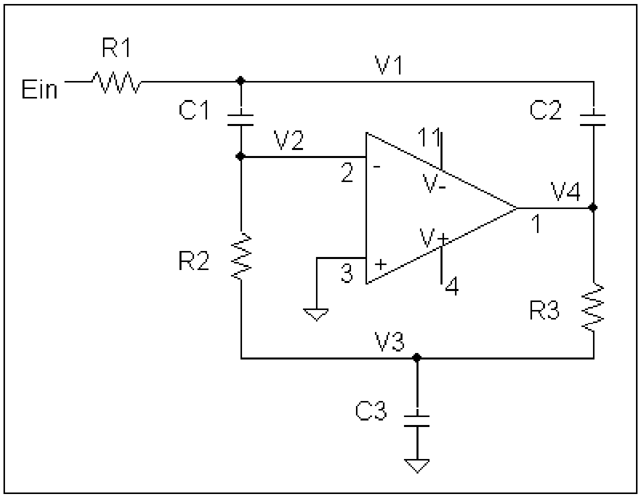
MCA of 3rd Order Butterworth Active Filter – Transient Analysis

To show an example of an active circuit transient analysis, the derivation is shown first.



Write KCL nodal equations at all nodes except V4, which is a hard controlled source.

At node V1: $i_{R1} = i_{C1} + i_{C2}$ (1)

At node V2 = 0 : $i_{C1} = i_{R2}$ (2)

At node V3: $i_{C3} = i_{R3} + i_{R2}$ (3)

From (1): $i_{C1} + i_{C2} = \dfrac{E1 - V1}{R1}$, $\quad R1 \cdot i_{C1} + R1 \cdot i_{C2} = -V1 + E1$ (4)

From (2): $i_{C1} = \dfrac{V2 - V3}{R2} = \dfrac{-V3}{R2}$, $\quad R2 \cdot i_{C1} = -V3$ (5)

From (3): $i_{C3} = \dfrac{-V3}{R2} + \dfrac{V4 - V3}{R3}$, substituting V4 = V1 - Vc2 to eliminate a non-state variable;

$$i_{C3} = -V3\left(\frac{1}{R2} + \frac{1}{R3}\right) + \frac{V1}{R3} - \frac{Vc2}{R3}, \qquad R3 \cdot i_{C3} = V1 - Vc2 - V3\left(1 + \frac{R3}{R2}\right) \qquad (6)$$

Form matricies W, Q & S from (4), (5), and (6) and diagonal matrix P: The columns of W should be labeled i_{C1}, i_{C2}, and i_{C3} from left to right as they contain the coefficients of these unknowns.

$$W = \begin{bmatrix} R1 & R1 & 0 \\ R2 & 0 & 0 \\ 0 & 0 & R3 \end{bmatrix}, \qquad P = \begin{bmatrix} C1 & 0 & 0 \\ 0 & C2 & 0 \\ 0 & 0 & C3 \end{bmatrix},$$

The columns of Q should be labeled, V1 = Vc1, Vc2, and V3 = Vc3.   S is the input column vector.

$$Q = \begin{bmatrix} -1 & 0 & 0 \\ 0 & 0 & -1 \\ 1 & -1 & -\left(1+\dfrac{R3}{R2}\right) \end{bmatrix}, \qquad S = \begin{bmatrix} E1 \\ 0 \\ 0 \end{bmatrix}$$

The state-space A and B arrays are then obtained from

$$C = WQ, \quad A = C \setminus Q, \quad B = C \setminus S$$

Plots: (See M-files for listings of bwfil3mca.m, bw3.m, & ps3.m.