[ENG61]

UNIVERSITY OF BOLTON

SCHOOL OF ENGINEERING

B.ENG (HONS) ELECTRICAL & ELECTRONIC ENGINEERING

SEMESTER 2 EXAMINATION 2024/25

ANALOGUE SIGNAL PROCESSING & COMMUNICATIONS

MODULE NO: EEE5015

Date: May 2025 **Time:10.00am - 12.30pm**

INSTRUCTIONS TO CANDIDATES:

There are SIX questions.

Answer any FOUR questions.

All questions carry equal marks.

Marks for parts of questions are shown in brackets.

Electronic calculators may be used provided that data and program storage memory is cleared prior to the examination.

CANDIDATES REQUIRE:

A formula sheet is included following questions.

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Question 1

Consider the second order passive high pass filter shown in Figure 1. The component values are

$$R = 360\Omega \quad C = 25\mu F \quad L = 800mH$$

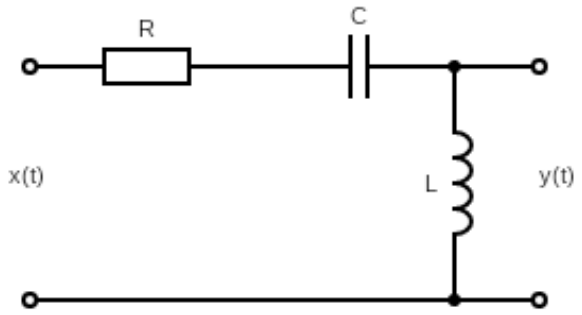

Figure 1

(a) Calculate $\frac{R}{L}$ and $\frac{1}{LC}$ and hence find the transfer function *H(s)* of the system.

(10 marks)

(b) Resolve the transfer function $H(s)$ into partial fractions.

(10 marks)

(c) Hence find the impulse response $h(t)$ of the system.

(5 marks)

Total - 25 marks

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Question 2

(a) A system has impulse response $h(t) = 30e^{-50t}$.

Suppose that the input to the system is a step $x(t) = 20$ for $x > 0$.

By convolution, calculate the output $y(t) = h(t) * x(t)$

(10 marks)

(b) Consider the filter shown in Figure 2. The component values are

$$R_1 = 1k\Omega \quad R_2 = 2k\Omega \quad L = 100mH$$

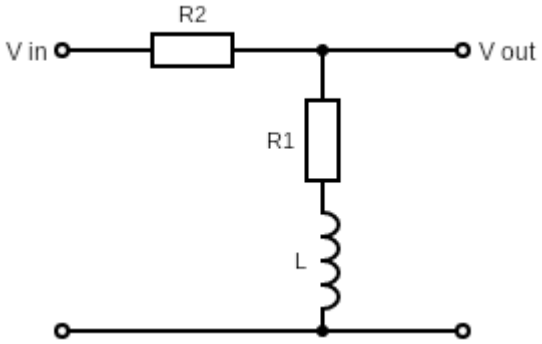

Figure 2

Find the transfer function of this filter.

(5 marks)

For a sine wave input with $\omega = 20000$*rad/s* determine the frequency response by finding

(i) the gain

(6 marks)

(ii) the phase shift

(4 marks)

Total - 25 marks

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Question 3

(a) State the poles of each of the following transfer functions:

$$\frac{200s}{s^2+200s+20000} \qquad \frac{30000}{s^2+200s-30000} \qquad \frac{s^2}{s^2+90000}$$

In each case, comment on the stability of the corresponding system.

(10 marks)

(b) A voltage rises on a ramp from 0 volts at *t* = 0 to 1 volt at *t* = 1.

It remains constant at 1 volt until *t* = 2, and then falls back to 0 volts.

This is shown in Figure 3 below.

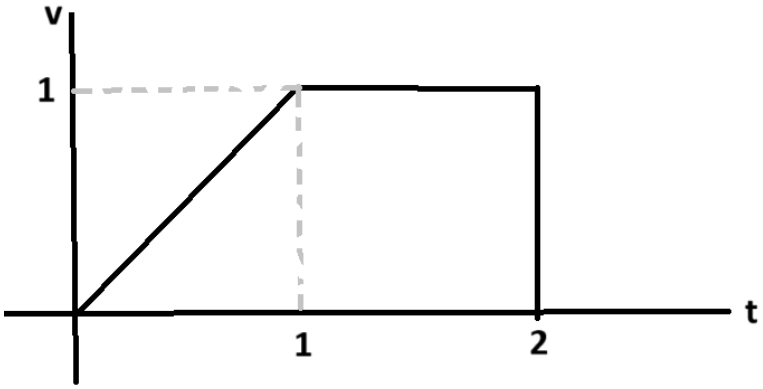

Figure 3

Using shift in the t domain, find the s domain representation of the signal.

