

nlmmul.exe Exercises for Chapter nlmmul

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.

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?

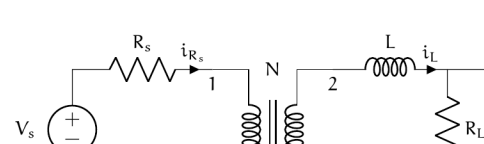


Figure exe.1: circuit diagram for Exercise 1 and Exercise 1mmul.

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 50 Ω. What is the Thévenin equivalent circuit?
- (c) In the preceding part of this question, what is the Norton equivalent?
- (d) When can we use impedance analysis?

For the circuit diagram of Fig. exe.1, solve for v_o(t) if V_s(t) = A cos ωt. 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 t_0 = 0 be the initial condition.

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

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

- v_s = 5.8, -3 V
- T = 38, 21, 28 °C.

The diode can be assumed to have a saturation current of i_s = 10⁻¹¹ A. You may find the following helpful.

- Boltzmann constant: 1.38 × 10⁻²³ J/K, and
- fundamental charge: 1.602 × 10⁻¹⁹ C.

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. nlmmul also 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 kΩ resistor. Treat each diode as an ideal diode.

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

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.

Source V_1 effectively adjusts the maximum possible load voltage v_o, and V_2 the minimum. Let V_1(t) = 10 cos ωt, V_2 = 5 V, V_3 = -3 V, and R_1 = R_2 = 50 Ω. Solve for v_o(t). Use the ideal diode model.

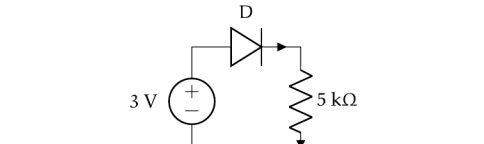
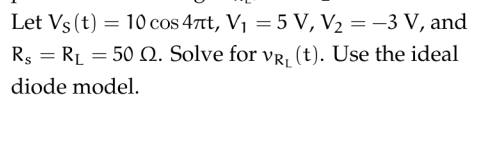
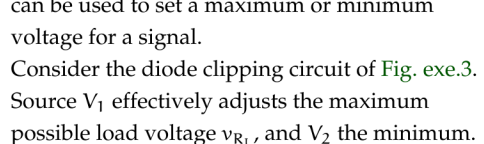
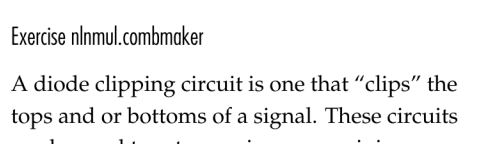


Figure exe.2: diode circuit for Exercise 2mmul.

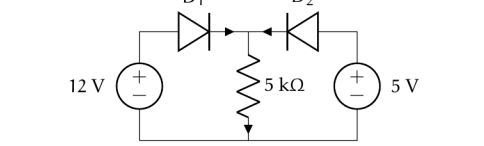


Figure exe.3: diode clipping circuit for Exercise 3mmul.

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

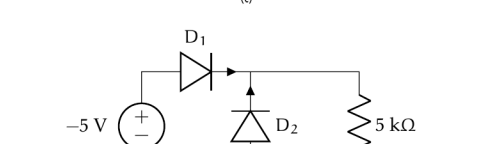


Figure exe.4: circuit diagram for Exercise 4mmul.

Solve for the circuit diagram of Fig. exe.4, solve for v_o(t) if V_s(t) = A cos ωt for some given A > 0. Let v_o(t=0) = 0 V be the initial condition. Use piecewise linear model for the diode with some R_d ∈ R_+ ∪ ∞. Do not estimate R_d.

For the circuit shown in Fig. exe.5, determine the voltage across the load v_o in terms of parameters and the gate voltage source voltage V_g and V_s. The parameters of the MOSFET are K and V_T. Assume MOSFET saturation operation.

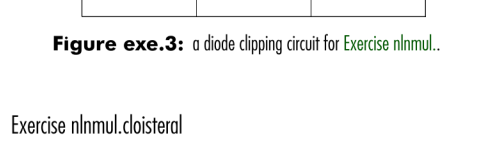


Figure exe.5: circuit for Exercise 5mmul.

