Labo Signaalverwerking

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Opdracht S2: Chebyshev filter

Specificatie

- Type: Chebyshev
- $|H(0)| = 3dB$
- $A_p = 3dB$
- $A_s = 40dB$
- $f_c = 2kHz$
- $f_s = 6,2kHz$

Synthese & Analyse (MATLAB)

```
% Gegevens
K = sqrt(2); % 3dB
Ap = 3; % 3dB
As = 40; % 40dB
fc  =2000; % 2kHz
fs = 6200; % 6.2kHz

% 's' nodig om analoge filter te maken
% Bepaal order
[n, wp] = cheb1ord(2*pi*fc, 2*pi*fs, Ap, As, 's')   % OUTPUT: n = 3 wp = 1.2566e+04
% Bepaal H (als Teller en Noemer)
[T, N] = cheby1(n, Ap, wp, 's')
% OUTPUT:
% T = 1.0e+11 * [0   0     0              4.9728]
%N = 1.0e+11 * [0   0     0.0015      4.9728]
% K Niet vergeten!
filter = K * tf(T, N)
%OUTPUT: filter=
%                9.946e11
% ---------------------------------------
% s^3 + 7505 s^2 + 1.466e08 s + 4.973e11

% Zien of het klopt
figure(1); clf; hold on; bode(filter);
figure(2); clf; hold on; step(filter);
figure(3); clf; hold on; axis equal; pzmap(filter);

trappen = zpk(filter)
%OUTPUT: trappen =
%              9.9456e+11
%  -----------------------------------
%  (s+3753) (s^2 + 3753s + 1.325e08)

[r, p, k]  = zpkdata(trappen)

% zeta = 1 bij 1e trap
[wn, zeta] = damp(filter)
% OUTPUT:
% wn = 1.0e+04 * [0.3753     1.1512   1.1512]
% zeta = [1.0000 0.1630   0.1630]
i1eorde = 1;
i2eorde = 2;

```

```
H1N = [  0             1];
H1D = [1/wn(i1eorde)   1];

H1 = tf(H1N, H1D)
% OUTPUT: H1=
%            1
%   ----------------
%   0.0002665 s + 1
figure(1); bode(H1);
figure(2); step(H1);
figure(3); pzmap(H1);

Q2 = 1/(2*zeta(i2eorde))
wn2 = wn(i2eorde)
H2N = [0        0             1];
H2D = [1/wn2^2   1/(Q2 *wn2)  1];

% K meenemen
H2 = K * tf(H2N, H2D)
% OUTPUT: H2=
%                        1
%   ------------------------------------
%   7.546e-09 s^2 + 2.832e-05 s + 1
figure(1); bode(H2);
figure(2); step(H2);
figure(3); pzmap(H2);

% OntwerpVGL
C1 = 1                                              % OUTPUT: C1 = 1
R = 1/(wn2*C1)                          % OUTPUT: R = 8.6869e-05
R1 = R/K                                         % OUTPUT: R1 = 6.1426e-05
R2 = Q2/(wn2*C1)              % OUTPUT: R2 = 2.6648e-04

%Realistische waarden
ISF = 10^8;
C1 = C1/ISF                             % OUTPUT: C1 = 1.0000e-08
R1 = R1*ISF                             % OUTPUT: R1 = 6.1426e+03
R2 = R2*ISF                             % OUTPUT: R2 = 2.6648e+04
R = R*ISF                                  % OUTPUT: R = 8.6869e+03

H2Nc = [0      0                         (R/R1)*(1/(R^2*C1^2))];
H2Dc = [1      1/(R2*C1)      1/(R^2*C1^2)];
H2c = tf(H2Nc, H2Dc)

figure(1); bode(H2c); %H2c moet hier op H2 liggen
figure(2); step(H2c);
figure(3); pzmap(H2c);

% Dit zou gelijk moeten zijn aan filter
%total = H1*H2;
%figure(1); bode(total);
%figure(2); step(total);
%figure(3); pzmap(total);
```

