higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

# NATIONAL CERTIFICATE

# COMMUNICATION-ELECTRONICS N5

(8080235)

**19 November 2024 (X-paper)**
**09:00–12:00**

**Drawing instruments and non-programmable calculators may be used.**

**This question paper consists of 6 pages and a 5-page formula sheet.**

018Q1E2419

Copyright reserved

# DEPARTMENT OF HIGHER EDUCATION AND TRAINING
# REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE
COMMUNICATION-ELECTRONICS N5
TIME: 3 HOURS
MARKS: 100

---

**INSTRUCTIONS AND INFORMATION**

1. Answer all the questions.
2. Read all the questions carefully.
3. Number the answers according to the numbering system used in this question paper.
4. Use only a black or blue pen.
5. Write neatly and legibly.

---

Copyright reserved 

## QUESTION 1: AC NETWORKS

1.1 Refer to the circuit diagram in FIGURE 1 below and calculate the following:

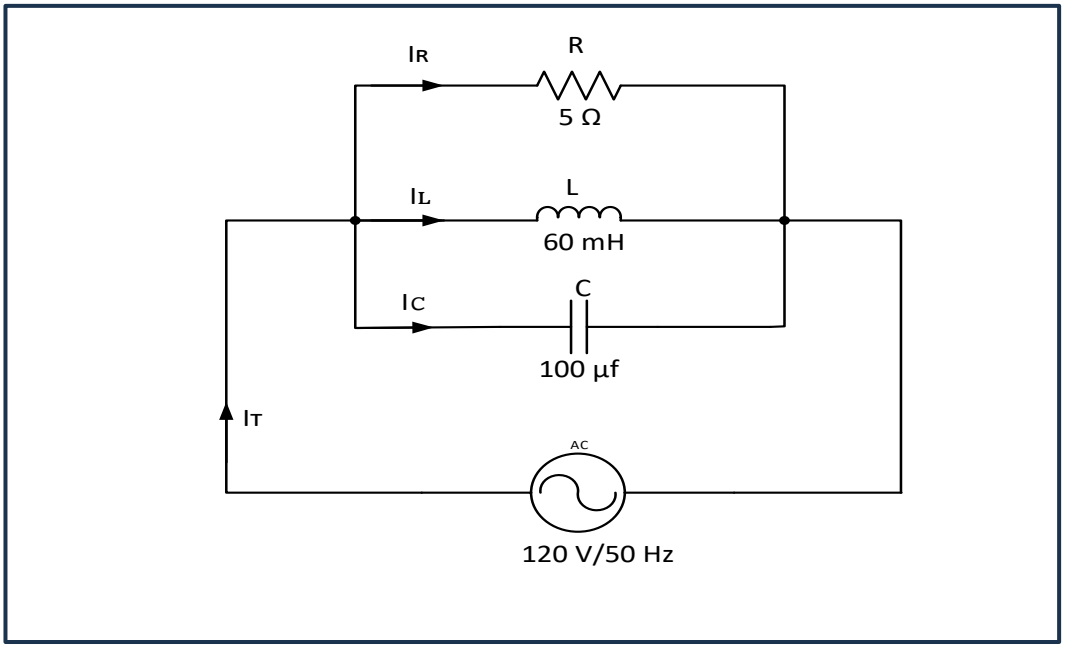



**FIGURE 1**

1.1.1 Dynamic impedance (3)

1.1.2 The current through each branch (8)

1.1.3 Q-factor of the circuit (3)

1.2 Draw the basic graphs of the following resonance circuits:

1.2.1 Current versus frequency for a parallel-tuned circuit

1.2.2 Impedance versus frequency for a parallel-tuned circuit

1.2.3 Current versus frequency for a series-tuned circuit

(3 × 2) (6)

1.3 Define the *quality factor* of a circuit. (2)

**[22]**

## QUESTION 2: FOUR-TERMINAL NETWORKS

2.1 Briefly explain why the bridged T-type attenuator network is the one most commonly used in electronic communication. (4)

2.2 Define the following terms as applicable to four-terminal networks:

2.2.1 T-type attenuator network (3)

2.2.2 Attenuation (2)

2.3 State THREE requirements of an attenuator network. (3)

2.4 FIGURE 2 below which depicts an L-type attenuator. Study the figure and determine the output image impedance $R_2$ of the network.

