higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

T390**(E)**(J26)T

NATIONAL CERTIFICATE

COMMUNICATION-ELECTRONICS N5

(8080235)

26 July 2019 (X-Paper)
09:00–12:00

This question paper consists of 7 pages and a formula sheet of 5 pages.

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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. Start each section on a NEW page.
5. Use only a blue or black pen.
6. Write neatly and legibly.

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QUESTION 1: GENERAL

Complete the following sentences by using the words in the list below. Write only the missing word or words next to the question number (1.1–1.5) in the ANSWER BOOK.

insertion loss; bandwidth; oppose; microphone; prototype; electrical; direct current; mismatch; networks; controllers

1.1 In a/an … circuit, the only component available to … current flow in the circuit is resistance.

1.2 … is the total loss or the … losses combined with the attenuation losses when a network is inserted.

1.3 When designing … filters, both the T- and π- … must be designed.

1.4 The … converts mechanical sound waves to … currents for amplification by the audio amplifier.

1.5 Phase-lead and lag-network … are used chiefly to improve the accuracy of the … and amplifier stability.

(5 × 2) **[10]**

QUESTION 2: AC NETWORKS

2.1 Consider FIGURE 1 and answer the questions.

E = 100L0°
ω = 377 rad/s

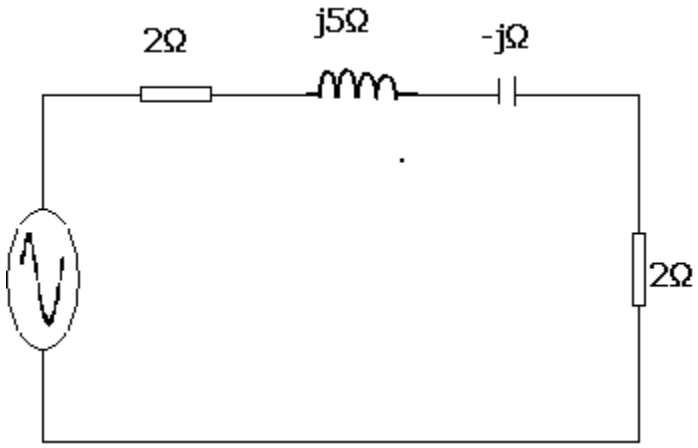


FIGURE 1

2.1.1 Determine the total current. (3)

2.1.2 Write the expression for the current as a function of time. (3)

2.1.3 Draw the phasor diagram. (2)

2.2 Consider FIGURE 2 and derive the formula for RLC parallel impedance. (10)

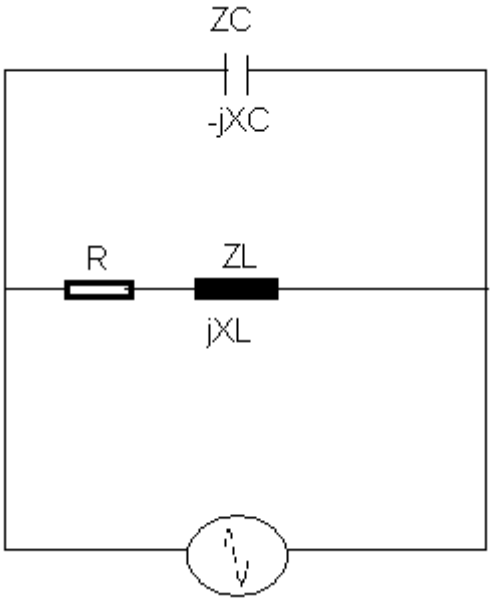
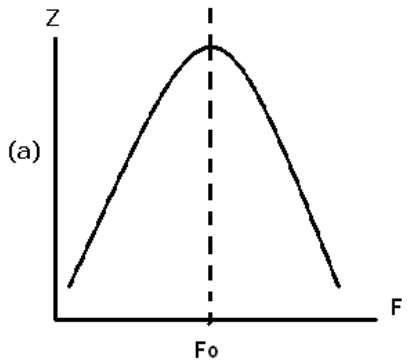