Pole Zero plot

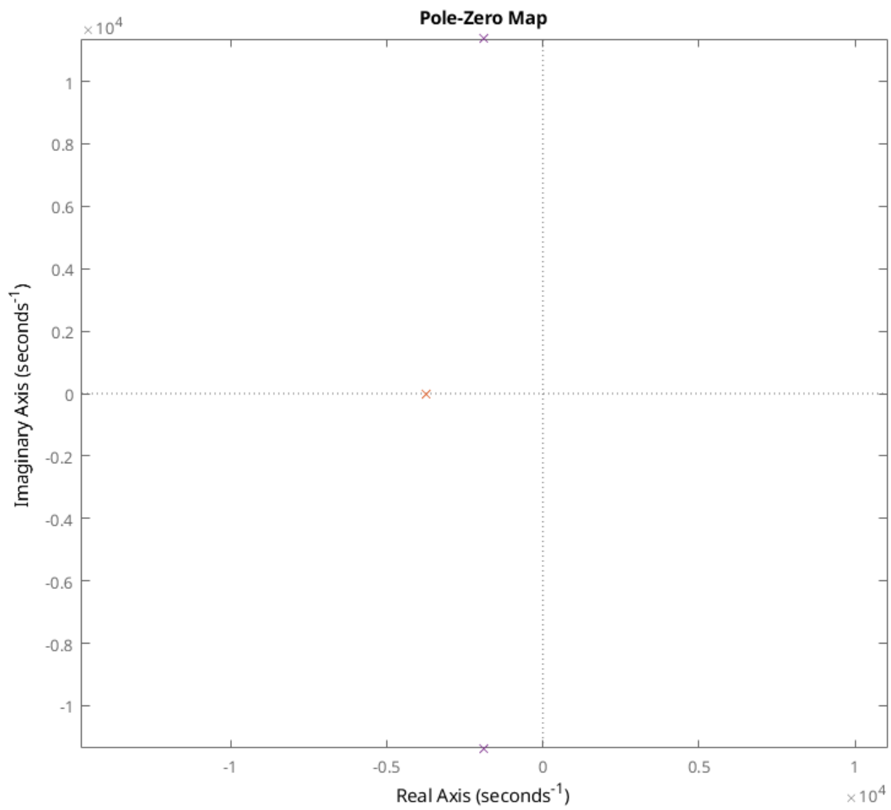

Figure 1: Pole zero plot

Bode plot

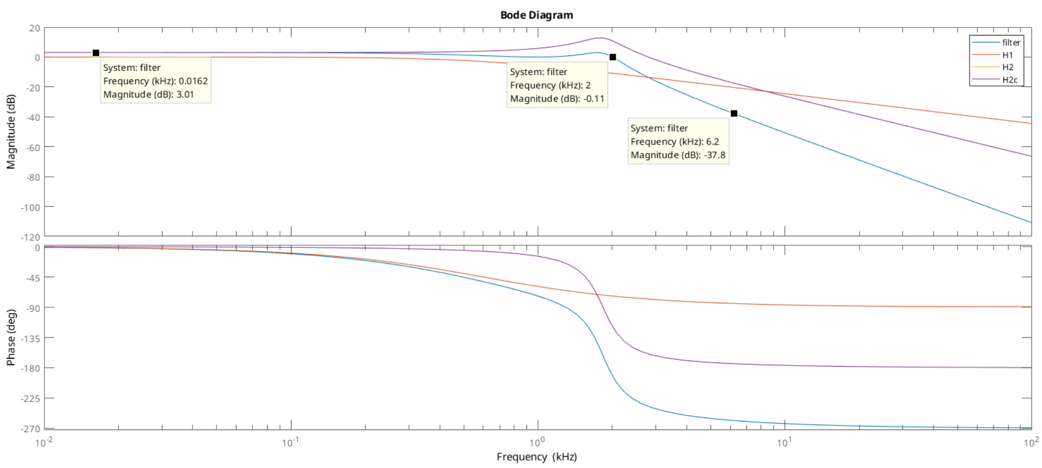

Figure 2: Bode Plot

Stapresponsie

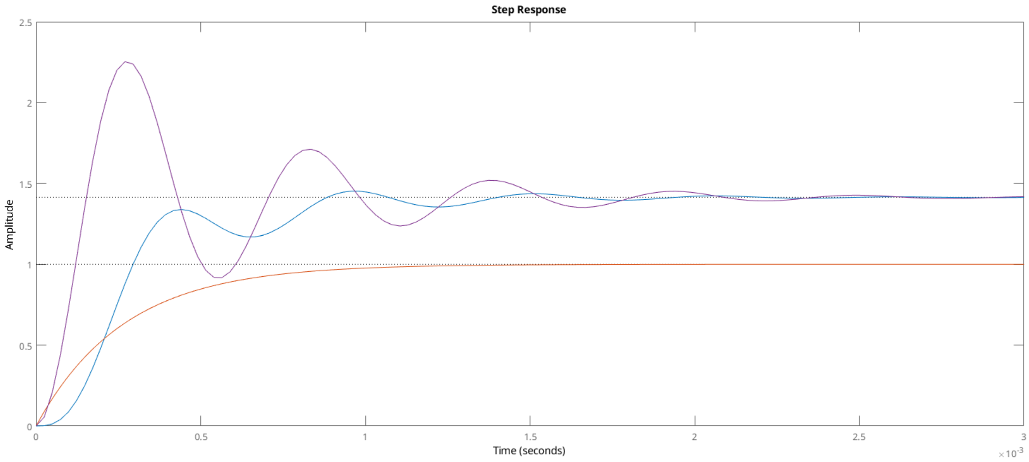

Figure 3: Stapresponsie

Synthese 2e actieve filtertrap Biquad

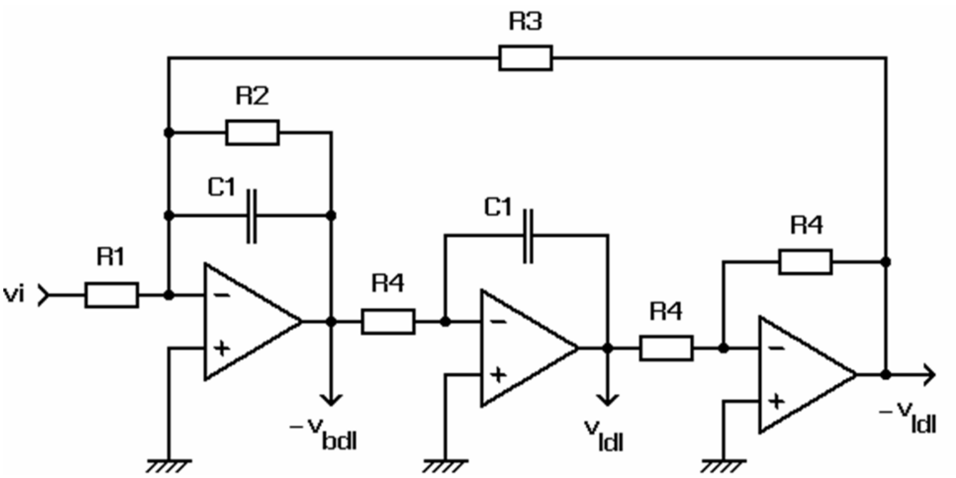

Figure 4: Het Biquad schema

$$H(s) = \frac{\frac{R3}{R1}\frac{1}{R3 \cdot R4 \cdot C1^2}}{s^2 + s(\frac{1}{R2 \cdot C1}) + \frac{1}{R3 \cdot R4 \cdot C1^2}}$$

Ontwerpvergelijkingen

Staan in cursus Signaalverwerking, pagina CMT17-CMT18.

$C1 = 1$

$R1 = \frac{1}{K\omega_n}$

$R2 = \frac{Q}{\omega_n}$

$R3 = R4 = R = \frac{1}{\omega_n}$

MATLAB code staat bij in het eerste deel, samen met de uitkomesten van de bewerkingen.

SPICE

Dit is (zoals in de opgave) enkel de 2^e orde trap!

Netlist

```
* Bode (LTSpice export)
.inc opampIdeaal.cir

.model r res(r = 1 DEV 1%)
.model c cap(c = 1 DEV 1%)

R1 N001 vin r 6.1426K
V1 vin 0 AC 1
XU1 N001 0 N002 opampIdeal
C1 N002 N001 c 1e-8
R2 N002 N001 r 26.648K
R3 vout N001 r 8.6869K
XU2 N003 0 N004 opampIdeal
XU3 N005 0 vout opampIdeal
R4 N003 N002 r 8.6869K
R5 N005 N004 r 8.6869K
R6 vout N005 r 8.6869K
C2 N004 N003 c 1e-8

.ac dec 100 100 1MEG
.mc 10 AC V(R6) YMAX LIST OUTPUT ALL
.probe
.end
```

