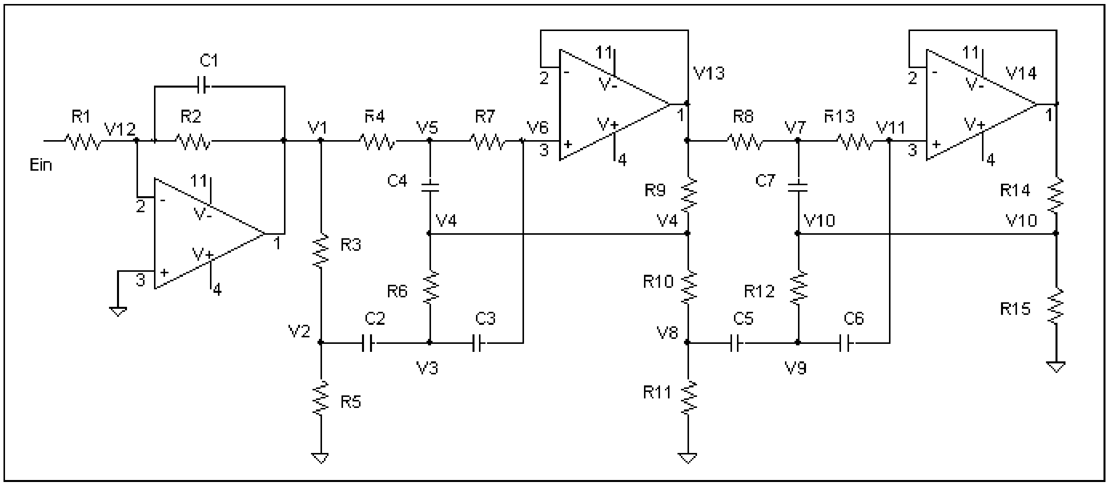
Elliptical Low Pass Filter DS Method Using MATLAB



In this circuit, N = 7, and U = 14 – 3 = 11. Hence U+N = 18 equations are required.

Summing the currents at each node:

Node V1 $$i_{C1} - \frac{V1}{R2} = \frac{Ein}{R1}$$

In creating the A1 and B2 arrays, care must be taken in placing the coefficients in the correct row and column. For the rows, this is easy to remember. Node 1 goes in row1, node 2 equation in row 2 and so forth. Placing the coefficients in the correct column may require a sequenced column list as show below:

```
V1 V2 V3 V4 V5 V6 V7 V8 V9 V10 V11 iC1 iC2 iC3 iC4 iC5 iC6 iC7  unknown
1  2  3  4  5  6  7  8  9  10  11  12  13  14  15  16  17  18   column
```

Now the bookkeeping task is simplified.

From above list, the coefficients of V1 go in column 1, those for V2 in column 2, and so forth. The coefficients of the iC's start in column 12 for iC1, column 13 for iC2 and so forth. Then the node 1 equation is inserted into row 1 of A1 as follows

$$\begin{array}{cc} & \text{V1} \qquad\qquad\qquad\qquad\qquad\qquad\qquad \text{iC1} \\ A1_1 = & \begin{bmatrix} \frac{-1}{R2} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix} \end{array}$$

The RH side will be placed in B2.

Node V2: $$i_{C2} + \frac{V1 - V2}{R3} - \frac{V2}{R5} = 0, \quad \text{or} \quad V2\left(\frac{1}{R3} + \frac{1}{R5}\right) - \frac{V1}{R3} - i_{C2} = 0$$

Here the coefficient of V2 goes in column 2, the coefficient of V1 in column 1, and the coefficient of iC2 (-1) goes in column 13. Then row 2 of A1 is

$$A1_2 = \begin{bmatrix} \frac{-1}{R3} & \frac{1}{R3} + \frac{1}{R5} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -1 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

See the M-file E7x.m for placement of all coefficients using the 18 equations (the rest of which are given below). (Note to the reader: Do not be overwhelmed by the size of this array. It is not more complex, just bigger!)

