

# ORDRE DES INGÉNIEURS DU QUÉBEC

May 2023 SESSION

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

## 16-EL-A1-CIRCUITS

### Question 1 (16 points = 12 (a) + 4 (b) )

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

- a) Provide the equation describing the voltage ratio  $\frac{V_{out}}{V_{in}}$  as a function of the 4 resistors, i.e.  
$$\frac{V_{out}}{V_{in}} = f(R_1, R_2, R_3, R_4).$$
- b) Assume that  $R_1 = R_2 = 1\text{ k}\Omega$  and  $R_3 = 3\text{ k}\Omega$ . Compute the value of  $R_4$  required to obtain  $\frac{V_{out}}{V_{in}} = \frac{1}{6}$ .

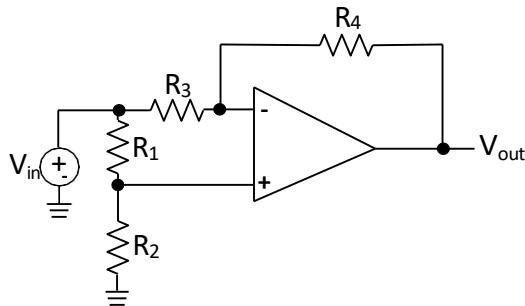


Figure 1

### Question 2 (16 points)

Compute the current ratio,  $HH(ss) = \frac{I_{LL}}{I_{SS}}$  in the circuit shown in Figure 2.

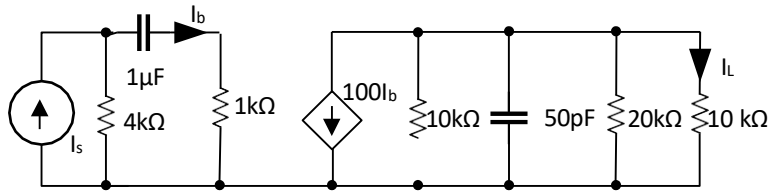


Figure 2

### Question 3 (19 points = 15 (a) + 4 (b) )

Consider the circuit shown in Figure 3.

- Compute the average power absorbed by each of the three passive elements.
- Compute the average power supplied by each source.

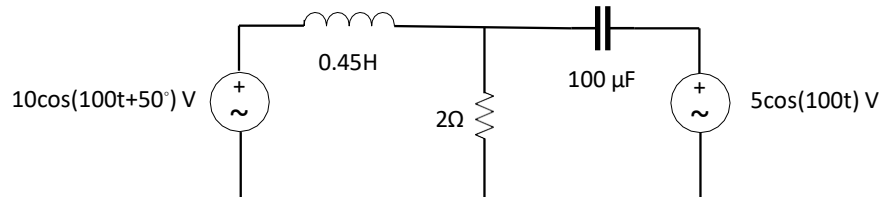
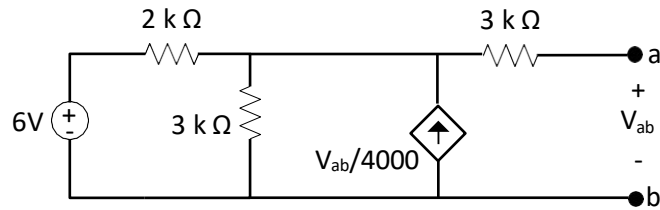


Figure 3

**Question 4 (17 points = 12 (a) + 5 (b) )**

Consider the circuit shown in Figure 4.

- a) Draw the Norton equivalent circuit
- b) Draw the Thevenin equivalent circuit

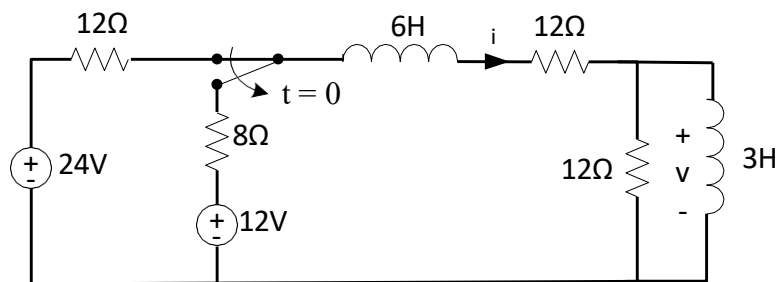


**Figure 4**

**Question 5 (20 points = 20 (a) + 4 (b) )**

Consider the circuit shown in Figure 5. The switch which was in the initial position for a long time is moved to the second position at time  $t = 0$ .

- a) Compute  $i(t)$  for  $t \geq 0^+$ .
- b) Compute  $v(t)$  for  $t \geq 0^+$ .



**Figure 5**

**Question 6 (8 points)**

Consider the circuit shown in Figure 6 where a 60-Hz generator ( $V_G$ ) supplies a load through a transmission line of resistance  $R_T = 20\ \Omega$ . A capacitance is added in parallel with the load to correct the power factor to unity. With the capacitor in place, the load-voltage effective value is 1000V. The load takes 200 kVA at a lagging power factor of 0.707. Find the value of the capacitance.

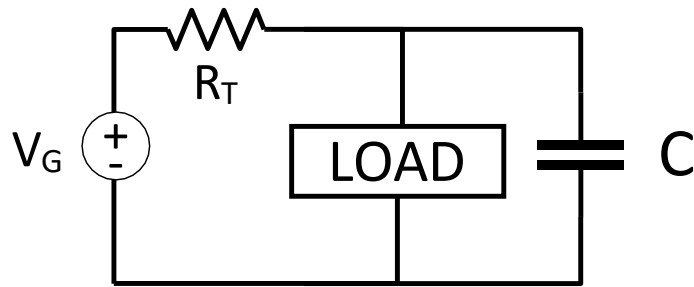


Figure 6