GLASGOW COLLEGE UESTC

Exam paper

Circuits Analysis and Design (UESTC 2022)

Date: Dec.27th, 2021
Time: 9:30-11:30am

Attempt all PARTS. Total 100 marks

Use one answer sheet for each of the questions in this exam.
Show all work on the answer sheet.

For Multiple Choice Questions, use the dedicated answer sheet provided.

Make sure that your University of Glasgow and UESTC Student Identification Numbers are on all answer sheets.

An electronic calculator may be used provided that it does not allow text storage or display, or graphical display.

All graphs should be clearly labelled and sufficiently large so that all elements are easy to read.

The numbers in square brackets in the right-hand margin indicate the marks allotted to the part of the question against which the mark is shown. These marks are for guidance only.

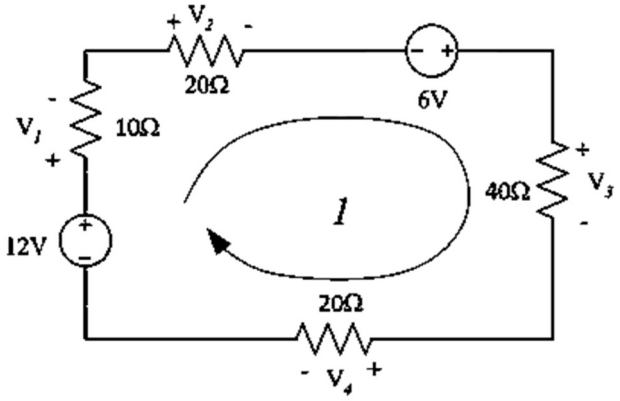
Attempt all PARTS

Q1 Choose a single answer to each of the following multiple-choice questions in the answer sheet provided. **Make sure that you provide your answers in the answer sheet, not on this paper.**

(1) A loop of a circuit is a closed path starting from a node and returning to_____ [2]

A. The ground
B. The voltage source
C. The same node
D. The same mesh

(2) Which one of the following Kirchhoff's Voltage Law (KVL) equations describes the circuit given in the figure? [3]



A. $+12V + V_1 + V_2 + 6V + V_3 + V_4 = 0$
B. $+12V - V_1 - V_2 + 6V - V_3 + V_4 = 0$
C. $-12V + V_1 + V_2 - 6V + V_3 + V_4 = 0$
D. $-12V + V_1 + V_2 + 6V + V_3 + V_4 = 0$

(3) Three capacitors with capacitance values of $C_1 = 0.1$ μF, $C_2 = 0.22$ μF, and $C_3 = 0.47$ μF are connected in parallel. The equivalent capacitance value is: [3]

A. 790 μF
B. 79 μF
C. 0.79 μF
D. 0.079 μF

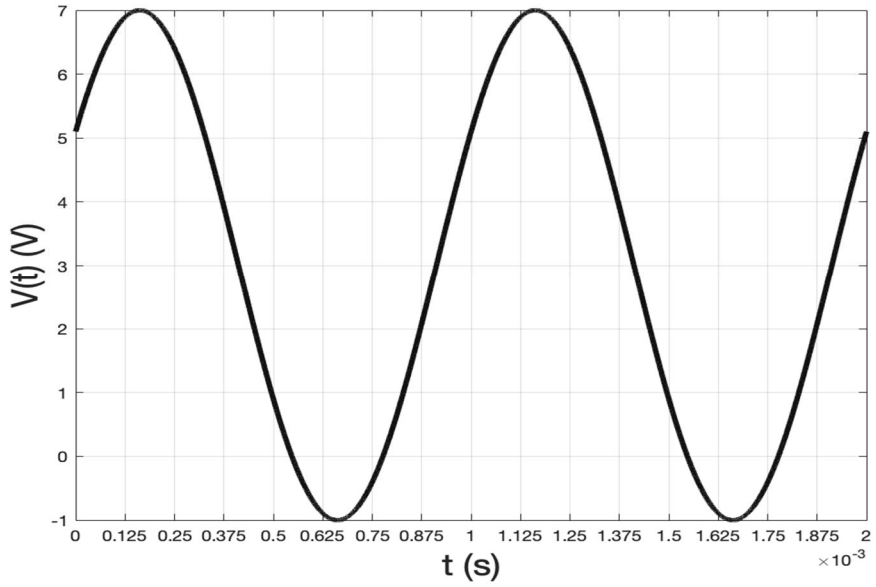
(4) Calculate the impedance of an RL series element with R=500Ω and L=20mH at the operating frequency of 2 kHz [4]