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_s, and (b) not assuming v_i = v_s, rather, assuming the open loop gain of the opamp A is large. Comment on the differences between the methods of (a) and (b).

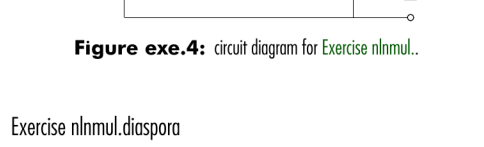


Figure exe.6: circuit for Exercise 6mmul.

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

- (a) Write the elemental equations in terms of Z_s, Z_e, Z_o, Z_L and Z_i (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_s, Z_e, Z_o, Z_L and Z_i).

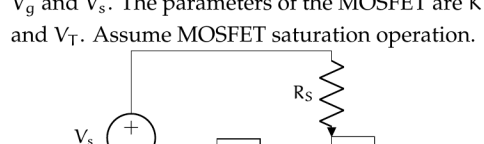


Figure exe.7: circuit for Exercise 7mmul.

Consider the circuit in Fig. exe.8. Solve for v_o(t) for input voltage v_i(t) = 5 V cos ωt, and a sine wave of v_i(t) = 5 sin 25t, and a sine wave of v_i(t) = 5 sin 252t. Let R_1 = 50 Ω, R_2 = 10 kΩ, C = 10 μF, and the opamp open-loop gain be A = 10⁵. Let the initial condition be v_o(t) = 0 V. In each case, plot the solution to show the transient response until it reaches steady-state.

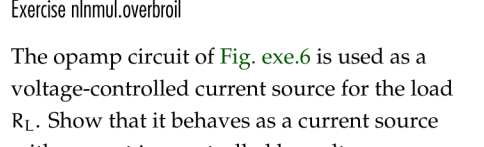


Figure exe.8: opamp circuit for Exercise 8mmul.

Consider the circuit in Fig. exe.9. Solve for v_o(t) for a known input voltage v_i(t).

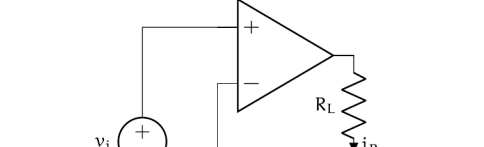


Figure exe.9: opamp circuit for Exercise 9mmul.

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

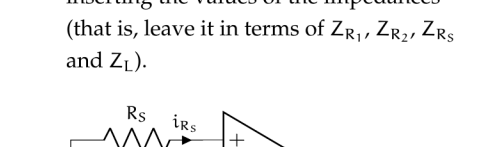
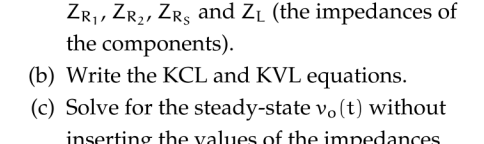
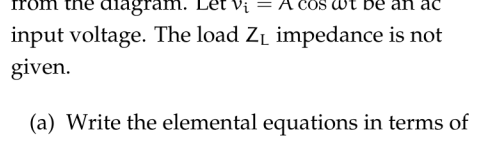
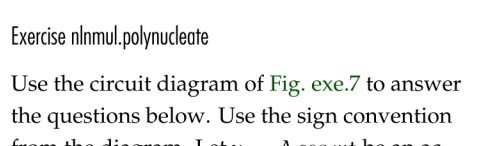
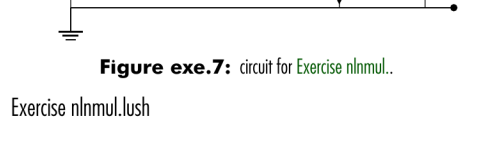
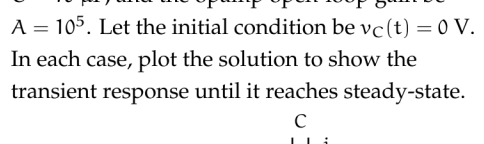


Figure exe.10: circuit for Exercise 10mmul.