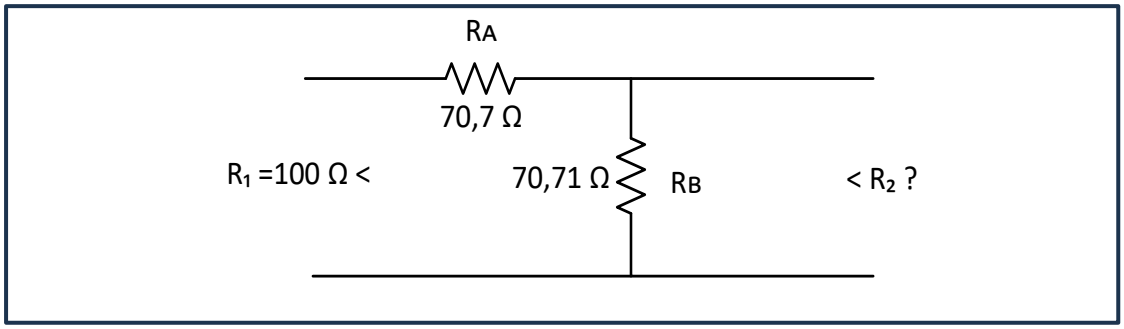



**FIGURE 2** (4)

2.5 Refer to FIGURE 3 below and calculate the attenuation of the network in dB.

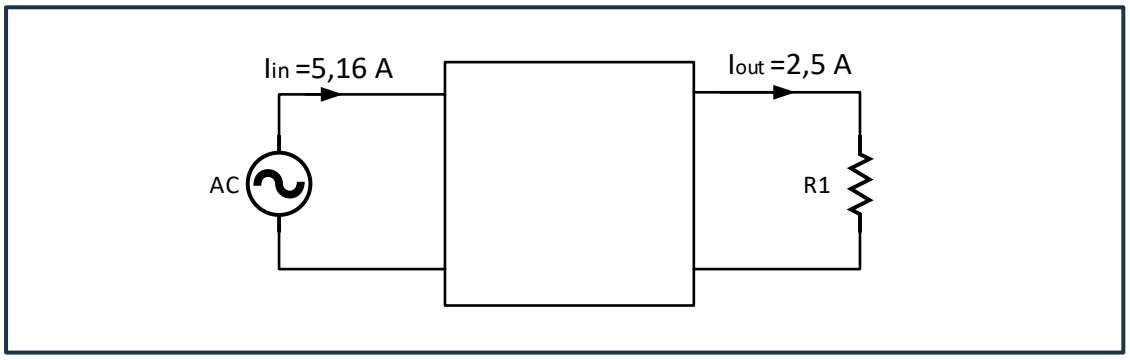



**FIGURE 3** (3)

**[19]**

## QUESTION 3: FILTER NETWORKS

3.1 Briefly explain how the characteristic impedance of a T-type low-pass filter can be real or imaginary.

NOTE: Do NOT derive the formula. (6)

3.2 Design a prototype filter that will pass all frequencies below 4,5 kHz for a design impedance of 600 ohm.

Draw the completed filter and insert all the calculated values. (8)



**[14]**

## QUESTION 4: TRANSMITTERS AND RECEIVERS

4.1 Briefly explain with the aid of a neat, labelled sketch the operation of an AM half-wave voltage envelope detector. (10)

4.2 Draw a neat, labelled block diagram of a typical FM transmitter automatic frequency control (AFC) module. (12)

4.3 A double sideband (DSB) AM transmitter gives a power of 10 kW when it is modulated by an 85% sine wave. The carrier is less than 15% speech-modulated, and the carrier as well as one sideband is suppressed.



Calculate the mean output power in the remaining sideband. (5)

**[27]**

## QUESTION 5: ANTENNAS

5.1 Explain in your own words why antennas are used in communication. (3)

5.2 State ONE application of a rhombic antenna. (2)

5.3 Define the following terms regarding antennas:

5.3.1 Isotropic

5.3.2 Effective aperture

5.3.3 Power transfer



(3 × 2) (6)

**[11]**

## QUESTION 6: BODE DIAGRAMS

6.1 State TWO facts about the importance of pole and zero diagrams regarding Bode plots. (2)

6.2 State the THREE limits of pole and zero diagrams regarding Bode plots. (3)

6.3 Name TWO RC circuits for Bode plots. (2)

**[7]**

**TOTAL: 100**

Copyright reserved

**COMMUNICATION-ELECTRONICS N5**

**FORMULA SHEET**

Any other applicable formula may also be used.

