

**COURSE TEST 2 EL10A CIRCUIT ANALYSIS  
NOVEMBER, 26<sup>TH</sup> 2004**



**Instructions:**

- 1. Answer the three questions. Question 4 will be provided on Wednesday, 2<sup>nd</sup> December, 2004**

	<b>Marks</b>
<b>Question 1</b>	<b>/25</b>
<b>Question 2</b>	<b>/25</b>
<b>Question 3</b>	<b>/25</b>
<b>Question 4</b>	<b>/25</b>
<b><u>Total Course Test # 2</u></b>	<b><u>/10</u></b>

## Question 1 First Order

Answer the following questions on the circuit in Figure 1.1. SW1 is closed for a long time before  $t = 0$ . It is then opened at  $t = 0$ .

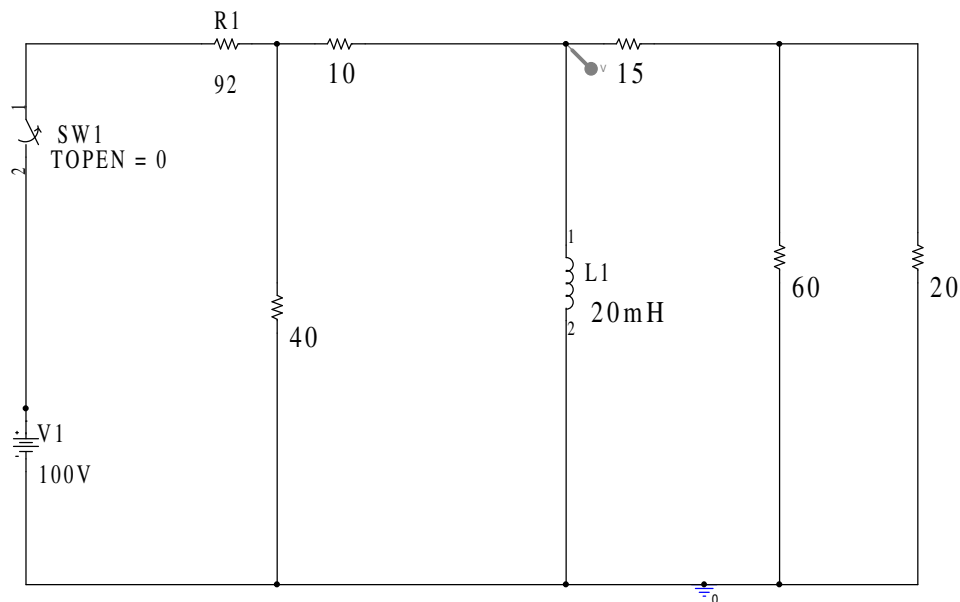


Figure 1.1

- 1.1.1 **Draw** the circuit as it would appear before SW1 is opened at time  $t = 0$ . (3)
- 1.1.2 **Calculate** the initial current which flows in the inductor,  $I_0$ . (3)
- 1.1.3 **Draw** the circuit just after the switch is opened at time  $t = 0$ . (3)
- 1.1.4 **Calculate** the time constant for the circuit. (3)
- 1.1.5 **How** long will it take before the current in the inductor has decayed to 20% of its initial value. (3)
- 1.1.6 **Simulate** the circuit and attach a graph of the decay of the current with time. Use this graph to verify your calculation in 1.1.5. (3)
- 1.1.7 **Redraw** your circuit of 1.1.3 with currents in the inductor and equivalent resistor clearly marked. **What** is the initial voltage across the inductor and equivalent resistor? (3)
- 1.1.8 **How** long will it take for the voltage across the inductor and equivalent resistor to decay to 40% of the initial value? (4)

## Question 2. RLC circuits

### 1.1 Answer the following questions on Figure 2.1.

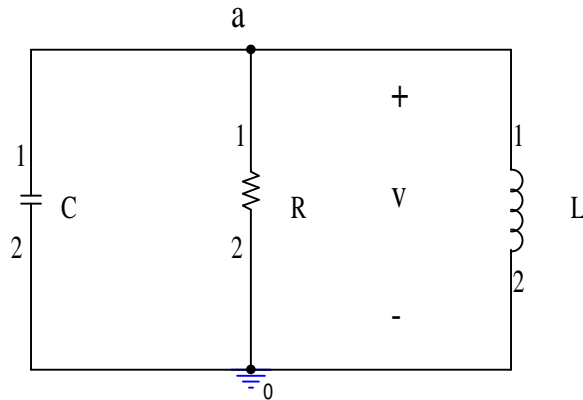


Figure 2.1

- 2.1.1 **Apply** KCL to sum the three currents at node a expressed in terms of  $v$  and hence show that  $\frac{d^2v}{dt^2} + \frac{1}{RC} \frac{dv}{dt} + \frac{v}{LC} = 0$  (3)
- 2.1.2 **Write** down expressions for the two characteristic roots. (2)
- 2.1.3 **What** expression for  $R$  will determine if the circuit will be critically damped for given values of  $L$  and  $C$ ? (2)