Determine V_3 and V_4. Determine V_3 such that the load voltage v_o = 10 V. Let R_1 = 2 kΩ, K = 0.5 mA/V², V_T = 0.7 V, V_s = 20 V.



Consider the circuit below with input voltage source v_s(t) = A cos ωt 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(t=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_s and v_c) and you can therefore treat the two parts of the circuit separately.



$$\frac{1}{a + jb} = \frac{a - jb}{a - jb} = \frac{a - jb}{a^2 + b^2}$$

$$V_s = V_{R_1} = R_1 i_{R_1} = R_1 i_L$$

$$V_L = R_L i_L$$

$$V_s = V_{R_1} + V_L = (R_1 + R_L) i_L$$

$$i_L = \frac{V_s}{R_1 + R_L}$$

$$V_o = R_L i_L = \frac{R_L V_s}{R_1 + R_L}$$

$$\frac{dV_o}{dt} = \frac{R_L}{R_1 + R_L} \frac{dV_s}{dt}$$

$$V_o = \frac{R_L}{R_1 + R_L} V_s$$

$$V_o = \frac{R_L}{R_1 + R_L} A \cos \omega t$$

$$V_o = \frac{R_L}{R_1 + R_L} A \cos \omega t$$

$$V_o = \frac{R_L}{R_1 + R_L} A \cos \omega t$$

$$V_o = \frac{R_L}{R_1 + R_L} A \cos \omega t$$

$$V_o = \frac{R_L}{R_1 + R_L} A \cos \omega t$$

$$V_o = \frac{R_L}{R_1 + R_L} A \cos \omega t$$

$$V_o = \frac{R_L}{R_1 + R_L} A \cos \omega t$$

$$V_o = \frac{R_L}{R_1 + R_L} A \cos \omega t$$

$$V_o = \frac{R_L}{R_1 + R_L} A \cos \omega t$$

$$V_o = \frac{R_L}{R_1 + R_L} A \cos \omega t$$

$$V_o = \frac{R_L}{R_1 + R_L} A \cos \omega t$$

$$V_o = \frac{R_L}{R_1 + R_L} A \cos \omega t$$

$$V_o = \frac{R_L}{R_1 + R_L} A \cos \omega t$$

$$V_o = \frac{R_L}{R_1 + R_L} A \cos \omega t$$

$$V_o = \frac{R_L}{R_1 + R_L} A \cos \omega t$$

$$V_o = \frac{R_L}{R_1 + R_L} A \cos \omega t$$

$$V_o = \frac{R_L}{R_1 + R_L} A \cos \omega t$$

$$V_o = \frac{R_L}{R_1 + R_L} A \cos \omega t$$

$$V_o = \frac{R_L}{R_1 + R_L} A \cos \omega t$$

$$V_o = \frac{R_L}{R_1 + R_L} A \cos \omega t$$

$$V_o = \frac{R_L}{R_1 + R_L} A \cos \omega t$$

$$V_o = \frac{R_L}{R_1 + R_L} A \cos \omega t$$

$$V_o = \frac{R_L}{R_1 + R_L} A \cos \omega t$$

$$V_o = \frac{R_L}{R_1 + R_L} A \cos \omega t$$

$$V_o = \frac{R_L}{R_1 + R_L} A \cos \omega t$$

$$V_o = \frac{R_L}{R_1 + R_L} A \cos \omega t$$

$$V_o = \frac{R_L}{R_1 + R_L} A \cos \omega t$$

$$V_o = \frac{R_L}{R_1 + R_L} A \cos \omega t$$

$$V_o = \frac{R_L}{R_1 + R_L} A \cos \omega t$$

$$V_o = \frac{R_L}{R_1 + R_L} A \cos \omega t$$

$$V_o = \frac{R_L}{R_1 + R_L} A \cos \omega t$$

$$V_o = \frac{R_L}{R_1 + R_L} A \cos \omega t$$

$$V_o = \frac{R_L}{R_1 + R_L} A \cos \omega t$$

