PAST EXAM PAPERS & MEMOS FOR ENGINEERING STUDIES N1-N6

higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE

COMMUNICATION-ELECTRONICS N6

(8080246)

14 April 2020 (X-paper)
09:00–12:00

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

239Q1A2014

DEPARTMENT OF HIGHER EDUCATION AND TRAINING
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE
COMMUNICATION-ELECTRONICS N6
TIME: 3 HOURS
MARKS: 100

INSTRUCTIONS AND INFORMATION

1. Answer all the questions.

2. Read all the questions carefully.

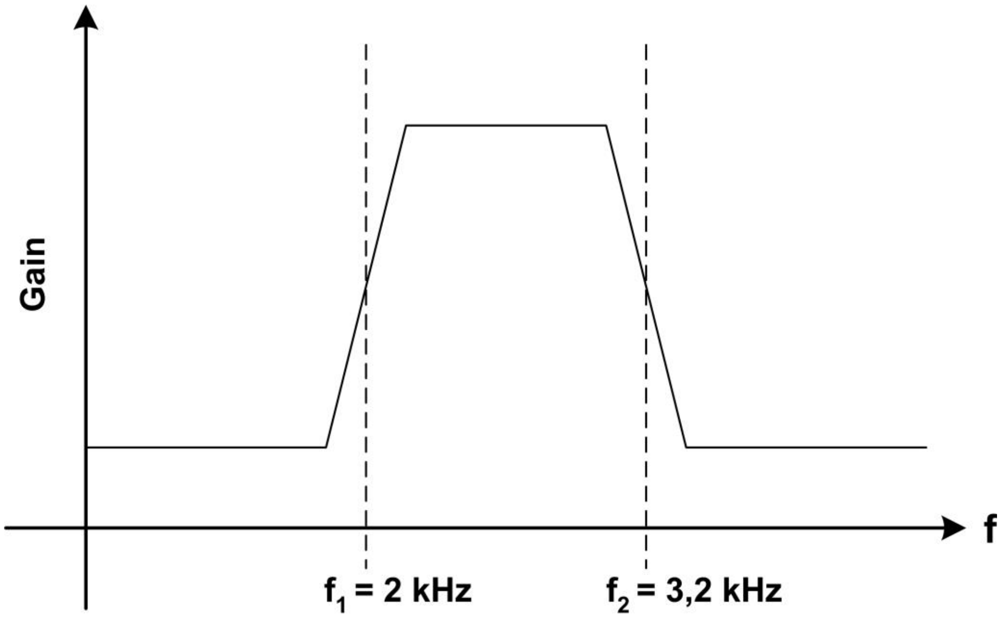
3. Number the answers according to the numbering system used in this question paper.

4. Start each question on a new page.

5. Write neatly and legibly.

QUESTION 1

1.1



Use the information in the given graph and design a filter for a 600 Ω transmission line. Draw the completed filter and insert all relevant values. (6)

1.2 Design a T-section filter network that will eliminate all frequencies between the ranges of 7,5 kHz and 10 kHz for a 600 Ω transmission line. Draw the completed network and insert all relevant values. (6)

1.3 Design the terminating half-sections for a low-pass π-type filter given the following specifications:

f_c = 3,25 kHz
f_∞ = 3,75 kHz
Z_o = 600 Ω

Draw the completed filter networks and insert all relevant component values. (7)

[19]

QUESTION 2

2.1 Draw and fully label each of the following balanced attenuator networks:

2.1.1 π-type

2.1.2 L-type

2.1.3 T-type

(3 × 2) (6)

2.2 A variable bridged T-network is required for a 600 Ω transmission line to give attenuation between the ranges of 3 dB and 5 dB.

Obtain the maximum and minimum values for the potentiometers required. Draw the network and insert all relevant values. (8)

[14]

QUESTION 3

3.1 Calculate the standing wave ratio for each of the following loads connected to a 600 Ω transmission line:

3.1.1 750 Ω (1)

3.1.2 300 + j450 Ω (4)

3.2 Draw a neat, labelled sketch of a two-hole directional coupler. (8)

3.3 Explain how the reactive component can be tuned out of a transmission line. Use a simple sketch to substantiate the explanation. (4)

[17]

QUESTION 4

4.1 The following information concerning a two-stage amplifier is given:

	STAGE 1	STAGE 2
Gain	10	15
Input resistance	9 kΩ	20 kΩ
Equivalent resistance	12 kΩ	15 kΩ
Output resistance	18 kΩ	30 MΩ

Determine the:

4.1.1 Equivalent noise resistance (5)

4.1.2 Output noise voltage for a bandwidth of 9 MHz and a temperature of 25 °C (2)

4.2 The input resistor to an amplifier has a value of 27 kΩ and a frequency range of 21 kHz to 30 kHz at a temperature of 24 °C.

