GLASGOW COLLEGE UESTC

Exam paper

Circuits Analysis and Design (UESTC 2022)

Date: 27th Dec. 2018
Time: 09:30-11:30 AM

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

Continued overleaf

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) According to Ohm's law, the voltage drop across a resistor is [2]

A. inversely proportional to the current
B. inversely proportional to the resistance
C. always equal to the current
D. none of these answers
E. independent of the resistance

(2) Three identical resistors R=33Ω are connected in parallel. What is the equivalent resistance? [2]

A. 297 Ω
B. 0.01 Ω
C. 99 Ω
D. 11 Ω
E. None of these answers

(3) An AC signal with angular frequency ω=6280 rad/s has a corresponding common frequency of? [2]

A. Approximately 1 kHz
B. Approximately 6300 kHz
C. Approximately 6.28 Hz
D. None of these answers
E. Approximately 1 kHz

(4) The impedance of a capacitor can be calculated as [2]

A. $Z = j\omega C$
B. $Z = 1/j\omega C$
C. $Z = jC/\omega$
D. $Z = j\omega/C$
E. None of these answers

(5) A filter that attenuates signals with frequency components below the cut-off frequency is called [2]

A. A low pass filter
B. A band pass filter
C. A high pass filter
D. None of these answers
E. A band stop or notch filter

(6) The value of the time constant of a *RC* series circuit with R=25kΩ and C=40nF is equal to [2]

A. 10ms
B. 1s
C. 1ms
D. 100ms
E. None of these answers

Continued overleaf

(7) The Norton theorem transforms an electric circuit into a simpler equivalent circuit typically made of [2]

A. An equivalent current source and a parallel impedance
B. An equivalent current source and a series impedance
C. An equivalent voltage source and a series impedance
D. An equivalent voltage source and a parallel impedance
E. None of these answers

(8) Write the phasor of the voltage source $V(t) = 16\cos(2\pi 1000t + 30°)\,V$ [2]

A. $16e^{j1000°}$
B. $16e^{-j30°}$
C. $16e^{j\pi/6}$
D. $16e^{j\pi/4}$
E. None of these answers

(9) Consider an electrical circuit containing a resistor R, a capacitor C, and an inductor L in series. What can you do in general to make sure that the transient of the circuit is overdamped and does not present sinusoidal oscillations? [2]

A. Increase the value of the resistance
B. Decrease the value of the resistance
C. None of these answers
D. Increase the value of the inductance
E. Decrease the value of the capacitance

(10) Before a transient event at $t=0^+$, what is the value of the current flowing through a capacitor if the DC circuit has been at steady state for a long time? [3]

A. Equal to the second derivative of the voltage
B. Equal to the integral of the voltage
C. Equal to zero
D. Equal to the product of the voltage and the capacitance
E. None of these answers

(11) Calculate the impedance of an RC series element with R=1kΩ and C=15μF at the operating frequency of 1000 Hz [4]

A. 1000-j66.67Ω
B. 1000+j0.094Ω
C. 1000-j10.61Ω
D. None of these answers
E. 1000+j0.015Ω

Continued overleaf

Q2

(a) A band-pass filter can be implemented by using a first order low-pass filter and a first order high-pass filter. Sketch the circuit diagram, indicating the input and the output signals. [3]

(b) Sketch the theoretical frequency response of the gain of the band-pass filter, indicating the two cut-off frequencies with respect to the high-pass filter and the low-pass filter sections of the circuit. [3]

(c) Assume to have as input of your band-pass filter an audio signal *v(t)*, with its most relevant information within the bandwidth from 2 to 4 kHz. Design the band-pass filter accordingly, choosing among the following available components: R1=3.3kΩ, R2=1.8kΩ, C1=21nF, C2=33nF.
Explain your choice of components used for the high pass and low pass sections of the band-pass filter. Calculate the cut-off frequencies of your band-pass filter, and sketch the circuit.
Assume that there are no loading effects between the high pass and low pass sections, i.e. they do not influence each other's behaviour. [7]

(d) The resistors available to you have a tolerance of 10% on their values. What is the widest and narrowest bandwidth that your band-pass filter can achieve? (Consider the difference between the two cut-off frequencies as a measure of the filter bandwidth) [6]

(e) Your input audio signal *v(t)* changes, and lower frequencies components in the band 0.8-2 kHz are added to its significant bandwidth. Modify your band-pass filter so that its pass-band includes also these additional frequencies. Comment on what components you would change to redesign your filter, how you would change them (smaller or larger values?), and why. [6]

Continued overleaf

Q3 For the circuit shown in Figure 1 below.

