higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

T280**(E)**(N17)T

NOVEMBER EXAMINATION

NATIONAL CERTIFICATE

COMMUNICATION ELECTRONICS N5

(8080235)

17 November 2016 (X-Paper)
09:00–12:00

Calculators may be used.

This question paper consists of 6 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. Keep questions and subsections of questions together.
5. ALL the diagrams must be clearly labelled.
6. Rule off on completion of each answer.
7. Write neatly and legibly.

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QUESTION 1: AC NETWORKS

1.1 A parallel resonance circuit is connected to a 100 V alternating-current supply with a series resistance of 5 Ω and an inductor of 585 µH connected in parallel to a capacitor of 120 pF.

1.1.1 Make a drawing of the circuit. (2)

1.1.2 Calculate the dynamic impedance. (2)

1.1.3 Calculate the Q-factor of the circuit. (2)

1.1.4 Calculate the current flowing through the capacitor. (5)

1.1.5 Calculate the frequency at resonance. (2)

1.2 Use an alternate formula to find Q in QUESTION 1.1.3. (4)

1.3 Define the term *coefficient of coupling.* (3)

1.4 Consider the rules of interaction for mutually inductive coupled circuits. Complete the following sentences by using the words in the list below. Write the letter (a–j) and the answer next to the question number (1.4.1–1.4.3) in the ANSWER BOOK.

induced; current; coupled; primary; lags; impedance; reflected; winding; voltage; secondary

1.4.1 As far as the (a) … circuit is concerned the effect of the secondary circuit is as if an/a (b) … has been added in series with the primary impedance and is called the (c) … or (d) … impedance. (4)

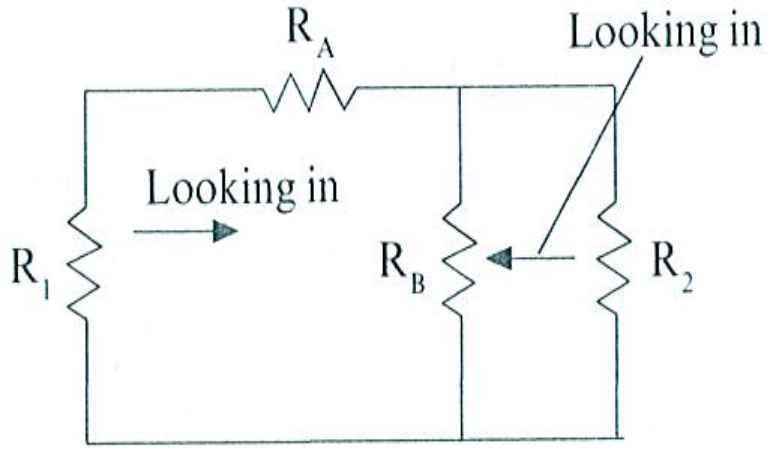
1.4.2 The (e) …is induced in a secondary circuit by the primary (f) … as a magnitude of WMIp and (g) … behind the current by 90°. (3)

1.4.3 The (h) … current is exactly the same current that would flow if the (i) … voltage was applied in series with the secondary circuit and the primary (j) … was absent. (3)

[30]

QUESTION 2: FOUR-TERMINAL NETWORKS

Derive from the first principle the formulae for R_A and R_B using the L-type pad below for matching purposes to give minimum attenuation.

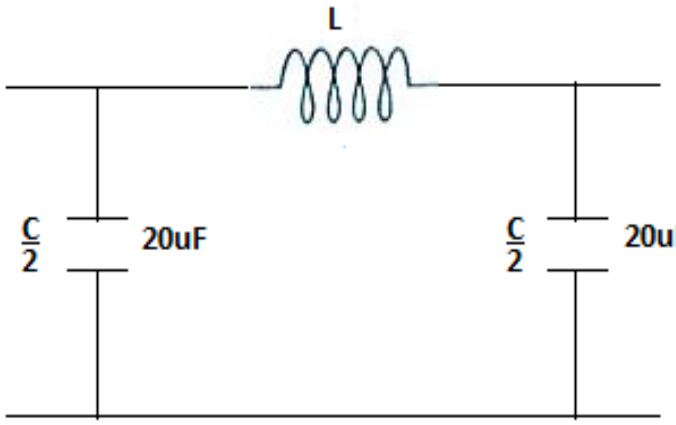


[30]

