[ENG25]

UNIVERSITY OF BOLTON

SCHOOL OF ENGINEERING

BENG (HONS) ELECTRICAL & ELECTRONIC ENGINEERING

SEMESTER TWO EXAMINATIONS 2021/22

ANALOGUE SIGNAL PROCESSING & COMMUNICATIONS

MODULE NO: EEE5015

Date: Friday 20th May 2022 **Time: 10.00 to 12.30**

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.**

Question 1.

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

$$R = 45\Omega \quad C = 200\mu F \quad L = 100mH$$

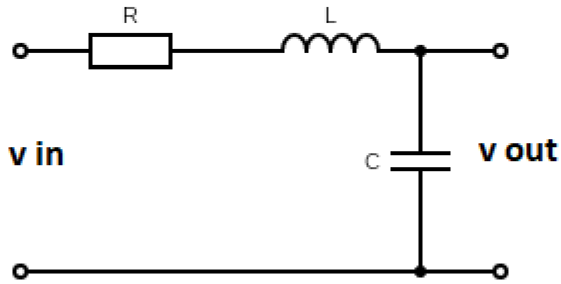

Figure 1

(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

Question 2

(a) A system has impulse response $h(t) = 400e^{-400t}$.

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

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

$$R_1 = 3k\Omega \qquad R_2 = 4k\Omega \qquad C = 1\mu F$$

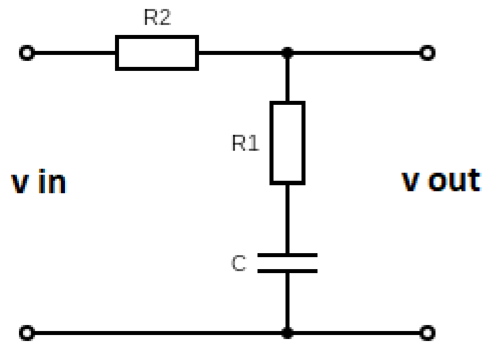

Figure 2

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

For a sine wave input with $\omega = 200$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) A system has the following transfer function:

$$\frac{s^2 - 10s - 2000}{s^2 + 80s + 2000}$$

Find the zeros and the poles of the system. [6 marks]

State, with reasons, whether or not the system is stable. [2 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.

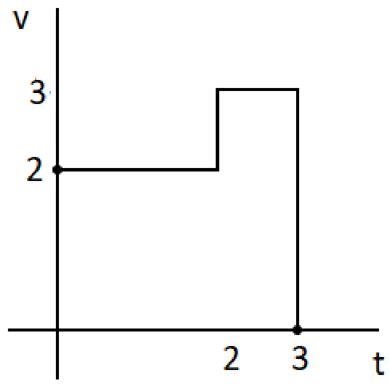

Figure 3

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

[10 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 filter system based around an inverting operational amplifier shown in Figure 4. The component values are:

$$R_1 = 4k\Omega,\ \ R_2 = 2k\Omega,\ \ C_1 = 10\mu F,\ \ C_2 = 1\mu F$$

(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 $\omega = 100$rad/s.

[5 marks]

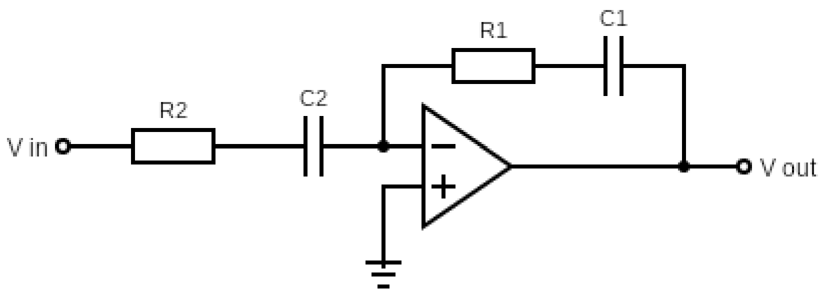

Figure 4

Total 25 marks

Question 5

(a) A two-pole amplifier has the transfer function given by:

$$\frac{1000}{\left[1+\frac{s}{5\times 10^3}\right]\left[1+\frac{s}{100\ \times 10^3}\right]}$$

(i) State the break frequencies

[4 marks]

(ii) Show a schematic of the Bode gain at high frequencies showing the slopes of the linear asymptotes.

[5 marks]

(iii) Determine A_{ol} for the following values of f. Assume critical frequency $f_{c(ol)}$ = 100 Hz and midrange open loop gain $A_{ol(mid)}$ =100,000.

(a) f = 10 Hz [4 marks]

(b) f = 0 Hz

[4 marks]

(b)

(i) A rectifier is an electronic circuit that converts alternating current (AC) into pulsating direct current (DC).
Highlight the key differences between a full wave rectifier and a half wave rectifier.

[4 marks]

(ii) Determine the characteristic impedance of RG58C coaxial cable, which has a capacitance of 28.5pF per metres and an inductance of 7.12μH per 100 metres.

[4 marks]

Total 25 marks

Question 6

(a) A carrier frequency of 1200 kHz is modulated by a sinusoidal wave with a frequency of 25 kHz by a standard amplitude modulator.

(i) Determine the output frequency spectrum. [5 marks]

(ii) The output frequency of a certain VCO changes from 50 kHz to 75 kHz when the control voltage increases from 0.5 V to 1 V.

Calculate the conversion gain, K.

[5 marks]

(b) (i) Explain what is meant by an amplitude modulator. [1 mark]

(ii) Explain the difference between balanced modulator and standard AM. [2 marks]

(iii) State the two output signals are used in amplitude modulation. [2 marks]

(c) Determine the output expression for a multiplier with one sinusoidal input having a peak voltage of 5 mV and a frequency of 1200 kHz and the other input having a peak voltage of 10 mV and a frequency of 1800 kHz. [5 marks]

(d) Assume the transmitted power from a radar is 10kW. A directional coupler (a device that samples the transmitted signal) has an output that represents -40 dB of attenuation. Two 3 dB attenuators are connected in series to this output, and attenuated signal is terminated with a 50 Ω terminator (load resistor).

Calculate the power dissipated in the terminator.

[5 marks]

Total 25 marks

END OF QUESTIONS

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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	$\frac{1}{s^2}$
$e^{-\alpha t}$	$\frac{1}{s+\alpha}$
$\sin \omega t$	$\frac{\omega}{s^2+\omega^2}$
$\cos \omega t$	$\frac{s}{s^2+\omega^2}$
$e^{-\alpha t}f(t)$	$F(s+\alpha)$
$tf(t)$	$-\frac{d}{ds}F(s)$

END OF PAPER