S=Ein*[1;1;1];P=diag([C1 C2 C3]);
%
% Get A, B, D, & E arrays:
%
C=inv(W*P);A=C*Q;B=C*S;
% D & E
D=[0 0 0];E=0;
%
F=[0 0 R3]; % R3 is the coefficient of both iC1 and iC2 in Vo2
% which are derivative terms (iC=dVc/dt, etc.)
G=F*P;
%
% * * * * * * * * * * * * Frequency response * * * * * * * * * * * *
%
I=eye(N); % identity matrix
%
% Log frequency sweep from BF to BF+ND
%
BF=2;ND=2;PD=50;NP=ND*PD+1;Fr=logspace(BF,BF+ND,NP);
for i=1:NP
   s=2*pi*Fr(i)*j; % j = sqrt(-1)
   stm=(s*I-A)\B;
   v2=abs((D+G*A)*stm+E+G*B);Vo(i)=20*log10(v2);
   asym(i)=60*log10(Fr(i)/1000); % +60 dB/decade slope
end
%
h=plot(log10(Fr),Vo,'r',log10(Fr),asym,'k--');
set(h,'LineWidth',2);
grid on;
axis([2 4 -60 20]);
ylabel('dBV');title('Bessel HPF');
xlabel('Log Freq(Hz)');
legend('Vo','Asymptote');
figure(1);
%
```