UNIVERSITY OF CALGARY

FACULTY OF ENGINEERING

ENGG 325 - Electric Circuits and Systems

Final Examination

Monday, December 13, 2004
Time: 8:00 - 11:00 AM

Red Gym

L01 (Norm Bartley)
L02 (Ed Nowicki)

Instructions:

- Time allowed is 3 hours.
- The examination is closed-book. One double-sided 8.5x11-inch formula sheet may be used in the examination.
- Any type of portable calculator is permitted.
- The maximum number of marks is 100, as indicated. The final examination counts toward 50% of the final grade. Please attempt all six questions.
- Please use a pen or heavy pencil to ensure legibility.
- If you use more than one examination booklet, please make sure that your name and ID number are on each.
- Where appropriate, marks will be awarded for proper and well-reasoned explanations.

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1. Consider the DC circuit shown in Fig. P1.

   (a) Using the analysis method of your choosing, find V_A and V_B. Note that a ground reference is provided.

   [12 marks.]

   (b) Determine the power in the 9A source, and indicate whether it is absorbing or generating power.

   [4 marks.]

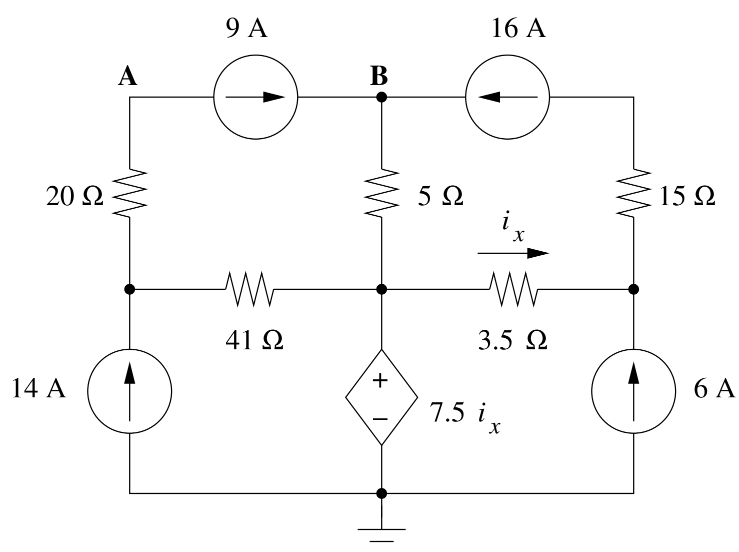

Fig. P1. Solve by the analysis method of your choosing

[16 marks total.]

2. Consider the circuit given in Fig. P2(a), which is driven by a 60 Hz AC voltage source.

   (a) Determine the Thévenin equivalent circuit to the left of the terminals **A** and **B**. Express $\mathbf{V}_T$ in phasor form.

   [6 marks.]

   (b) Employing the above Thévenin equivalent circuit as shown in Fig. P2(b), find:

   - Phasor voltage $\mathbf{V}_{AB}$ (expressed in terms of magnitude and phase), and also give the corresponding time-domain expression for $v_{AB}(t)$;
   - The phasor current $\mathbf{I}_0$ and the corresponding time-domain expression for $i_o(t)$;
   - The average power delivered to R;
   - The average power delivered to L.

   [10 marks.]

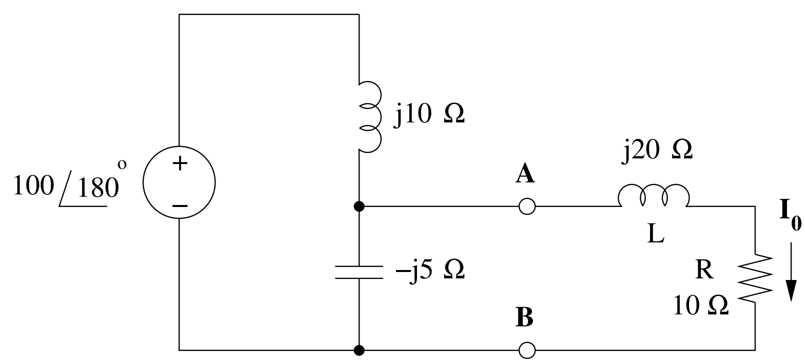

Fig. P2(a). Find the Thévenin equivalent circuit

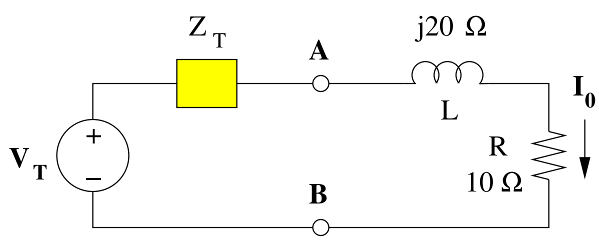

Fig. P2(b). Using the Thévenin equivalent circuit

[16 marks total.]

