Strathmore UNIVERSITY

SCHOOL OF COMPUTING AND ENGINEERING SCIENCES

BACHALOR OF SCIENCE IN ELECTRICAL AND ELECTRONIC ENGINEERING

BSEE 3103 Unit Name: Network Theory

END OF SEMESTER EXAM

Date: 2nd December 2022 **Time:** Two Hours

Instructions:

This Examination consists of **FIVE** questions

Answer **Question ONE (COMPULSORY)** and any other **TWO** questions.

Question One [30 Marks]

a) Write down the current and voltage relations (equations) for the following passive network elements. **(6 marks)**
   i. Resistance (R)
   ii. Capacitance (C)
   iii. Inductance (L)

b) Consider a discrete LTI system with impulse response h[n] and input signal x[n], as illustrated in Fig. 1(b). Obtain and illustrate the output signal y[n] for the system **(5 marks)**

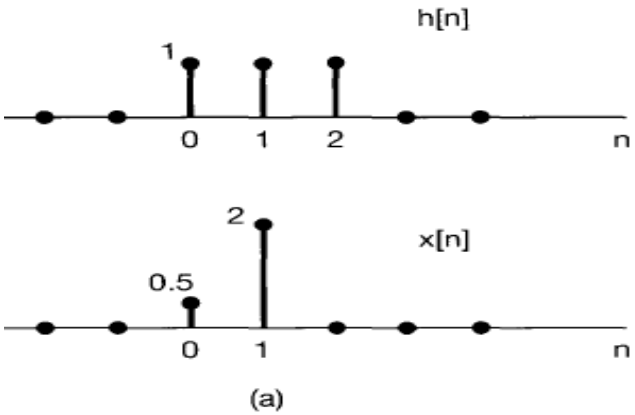

Fig. 1(b)

c) Determine the transmission (ABCD) parameters in the s domain for the network shown Fig. 1(c) **(4 marks)**

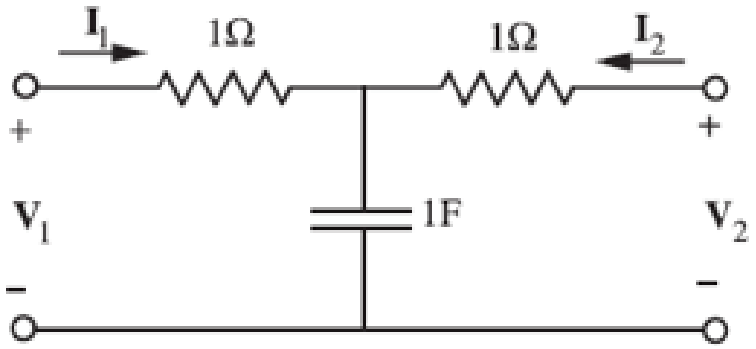

Fig. 1(c)

d) For second order circuits (R-L-C), state and explain their classification, considering the damping factor (α) and resonant frequency (ω_0) **(5 marks)**

e) Develop a Bode plot of a system whose mathematical model (response) is described by the transfer function **(6 marks)**

$$H(s)=\frac{1}{s+1} \quad \Rightarrow \quad H(j\omega)=\frac{1}{j\omega+1}$$

f) Design a Butterworth Filter, to meet the following specifications/ requirements;
a) No more than 1.5 dB deviation from ideal filter at 1300 Hz;
b) At least 35 dB for frequencies above 6000 Hz. **(4 marks)**

Question Two [15 Marks]

a) Determine the h-parameters (expressed in terms of R_A, R_B, R_C and α) for the circuit shown in Fig. 2(b) **(7 marks)**

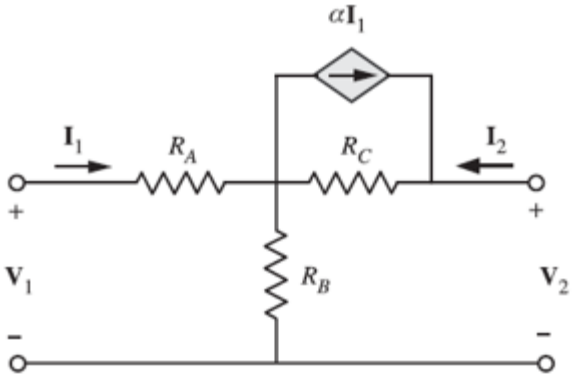

Fig. 2(b)

b) Design a Chebyshev filter for the following specifications, using either bilinear transformation or impulse invariant method **(8 marks)**

Specifications

$$0.8 \le \left|H(e^{j\omega})\right| \le 1, \quad 0 \le \omega \le 0.2\pi$$

$$\left|H(e^{j\omega})\right| \le 0.2, \quad 0.6\pi \le \omega \le \pi$$

Question Three [15 Marks]

a) Consider the electric circuit shown in Fig. 3(a).

