Simulation Methods for Electronic Circuits
Assignment on Contents 2

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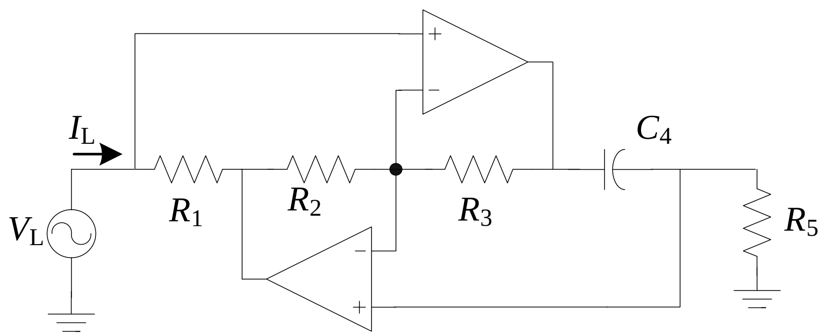
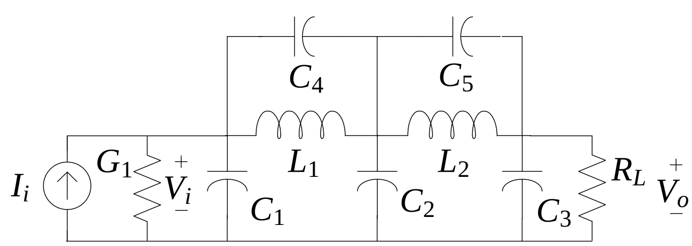
1) Apply the Tableau approach to analyze the generalized impedance converter shown below: (a) draw an oriented graph; (b) obtain the incidence matrix $\boldsymbol{A}$; (c) obtain the matrices $\boldsymbol{Y}$, $\boldsymbol{Z}$ and $\boldsymbol{W}$ from the circuit element definitions (assuming ideal Op-Amps); (d) assemble matrix $\boldsymbol{T}$; (e) solve $\boldsymbol{Tx} = \boldsymbol{W}'$ for $\boldsymbol{x}$ using Matlab or any other similar program; (f) calculate the impedance $Z_L = V_L/I_L$. Assume $R_1 = R_5 = 1$ KΩ, $R_2 = R_3 = 3.3$ KΩ, $C_4 = 1$ μF, and $V_L = 10$ mV at 1KHz (sinusoidal input). Assume zero initial conditions. From the value found for Z_L at 1 KHz, what is the equivalent inductance L_{eq} at that node at 1 KHz?



2) Apply the Nodal formulation to the circuit shown below: (a) draw an oriented graph; (b) obtain the incidence matrix $\boldsymbol{A}$; (c) obtain the matrices $\boldsymbol{Y}$ and $\boldsymbol{J}$ from the circuit element definitions; (d) solve $\boldsymbol{AYA}^T\boldsymbol{V}_n = -\boldsymbol{AJ}$ for $\boldsymbol{V}_n$ using Matlab at the following frequencies: 10 Hz, 50 MHz, 100 MHz, and 150 MHz. Assume $G_1 = 100$ μS, $R_L = 50$ Ω, $L_1 = L_2 = 60.78$ nH, $C_1 = C_3 = 10.16$ pF, $C_2 = 36.02$ pF, $C_4 = C_5 = 14.87$ pF, and $|I_i| = 1$mA at all frequencies. Also assume zero initial conditions. Show $\boldsymbol{V}_n$ at the four frequencies in magnitude and phase (degrees). Plot $|A_v| = |V_o/V_i|$ versus frequency, from 10 Hz to 200 MHz (in linear scale).



