[ENG11]

UNIVERSITY OF BOLTON

SCHOOL OF ENGINEERING

BENG (HONS) ELECTRICAL & ELECTRONIC ENGINEERING

SEMESTER 2 EXAMINATIONS 2023/24

ANALOGUE SIGNAL PROCESSING & COMMUNICATIONS

MODULE NO: EEE5015

Date: Friday 17th May 2024 **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.

School of Engineering
BEng (Hons) Electrical and Electronic Engineering
Semester 2 Examination 2023-2024
Analogue Signal Processing & Communications
Module No. EEE5015

Question 1.

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

$$R = 150\Omega \quad C = 20\mu F \quad L = 100mH$$

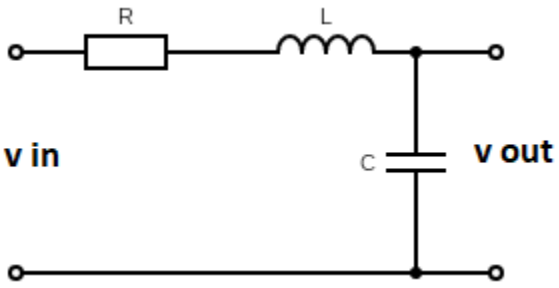

Figure 1

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

[8 marks]

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

[12 marks]

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

[5 marks]

Total 25 marks

Please turn the page…

School of Engineering
BEng (Hons) Electrical and Electronic Engineering
Semester 2 Examination 2023-2024
Analogue Signal Processing & Communications
Module No. EEE5015

Question 2

(a) A system has impulse response $\mathrm{h(t)} = 200\mathrm{e}^{-100\mathrm{t}}$.

Suppose that the input to the system is $x(\mathrm{t}) = e^{-80t}$

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

$$\mathrm{R_1} = 5\mathrm{k\Omega} \quad \mathrm{R_2} = 3\mathrm{k\Omega} \quad \mathrm{C} = 50\mathrm{nF}$$

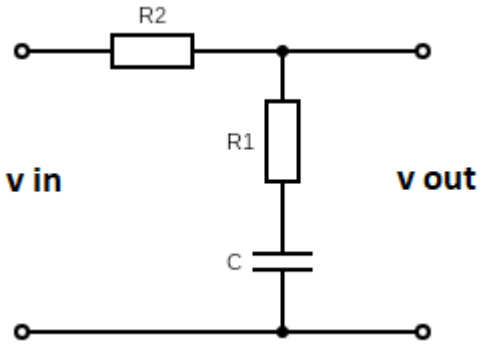

Figure 2

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

For a sine wave input with $\omega = 5000$rad/s determine the frequency response by finding

(i) the gain **[6 marks]**

(ii) the phase shift **[4 marks]**

Total 25 marks

Please turn the page…

School of Engineering
BEng (Hons) Electrical and Electronic Engineering
Semester 2 Examination 2023-2024
Analogue Signal Processing & Communications
Module No. EEE5015

Question 3

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

$$\frac{s^2}{s^2+400s+30000} \qquad \frac{200s}{s^2-200s+50000} \qquad \frac{80000}{s^2+40000}$$

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

[10 marks]

(b) A voltage rises from 0 volts to 2 volts at $t = 0$, rises further to 3 volts at $t = 2$, and falls back to 0 volts at $t = 3$. This is shown in Figure 3 below.

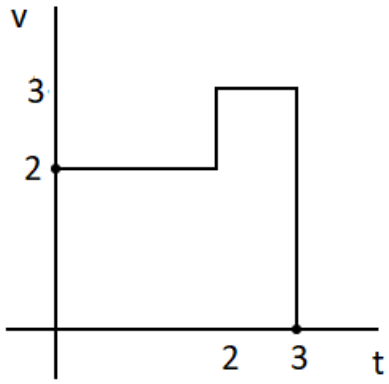

Figure 3

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

Please turn the page…

School of Engineering
BEng (Hons) Electrical and Electronic Engineering
Semester 2 Examination 2023-2024
Analogue Signal Processing & Communications
Module No. EEE5015