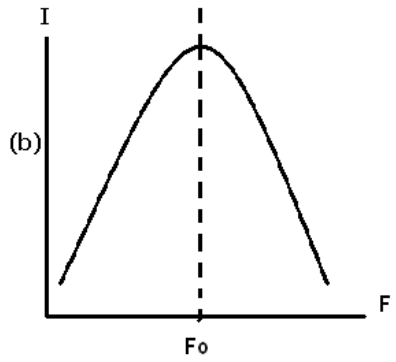
FIGURE 2

2.3 Identify the FOUR basic graphs for tuned circuits at resonance.

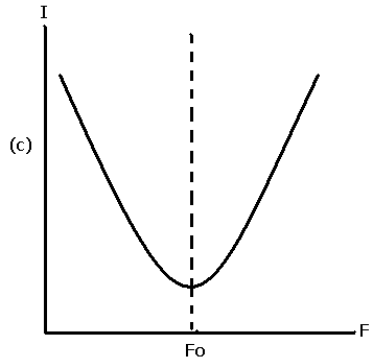
2.3.1



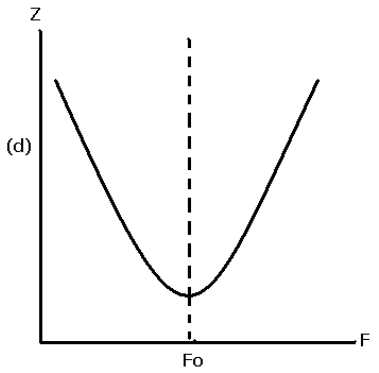
2.3.2



2.3.3



2.3.4



(4 × 3) (12)
[30]

QUESTION 3: FOUR-TERMINAL NETWORKS

3.1 Define a *symmetrical two-port network*. (3)

3.2 The values of pure resistances of a typical symmetrical T-network are:

Open circuit (ZOC) = 800 ∟0° Ω

Short circuit (ZSC) = 600 ∟0° Ω

3.2.1 Calculate Z1 and Z2. (5)

3.2.2 Draw the network. (2)
[10]

QUESTION 4: FILTERS

4.1 Define a *K-constant filter* in detail. (4)

4.2 Design a prototype low-pass filter with an impedance of 600 Ω and a cut-off frequency of 1 000 Hz. (6)
[10]

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QUESTION 5: RECEIVERS AND TRANSMITTERS

5.1 The stages shown below are that of an AM transmitter.

- RF oscillator
- Buffer amplifier
- Frequency multiplier
- Modulator
- Microphone
- AF amplifier
- RF power amplifier
- Antenna

Explain the function of each stage in detail. (8 × 2) (16)

5.2 Name the THREE components contained by the AM-RF carrier wave according to the AM spectrum. (3)

[19]

QUESTION 6: ANTENNAE

6.1 Show, with the aid of sketches, how the THREE parts of the Yagi-Uda antenna are connected. (4)

6.2 Define the following THREE elements of an antenna:

6.2.1 Directive gain

6.2.2 Radiation resistance

6.2.3 Polarisation

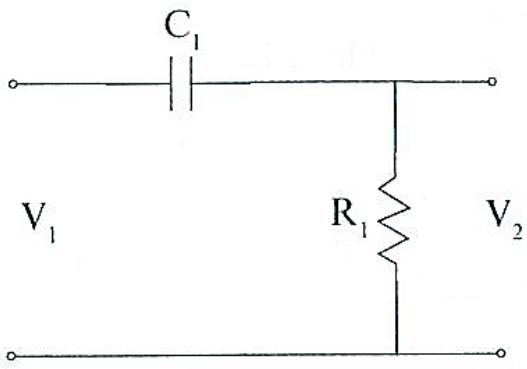
(3 × 3) (9)

[13]