3) Apply the Modified Nodal formulation to the Sallen-Key high-pass 2nd order active filter shown below: (a) draw an oriented graph; (b) obtain the incidence matrices $\boldsymbol{A}_1$ and $\boldsymbol{A}_2$; (c) obtain the matrices $\boldsymbol{Y}_2$, $\boldsymbol{Z}_2$, $\boldsymbol{W}_2$, $\boldsymbol{Y}_1$ and $\boldsymbol{J}_1$ from the circuit element definitions (assuming an ideal Op-Amp); (d) solve the MNA equation for $\boldsymbol{V}_n$ and $\boldsymbol{I}_2$ using Matlab at 3000 frequency points from 10 Hz to 100 KHz in semi-logarithmic scale. Assume $R_A = 1.27$ KΩ, $R_B = 2.3$ KΩ, $G_1 = 1/R_A$, $G_2 = 1/R_B$, $C_1 = C_2 = 0.1$ μF, and $|V_i| = 1$ mV at all frequencies. Plot the magnitude (in dB) and phase (in degrees) of the voltage gain (V_{out}/V_{in}) versus frequency in semi-logarithmic scale (from 10 Hz to 100 KHz). Assume zero initial conditions.

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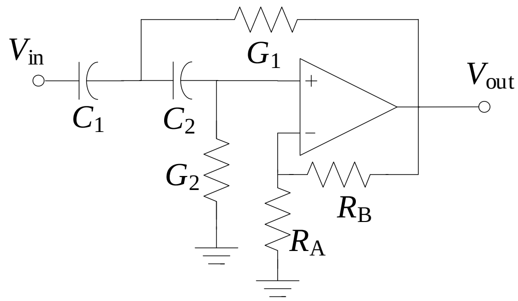
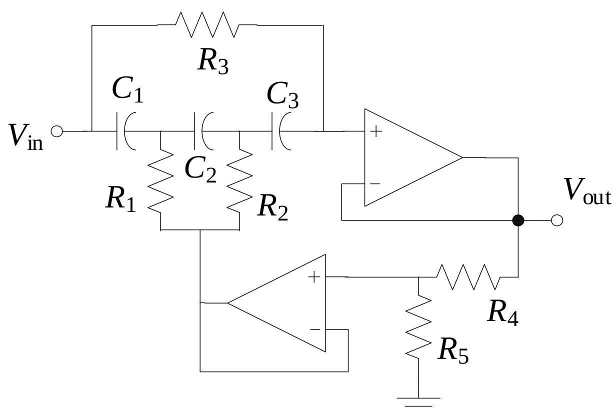


4) For the circuit in problem 1: (a) obtain an MNA formulation using stamps (write down ***H*** and ***W*** by inspection); (b) Using Matlab solve ***HX*** = ***W*** for ***X*** ; (c) calculate the impedance $Z_L = V_L/I_L$; (d) Compare these results with those obtained in problem 1, and check they are equivalent; (e) Plot the equivalent inductance L_{eq} versus frequency, from 10 Hz to 100 MHz (in linear scale).

5) For the buffered notch filter illustrated below: a) obtain an MNA formulation using stamps (write down ***H*** and ***W*** by inspection); (b) Using Matlab solve ***HX*** = ***W*** for ***X***, from 1Hz to 120Hz, using 301 frequency points linearly distributed; (c) Plot the magnitude of the output voltage versus frequency in linear scale. Assume zero initial conditions and ideal Op-Amps. Take R_1 = 19 KΩ, R_2 = 57.6 KΩ, R_3 = 464 KΩ, R_4 = 200 Ω, R_5 = 4.8 KΩ, $C_1 = C_2 = C_3$ = 47 nF, and $|V_{in}|$ = 1 V at all frequencies.



6) For the buffered notch filter of the previous problem: a) express your ***HX*** = ***W*** formulation into the form $(\boldsymbol{H}_1+s\boldsymbol{H}_2)\boldsymbol{X} = \boldsymbol{W}$; (b) using Matlab, obtain the transient response of the circuit from 0 to 500 ms by solving $\boldsymbol{H}_2\boldsymbol{x}' = \boldsymbol{w} - \boldsymbol{H}_1\boldsymbol{x}$ for ***x*** with a Trapezoidal rule, assuming that the input signal is a pulse with 3 V of amplitude, 200 ms of pulse width, and a rise time and fall time of 5ms; (c) Plot versus time (from 0 to 500 ms) the input and output voltages, as well as the input current.

Submission deadline: March 4, 2020.