QUESTION 3: FILTERS

3.1 Design a T-type and a π-type high-pass filter with an impedance of 600 Ω and a cut-off frequency of 50 Hz. (8)

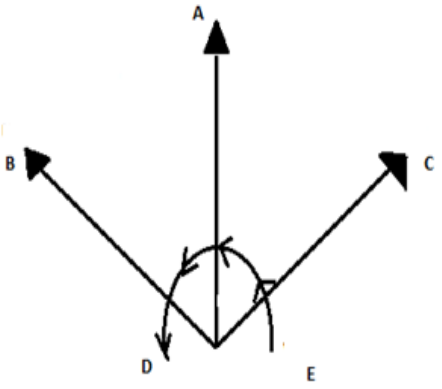
3.2 Determine the cut-off frequency of the following low-pass filter:



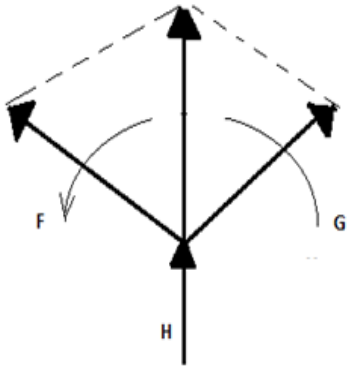
(2)
[10]

QUESTION 4: RECEIVERS AND TRANSMITTERS

4.1 Identify the two sketches below and label them. Write the letter (A–H) and the answer next to the question number (4.1) in the ANSWER BOOK.



(a)



(b) (10)

4.2 Give the THREE differences between the transmitters below.

4.2.1 Double sideband

4.2.2 Single sideband

(2 × 3) (6)

4.3 Determine the bandwidth required for an FM signal in which the modulation frequency is 5 kHz and the maximum deviation is 15 kHz.

BESSEL FUNCTIONS TABLE

x	n or order																
(m_f)	J_0	J_1	J_2	J_3	J_4	J_5	J_6	J_7	J_8	J_9	J_{10}	J_{11}	J_{12}	J_{13}	J_{14}	J_{15}	J_{16}
0.00	1.00	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
0.25	0.98	0.12	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
0.5	0.94	0.24	0.03	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1.0	0.77	0.44	0.11	0.02	—	—	—	—	—	—	—	—	—	—	—	—	—
1.5	0.51	0.56	0.23	0.06	0.01	—	—	—	—	—	—	—	—	—	—	—	—
2.0	0.22	0.58	0.35	0.13	0.03	—	—	—	—	—	—	—	—	—	—	—	—
2.5	−0.05	0.50	0.45	0.22	0.07	0.02	—	—	—	—	—	—	—	—	—	—	—
3.0	−0.26	0.34	0.49	0.31	0.13	0.04	0.01	—	—	—	—	—	—	—	—	—	—
4.0	−0.40	−0.07	0.36	0.43	0.28	0.13	0.05	0.02	—	—	—	—	—	—	—	—	—
5.0	−0.18	−0.33	0.05	0.36	0.39	0.26	0.13	0.05	0.02	—	—	—	—	—	—	—	—
6.0	0.15	−0.28	−0.24	0.11	0.36	0.36	0.25	0.13	0.06	0.02	—	—	—	—	—	—	—
7.0	0.30	0.00	−0.30	−0.17	0.16	0.35	0.34	0.23	0.13	0.06	0.02	—	—	—	—	—	—
8.0	0.17	0.23	−0.11	−0.29	−0.10	0.19	0.34	0.32	0.22	0.13	0.06	0.03	—	—	—	—	—
9.0	−0.09	0.24	0.14	−0.18	−0.27	−0.06	0.20	0.33	0.30	0.21	0.12	0.06	0.03	0.01	—	—	—
10.0	−0.25	0.04	0.25	0.06	−0.22	−0.23	−0.01	0.22	0.31	0.29	0.20	0.12	0.06	0.03	0.01	—	—
12.0	0.05	−0.22	−0.08	0.20	0.18	−0.07	−0.24	−0.17	0.05	0.23	0.30	0.27	0.20	0.12	0.07	0.03	0.01
15.0	−0.01	0.21	0.04	−0.19	−0.12	0.13	0.21	0.03	−0.17	−0.22	−0.09	0.10	0.24	0.28	0.25	0.18	0.12

