[ENG03]

UNIVERSITY OF BOLTON

SCHOOL OF ENGINEERING

BENG (HONS) ELECTRICAL & ELECTRONIC ENGINEERING

SEMESTER 2 EXAMINATIONS 2022/23

ANALOGUE SIGNAL PROCESSING & COMMUNICATIONS

MODULE NO: EEE5015

Date: Friday 12th May 2023 **Time:10.00am - 12.30pm**

INSTRUCTIONS TO CANDIDATES:

There are SIX questions.

Answer any FOUR (4) 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 band pass filter shown in Figure 1, with input and output $x(t)$ and $y(t)$ respectively. The component values are

$$R = 160\Omega \quad C = 25\mu F \quad L = 800mH$$

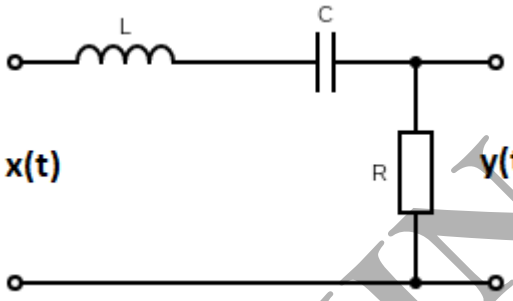

Figure 1

(a) Calculate $\frac{R}{L}$ and $\frac{1}{LC}$ and hence find the transfer function *H(s)* of the system. **(8 marks)**

(b) Complete the square in the denominator of *H(s)* **(5 marks)**

(c) Hence find the impulse response *h(t)* of the system. **(12 marks)**

Total 25 marks

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Question 2

(a) A system has impulse response $\mathrm{h(t)} = 250\mathrm{e}^{-250\mathrm{t}}$.

Suppose that the input to the system is $x(\mathrm{t}) = e^{-300t}$

By convolution, calculate the output $\mathrm{y(t)} = \mathrm{h(t)} * \mathrm{x(t)}$

[10 marks]

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

$$\mathrm{R_1} = 2\mathrm{k\Omega} \quad \mathrm{R_2} = 6\mathrm{k\Omega} \quad \mathrm{L} = 100\mathrm{mH}$$

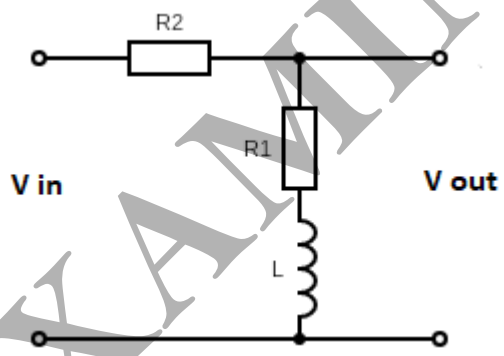

Figure 2

Find the transfer function of this filter. **[5 marks]**

For a sine wave input with $\omega = 50000$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) An active high pass filter has transfer function given by

$$\frac{As^2}{s^2 + 50(3 - A)s + 2500}$$

where *A* is a parameter set by the gain of an op amp.

For each of the following values of *A*, find the poles of the transfer function, and comment on the stability of the system.

(i) $A = 0.5$ (ii) $A = 1.4$ (ii) $A = 3.0$ **[10 marks]**

(b) A voltage rises from 0 volts to 4 volts at t = 0, drops to 3 volts at t = 1, and falls back to 0 volts at t = 3. This is shown in Figure 3 below.

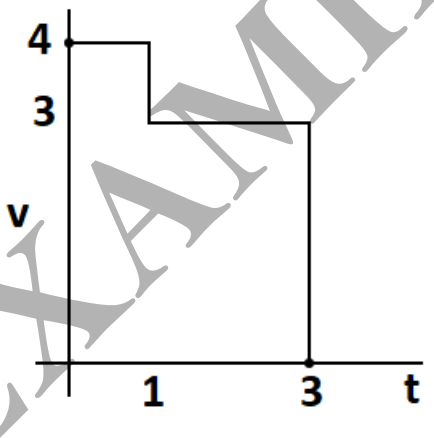

Figure 3

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 $T = 4$. 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 filter system based around an inverting operational amplifier shown in Figure 4. The component values are:

$$R_1 = 2k\Omega,\ R_2 = 4k\Omega,\ C_1 = 10\mu F,\ C_2 = 2.5\mu F$$

(a) Find the transfer function of the system.

