



**SCHOOL OF COMPUTING AND ENGINEERING SCIENCES  
BACHELOR OF ELECTRICAL AND ELECTRONICS ENGINEERING  
END OF SEMESTER EXAMINATION**

**BEE 2203: NETWORK THEORY**

**DATE: 18<sup>th</sup> March 2025**

**Time: 13:30-15:30 Hours**

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**Instructions**

1. This examination consists of **FIVE** questions.
2. Answer **Question ONE (COMPULSORY)** and any other **TWO** questions.
3. Do not write on the question paper.

**QUESTION ONE**

**(Total: 30 Marks)**

- a) Discuss the significance of Poles and Zeros in design of filters. (3 Marks)
- b) For a third order system with a transfer function given below, determine its magnitude and phase and construct their corresponding Bode plots. (8 Marks)

$$G(s) = \frac{0.1(s + 1)}{s^2(s + 10)}$$

- c) A radio receiver is designed to pick up signals from a specific FM radio station operating at 94.7 MHz. However, the receiver is experiencing interference from nearby stations broadcasting at 93.5 MHz and 96.2 MHz. *NB: FM has a bandwidth of 200 KHz.*
  - i. Which type of filter would be best suited to ensure that the receiver only processes the signal at 94.7 MHz while rejecting the others? Explain your choice. (2 Marks)
  - ii. Determine the upper and lower cutoff frequencies for the filter in this application. (2 Marks)
- d) Determine the type of the filter shown in figure 1 and derive its transfer function. (7 Marks)

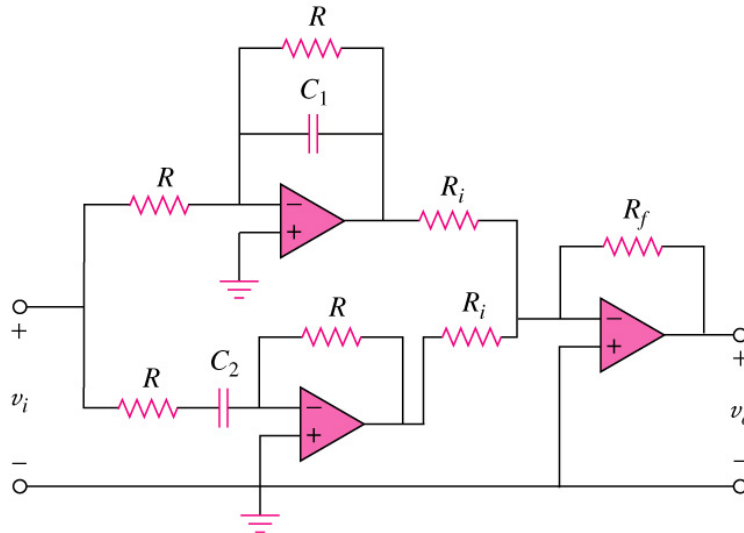


Figure 1

- e) A voltage amplifier circuit in a communication system is modelled as a two-port network shown in figure 2. The resistors represent the internal resistances of the amplifier circuit. To analyze the network's performance and determine the relationship between input/output currents and voltages, the hybrid parameters (h-parameters) need to be determined.

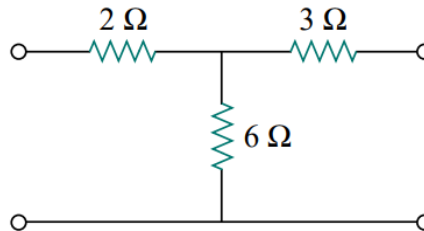


Figure 2

- i. Explain the significance of h-parameters in analyzing two-port networks. (2 Marks)
  - ii. Calculate the h-parameters for the given network. (4 Marks)
- f) What is critical frequency as used in filters? Show the location of this critical frequency in a high-pass frequency response plot. (2 Marks)