Question 4

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

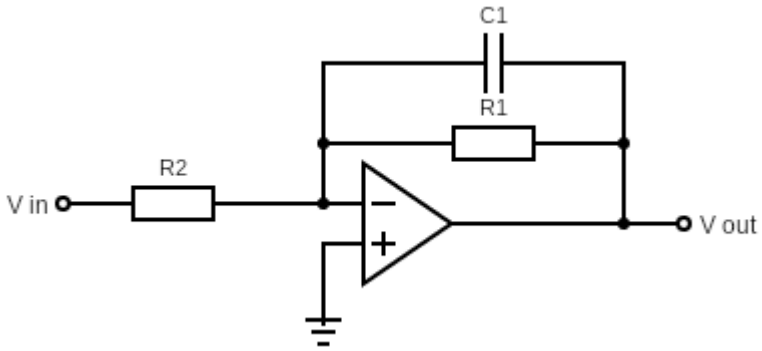

Figure 4

(a) Find the transfer function of the system.

[10 marks]

(b) The value of the capacitor is $C_1 = 50nF$.

If the corner frequency is required to be 4000 rad/s, find the value of the resistor R_1.

[4 marks]

(c) Find the value for the resistor R_2 which gives a value of -2 for the DC gain of the filter.

[4 marks]

(d) Find the response of the filter to a stepped input of 3 volts.

[7 marks]

Total 25 marks

Please turn the page…

School of Engineering
BEng (Hons) Electrical and Electronic Engineering
Semester 2 Examination 2023-2024
Analogue Signal Processing & Communications
Module No. EEE5015

Question 5

(a) For a *first* order high 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 high pass filter. **[8 marks]**

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

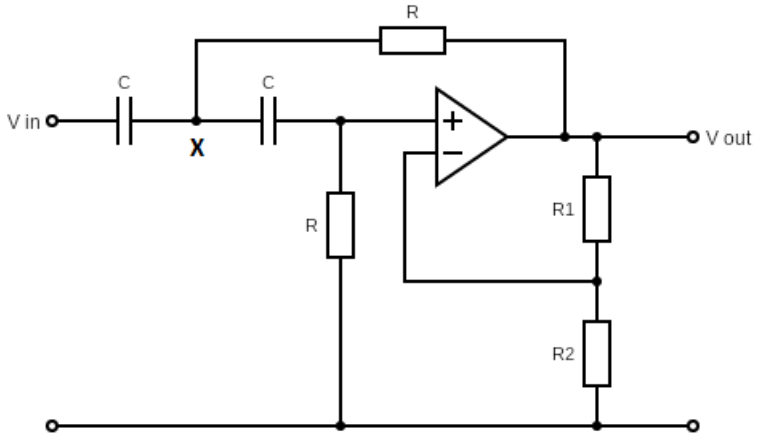

Figure 5

The required corner frequency of the filter is 40000rad/s. The two resistors labelled *R* have value $2k\Omega$. Assuming that the two capacitors that meet at the point **x** have the same value, find this value.

[3 marks]

The required *Q* factor of the filter is 0.8. Suggest values for the two resistors *R1* and *R2*.

[6 marks]

Total 25 marks

Please turn the page…

School of Engineering
BEng (Hons) Electrical and Electronic Engineering
Semester 2 Examination 2023-2024
Analogue Signal Processing & Communications
Module No. EEE5015

Question 6

(a) (i) Briefly describe each of the following modulation types

Amplitude modulation (AM)

Frequency modulation (FM)

[8 marks]

(ii) Give two advantages that AM holds over FM;

Give two advantages that FM holds over AM.

[8 marks]

(b) A dipole antenna is designed to have a resonant frequency of 78MHz.

Calculate the total length of the dipole in centimetres.

[5 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

Please turn the page…

School of Engineering
BEng (Hons) Electrical and Electronic Engineering
Semester 2 Examination 2023-2024
Analogue Signal Processing & Communications
Module No. EEE5015

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