A. 500+j40Ω
B. 500+j251.3Ω
C. 500-j0.025Ω
D. 500-j1.98Ω

(5) Before a transient event at $t=0^+$, what is the value of the voltage across an inductor if a generic circuit having DC input has been at steady state for a long time? [3]

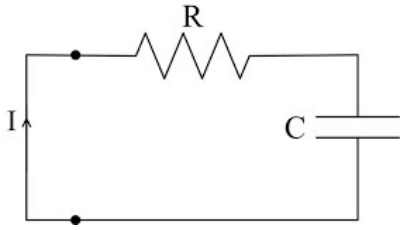
A. Equal to the integral of the current
B. Equal to inductance multiplied by the integral of the current
C. Equal to the product of the current and the inductance
D. None of the above answers are correct

(6) For the sinusoidal signal given in figure below, phase angle at *t=0* is [3]



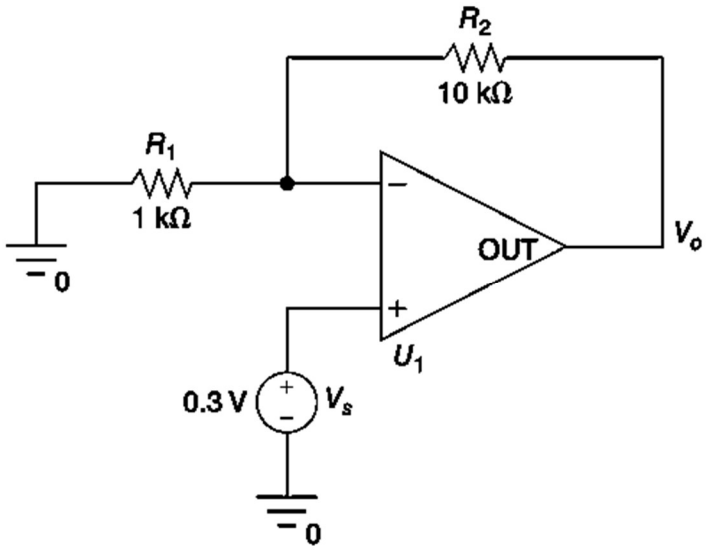
A. 0°
B. -30°
C. -45°
D. -60°

(7) In the following circuit, the resistor is R= 4kΩ and the capacitor is C = 0.5μF, what is the value of the time constant? [3]



A. 0.0002 second
B. 0.002 second
C. 0.008 second
D. 0.08 second

(8) What is the value of V_0 in the following circuit? [4]



A. 3.3V
B. 0V
C. 0.3V
D. 1.1V

Q2 For the circuit shown in the Figure Q2:

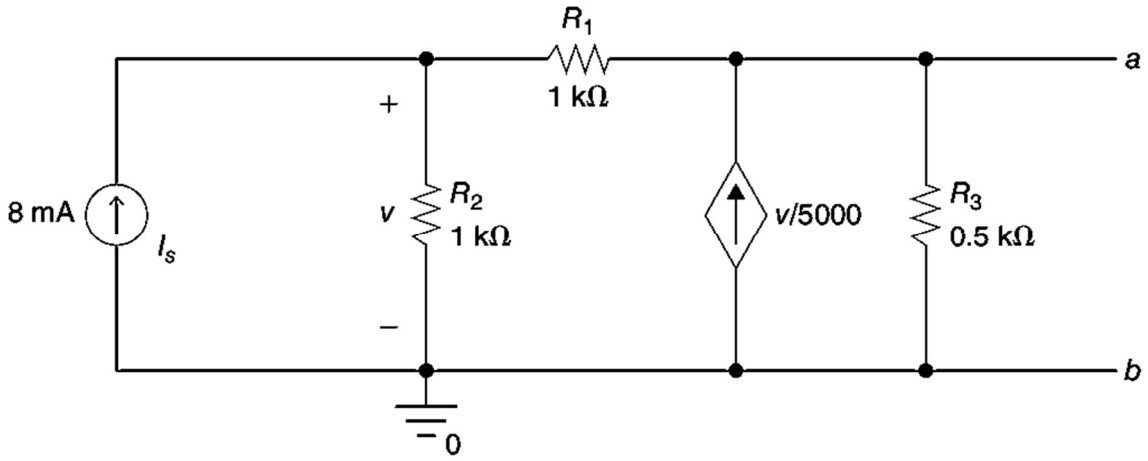


Figure Q2

Note: Please write your answers on the Q2 answer sheet.

