higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

T390**(E)**(M27)T

NATIONAL CERTIFICATE

COMMUNICATION-ELECTRONICS N5

(8080235)

27 March 2018 (X-Paper)
09:00–12:00

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

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. Write neatly and legibly.

Copyright reserved

QUESTION 1: ALTERNATING CURRENT NETWORKS

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

1.1.1 Draw the circuit (2)

Calculate the following:

1.1.2 Dynamic impedance (2)

1.1.3 Q-factor of the circuit (2)

1.1.4 Current flowing through the capacitor (5)

1.1.5 Frequency at resonance (2)

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

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

1.4 Consider the rules of interaction for mutually inductive coupled circuits.

Complete the sentences below by using the word or words in the list below. Write only the missing word next to the question number [1.4.1(a)–1.4.3(j)] 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) ... induced in a secondary circuit by the primary (f) ... as a magnitude of WMIp and (g) ... behind the current by 90°. (3)

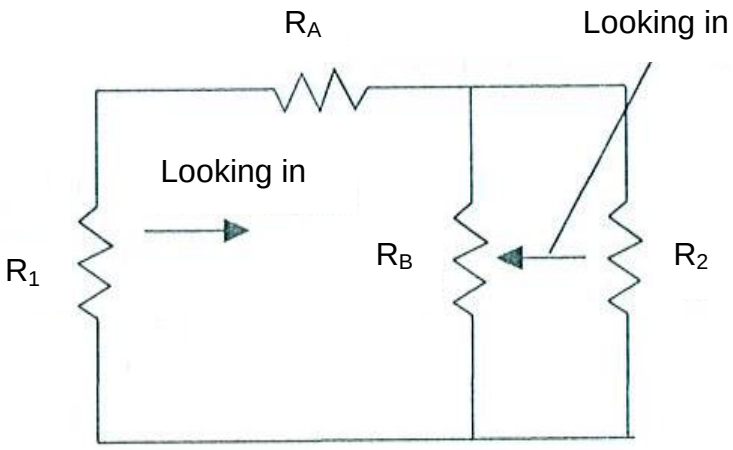
1.4.3 The (h) ... current is exactly the same current that will flow if the (I) ... voltage was applied in series with the secondary circuit and the primary (j) ... was absent. (3)

[30]

Copyright reserved

QUESTION 2: FOUR-TERMINAL NETWORKS

Consider the circuit diagram below and derive the formulae for R_A and R_B of the L-type pad from first principles.



[30]

QUESTION 3: FILTERS

3.1 Design TWO types of high-pass filters consisting of a T-filter and a TT-filter with an impedance of 600 Ω and a cut-off frequency of 15 kHz. (8)

3.2 Determine the cut-off frequency of the low-pass filter in FIGURE 1 with an inductor (L) of 100 mH.

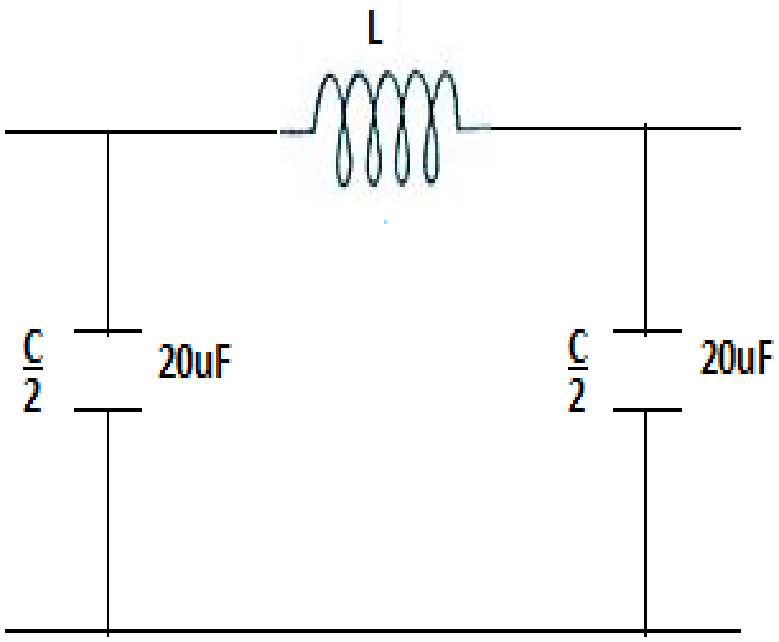
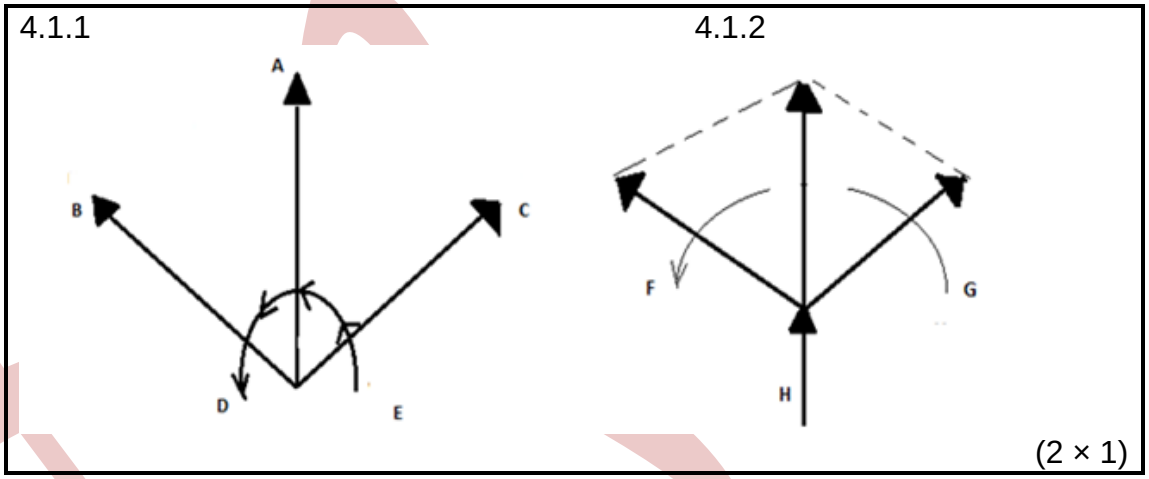