**QUESTION TWO**

**(Total: 15 Marks)**

- a) Sketch the attenuation response of a 6th order Chebyshev Type I. (2 Marks)
- b) A given lowpass filter has the following desired specifications: Maximum attenuation  $\alpha_{max} = 3dB$ , Minimum attenuation  $\alpha_{min} = 50 dB$ , Passband edge frequency  $\omega_p = 1000 rad/s$ , and Stopband edge frequency  $\omega_s = 2500 rad/s$ . Design the filter with a Butterworth response to meet the specifications given. (11 Marks)
- c) Sketch Chebyshev Type 1 filter magnitude response for  $n = 7$  (2 Marks)

**QUESTION THREE**

**(Total: 15 Marks)**

- a) Test whether the following function is positive real. (5 Marks)

$$H(s) = \frac{s^3 + 4s}{(s^2 + 1)(s^2 + 9)}$$

- b) Test whether the following polynomial is Hurwitz using continued fraction expansion. *Show all the steps* (5 Marks)

$$F(s) = s^6 + 6s^4 + 4s^2 + 24$$

- c) A given robotic arm control system is designed to position objects with high precision. The characteristic equation of the closed-loop control system is given as:

$$P(s) = s^5 + 15s^4 + 85s^3 + 225s^2 + 274s + 120$$

- To ensure precise and stable operation of the robotic arm, the system must be stable. Using the Routh-Hurwitz criterion, determine if the system is stable. *Show all the steps* (5 Marks)

#### QUESTION FOUR

(Total: 15 Marks)

- a) Synthesize the following RC impedance function using the second Cauer form and draw the resulting circuit. (7 Marks)

$$Z(s) = \frac{3(s + 2)(s + 4)}{s(s + 3)}$$

- b) A given audio amplifier used to connect a music player modeled by  $\{V_g = 2 V (rms), Z_g = 100 \Omega\}$  to a speaker modeled by a load resistor  $Z_L = 32 \Omega$  with a power rating of  $100 W$  is shown in figure 3. Using hybrid 2-port network analysis, test whether this audio system is safe to be used. (8 Marks)

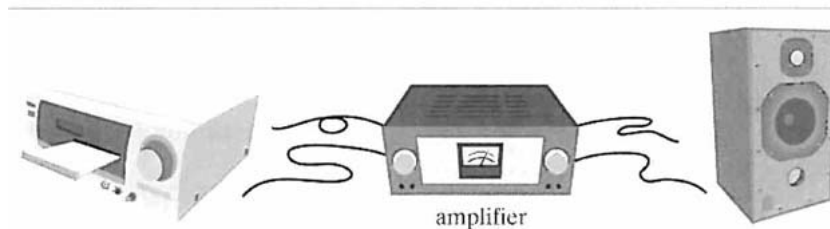
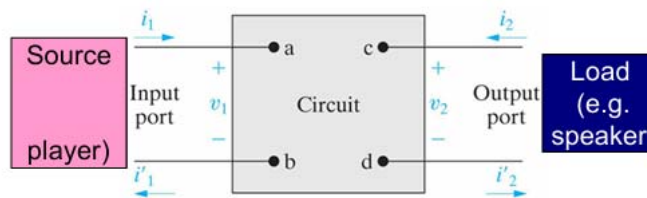


Figure 3

#### QUESTION FIVE

(Total: 15 Marks)

- a) One of the properties of an LC immittance network is that poles and zeros are simple and lie on the  $j\omega$ -axis. Using this property, test whether this condition of an LC network function is observed in the following function. (3 Marks)

$$Z(s) = \frac{s^2 + 4s + 3}{s^3 + 2s}$$

- b) As engineers at an R&D lab you are tasked with designing a passive LC network that meets specific impedance characteristics for a new signal processing application. The system is modeled by the following LC immittance function:

$$Z(s) = \frac{s^3 + 2s}{s^4 + 4s^2 + 3}$$

- i. Synthesize the given LC immittance function using Foster Form I and illustrate the resulting circuit. (6 Marks)
- ii. Repeat the synthesis process using Cauer Form II and draw the corresponding circuit. (5 Marks)
- iii. Compare the results obtained from Foster and Cauer synthesis approaches in terms of circuit complexity and practical implementation. (1 Mark)