3. For the resistor-capacitor circuit shown in Fig. P3, assume that the switch has been closed for a long time, allowing the circuit to reach DC steady-state. The switch is then opened at time $t = 0$.

   (a) Find v_1 at $t = 0^-$, $t = 0^+$, and $t \to \infty$. **[6 marks.]**

   (b) Sketch $v_1(t)$, and indicate the time constant τ. **[6 marks.]**

   (c) Sketch $v_2(t)$. **[6 marks.]**

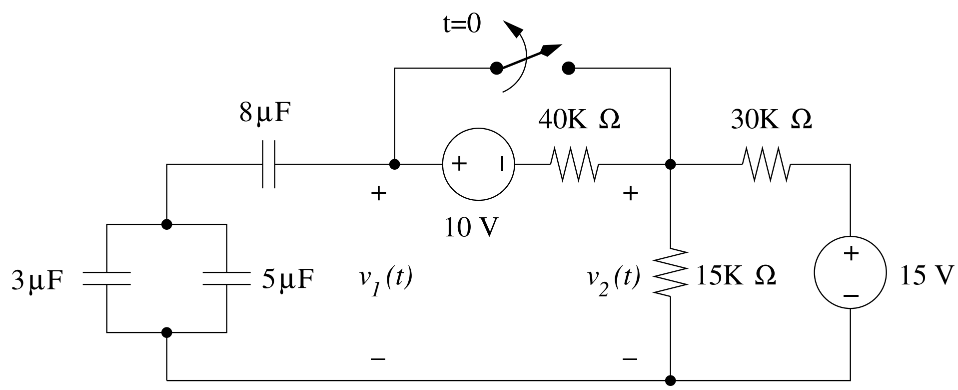

Fig. P3. A first-order RC circuit

[18 marks total.]

4. A shunt-connected DC motor has the following name-plate (i.e., rated, or full-load) parameters:

- Terminal voltage $V_T = 250$ V;
- Output (shaft) power $P_{out} = 30$ HP;
- Shaft speed $n = 4500$ rpm.

In addition, testing of the motor has revealed an armature resistance $R_A = 0.050\Omega$, and a total field resistance $R_F + R_{adj} = 125\Omega$. Testing also indicates that operation with rated conditions results in a motor emf $E_A = 245.1$ V.

(a) Determine the following:

- The rated (i.e., line) current I_L;
- The rated output (i.e., shaft) torque T_{out};
- The field loss, armature loss, and friction loss *(Hint: all three have units of Watts)*;
- The full-load efficiency (i.e., rated-condition) efficiency η_{FL}.

[12 marks.]

(b) A separately excited ENGG 325 student now physically modifies the motor to make it separately excited. The field terminal voltage $V_{TF} = 250$ V. Neglecting friction loss and keeping $R_F + R_{adj} = 125\Omega$, determine the armature terminal voltage V_{TA} if the shaft speed is 1500 rpm, and if the motor is operating with the rated torque load.

[4 marks.]

[16 marks total.]

5. Consider the diode circuit in Fig. P5(a).

   (a) Assuming all diodes are ideal, determine the diode voltages v_{D1}, v_{D2}, v_{D3}, and currents i_{D1}, i_{D2}, i_{D3}.

   [8 marks.]

   (b) Now assume that the diodes have the piecewise-linear characteristic shown in Fig. P5(b). Determine the diode voltages v_{D1}, v_{D2}, v_{D3}, and currents i_{D1}, i_{D2}, i_{D3}. *(Hint: your answers to part (a) should help you choose the appropriate line segments.)* **[8 marks.]**