Bode plot

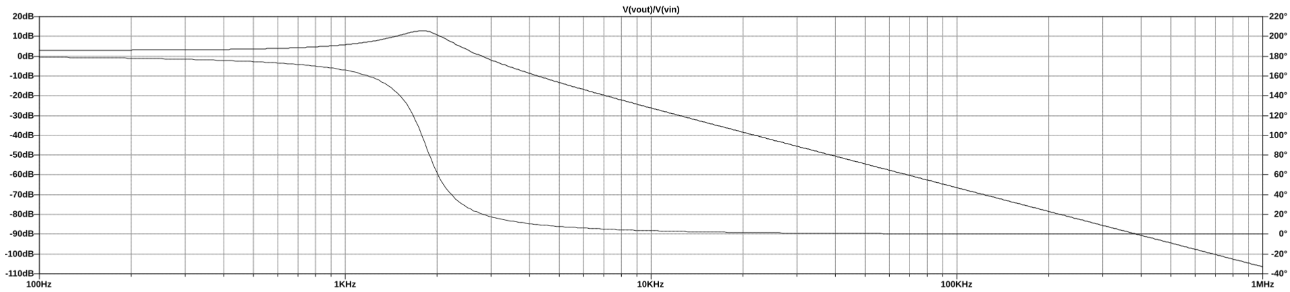

Figure 5: Bode Plot

Dit is vrijwel identiek aan de Matlab

Monte Carlo analyse

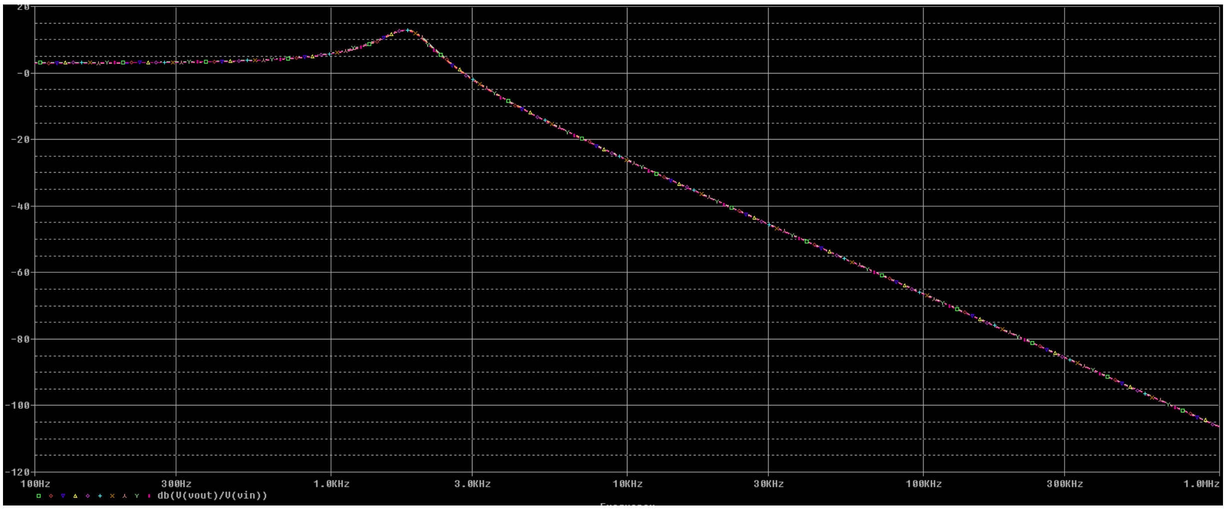

Figure 6: Monte Carlo analyse

Hier is bijna geen verschil. (Met 1% R en C.)

Ingangsimpedantie

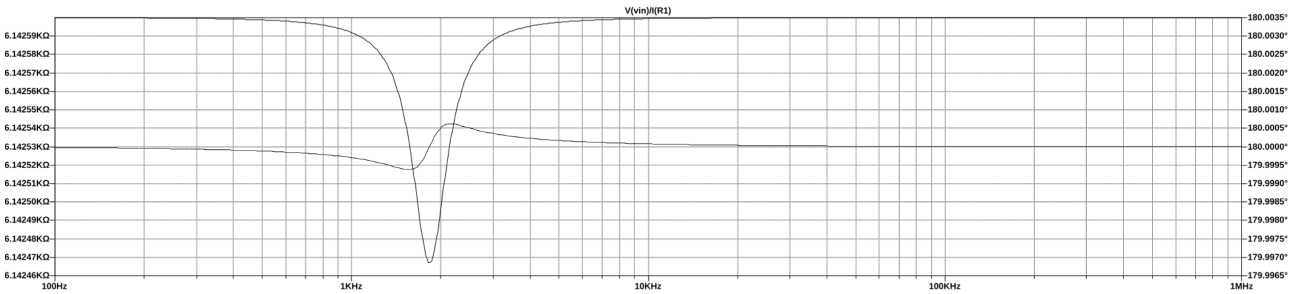

Figure 7: Ingangsimpedantie

Er is bijna geen variatie in de ingangsimpedantie.