Node V3: $\frac{V4 - V3}{R6} + i_{C3} - i_{C2} = 0$

Node V4:

$$i_{C4} + \frac{V6 - V4}{R9} + \frac{V3 - V4}{R6} + \frac{V8 - V4}{R10} = 0, \quad \text{or} \quad V4\left(\frac{1}{R6} + \frac{1}{R9} + \frac{1}{R10}\right) - \frac{V3}{R6} - \frac{V6}{R9} - \frac{V8}{R10} - i_{C4} = 0$$

To shorten this we use $G4 = \frac{1}{R6} + \frac{1}{R9} + \frac{1}{R10}$ so that $V4 \cdot G4 - \frac{V3}{R6} - \frac{V6}{R9} - \frac{V8}{R10} - i_{C4} = 0$

Node V5: $\frac{V1 - V5}{R4} - i_{C4} - i_{C3} = 0$

Node V6: $\frac{V5 - V6}{R7} - i_{C3} = 0$

Node V7: $\frac{V6 - V7}{R8} - i_{C6} - i_{C7} = 0$

Node V8: $\frac{V4 - V8}{R10} + i_{C5} - \frac{V8}{R11} = 0$

Node V9: $\frac{V10 - V9}{R12} + i_{C6} - i_{C5} = 0$

Node V10:

$$i_{C7} + \frac{V11 - V10}{R14} + \frac{V9 - V10}{R12} - \frac{V10}{R15} = 0, \quad \text{or} \quad V10\left(\frac{1}{R12} + \frac{1}{R14} + \frac{1}{R15}\right) - \frac{V9}{R12} - \frac{V11}{R14} - i_{C7} = 0$$

$G10 = \frac{1}{R12} + \frac{1}{R14} + \frac{1}{R15}$; then $V10 \cdot G10 - \frac{V9}{R12} - \frac{V11}{R14} - i_{C7} = 0$

Node V11: $\frac{V7 - V11}{R13} - i_{C6} = 0$

The remaining 7 equations come from the 1V voltage sources: (See the schematic)

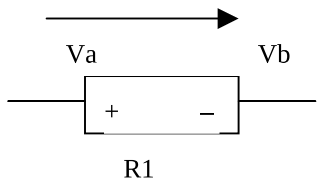
$-V1 = E1; \quad V3 - V2 = E2; \quad V6 - V3 = E3; \quad V5 - V4 = E4$

$V9 - V8 = E5; \quad V11 - V9 = E6; \quad V7 - V10 = E7$

And again Ein = 1 = E1 = E2 = E3, etc.

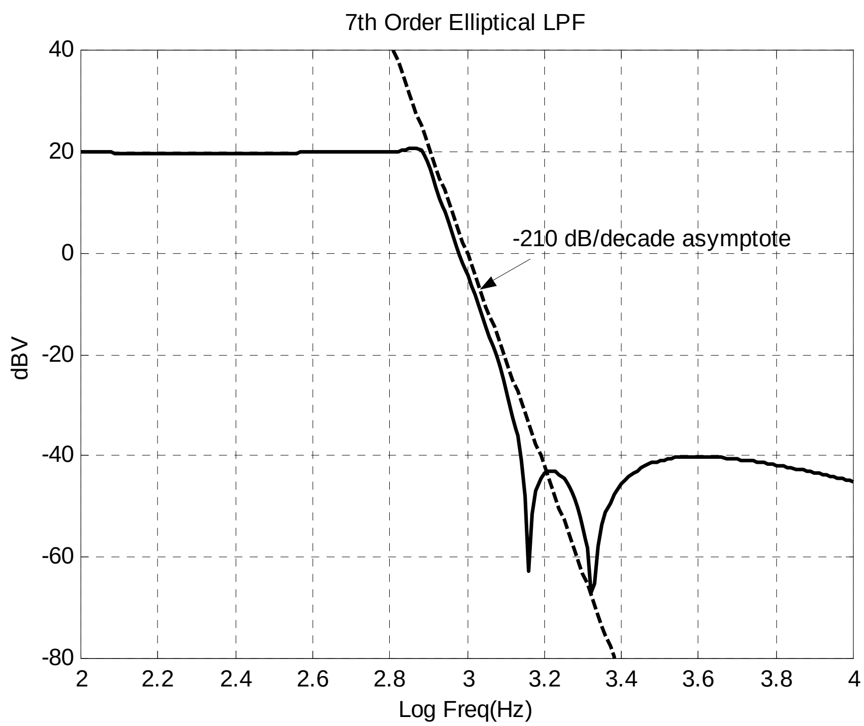
For current flow directions note that:

I1



$$I1 = \frac{Va - Vb}{R1} = -\frac{Vb - Va}{R1}$$

Output from M-file Ellipt7_2.m



Note: This is for demonstration purposes only. It is not recommended that circuits of this size be analyzed by the DS or the RA method. For large circuits the method is admittedly error-prone and rarely will the correct solution be obtained on the first pass. Too much time is required to find mistakes, assuming the user even knows what the correct solution is. See [1] below for a Spice-like node list method that can analyze circuits with up to 89 nodes. The Mathcad programs can be easily converted to MATLAB M-Files.

[1] *Node List Tolerance Analysis – Enhancing SPICE Capabilities with Mathcad*, R. Boyd, CRC Press, Mar 2006.