(a) Find the open circuit voltage between terminals *a* and *b*. [8]

(b) Draw the resulting circuit diagram if terminals *a* and *b* are short circuited. Also, find the short circuit current. [8]

(c) Using your calculations in Part (a) and (b), find the Norton equivalent resistance for the circuit. [2]

(d) Draw the Norton equivalent for the given circuit. [2]

(e) Which principle can be used to transform the Norton equivalent circuit in Part (d) to the Thévenin equivalent circuit? Find the values of corresponding Thévenin equivalent voltage and resistance and draw the circuit. [5]

Q3 As a radio engineer, you are required to design an RF system having the block diagram as given in Figure Q3-a.

Figure Q3-a

Note: Please write your answers on the Q3 answer sheet.

(a) The filter is implemented using a circuit as shown in Figure Q3-b having V_{in}=12V and R=2kΩ. The filter has a Q factor of 10 and a bandwidth of 10kHz. Calculate the expression of its frequency response with input V_{in} and output V_o as a function of ω. [4]

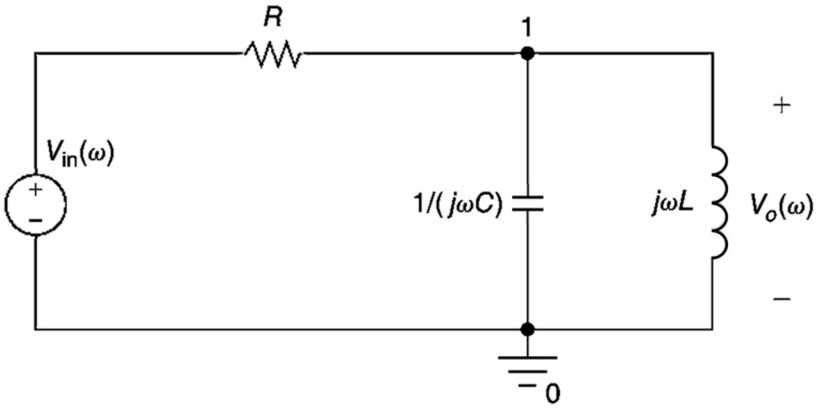


Figure Q3-b

(b) Calculate the resonant frequency of the filter. [4]

(c) Two inductors, L_1=50mH and L_2=50μH are available. Which inductor you would be using in the filter circuit to meet the design specifications given in Part (a)? Justify your choice based on calculations. [5]

(d) Using the chosen value of the inductor in Part (c), calculate the value of the capacitor that meets the filter specifications given in Part (a). [4]

(e) Another capacitor of what value must be connected in series with the one calculated in Part (d) to increase the bandwidth by 100%? [4]

(f) If an input radio signal having a spectrum shown in Figure Q3-c is applied to the input, sketch the spectrum of the output signal of the system. [4]

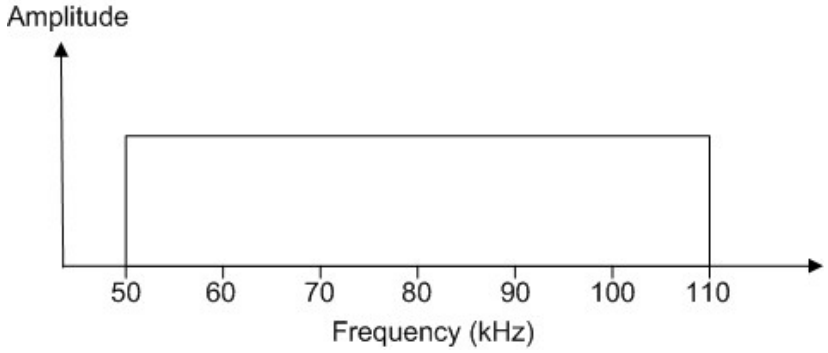


Figure Q3-c

Q4 Switch 1 in the circuit shown in Fig Q4-a has been closed for a long time before it is opened at t = 0. Switch 2 is closed at t = 0.12s.