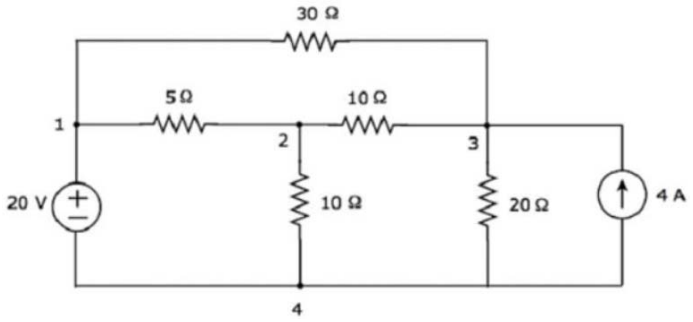

Fig. 3(a)

i) State whether the network topology of this circuit is hinged or planar **(1 mark)**

ii) Develop the directed graph of the circuit **(1 mark)**

iii) From the directed graph in (ii) above, draw the tree and co-tree models of the circuit **(2 marks)**

iv) Obtain the cut-set matrix for the circuit **(3 marks)**

b) The equivalent circuit of a short segment (Δz) of a two-wire transmission line is represented by a simple lumped-element equivalent circuit of Fig. (3c). For this circuit, derive expressions for the propagation, phase and attenuation constants, as functions of the lumped parameters (R, L, G and C).

(8 marks)

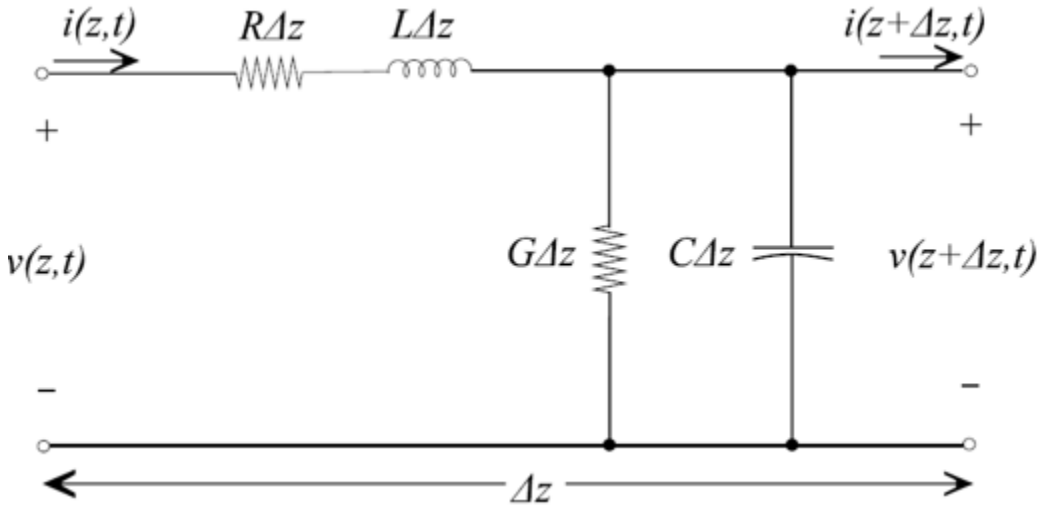

Fig. 3(c)

Question Four [15 Marks]

a) In the parallel circuit of Fig. 4(b), find the natural response v(t), for t>0, assuming v(0) = 5 volts, i(0) = 0, L = 1H, and C = 10Mf. Consider a case where R= 6.25 Ohms. State if the system is classified as underdamped, critically damped or overdamped. **(7 marks)**