**Initial conditions are set as follows.  $V_0=12\text{Volts}$ ,  $I_0 = 0\text{ma}$ . Component values are set at  $R=80\Omega$ ,  $L=20\text{mH}$  and  $C=0.5\mu\text{F}$ .**

- 2.2.1 **Determine** the type of damping present in the circuit. (2)
- 2.2.2 **Demonstrate** your circuit and confirm that the damping is what you predicted. (**Attach** a graph from PSPICE.) (2)
- 2.2.3 **Determine** the values of the characteristic roots. (3)
- 2.2.4 **Calculate** the current which flows in the resistor at time  $t = 0^+$ ? (2)
- 2.2.5 **Calculate** the current which flows in the capacitor at time  $t = 0^+$ ? (2)
- 2.2.6 **Write** down the general form of the solution of the differential equation and **determine** the constants from the initial conditions. (4)
- 2.2.7 **Match** your simulation result to your calculated result for time  $t=200$  microseconds. **Show** your graph. (3)

## Question 3 OPAMPS

### 3.1 Answer the following questions on the circuit in Figure 3.1

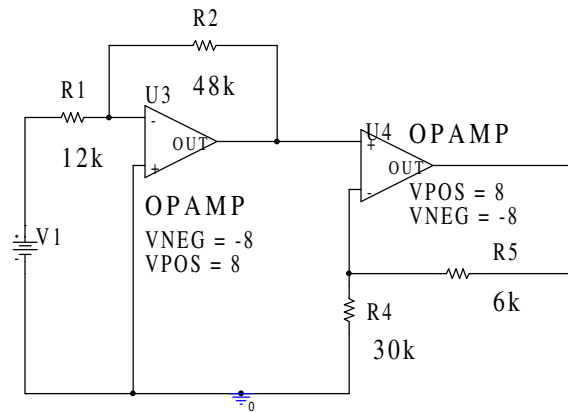


Figure 3.1

- 3.1.1 **What** property of an ideal amplifier determines the voltage on the inverting input terminal of U3 and **what** is it? (2)
- 3.1.2 **Determine** the output voltage of U3 in terms of its input voltage, V1. (3)
- 3.1.3 **What** is the voltage on the inverting input terminal of U4? (1)
- 3.1.4 **Determine** the output voltage of U4 in terms of the input voltage V1. (4)
- 3.1.5 **What** range of input voltages will keep the output of U4 from saturating? (3)
- 3.1.6 **Simulate** the circuit with V1 chosen in the middle of the range and attach the result of the bias simulation to show that your calculated value agrees with the simulated value. (2)

### 3.2 A resistor R3 is added to the circuit as shown in Figure 3.2.

- 3.2.1 **Apply** KCL at the inverting terminal of U3 and derive the relationship between the output voltage at U4 and the input voltage V1. **Hint: the same relationship from above which applied to U4 again holds true.** (5)
- 3.2.2 **What** range of input voltages will keep the output of U4 from saturating? (3)
- 3.2.3 **Simulate** the circuit and attach the result of the bias simulation to show that your calculated value agrees with the simulated value if V1 is set in the middle of the range. (2)

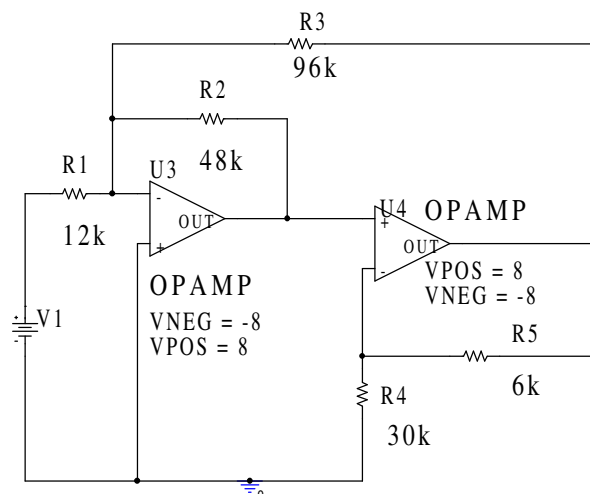


Figure 3.2

## **Question 4 General**

### **4.1 OPAMPS**

- 4.1.1 What are the fundamental rules that govern the analysis of OPAMP circuits? (2)
- 4.1.2 Use these rules to determine the gain of the two circuits of Figure 4.1. (4)

