higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE

COMMUNICATION-ELECTRONICS N5

(8080235)

15 November 2022 (X-paper)
09:00–12:00

Drawing instruments and nonprogrammable calculators may be used.

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

020Q1E2215

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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: AC NETWORKS

1.1 A parallel LC-circuit consists of a variable capacitor in parallel with a 100 µH inductor. The inductor has an internal resistance of 12 Ω.

Calculate the following:

1.1.1 The capacitor value at resonance of 45 MHz (3)

1.1.2 The dynamic impedance (2)

1.1.3 How much capacitance must be added/subtracted to obtain resonance at 48 MHz (4)

1.1.4 The Q-factor of the circuit at both resonating frequencies (4)

1.2 Derive the equation for the Q-factor for the capacitor from first principles. (10)
[23]

QUESTION 2: GENERAL

Choose the correct word or words from those given in brackets. Write only the answer next to the question number (2.1–2.8) in the ANSWER BOOK.

2.1 At parallel resonance circuit, the current is (maximum/minimum). (1)

2.2 The decibel is fundamentally a (a) (current/power) ratio that can be expressed in terms of (b) (voltage/current) ratio when the resistances are equal. (2)

2.3 An asymmetrical network is correctly terminated when it is terminated by its (image/iterative) impedances. (1)

2.4 The primary function of the RF amplifier is to provide (demodulation/selectivity). (1)

2.5 Carrier waves are used in (a) (telecommunications/modulation) to convey (b) (voltage/audio) signals. (2)

2.6 Demodulation is the act of returning (modulated/unmodulated) data signals to their original form. (1)

2.7 AGC is of most importance in (AM/PM) receivers. (1)

2.8 One dB is the equivalent of (0,115/8,686) neper. (1)
[10]

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QUESTION 3: FOUR TERMINAL NETWORKS

3.1 What is the purpose of the L-type asymmetrical? (2)

3.2 A bridged T-type attenuator with an attenuation of 25 dB is inserted between two 600 Ω impedances. Design and draw this network. All component values must be inserted. (8)

3.3 Derive the expression for the series impedance Z1 of a symmetrical t-type network. (11)

[21]

QUESTION 4: FILTERS

4.1 Simple define a *constant k-filter.* (2)

4.2 Refer to the given network of FIGURE 1 below and determine by calculation from first principles whether the characteristic impedance of the filter is real or imaginary at a given cut-off frequency of 3 kHz. (10)

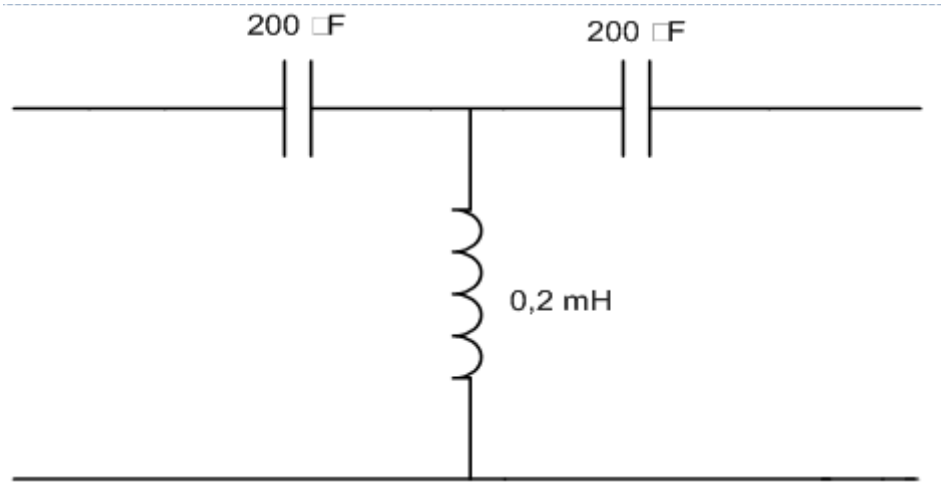


FIGURE 1

[12]

QUESTION 5: TRANSMITTERS AND RECEIVERS

5.1 State THREE components for the carrier wave in an AM spectrum. (3)

5.2 A certain AM transmitter radiates 12 kW when the carrier is unmodulated and 16 kW when the carrier is sinusoidal modulated.

Determine the following:

5.2.1 The modulating index (2)

5.2.2 The total radiated power if another sin wave with a modulating index of 20 % is simultaneously transmitted (3)

5.3 Draw a labelled basic diagram of an AM transmitter and state the function of each stage. (16)
[24]

QUESTION 6: ANTENNAS

6.1 State TWO advantages of a folded dipole antenna. (2)

6.2 What is the purpose of the rhombic antenna? (2)

6.3 Define the term *directive gain* with regard to antennas (2)
[6]

QUESTION 7: BODE PLOTS

7.1 Define *Bode diagrams.* (2)

7.2 What are the phase lead and lag network controllers used for in Bode diagrams? (2)
[4]

TOTAL: 100

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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

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

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

$$\phi = 0^\circ$$

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

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

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

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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

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

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

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

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

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

π-network

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

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

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

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

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

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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

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

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

NETWORK CONVERSIONS

T → π conversion

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

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

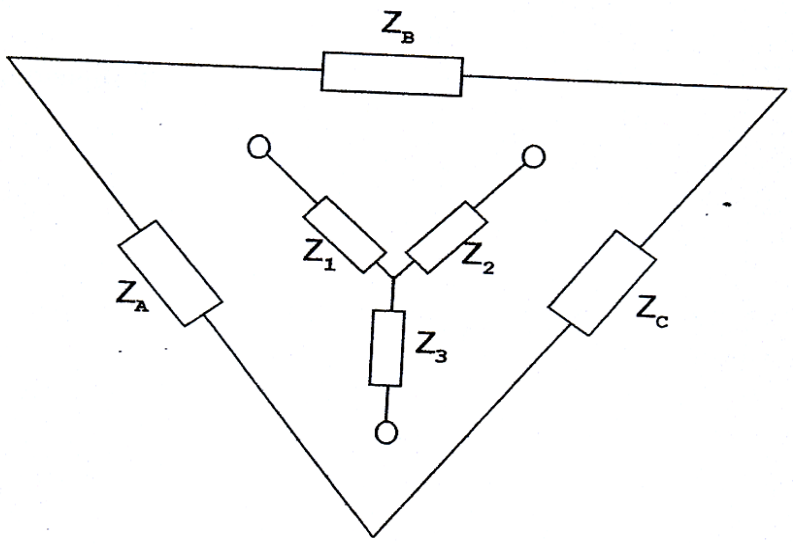
$$ZC = \frac{Z_1 Z_2 + Z_2 Z_3 + Z_1 Z_3}{Z_1}$$

π → T conversion

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

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

$$Z_3 = \frac{Z_A \cdot Z_C}{Z_A + Z_B + Z_C}$$



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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

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

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

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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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