Uitgangsimpedantie

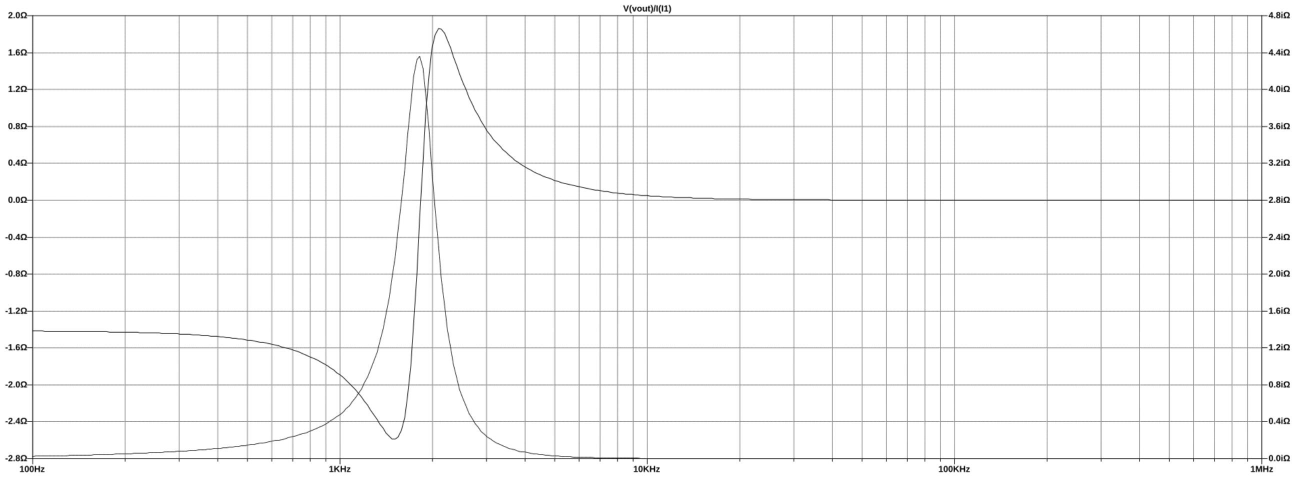

Figure 8: Uitgangsimpedantie

Staprespontie

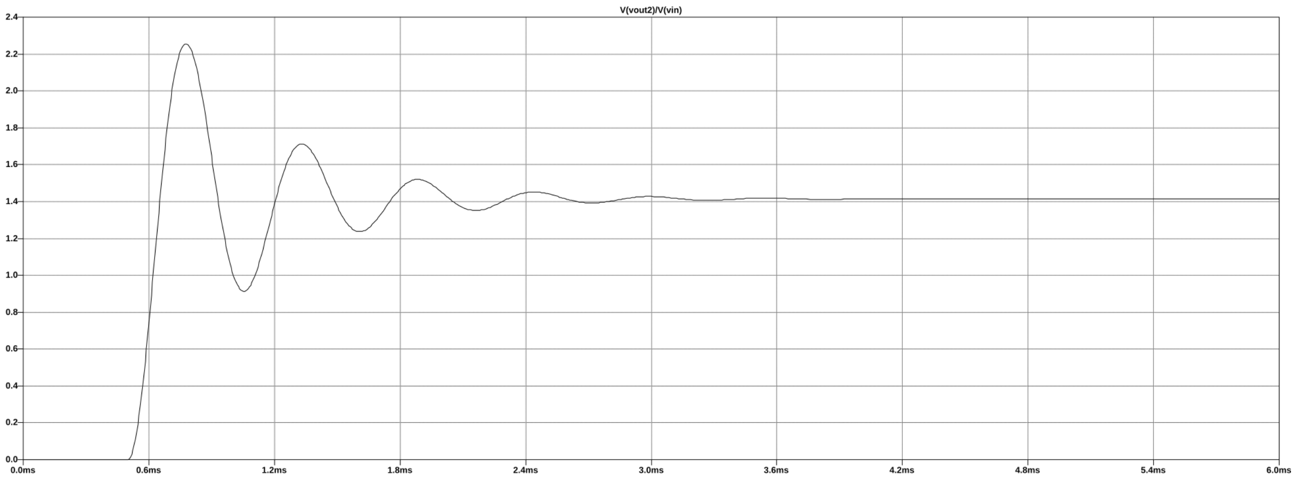

Figure 9: Staprespontie