a) Find the current flowing from top to bottom in the 10 kΩ resistor. [5]

b) Find the voltage drop across the 10 kΩ resistor, positive at the top [5]

c) Use voltage division to find the voltage across the 2 kΩ resistor, positive at the top. [5]

d) Using part (c) result, find the current through the 2 kΩ resistor from top to bottom. [5]

e) Use current division to find the current through the 18 kΩ resistor from top to bottom. [5]

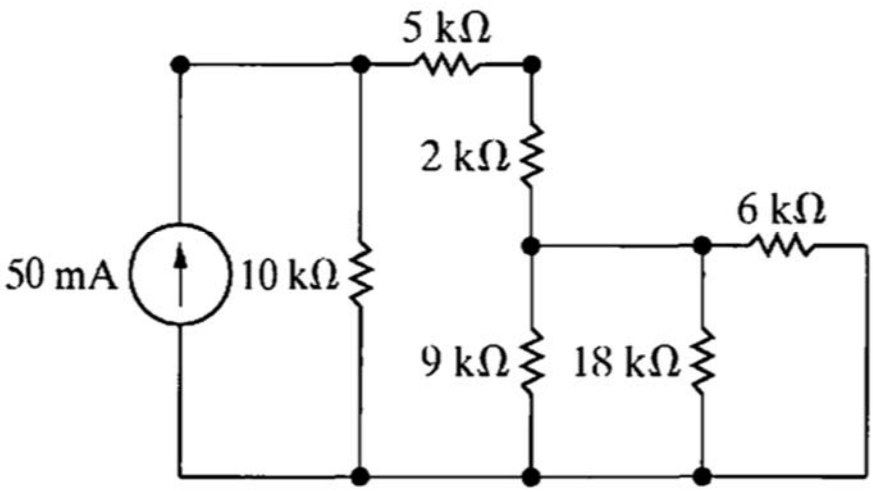

Figure 1

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Q4 For the circuit shown in Figure 2 below.

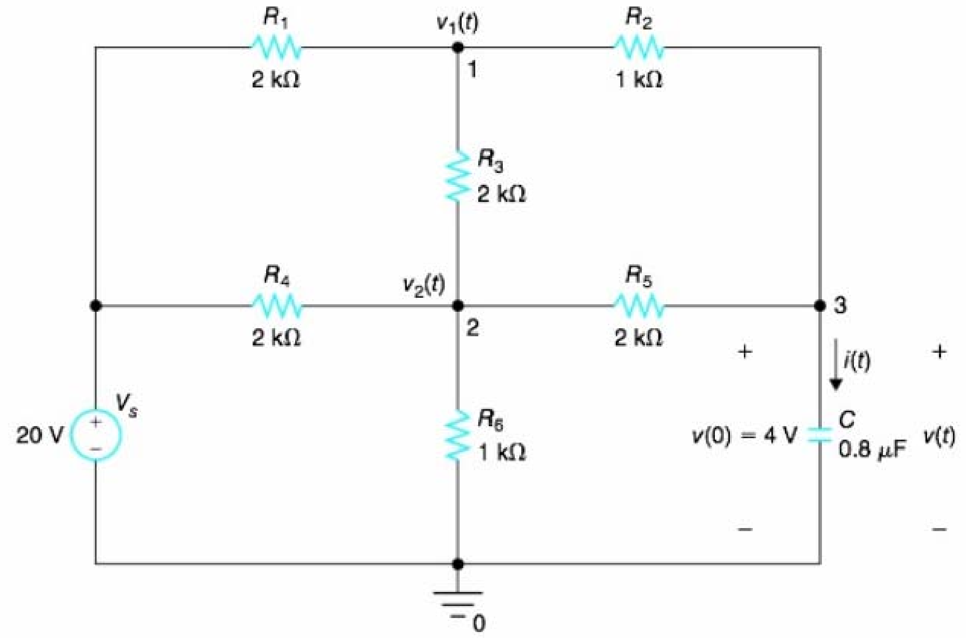

Figure 2

a) Write a node equation at node 1. Notice that the voltage at node 3 is given by $v3(t) = v(t)$. [5]

b) Write a node equation at node 2 by summing the currents away from node 2. Notice that the voltage at node 3 is given by $v3\ (t) = v(t)$. [4]

c) Solve the two node equations from (a) and (b) to express $v1(t)$ as a function of $v(t)$, and $v2(t)$ as a function of $v(t)$. [4]

d) Write a node equation at node 3 by summing the currents away from node 3. Use the results from (c) to simplify the equation as a first-order differential equation of $v(t)$. [4]

e) Solve the differential equation to find voltage $v(t),\ t \geq 0$, across the capacitor and plot $v(t)$. [4]

f) Find current $i(t)$, $t \geq 0$, through the capacitor and plot $i(t)$. [4]

End of question paper