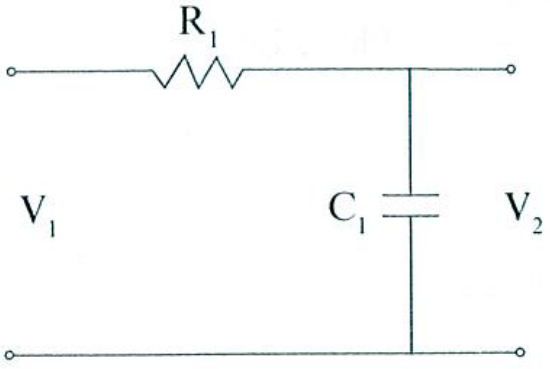
QUESTION 7: BODE PLOTS

7.1 Define *Bode diagrams*. (2)

7.2 Identify the following circuits:



7.2.1



7.2.2

(2 × 3) (6)

[8]

TOTAL: 100

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FORMULA SHEET

Any applicable formula may also be used.

Inductive reactance

$$X_L = 2\pi fL$$

Capacitive reactance

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

Series formulae

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

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

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

$$p.f = \cos\phi$$

$$P = VI\cos\phi$$

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

Parallel formulae

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

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

$$I_X = I_C - I_L$$

$$p.f = \cos\phi$$

$$P = VI\cos\phi$$

$$Y_T = Y_1 + Y_2$$

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

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

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

$$\phi = 0^\circ$$

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

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

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

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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

$$Z_{in} = Z_{out}$$

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

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

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

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

π-network

$$Z_{in} = Z_{out}$$

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

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

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

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

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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

$$Z'O_1 = \sqrt{\frac{Z_1^2}{4} + Z_1 Z_2} + \frac{Z_1}{2}$$

$$Z'O_2 = \sqrt{\frac{Z_1^2}{4} + Z_1 Z_2} - \frac{Z_1}{2}$$

NETWORK CONVERSIONS

T → π-conversion

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

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

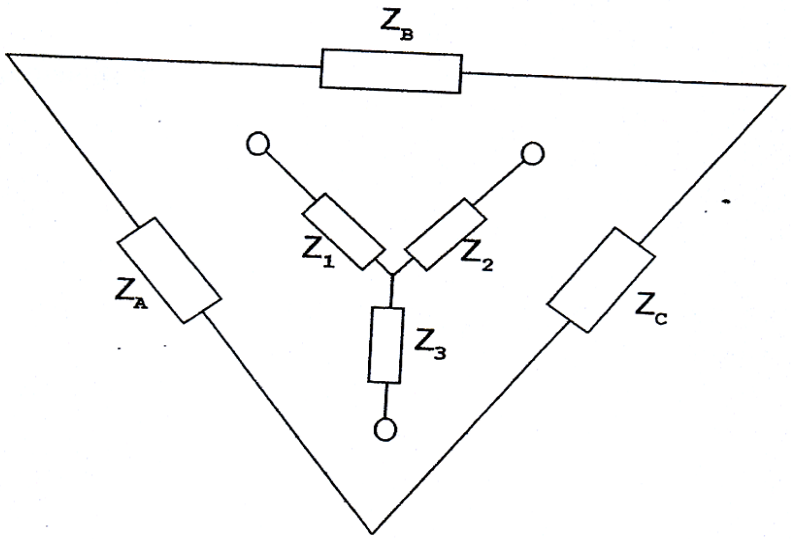
$$ZC = \frac{Z_1 Z_2 + Z_2 Z_3 + Z_1 Z_3}{Z_1}$$

π→T-conversion

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

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

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



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ATTENUATORS IN GENERAL

$dB = 8{,}686 \times \text{Neper}$

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

$dB = 20 \log \text{N}$

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

Symmetrical attenuators

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

Asymmetrical attenuators

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

T-type

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

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

L-type

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

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

π-type

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

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

Bridged T

$$R_a = R = Z_o$$

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

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

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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

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

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

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

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

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

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

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

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

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