

nlmmul.exe Exercises for Chapter nlmmul

Exercise nlmmul00000

Write a one- or two-sentence response to each of the following questions and imperatives. The use of equations is acceptable when they appear in a sentence. Don't quote me (use your own words, other than technical terminology).

- (a) Write the equivalent impedance of a resistor R and an inductor L in series. Express the result in rectangular and polar (phasor) form.
- (b) How do you find the Norton equivalent resistance?
- (c) Explain how a diode operates in forward-bias.
- (d) In a MOSFET, how much current will flow from the drain D to the source S when the gate-source voltage is 0.3 V ? Succinctly explain/justify.

Exercise nlmmul00001

Write a one- or two-sentence response to each of the following questions and imperatives. The use of equations is acceptable when they appear in a sentence. Don't quote me (use your own words, other than technical terminology).

- (a) Describe a couple differences between MOSFETs and opamps.
- (b) If a DC source is connected to a circuit in steady state, describe how an inductor in the circuit will be operating.
- (c) If a transformer increases an AC signal's voltage by a factor of 10, what happens to the signal's current?
- (d) How do we determine the diode resistance for the piecewise linear model of a diode?

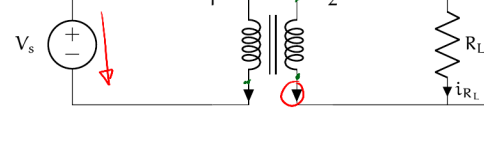


Figure exe.1: circuit diagram for Exercise nlmmul00001 and Exercise nlmmul00002.

Exercise nlmmul00002

Write a one- or two-sentence response to each of the following questions and imperatives. The use of equations is acceptable when they appear in a sentence. Don't quote me (use your own words, other than technical terminology).

- (a) If the current through an inductor is suddenly switched off, what happens?
- (b) Let the output voltage of a resistor circuit be 5 V and the equivalent resistance 50Ω . What is the Thévenin equivalent circuit?
- (c) In the preceding part of this question, what is the Norton equivalent circuit?
- (d) When can we use impedance analysis?

Exercise nlmmul00003

For the circuit diagram of Fig. exe.1, solve for $v_o(t)$ if $V_s(t) = A \cos \omega t$. Let $N = n_2/n_1$, where n_1 and n_2 are the number of turns in each coil, 1 and 2, respectively. Also let $i_o(t) = b$ be the initial condition.

Exercise nlmmul00004

Repeat Exercise nlmmul00003, but only consider the steady-state response. Use impedance methods!

Exercise nlmmul00005

Calculate the current through a diode using the ideal model under the following conditions.

- $v_o = 5.8 \text{ V}$
- $T = 38.21, 28^\circ\text{C}$.

The diode can be assumed to have a saturation current of $I_s = 10^{-12} \text{ A}$. You may find the following helpful.

- Boltzmann constant: $1.38 \times 10^{-23} \frac{\text{J}}{\text{K}}$, and
- fundamental charge: $1.602 \times 10^{-19} \text{ C}$.

Exercise nlmmul00006

When considering the steady state of circuits with only DC sources, all voltages and currents are constant and all diodes are in constant states (each is ON or OFF). The methods of Lec. nlmmul00001 still apply, of course, but we needn't be concerned with a time evolution. Consider the circuits of Fig. exe.2. For each circuit, solve for the voltage across the $5 \text{ k}\Omega$ resistor. Treat each diode as an ideal diode.

Exercise nlmmul00007

Repeat Exercise nlmmul00006, but use the piecewise linear model of each diode.

Exercise nlmmul00008

A diode clipping circuit is one that "clips" the tops and/or bottoms of a signal. These circuits can be used to set a maximum or minimum voltage for a signal.

Consider the diode clipping circuit of Fig. exe.3. Source V_1 effectively adjusts the maximum possible load voltage v_o , and V_2 the minimum. Let $V_2(t) = 10 \cos \omega t$, $V_1 = 5 \text{ V}$, $V_2 = -3 \text{ V}$, and $R_L = R_1 = 50 \Omega$. Solve for $v_o(t)$. Use the ideal diode model.