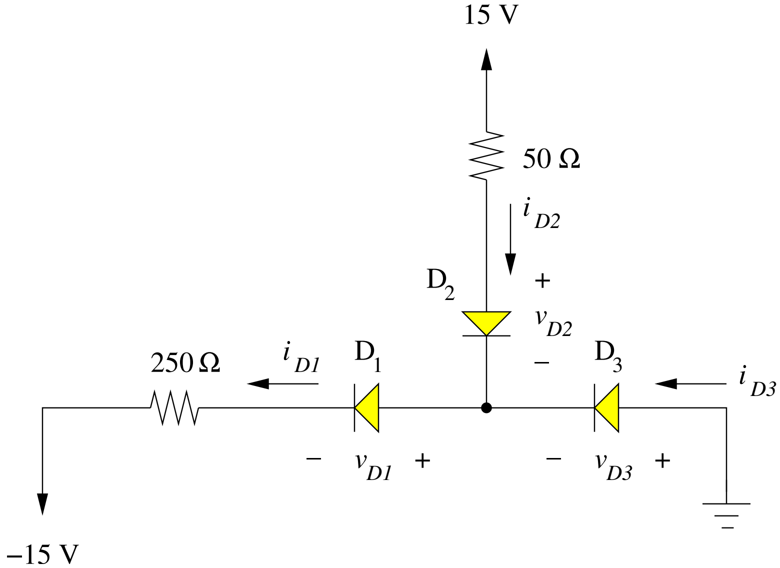

Fig. P5(a). Determine diode voltages and currents

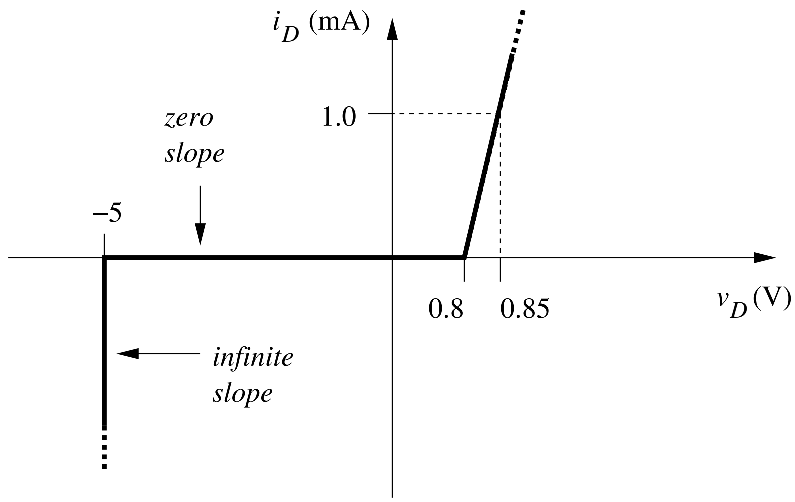

Fig. P5(b). Piecewise-linear diode characteristic

[16 marks total.]

6. The op amps in Fig. P6 are ideal.

   (a) With the switch open, find $A_2 = v_{o2}/v_{o1}$. **[6 marks.]**

   (b) With the switch still open, determine v_{o2} in terms of V_1, V_2, and V_3. **[6 marks.]**

   (c) Now with the switch closed, let $V_2 = V_3 = 0$. Determine v_{o2}/V_1. **[6 marks.]**

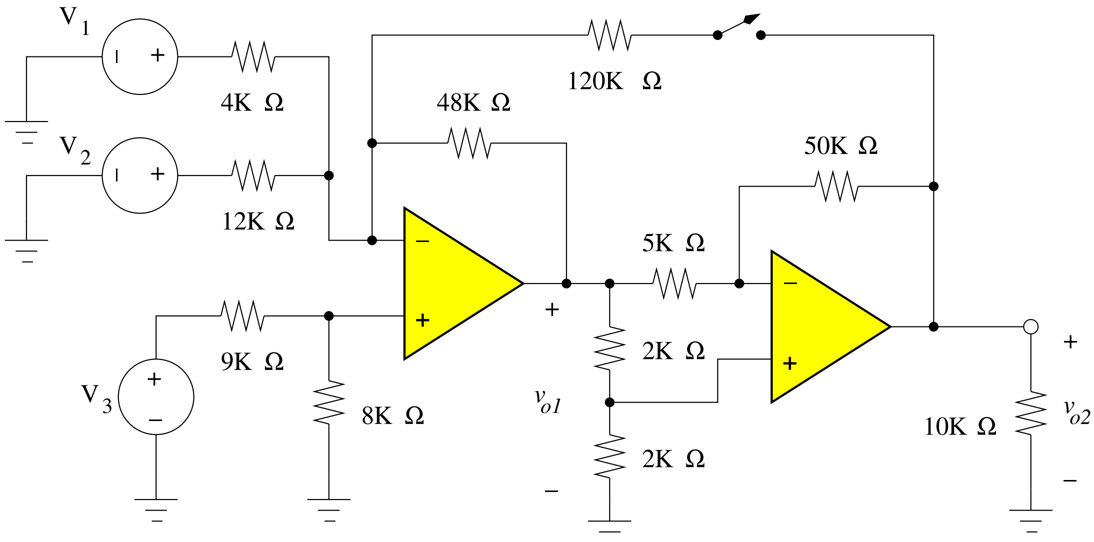

Fig. P6. An op amp circuit

[18 marks total.]