[8 marks]

(b) State the zeros and poles of the system, and comment on stability.

[4 marks]

(c) Calculate the response of the system to a unit step input.

[8 marks]

(d) Find the gain of the filter at $\omega = 150$rad/s.

[5 marks]

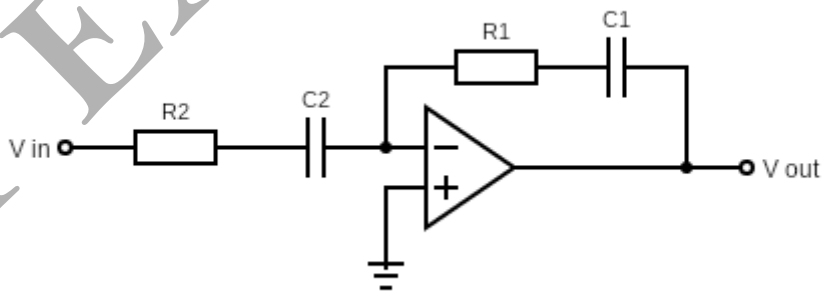

Figure 4

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 *second* order low pass filter. **[8 marks]**

(b) An active second order low pass filter is implemented using the circuit in figure 5.

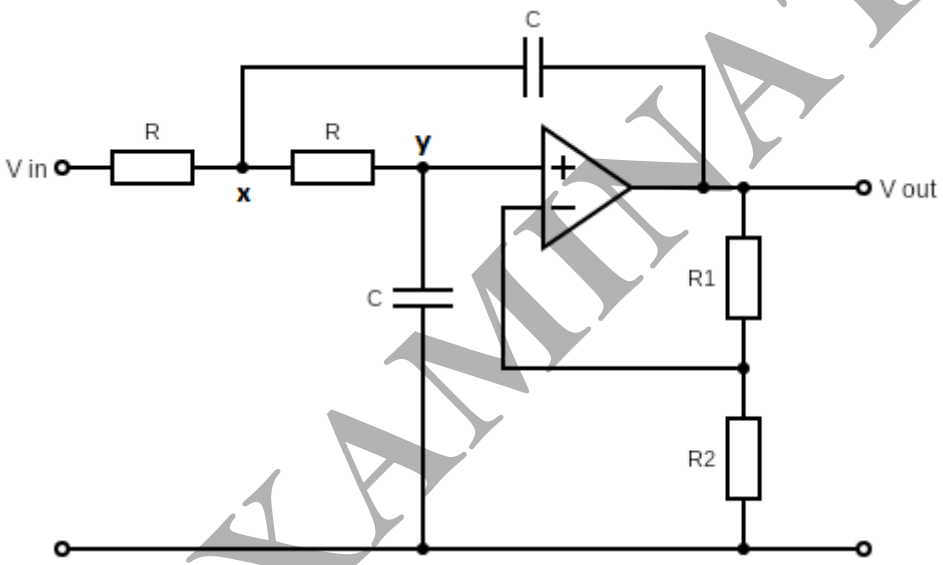

Figure 5

The required corner frequency of the filter is 20000rad/s. The two capacitors have value 25nF. Assuming that the two resistors that meet at the point **x** have the same value, find this value.

[3 marks]

The required *Q* factor of the filter is 0.6. Suggest values for the two resistors *R1* and *R2*.

[6 marks]

Total 25 marks

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Question 6

(a) A carrier with a radio frequency of 800kHz is modulated with an audio tone of frequency 5kHz, using amplitude modulation.

Draw a diagram indicating the frequencies of the sidebands, and state the bandwidth of the signal.

[5 marks]

(b) Explain briefly with the help of diagrams what is meant by single sideband (SSB) modulation with supressed carrier, and how this differs from regular amplitude modulation (AM).

[6 marks]

State *three* advantages that SSB holds over AM.

[6 marks]

(c) A parabolic microwave dish has a gain of 29dB relative to a theoretical isotropic radiator.

For an input power of 5 watts, find the effective radiated power (ERP).

Calculate the input power required to give an ERP of 6kW.

[8 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 PAPER