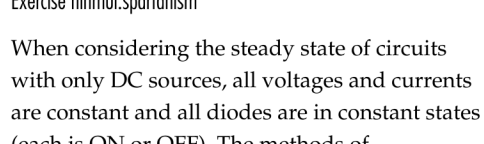


Figure exe.2: diode circuit for Exercise nlmmul00006.

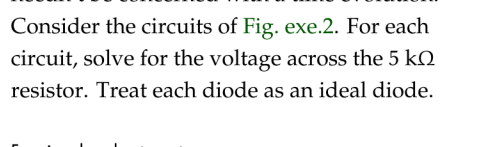


Figure exe.3: diode clipping circuit for Exercise nlmmul00008.

Exercise nlmmul00009

Repeat Exercise nlmmul00008, but use the piecewise linear model of each diode.

Exercise nlmmul00010

The opamp circuit of Fig. exe.6 is used as a voltage-controlled current source for the load R_L . Show that it behaves as a current source with current i_o , controlled by voltage source v_i .

Use two separate methods: (a) assuming $v_i = v_o$, and (b) not assuming $v_i = v_o$, rather, assuming the open loop gain of the opamp A is large. Comment on the differences between the methods of (a) and (b).

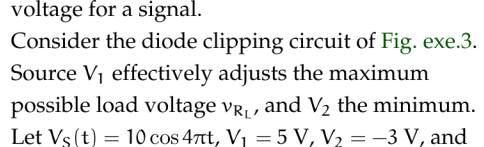


Figure exe.6: circuit diagram for Exercise nlmmul00010.

Exercise nlmmul00011

The opamp circuit of Fig. exe.7 is used as a voltage-controlled current source for the load R_L . Show that it behaves as a current source with current i_o , controlled by voltage source v_i .

Use two separate methods: (a) assuming $v_i = v_o$, and (b) not assuming $v_i = v_o$, rather, assuming the open loop gain of the opamp A is large. Comment on the differences between the methods of (a) and (b).

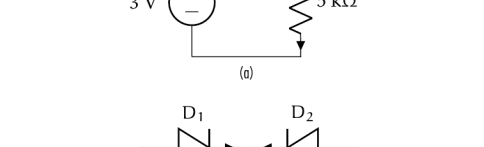


Figure exe.7: circuit diagram for Exercise nlmmul00011.

Exercise nlmmul00012

Use the circuit diagram of Fig. exe.7 to answer the questions below. Use the sign convention from the diagram. Let $v_i = A \cos \omega t$ be an ac input voltage. The load Z_L impedance is not given.

- (a) Write the elemental equations in terms of Z_L , Z_R , Z_C , and Z_L (the impedances of the components).
- (b) Write the KCL and KVL equations.
- (c) Solve for the steady-state $v_o(t)$ without inserting the values of the impedances (that is, leave it in terms of Z_L , Z_R , Z_C , and Z_L).

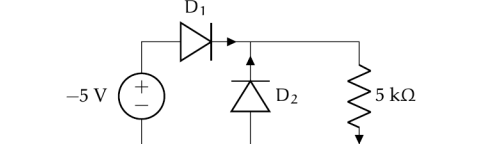


Figure exe.8: circuit diagram for Exercise nlmmul00012.

Exercise nlmmul00013

Consider the circuit in Fig. exe.8. Solve for $v_o(t)$ for input voltage $v_i(t) = 5 \text{ V}$ sine wave of $v_i(t) = 5 \sin 25t$, and a sine wave of $v_i(t) = 5 \sin 252t$. Let $R_1 = 50 \Omega$, $R_2 = 10 \text{ k}\Omega$, $C = 10 \mu\text{F}$, and the opamp open-loop gain be $A = 10^5$. Let the initial condition be $v_o(1) = 0 \text{ V}$. In each case, plot the solution to show the transient response until it reaches steady-state.

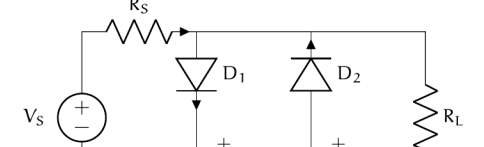


Figure exe.9: circuit diagram for Exercise nlmmul00013.

