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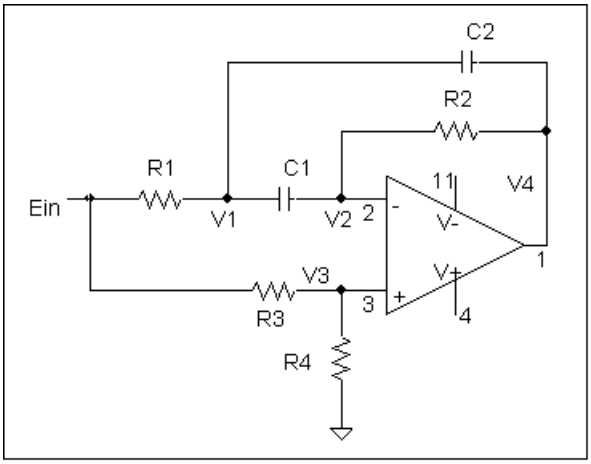
Allpass Filter Monte Carlo Analysis– DS Method

Output phase angle is nominally 90 degrees at 500 Hz.



Component values given in M-file allpass2.m.

There are four unknown nodes, V1, V2, V3, & V4. Due to the opamp, V2 = V3. Hence there are now only three unknown nodes V1, V2, & V4. Parameter U (number of unknown nodes) then is 3. The output node is V4, which is the third and last unknown node. Hence Y = 3.

The circuit equations start at node V1; (corresponds to row 1 of A1 & B2)

$$\frac{Ein - V1}{R1} = i_{C1} + i_{C2}, \quad \text{or} \quad \frac{V1}{R1} + i_{C1} + i_{C2} = \frac{Ein}{R1}$$

Unknowns on LH side for A1, knowns on RH for B2.

At node V2: (Row 2)

$$i_{C1} = \frac{V2 - V4}{R2}, \quad \text{or} \quad i_{C1} - \frac{V2}{R2} + \frac{V4}{R4} = 0$$

At node V3 = V2 (Row 3)

$$\frac{Ein - V2}{R3} = \frac{V2}{R4}, \quad \text{or} \quad V2 \cdot \left(\frac{1}{R3} + \frac{1}{R4} \right) = \frac{Ein}{R3}$$

We need U+N=5 equations. The last two are from the 1V ideal sources E1 and E2 replacing C1 and C2.

V1 – V2 = E1, V1 – V4 = E2

Arrays A1, B2 & P are then as shown below:

$$\begin{array}{cccccc} V1 & V2 & V4 & iC1 & iC2 \end{array}$$

$$A1 = \begin{bmatrix} \frac{1}{R1} & 0 & 0 & 1 & 1 \\ 0 & \frac{-1}{R2} & \frac{1}{R2} & 1 & 0 \\ 0 & \frac{1}{R3}+\frac{1}{R4} & 0 & 0 & 0 \\ 1 & -1 & 0 & 0 & 0 \\ 1 & 0 & -1 & 0 & 0 \end{bmatrix} \qquad \begin{array}{ccc} E1 & E2 & Ein \end{array} \qquad B2 = \begin{bmatrix} 0 & 0 & \frac{1}{R1} \\ 0 & 0 & 0 \\ 0 & 0 & \frac{1}{R3} \\ 1 & 0 & 0 \\ 0 & 1 & 0 \end{bmatrix}$$

Column labels

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

E1 and E2 in array B2 are in the same order as C1 and C2 in P. If C1 and C2 were different values and reversed, the solution would be incorrect. Ein is always in the last column of B2. For A1, the unkown V's are first, then the iC's and/or eL's if inductors are present. See allpass_mca.m below for calculations.

Plot output from the M_file allpass_mca.m is: