

ORDRE DES INGÉNIEURS DU QUÉBEC

NOVEMBER 2022 SESSION

Open-book examination
Calculators : only authorized models
Duration : 3 hours

16-EL-A1-CIRCUITS

Question 1 (16 points = 9 (a) + 7 (b))

The operational amplifier shown in Figure 1 is assumed to be ideal.

- Provide the equation describing the output voltage V_{out} as a function of the 4 resistors and the 2 input voltage levels, i.e. $V_{out} = f(R_1, R_2, R_3, R_4, V_1, V_2)$.
- Assume that $R_1 = 1k\Omega$, $R_2 = 2k\Omega$ and $R_3 = 3k\Omega$. Compute the values of R_4 required to obtain an output voltage V_{out} twice as large as the input voltage difference $V_2 - V_1$.

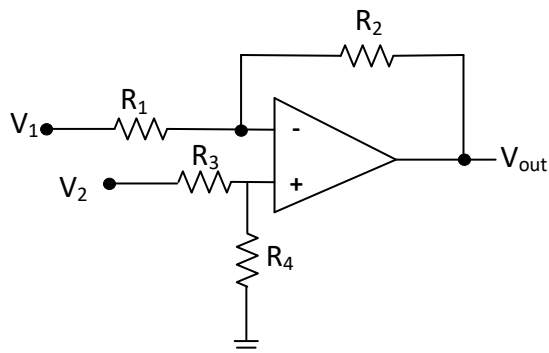


Figure 1

Question 2 (18 points = 10 (a) + 8 (b))

- Compute the voltage ratio $\frac{V_L}{V}$ in the circuit shown in Figure 2a.
- Consider that $R_o = 3 \Omega$ in the circuit shown in Figure 2b. Which value of μ causes the ratio $\frac{V_L}{V}$ to be the same as that found in a)?

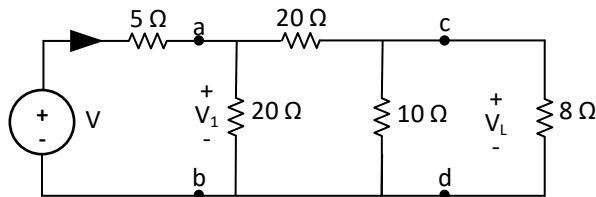


Figure 2a

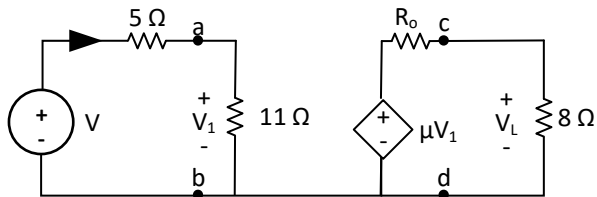


Figure 2b

Question 3 (18 points = 5 (a) + 8 (b) + 5 (c))

Consider the circuit shown in Figure 3 where the current in the capacitor and the total input current are respectively $i_c = 10\sqrt{2}\cos(10^6 t)$ and $I = (6-10j)$ A.

- Compute the effective voltage (V_{eff}) at the input of the circuit.
- Compute the average power in each of the 3 elements of the circuit.
- Show that the total average power of the circuit is dissipated through the (4Ω) resistor.

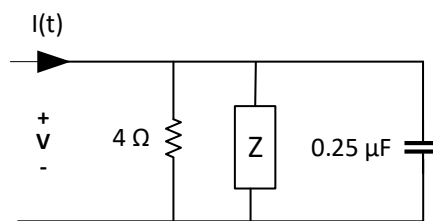


Figure 3

Question 4 (18 points = 8 (a) + 6 (b) + 4 (c))

Consider the circuit shown in Figure 4.

- Draw the Norton equivalent circuit
- Draw the Thevenin equivalent circuit
- Compute the value of R that would allow this circuit to transfer the maximum power to a resistive load of $4\ \Omega$ connected between poles a and b.

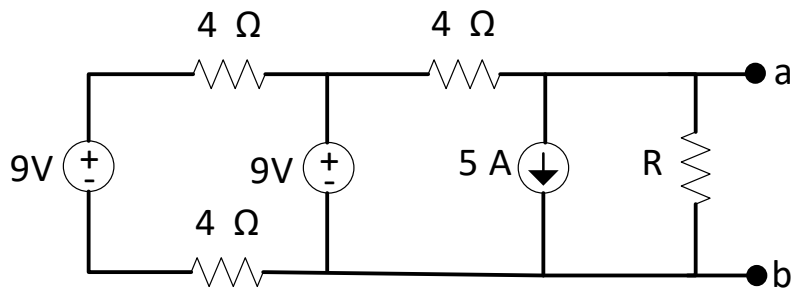


Figure 4

Question 5 (16 points = 10 (a) + 6 (b))

Consider the circuit shown in Figure 5. The switch which was closed for a long time is open at time $t = 0$.

- Compute $i(t)$ for $t \geq 0^+$.
- Compute $V_L(t)$ for $t \geq 0^+$.

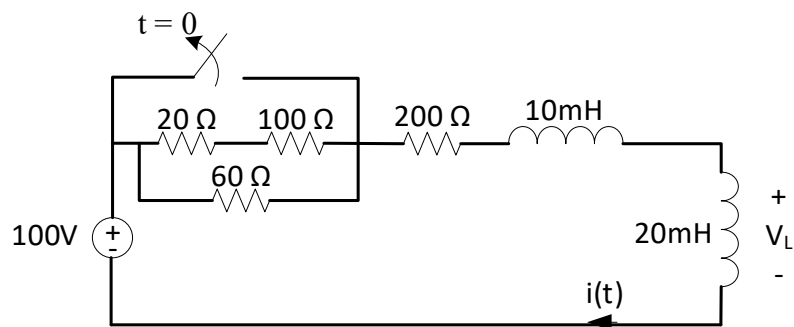


Figure 5

Question 6 (14 points = 2 (a) + 2 (b) + 2 (c) + 2 (d) + 2 (e) + 2 (f) + 2 (g))

Consider the circuit shown in Figure 6 where $I = 4 \angle 35^\circ$ A rms.

- a) Find the average power supplied by the source
- b) Find the average power supplied to the $20\ \Omega$ resistor
- c) Find the average power supplied to the load
- d) Find the apparent power supplied by the source
- e) Find the apparent power supplied to the $20\ \Omega$ resistor
- f) Find the apparent power supplied to the load
- g) Compute the power factor of the load.

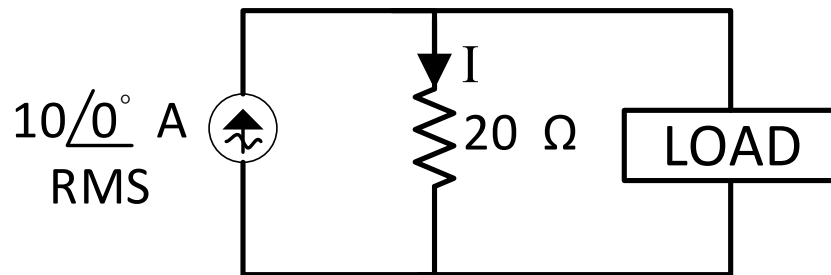


Figure 6