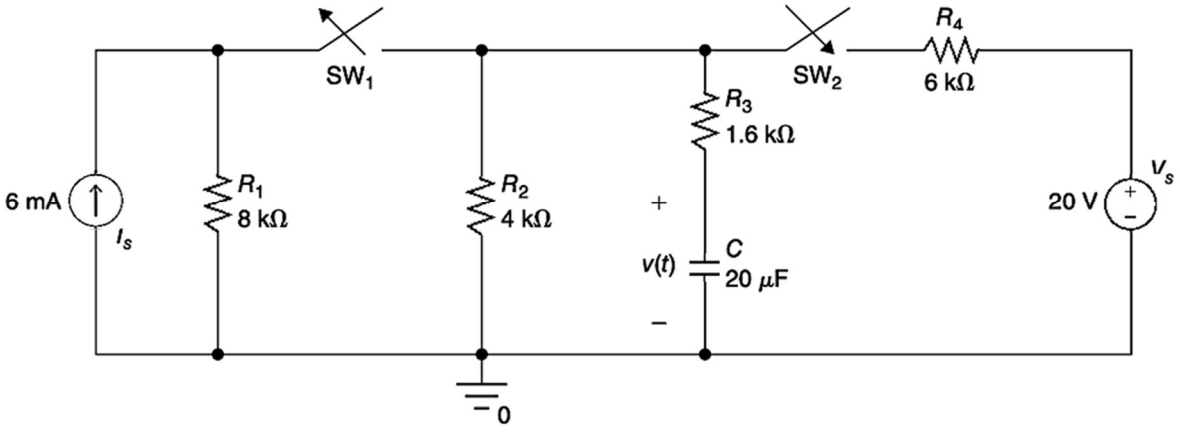


Figure Q4-a

Note: Please write your answers on the Q4 answer sheet.

(a) Find the initial voltage across the capacitor at $t = 0$; that is v(0) = V_0 . [5]

(b) Find the expression of the voltage $v(t)$ across the capacitor for $0 \leq t < 0.12$ s. [5]

(c) Find the value of the voltage $v(t)$ across the capacitor at $t = 0.12$ s. [5]

(d) Find the expression of the voltage $v(t)$ across the capacitor for $t > 0.12$ s. [5]

(e) Please draw the voltage curve in your Q4 answer sheet. [5]

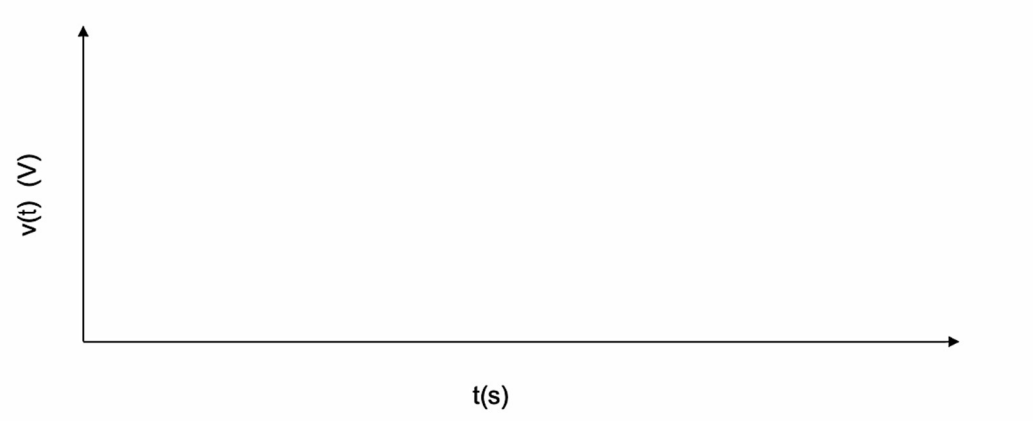


Figure Q4-b