(4)

[20]

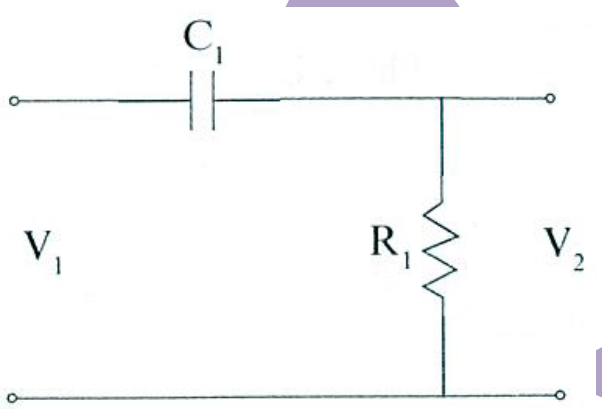
QUESTION 5: ANTENNAE

5.1 Give the TWO disadvantages of a half-wave dipole. (2)

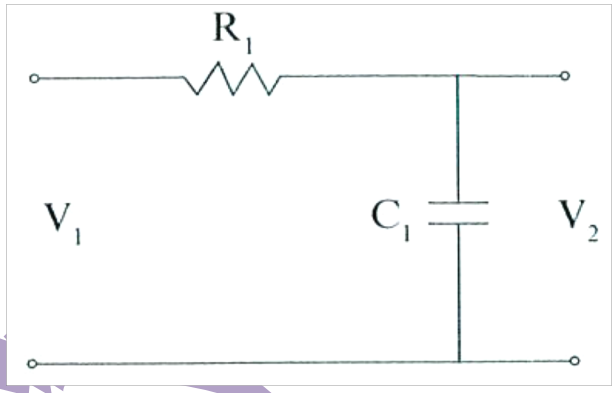
5.2 Define *effective aperture.* (3)
[5]

QUESTION 6: BODE PLOTS

6.1 Identify the TWO circuits below.



(a)



(b) (2 × 2) (4)

6.2 Give ONE of their main functions. (1)
[5]

TOTAL: 100

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COMMUNICATION ELECTRONICS N5

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

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

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

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

$$p.f = Cos\phi$$

$$P = VICos\phi$$

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

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

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

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

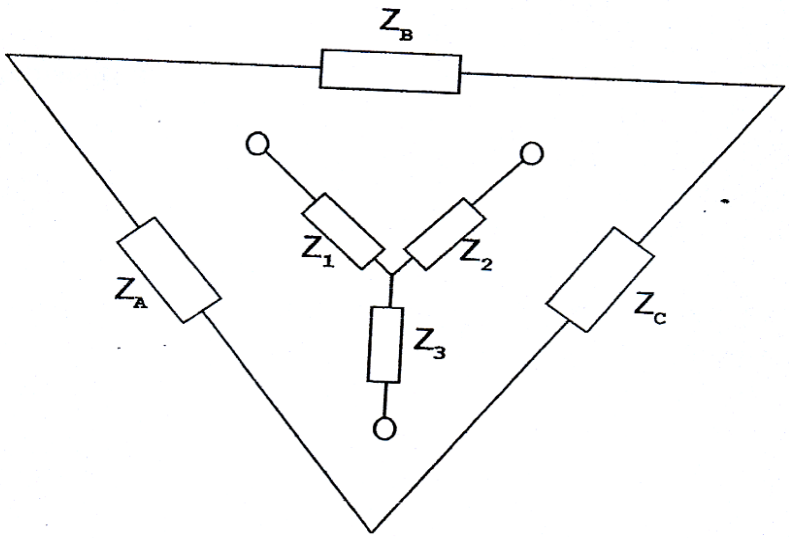
$$ZC = \frac{Z_1 Z_2 + Z_2 Z_3 + Z_1 Z_3}{Z_1}$$

π → T conversion

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

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

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



ATTENUATORS IN GENERAL

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

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

$dB = 20 \log N$

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

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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