Determine the difference in noise voltage generated, should the temperature be reduced to 18 °C. Take Boltzmann's constant as $1{,}38 \times 10^{-23}$ J/K. (3)

4.3 Explain each of the following terms and give a mathematical expression to substantiate each explanation:

4.3.1 Noise factor

4.3.2 Signal-to-noise ratio

(2 × 3) (6)
[16]

QUESTION 5

5.1 Draw a neat, labelled circuit diagram of a Class C modulator using an NPN-transistor. Indicate all relevant waveforms. (7)

5.2 Explain the full operation of the Class C modulator in QUESTION 5.1. (5)

5.3 Explain sampling with reference to TDM. Use neat sketches to substantiate the explanation. (6)
[18]

QUESTION 6

6.1 Indicate whether the following statement is TRUE or FALSE by writing only 'True' or 'False' next to the question number (6.1) in the ANSWER BOOK.

The gain of an antenna effectively increases the effective aperture of the antenna. (1)

6.2 Define the term *bandwidth of an antenna*. (2)

6.3 Define each of the following terms with reference to antennae:

6.3.1 Polarisation

6.3.2 Isotrope

(2 × 2) (4)

6.4 A radar installation is used to detect a 9 m^2 target at a distance of 100 km. The frequency of operation is 3 GHz and both the transmitter and receiver antennas have a gain of 20 each. To detect the target successfully, a minimum power of $1{,}8 \times 10^{-18}$ W is needed. There is however an attenuation of 0,002 dB/km.

Determine the minimum transmitter power required to detect this target. (9)
[16]

TOTAL: 100

FORMULA SHEET

1. Filters

Low-pass

$$f_c = \frac{1}{\pi \sqrt{L \, . \, C}}$$

$$Z_o = \sqrt{\frac{L}{C}}$$

High-pass

$$f_c = \frac{1}{4 \, . \, \pi \sqrt{L \, . \, C}}$$

$$Z_o = \sqrt{\frac{L}{C}}$$

Low-pass m-derived sections (also for half-sections)

T-section

Series $L = \frac{m \, . \, L}{2}$

Shunt $C = m \, . \, C$

Shunt $L = \frac{1 - m^2}{4 \, . \, m} \, . \, L$

π-section

Shunt $C = \frac{m \, . \, C}{2}$

Series $L = m \, . \, L$

Series $C = \frac{1 - m^2}{4 \, . \, m} \, . \, C$

$$m = \sqrt{1 - \frac{f_c^2}{f_\infty^2}} \qquad L = \frac{Z_o}{\pi \, . \, f_c} \qquad C = \frac{1}{\pi \, . \, Z_o \, . \, f_c}$$

High-pass m-derived sections (also for half-sections)

T-section

Series $C = \frac{2 \, . \, C}{m}$

Shunt $C = \frac{4 \, . \, m}{1 - m^2} \, . \, C$

Shunt $L = \frac{L}{m}$

π-section

Series $C = \frac{C}{m}$

Series $L = \frac{4 \, . \, m}{1 - m^2} \, . \, L$

Shunt $L = \frac{2 \, . \, L}{m}$

$$m = \sqrt{1 - \frac{f_\infty^2}{f_c^2}} \qquad L = \frac{Z_o}{4 \, . \, \pi \, . \, f_c} \qquad C = \frac{1}{4 \, . \, \pi \, . \, Z_o \, . \, f_c}$$

Band-pass sections

Series $L = \dfrac{Z_o}{2\,.\,\pi\,[f_2 - f_1]}$

Series $C = \dfrac{f_2 - f_1}{2\,.\,\pi\,.\,Z_o\,.\,f_1\,.\,f_2}$

Shunt $L = \dfrac{Z_o\,[f_2 - f_1]}{4\,.\,\pi\,.\,f_1\,.\,f_2}$

Shunt $C = \dfrac{1}{\pi\,.\,Z_o\,[f_2 - f_1]}$

Band-stop sections

Series $L = \dfrac{Z_o\,[f_2 - f_1]}{2\,.\,\pi\,.\,f_1\,.\,f_2}$

Series $C = \dfrac{1}{2\,.\,\pi\,.\,Z_o\,[f_2 - f_1]}$

Shunt $L = \dfrac{Z_o}{4\,.\,\pi\,.\,[f_2 - f_1]}$

Shunt $C = \dfrac{f_2 - f_1}{\pi\,.\,Z_o\,.\,f_1\,.\,f_2}$

2. Attenuators

Symmetrical

Bridged T-type

$$Z_B = Z_o\,[N - 1]$$

$$Z_c = \frac{Z_o}{N - 1}$$

$$Z_A = Z_o$$

where $dB = 20 \log N$

Asymmetrical

L-type

$$Z_A = \sqrt{R_1\,(R_1 - R_2)}$$

$$Z_B = \sqrt{\frac{(R_1\,.\,R_2^2)}{R_1 - R_2}}$$

T-type

$$Z_1 = R_1 \left[\frac{N^2 + 1}{N^2 - 1} \right] - 2\sqrt{R_1 \,.\, R_2} \left[\frac{N}{N^2 - 1} \right]$$

