higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

T310**(E)**(A7)T

APRIL EXAMINATION

NATIONAL CERTIFICATE

COMMUNICATION-ELECTRONICS N5

(8080235)

7 April 2016 (X-Paper)
9:00–12:00

Calculators may be used.

This question paper consists of 5 pages and 1 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. Sketches should be neat and be clearly labelled.
5. Keep questions and subsections of questions together.
6. Rule off across the page on completion of each question.
7. Write neatly and legibly.

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QUESTION 1: AC NETWORKS

1.1 Explain the THREE characteristics of each of the following RLC circuits at resonance:

1.1.1 Series circuit

1.1.2 Parallel circuit (3 x 2) (6)

1.2 A supply of 20 V at a frequency of 50 Hz is connected across a parallel circuit consisting of a 1 kilo-ohm resistor, a coil of 0,5 H and a 10 micro farad capacitor.

1.2.1 Draw the circuit. (2)

1.2.2 Calculate the following:

(a) The total supply current (8)
(b) The phase angle (2)

1.3 Draw the phaso diagram. (5)
[23]

QUESTION 2: FOUR-TERMINAL NETWORKS

2.1 Define *insertion loss* of a symmetrical two-port network. (5)

2.2 Draw the π-network with Z- open circuit and Z- short circuit to derive from first principle the characteristic impedances of a π-network considering the open and short-circuit conditions. (10)

2.3 Draw the π-network with the following values and convert it to a T-network:

Z_A = 200 ohms
Z_B = 200 ohms
Z_C = 400 ohms (10)
[25]

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QUESTION 3: FILTERS

3.1 Design and determine the cut-off frequency of a low-pass π-type filter having the following values:

- C/2 = 1 Mf
- L = 100 mH

(5)

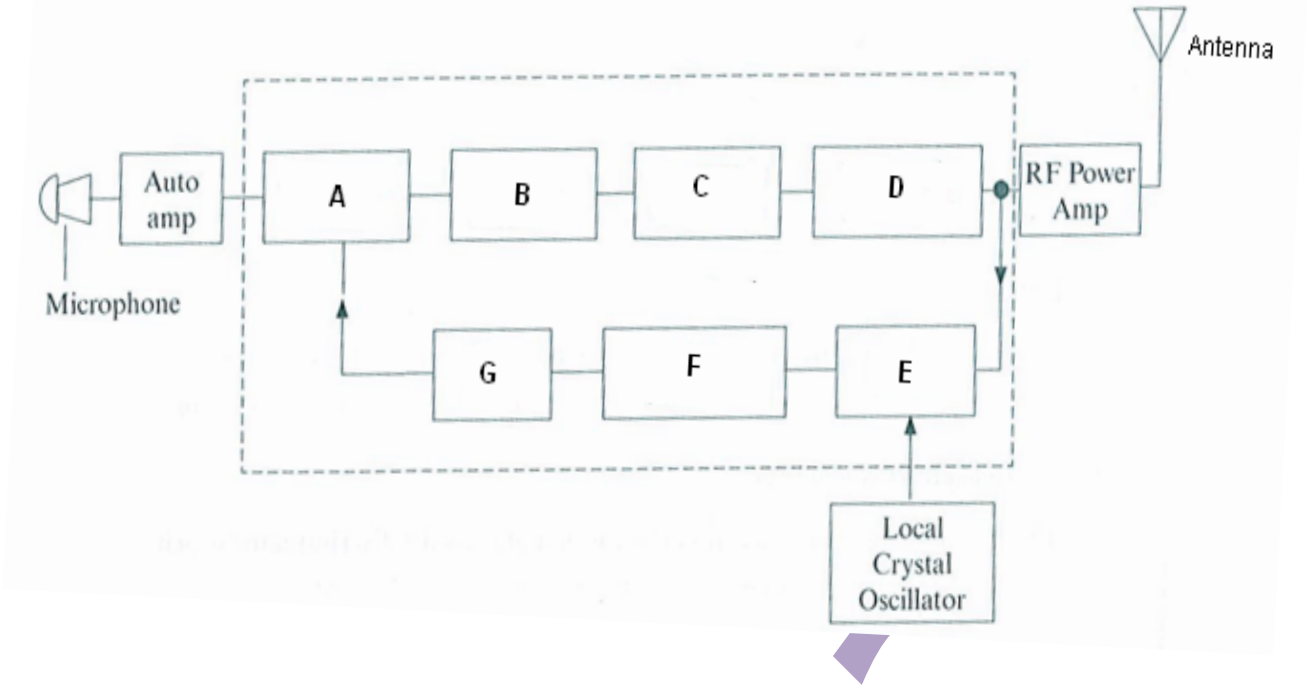
3.2 Design from first principle a prototype high-pass filter having a design impedance of 600 ohms and a cut-off frequency of 10 KHz, considering the following:

- $Z_1 = 1/jwc$
- $Z_2 = jwl$

(15)
[20]

QUESTION 4: RECEIVERS AND TRANSMITTERS

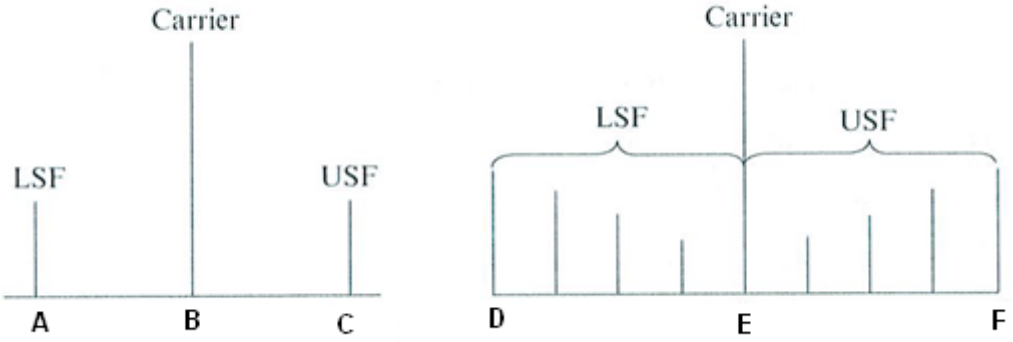
4.1 Identify the block diagram below and label all the stages shown from A–G. Write only the answer next to the letter (A–G) in the ANSWER BOOK.



(8)

4.2 Identify the TWO sketches of an AM spectrum below with regard to the carrier wave and neatly label the frequencies on positions A, B, C, D, E and F.

Redraw the sketches and label them.



(8)
[16]

QUESTION 5: ANTENNAS

5.1 With an aid of a sketch showing a reflector and radiation pattern, describe the construction of a Yagi-Uda antenna. (10)

5.2 Define the following terms with regard to antennas:

5.2.1 Directive gain

5.2.2 Radiation resistance

5.2.3 Polarisation (3 x 2) (6)
[16]

TOTAL: 100

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COMMUNICATION-ELECTRONICS N5

FORMULA SHEET

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

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

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

NETWORK CONVERSIONS

T → π conversion

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

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

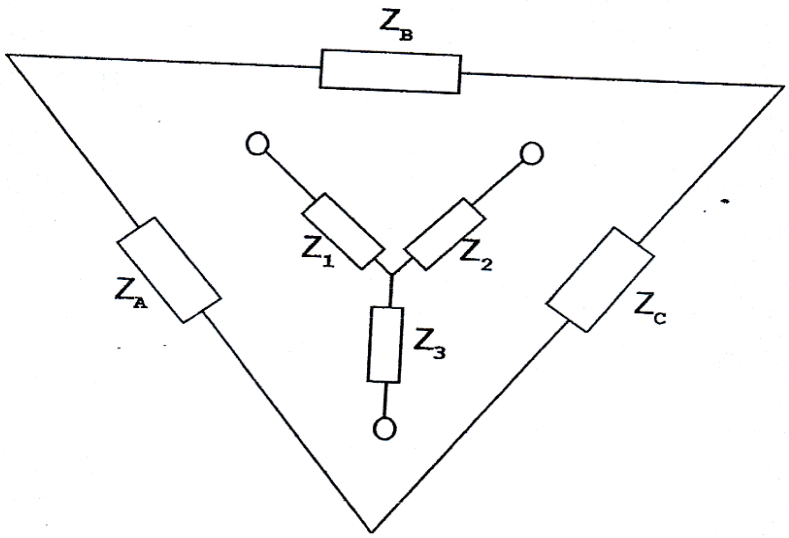
$$ZC = \frac{Z_1 Z_2 + Z_2 Z_3 + Z_1 Z_3}{Z_1}$$

π →T conversion

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

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

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



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ATTENUATORS IN GENERAL

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

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

$dB = 20 \log N$

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

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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