(8 marks)

(c) Suppose that the signal in part (b) above is extended to all positive t by making the function periodic with a period $T = 3$. Express the Laplace transform as a geometric series, and hence find the s domain representation of the periodic signal.

(7 marks)

Total - 25 marks

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Question 4

Consider the inverting high pass filter system shown in Figure 4.

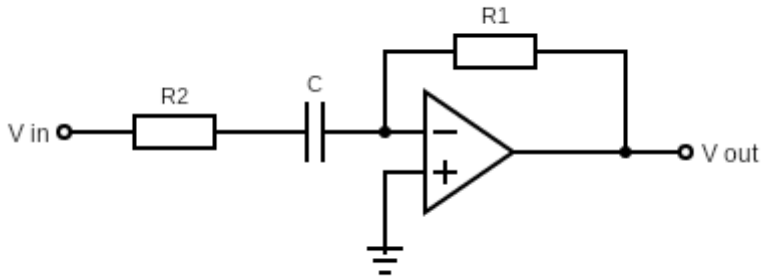

Figure 4

(a) Find the transfer function of the system.

(7 marks)

(b) The value of the capacitor is $C = 0.25\mu F.$

If the corner frequency is required to be 800 rad/s, find the value of the resistor R_2.

(4 marks)

(c) Find the value for the resistor R_1 for which the gain of the filter tends toward -5 as the frequency increases.

(4 marks)

(d) Find the response of the filter to the input $x(t) = \sin 600t$ volts.

(10 marks)

Total - 25 marks

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Question 5

(a) For a first order low pass filter, draw and label Bode plots for magnitude and phase shift. Your magnitude plot should include the approximate slope of the graph, and your phase shift plot should label relevant angles.

(8 marks)

Repeat this procedure for a band pass filter.

(8 marks)

(b) An active second band stop filter is implemented using the circuit in figure 5.

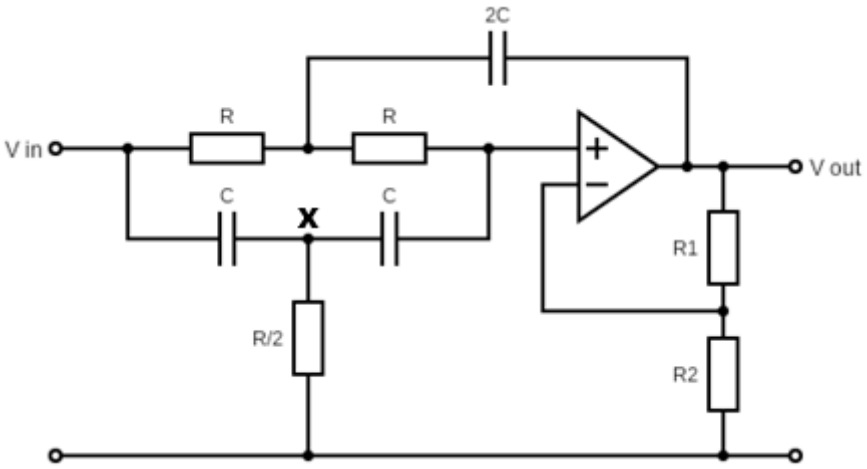

Figure 5

The required centre frequency of the filter is 50000rad/s. The two resistors labelled R have value $4\text{k}\Omega$. Assuming that the two capacitors that meet at the point **x** have the same value, find this value.

(3 marks)

The *Q* factor is related to the gain *A* of the op amp by

$$Q = \frac{1}{4 - A}$$

The required Q factor of the filter is 5. Suggest values for the two resistors R1 and R2.

(6 marks)

Total - 25 marks

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Question 6

(a) Describe the roles of the *D* and *F* layers of the ionosphere in radio wave propagation for frequencies between 3 MHz and 30 MHz.

(10 marks)

Explain which frequency ranges are typically most useful for long range communication during daylight hours and during the night.

(5 marks)

(b) A dipole antenna is designed to have a resonant frequency of 120 MHz.

Calculate the total length of the dipole in centimetres.

(6 marks)

Draw a sketch of the radiation pattern of the dipole.

(4 marks)

Total - 25 marks

END OF QUESTIONS

Formula sheet follows over the page

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FORMULA SHEET

Table of Laplace Transforms

$f(t)$	$F(s) = \int_0^\infty f(t)e^{-st}dt$
$\delta(t)$	1
$u(t)$	$\frac{1}{s}$
t	$\frac{1}{s^2}$
$e^{-\alpha t}$	$\frac{1}{s+\alpha}$
$\sin \omega t$	$\frac{\omega}{s^2+\omega^2}$
$\cos \omega t$	$\frac{s}{s^2+\omega^2}$
$e^{-\alpha t}f(t)$	$F(s+\alpha)$
$tf(t)$	$-\frac{d}{ds}F(s)$
$f'(t)$	$sF(s)-f(0)$

End of Formula Sheet

END OF PAPER