FIGURE 1

(2)
[10]

QUESTION 4: RECEIVERS AND TRANSMITTERS

4.1 Identify the TWO phasor diagrams in FIGURE 2 by writing the answer next to the question number (4.1.1–4.1.2) in the ANSWER BOOK.



(2)

FIGURE 2

4.2 Label the components of the diagrams in QUESTION 4.1 by writing only the answer next to the letter (A–H) in the ANSWER BOOK. (8)

4.3 Give THREE differences between each of the following transmitters:

4.3.1 Double sideband

4.3.2 Single sideband

(2 × 3) (6)

4.4 Use the Bessel Functions Table below to 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

J0–J16

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]

Copyright reserved

QUESTION 5: ANTENNAS

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

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

QUESTION 6: BODE PLOTS

6.1 Identify the TWO RC circuits in FIGURE 2 and FIGURE 3.

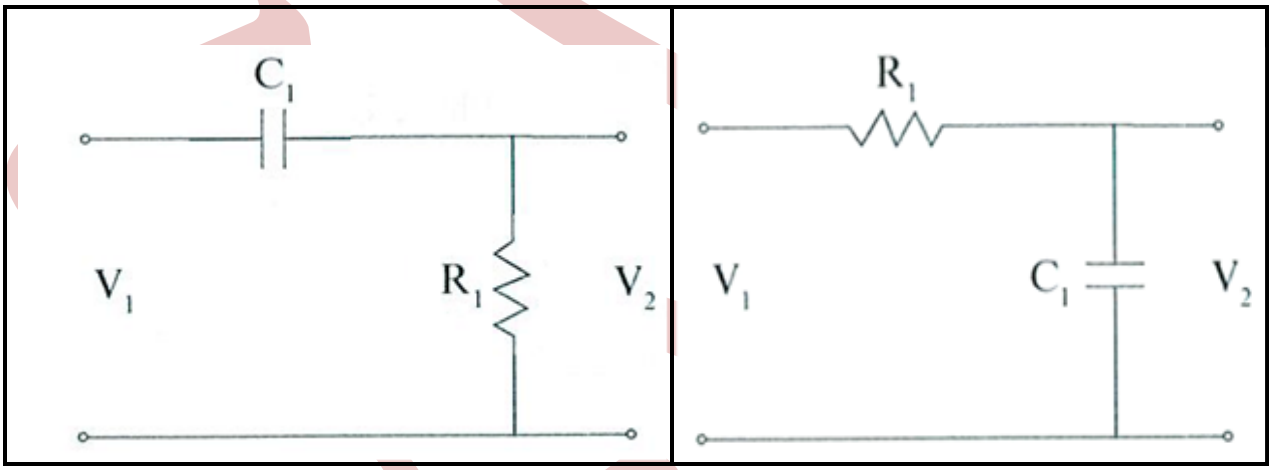


FIGURE 2 **FIGURE 3** (2)

6.2 Explain the main common function of the circuits in QUESTION 6.1 when used in RC circuits. (3)
[5]

TOTAL: 100

Copyright reserved

Copyright reserved

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

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

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

$$\phi = 0^\circ$$

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

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

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

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

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

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

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

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

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

π -network

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

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

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

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

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

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

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

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

NETWORK CONVERSIONS

T → π conversion

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

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

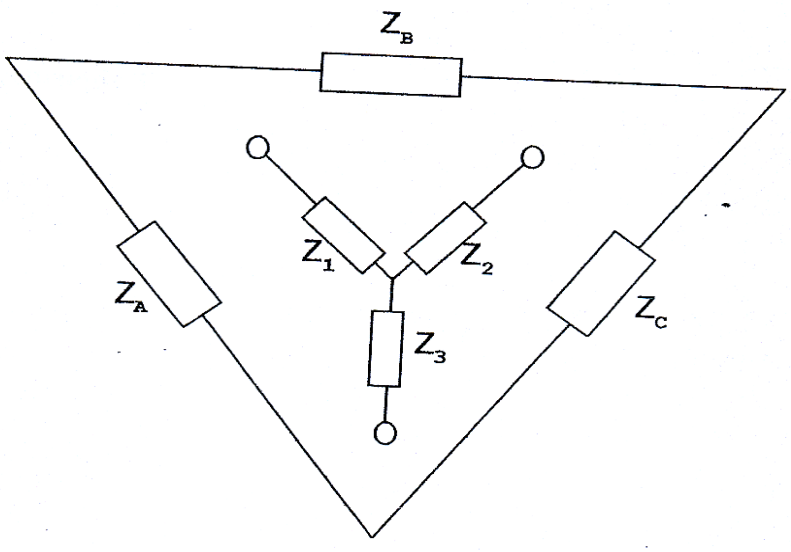
$$ZC = \frac{Z_1 Z_2 + Z_2 Z_3 + Z_1 Z_3}{Z_1}$$

π →T conversion

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

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

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



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