**Inductive reactance**

$$X_L = 2\pi fL$$

**Capacitive reactance**

$$X_c = \frac{1}{2\pi\ fC}$$

**Series formulae**

$$Z_T = \sqrt{R^2 + (X_L - X_c)^2}$$

$$\tan\theta = \frac{X_L - X_C}{R}$$

$$BW = \frac{f_o}{Q} = \frac{R}{2\pi\ L}$$

$$p.f = Cos\phi$$

$$P = VICos\phi$$

$$Y = \frac{1}{Z} = G \pm jB$$

**Parallel formulae**

$$I_T = \sqrt{I_R^2 + (I_C - I_L)^2}$$

$$\tan\theta = \frac{I_C - I_L}{I_R}$$

$$I_X = I_C - I_L$$

$$p.f = Cos\phi$$

$$P = VICos\phi$$

$$Y_T = Y_1 + Y_2$$

**Series resonance**

$$f_r = \frac{1}{2\pi\ \sqrt{LC}}$$

$$Z = R$$

$$\phi = 0^\circ$$

$$p.f = Cos\phi = 1$$

$$Q = \frac{X_L}{R} = \frac{X_C}{R} = \frac{1}{R}\sqrt{\frac{L}{C}}$$

$$BW = \frac{f_o}{Q} = \frac{R}{2\pi\ L}$$

**Parallel resonance**

$$f_r = \frac{1}{2\pi}\sqrt{\frac{1}{LC} - \frac{R^2}{L^2}}$$

$$Z_D = \frac{L}{RC}$$

$$\phi = 0^\circ$$

$$p.f = Cos\phi = 1$$

$$Q = \frac{X_L}{R} = \frac{X_C}{R} = \frac{1}{R}\sqrt{\frac{L}{C}}$$

Copyright reserved 

## FILTERS

### Low-pass

$$R_o = \sqrt{\frac{L}{C}}$$

$$f_c = \frac{1}{\pi\sqrt{LC}}$$

$$C = \frac{1}{\pi\ R_o\ f_c}$$

$$L = \frac{R_o}{\pi\ f_c}$$

$$Z_{OT} = \sqrt{\frac{L}{C}} \times \sqrt{1 - \frac{\omega^2 LC}{4}}$$

$$Z_{o\pi} = \frac{R_o}{\sqrt{1 - \frac{\omega^2 LC}{4}}}$$

### High-pass

$$R_o = \sqrt{\frac{L}{C}}$$

$$f_c = \frac{1}{4\pi\sqrt{LC}}$$

$$C = \frac{1}{4\pi\ R_o\ f_c}$$

$$L = \frac{R_o}{4\pi\ f_c}$$

$$Z_{OT} = \sqrt{\frac{L}{C}} \times \sqrt{1 - \frac{1}{4\omega^2 LC}}$$

$$Z_{o\pi} = \frac{R_o}{\sqrt{1 - \frac{1}{4\omega^2 LC}}}$$

## SYMMETRICAL FOUR-TERMINAL NETWORKS

### T-network

$$Z_{in} = Z_{out/uit}$$

$$Z_{OT} = \sqrt{Z_{oc} Z_{sc}}$$

$$Z_{OT} = \sqrt{\frac{Z_1^{\ 2}}{4} + Z_1 Z_2} = \frac{Z_1 Z_2}{Z_{O\pi}}$$

$$Z_1 = 2\left[Z_{oc} - \sqrt{Z_{oc}(Z_{oc} - Z_{sc})}\right]$$

$$Z_2 = \sqrt{Z_{oc}(Z_{oc} - Z_{sc})}$$

### $\pi$-network

$$Z_{in} = Z_{out/uit}$$

$$Z_{O\pi} = \sqrt{Z_{oc} Z_{sc}}$$

$$Z_{O\pi} = \frac{Z_1 Z_2}{\sqrt{\frac{Z_1^{\ 2}}{4} + Z_1 Z_2}} = \frac{Z_1 Z_2}{Z_{OT}}$$

$$Z_1 = \frac{Z_{sc}\left[Z_{oc} \pm \sqrt{Z_{oc}\ (Z_{oc} - Z_{sc})}\right]}{Z_{oc} + \sqrt{Z_{oc}(Z_{oc} - Z_{sc})} - Z_{sc}}$$