$$V_o = \frac{R_L}{R_1 + R_L} A \cos \omega t$$

$$V_o = \frac{R_L}{R_1 + R_L} A \cos \omega t$$

$$V_o = \frac{R_L}{R_1 + R_L} A \cos \omega t$$

$$V_o = \frac{R_L}{R_1 + R_L} A \cos \omega t$$

$$V_o = \frac{R_L}{R_1 + R_L} A \cos \omega t$$

$$V_o = \frac{R_L}{R_1 + R_L} A \cos \omega t$$

$$V_o = \frac{R_L}{R_1 + R_L} A \cos \omega t$$

$$V_o = \frac{R_L}{R_1 + R_L} A \cos \omega t$$

$$V_o = \frac{R_L}{R_1 + R_L} A \cos \omega t$$

$$V_o = \frac{R_L}{R_1 + R_L} A \cos \omega t$$

$$V_o = \frac{R_L}{R_1 + R_L} A \cos \omega t$$

$$V_o = \frac{R_L}{R_1 + R_L} A \cos \omega t$$

$$V_o = \frac{R_L}{R_1 + R_L} A \cos \omega t$$

$$V_o = \frac{R_L}{R_1 + R_L} A \cos \omega t$$

$$V_o = \frac{R_L}{R_1 + R_L} A \cos \omega t$$

$$V_o = \frac{R_L}{R_1 + R_L} A \cos \omega t$$

$$V_o = \frac{R_L}{R_1 + R_L} A \cos \omega t$$

$$V_o = \frac{R_L}{R_1 + R_L} A \cos \omega t$$

$$V_o = \frac{R_L}{R_1 + R_L} A \cos \omega t$$

$$V_o = \frac{R_L}{R_1 + R_L} A \cos \omega t$$

$$V_o = \frac{R_L}{R_1 + R_L} A \cos \omega t$$

$$V_o = \frac{R_L}{R_1 + R_L} A \cos \omega t$$

$$V_o = \frac{R_L}{R_1 + R_L} A \cos \omega t$$

$$V_o = \frac{R_L}{R_1 + R_L} A \cos \omega t$$

$$V_o = \frac{R_L}{R_1 + R_L} A \cos \omega t$$

$$V_o = \frac{R_L}{R_1 + R_L} A \cos \omega t$$

$$V_o = \frac{R_L}{R_1 + R_L} A \cos \omega t$$

$$V_o = \frac{R_L}{R_1 + R_L} A \cos \omega t$$

$$V_o = \frac{R_L}{R_1 + R_L} A \cos \omega t$$

$$V_o = \frac{R_L}{R_1 + R_L} A \cos \omega t$$

$$V_o = \frac{R_L}{R_1 + R_L} A \cos \omega t$$

$$V_o = \frac{R_L}{R_1 + R_L} A \cos \omega t$$

$$V_o = \frac{R_L}{R_1 + R_L} A \cos \omega t$$

$$V_o = \frac{R_L}{R_1 + R_L} A \cos \omega t$$

$$V_o = \frac{R_L}{R_1 + R_L} A \cos \omega t$$

$$V_o = \frac{R_L}{R_1 + R_L} A \cos \omega t$$

$$V_o = \frac{R_L}{R_1 + R_L} A \cos \omega t$$

$$V_o = \frac{R_L}{R_1 + R_L} A \cos \omega t$$

$$V_o = \frac{R_L}{R_1 + R_L} A \cos \omega t$$

$$V_o = \frac{R_L}{R_1 + R_L} A \cos \omega t$$

$$V_o = \frac{R_L}{R_1 + R_L} A \cos \omega t$$

$$V_o = \frac{R_L}{R_1 + R_L} A \cos \omega t$$

$$V_o = \frac{R_L}{R_1 + R_L} A \cos \omega t$$

$$V_o = \frac{R_L}{R_1 + R_L} A \cos \omega t$$

$$V_o = \frac{R_L}{R_1 + R_L} A \cos \omega t$$

$$V_o = \frac{R_L}{R_1 + R_L} A \cos \omega t$$

$$V_o = \frac{R_L}{R_1 + R_L} A \cos \omega t$$

$$V_o = \frac{R_L}{R_1 + R_L} A \cos \omega t$$

$$V_o = \frac{R_L}{R_1 + R_L} A \cos \omega t$$