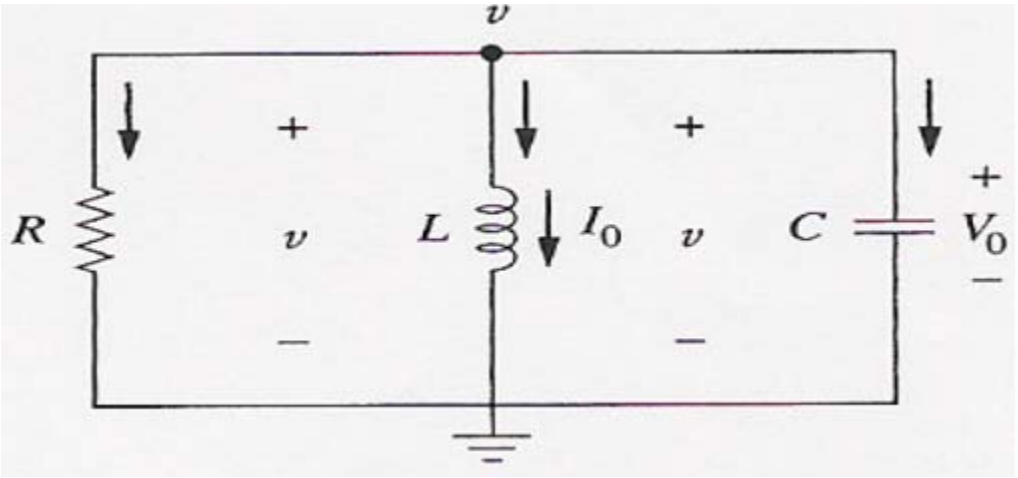

Fig. 4(b)

b) Consider a satellite controlled by the PD controller whose feedback control model is shown in Fig. 4©. Obtain the closed loop transfer function of this satellite controller and sketch it's root locus **(8 marks)**

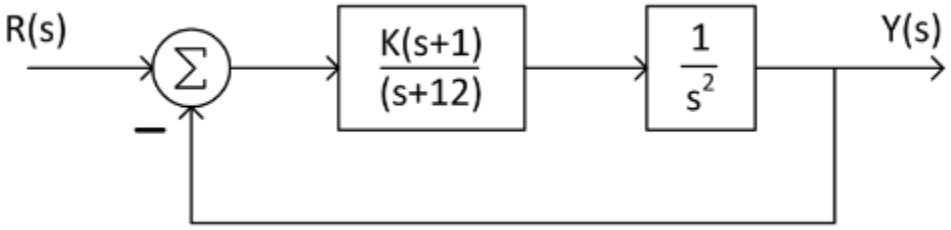

Fig. 4(c): PD Controller block diagram

Question Five (15 Marks)

a) The characteristic equation of a system is given below. Determine the stability of the system by applying Routh Hurwitz Criteria and forming Routh array. **(3 marks)**

$$4s^4 + 8s^3 + 2s^2 + 10s + 3 = 0$$

c) Synthesize the transfer function of the RC circuit shown in Fig. 3(b), state its poles (its stability limit) and represent the circuit in a block diagram **(6 marks)**

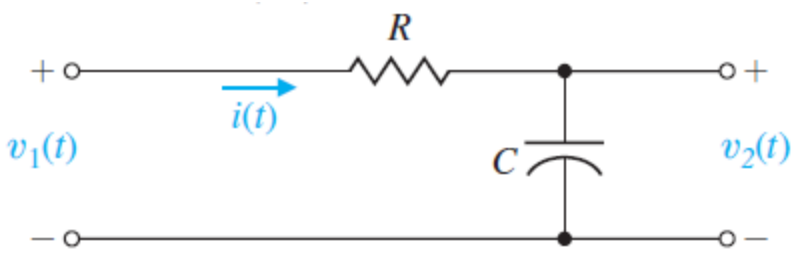

Fig. 3(b)

c) Two identical 750 turn coils A and B lie in parallel planes. A current changing at the rate of 1500 A/s in coil A induces an e.m.f. of 11.25 V in coil B. Calculate the mutual inductance of the arrangement. If the self-inductance of each coil is 15 mH, calculate the flux produced in coil A per ampere and the percentage of this flux which links the turns of coil B. **(6 marks)**

**********END**********

dB Scale Graph Paper