$$Z_2 = 2\sqrt{R_1 \,.\, R_2} \left[\frac{N}{N^2 - 1} \right]$$

$$Z_3 = R_2 \left[\frac{N^2 + 1}{N^2 - 1} \right] - 2\sqrt{R_1 \,.\, R_2} \left[\frac{N}{N^2 - 1} \right]$$

where $dB = 20 \log N$

π-type

$$Z_A = R_1 \left[\frac{N^2 - 1}{N^2 - 2 \,.\, N \,.\, S + 1} \right]$$

$$Z_B = \frac{\sqrt{R_1 \,.\, R_2}}{2} \left[\frac{N^2 - 1}{N} \right]$$

$$Z_c = R_2 \left[\frac{N^2 - 1}{N^2 - 2 \,.\, N / S + 1} \right]$$

where $dB = 20 \log N$ and $S = \sqrt{\frac{R_1}{R_2}}$

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

3. Transmission lines

$$Z_o = \sqrt{Z_{o/c} \,.\, Z_{s/c}} \qquad Z_o = \sqrt{\frac{R + j\omega L}{G + j\omega C}}$$

$$\gamma = \sqrt{[R + j\omega L]\,[G + j\omega C]} \qquad \gamma = \alpha + j\beta$$

$$\lambda = \frac{2 \,.\, \pi}{\beta} \qquad V = \frac{\omega}{\beta} \qquad t = \frac{d}{v}$$

L.G = C.R

$$VSWR = \frac{Z_R}{Z_o} \;\; or \;\; \frac{Z_o}{Z_R}$$

Also $VSWR = \frac{1+\rho}{1-\rho}$

$$\rho = \frac{Z_R - Z_o}{Z_R + Z_o}$$

$$\rho = \frac{V_{(reflected)}}{V_{(incident)}}$$

Normalised impedance

$$Z_o^{'} = \frac{R}{Z_o} \pm j\,\frac{X}{Z_o}$$

4. Noise

$$E_n = \sqrt{4KT\Delta f R}$$

$$E_n = \sqrt{4KT\Delta f\ [R_1 + R_2]}$$

$$R_{eq} = R_A + \frac{R_B}{A_1^2} + \frac{R_c}{A_1^2 \cdot A_2^2}$$

where $R_A = R_{1in} + R_{1eq}$

$$R_B = \frac{R_{1(out)} \cdot R_{2(in)}}{R_{1(out)} + R_{2(in)}} + R_{2(eq)}$$

$$R_c = R_{2\ out}$$

$$F = 1 + \frac{R_{eq}^{'}}{R_a}$$

$$R_{eq}^{'} = R_{eq} - R_t$$

$$F = \frac{S/N_{(in)}}{S/N_{(out)}}$$

$$F = 1 + \frac{T_{eq}}{T_o}$$

$$C = \Delta f \log_2 [1 + S/N]$$

where $dB = 10 \log S/N$

5. Modulation

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

$$\eta = \frac{P_{dc}}{P_c} \times 100\%$$

$$P_{dc} = I_{mean} \times V_{dc}$$

$$P_{\text{mod}} = \frac{P_{SB}}{\eta}$$

$$P_{SB} = \frac{m^2 \, . \, P_c}{2}$$

$$P_T = P_c + P_{SB}$$

6. Antennae

$$P_r = P_d \times A \qquad A = \frac{\lambda^2}{4 \, . \, \pi}$$

$$\lambda = \frac{c}{f}$$

$$P_r = P_d \times A \, . \, G_r$$ where $$dB = 10 \log \, G$$

$$P_d = \frac{E^2}{120 \, . \, \pi}$$

$$P_d = \frac{P_t \, . \, G_t}{4 \, . \, \pi \, . \, d^2}$$

$$P_d = \frac{30 \, . \, G \, . \, P_t}{120 \, . \, \pi \, . \, d^2}$$

$$P_t = \frac{[4 \, . \, \pi]^3 \, . \, d^4 \, . \, P_r}{G_t \, . \, G_r \, . \, Q \, . \, \lambda^2}$$

$$P_r = \frac{10 \, . \, P_t \, . \, G_t}{4 \, . \, \pi \, . \, d^2}$$

$$E_r = \frac{\sqrt{30 \, . \, P_r}}{d}$$

$$E_S = \frac{\sqrt{30 \, . \, P_t \, . \, G_t}}{d}$$

$$A = \frac{G \, . \, \lambda^2}{4 \, . \, \pi}$$