$$Z_2 = \frac{1}{2}\left[Z_{oc} \pm \sqrt{Z_{oc}(Z_{oc} - Z_{sc})}\right]$$

Copyright reserved 

## ASYMMETRICAL FOUR-TERMINAL NETWORKS

### L-section image impedance

$$Z_{o_1} = \sqrt{Z_1^2 + Z_1 Z_2}$$

$$Z_{o_2} = \frac{Z_1 Z_2}{\sqrt{Z_1^2 + Z_1 Z_2}}$$

### L-section iterative impedance

$$Z'_{01} = \sqrt{\frac{Z_1{}^2}{4} + Z_1 Z_2} + \frac{Z_1}{2}$$

$$Z'_{02} = \sqrt{\frac{Z_1{}^2}{4} + Z_1 Z_2} - \frac{Z_1}{2}$$

## NETWORK CONVERSIONS

### T → $\pi$ conversion

$$ZA = \frac{Z_1 Z_2 + Z_2 Z_3 + Z_1 Z_3}{Z_2}$$

$$ZB = \frac{Z_1 Z_2 + Z_2 Z_3 + Z_1 Z_3}{Z_3}$$

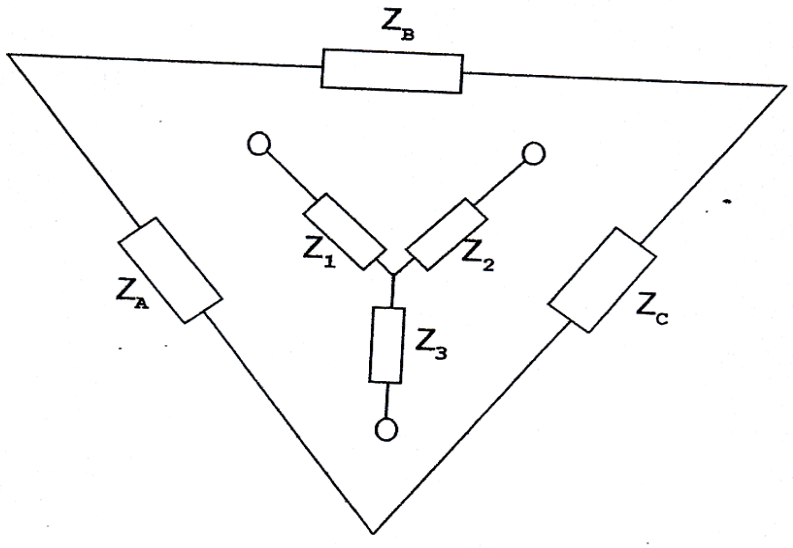
$$ZC = \frac{Z_1 Z_2 + Z_2 Z_3 + Z_1 Z_3}{Z_1}$$

### $\pi$ → T conversion

$$Z_1 = \frac{Z_A Z_B}{Z_A + Z_B + Z_C}$$

$$Z_2 = \frac{Z_B Z_C}{Z_A + Z_B + Z_C}$$

$$Z_3 = \frac{Z_A \,.\, Z_C}{Z_A + Z_B + Z_C}$$




Copyright reserved 

## ATTENUATORS IN GENERAL

$dB$ = 8,686 × Neper

$$dB = 10 \log \left( \frac{P_{in}}{P_{uit/out}} \right)$$

$dB$ = 20 log N

$$Insertion\,loss = 10\log\frac{P_1}{P_2} = 20\log\frac{I_1}{I_2}$$

## SYMMETRICAL ATTENUATORS

$$N = \frac{I_{in}}{I_{out/uit}} = \sqrt{\frac{P_{in}}{P_{out/uit}}}$$

### T-type

$$R_a = \frac{R\,(N-1)}{N+1}$$

$$R_b = \frac{2RN}{N^2-1}$$

### π-type

$$R_a = \frac{R\,(N+1)}{N-1}$$

$$R_b = \frac{R(N^2-1)}{2N}$$

### Bridged T

$$R_a = R = Z_o$$

$$R_b = R\,(N-1)$$

$$R_c = \frac{R}{N-1}$$

## ASYMMETRICAL ATTENUATORS

$$N = \sqrt{\frac{P_{in}}{P_{out/uit}}}$$

### L-type

$$R_a = \sqrt{R_1(R_1 - R_2)}$$

$$R_b = \sqrt{\frac{R_1 R_2^2}{R_1 - R_2}}$$

Copyright reserved 

**MUTUAL INDUCTANCE**

$$M = \sqrt{L_p \times L_s} \times k$$

$$k = \frac{M}{\sqrt{L_p P_s}}$$

$$k_c = \frac{1}{\sqrt{Q_p Q_s}}$$

$$Z_c = \frac{(\omega M)^2}{Z_s}$$

$$f_1 = \frac{f_o}{\sqrt{1+k}}$$

$$f_2 = \frac{f_o}{\sqrt{1-k}}$$

$$Q_p = \frac{X_{LP}}{R_p}$$

$$Q_s = \frac{X_{LS}}{R_s}$$

**Dot rule**

$$L_T = L_1 + L_2 + 2M$$

$$L_T = L_1 + L_2 - 2M$$

**AM**

$$m = \frac{V_m}{V_c}$$

$$P_T = P_c\left(1 + \frac{m^2}{2}\right)$$

$$P_{DSB} = \frac{m^2 Pc}{2}$$

$$m_T = \sqrt{m_1^2 + m_2^2}$$

$$v_c = V_C Sin\omega_C t + \frac{mV_C}{2}\cos(\omega_C - \omega_m)t - \frac{mV_C}{2}\cos(\omega_C + \omega m_m)t$$

**FM**

$$v_c = V_c \sin(\omega_{\cos} t - m\cos\omega_M t)$$

$$BW = f_{\text{mod}} \times (\text{number of sidebands}) \times 2$$

**SHANNON-HARTLEY**

$$C = \Delta f \log_2\left(1 + \frac{S}{N}\right)$$

$$dB = 10\log\left(\frac{\text{signal power}}{\text{noise power}}\right)$$

Copyright reserved