Exercise nlmmul00014

In each of the figures of Fig. exe.10, solve for the voltage v_o across the 100Ω resistor. Use the assumptions in the associated caption. Clearly justify each response.

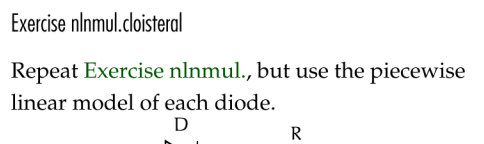
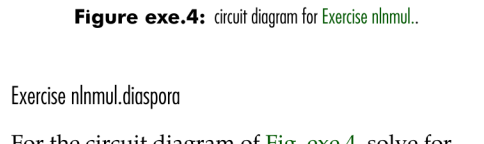


Figure exe.10: circuit diagrams for Exercise nlmmul00014.

Exercise nlmmul00015

Consider the circuit below with input voltage sources V_1 and V_2 . Determine V_3 such that the load voltage $v_o = 10 \text{ V}$. Let $R_1 = 2 \text{ k}\Omega$, $R_2 = 0.5 \text{ mA/V}^2$, $V_1 = 0.7 \text{ V}$, $V_2 = 20 \text{ V}$.



Exercise nlmmul00016

Consider the circuit below with input voltage source $V_1(t) = A \cos \omega t$ where $A > 0$ is a known (but unspecified) constant. Perform a circuit analysis to solve for $v_o(t)$ for the initial condition $v_o(0) = 0$. Hint: It is easier if you realize the opamp output voltage is effectively an ideal voltage source (so it does not depend on v_o and v_i) and you can therefore treat the two parts of the circuit separately.

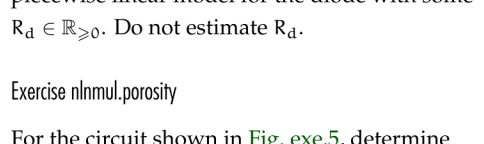


Figure exe.16: circuit diagram for Exercise nlmmul00016.

$$E_{1,2} = \dots$$

$$V_{R_1} = R_1 i_{R_1}$$

$$V_{R_2} = R_2 i_{R_2}$$

$$V_{R_3} = R_3 i_{R_3}$$

$$V_D = R_D i_D$$

$$V_o = V_{R_3} = R_3 i_{R_3}$$

$$i_{R_1} = \dots$$

$$i_{R_2} = \dots$$

$$i_{R_3} = \dots$$

$$i_D = \dots$$

$$E_{1,2} = \dots$$

$$V_{R_1} = Z_{R_1} i_{R_1}$$

$$V_{R_2} = Z_{R_2} i_{R_2}$$

$$V_{R_3} = Z_{R_3} i_{R_3}$$

$$V_D = Z_D i_D$$

$$V_o = V_{R_3} = Z_{R_3} i_{R_3}$$

$$i_{R_1} = \dots$$

$$i_{R_2} = \dots$$

$$i_{R_3} = \dots$$

$$i_D = \dots$$

$$V_o = V_1$$

$$V_o = V_2$$

$$V_o = V_1 + V_2$$

$$V_o = V_1 - V_2$$

$$V_o = V_1 + V_2 + V_3$$

$$V_o = V_1 - V_2 - V_3$$

$$V_o = V_1 + V_2 + V_3 + V_4$$

$$V_o = V_1 - V_2 - V_3 - V_4$$

$$V_o = V_1 + V_2 + V_3 + V_4 + V_5$$

$$V_o = V_1 - V_2 - V_3 - V_4 - V_5$$

$$V_o = V_1 + V_2$$

$$V_o = V_1 - V_2$$

$$V_o = V_1 + V_2 + V_3$$

$$V_o = V_1 - V_2 - V_3$$

$$V_o = V_1 + V_2 + V_3 + V_4$$

$$V_o = V_1 - V_2 - V_3 - V_4$$

$$V_o = V_1 + V_2 + V_3 + V_4 + V_5$$

$$V_o = V_1 - V_2 - V_3 - V_4 - V_5$$

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