### **4.2 Capacitors and Inductors**

- 4.2.1 Write down the  $v/i$  and  $i/v$  relationships that exist for capacitors and inductors. (2)

### **4.3 RL and RC Circuits.**

- 4.3.1 **Write** down the two general equations that govern the step and natural response of an inductor and capacitor at time  $t$  when charging and discharging through a resistor. (3)
- 4.3.2 **Calculate** the final values of the current (for the inductor) and voltage (for the capacitor) which the following two circuits of Figure 4.3 will support and how long will it be before the current and voltage reach 60% of these values? (4)

### **4.4 RLC circuits**

- 4.4.1 **Write** down the two characteristic roots of the equations which describe the behaviour of the voltage in a parallel RLC circuit in terms of  $R, L$  and  $C$ . (2)
- 4.4.2 **What** is the difference between these formulae and the ones for the current equation in a series RLC circuit? (1)
- 4.4.3 **What** sort of damping exists in the three circuits given in Figure 4.4? (4)
- 4.4.4 **What** is the frequency, in Hertz not radians/sec, at which the under-damped circuit will oscillate? (3)

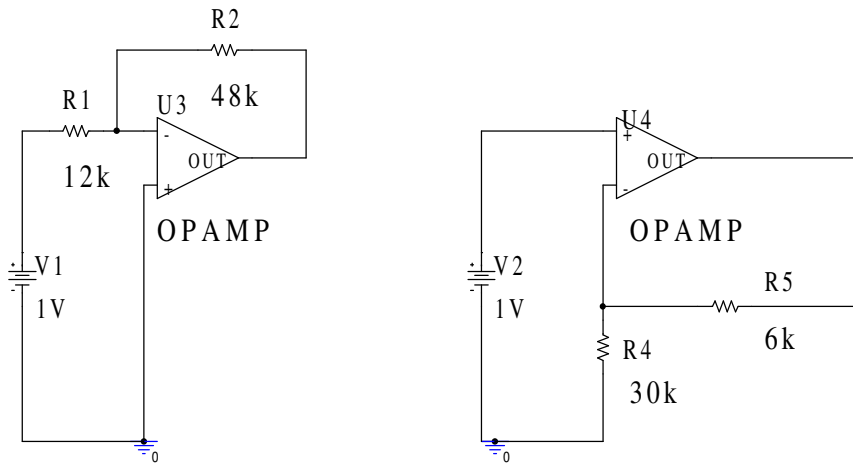


Figure 4.1

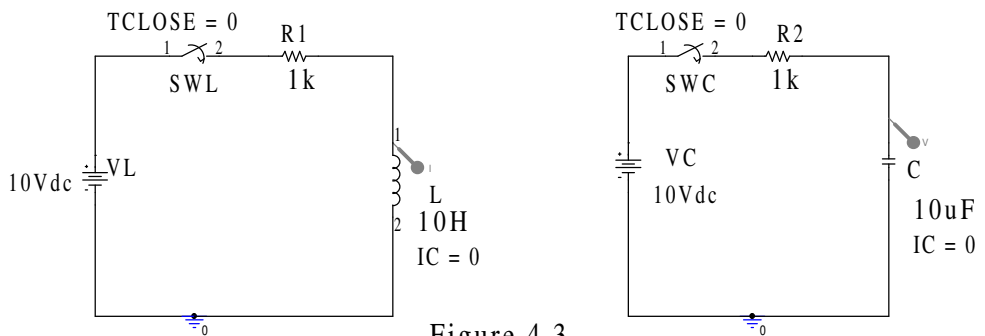


Figure 4.3

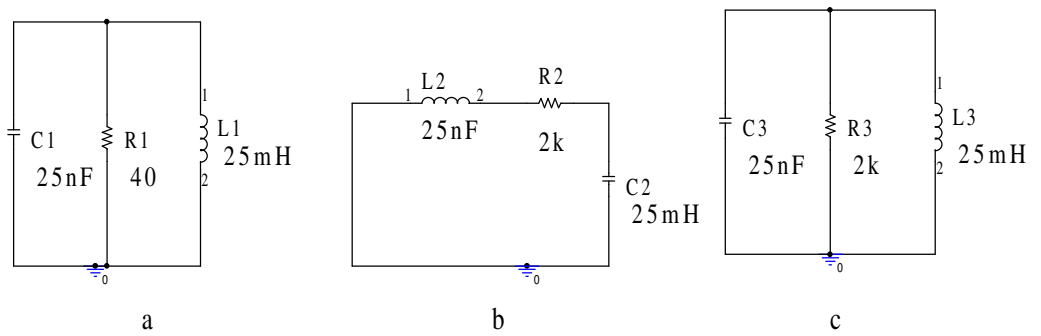


Figure 4.4