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higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE

COMMUNICATION-ELECTRONICS N6

(8080246)

14 April 2020 (X-paper)
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This question paper consists of 5 pages and a formula sheet of 5 pages.

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DEPARTMENT OF HIGHER EDUCATION AND TRAINING
REPUBLIC OF SOUTH AFRICA
NATIONAL CERTIFICATE
COMMUNICATION-ELECTRONICS N6
TIME: 3 HOURS
MARKS: 100

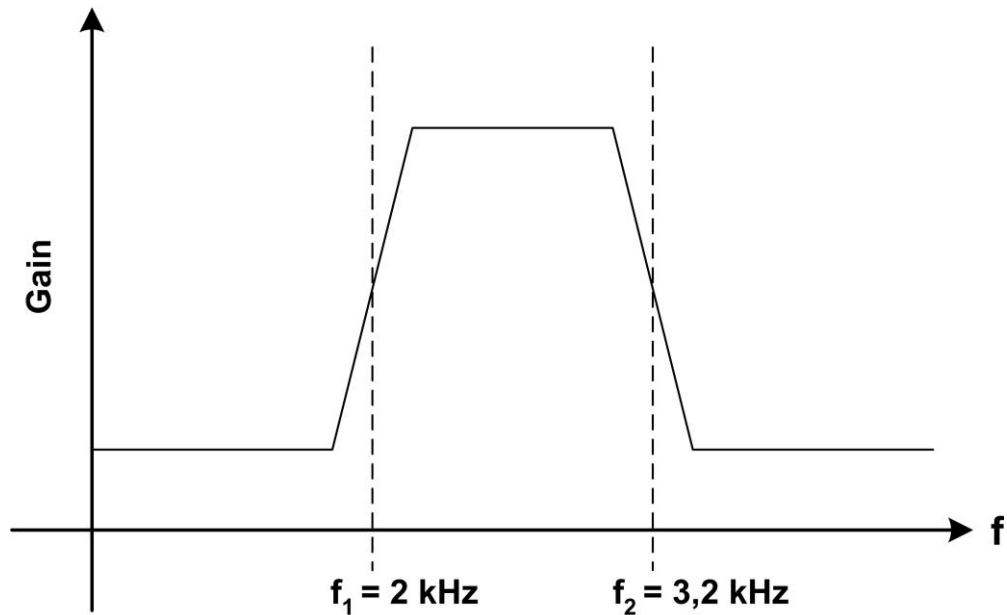
INSTRUCTIONS AND INFORMATION

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

倍



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

倍

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

$$f_c = 3.25 \text{ kHz}$$

$$f_\infty = 3.75 \text{ kHz}$$

$$Z_o = 600 \Omega$$

倍

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 倍

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.

倍

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 倍 (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 k Ω	20 k Ω
Equivalent resistance	12 k Ω	15 k Ω
Output resistance	18 k Ω	30 M Ω

Determine the:

4.1.1 Equivalent noise resistance 倍 (5)

4.1.2 Output noise voltage for a bandwidth of 9 MHz and a temperature of 25 $^{\circ}\text{C}$ (2)

- 4.2 The input resistor to an amplifier has a value of 27 k Ω and a frequency range of 21 kHz to 30 kHz at a temperature of 24 °C. 悟
- 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]**
- 悟

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. 悟 (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*. 悟 (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 m² 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. 悟
- Determine the minimum transmitter power required to detect this target. (9)
- [16]**

TOTAL: 100

FORMULA SHEET**1. Filters****Low-pass**

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

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

High-pass

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

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

Low-pass m-derived sections (also for half-sections)**T-section**

$$\text{Series } L = \frac{m \cdot L}{2}$$

$$\text{Shunt } C = m \cdot C$$

$$\text{Shunt } L = \frac{1 - m^2}{4 \cdot m} \cdot L$$

$$m = \sqrt{1 - \frac{f_c^2}{f_\infty^2}} \quad L = \frac{Z_o}{\pi \cdot f_c}$$

 π -section

$$\text{Shunt } C = \frac{m \cdot C}{2}$$

$$\text{Series } L = m \cdot L$$

$$\text{Series } C = \frac{1 - m^2}{4 \cdot m} \cdot C$$

$$C = \frac{1}{\pi \cdot Z_o \cdot f_c}$$

High-pass m-derived sections (also for half-sections)**T-section**

$$\text{Series } C = \frac{2 \cdot C}{m}$$

$$\text{Shunt } C = \frac{4 \cdot m}{1 - m^2} \cdot C$$

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

$$m = \sqrt{1 - \frac{f_\infty^2}{f_c^2}} \quad L = \frac{Z_o}{4 \cdot \pi \cdot f_c}$$

 π -section

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

$$\text{Series } L = \frac{4 \cdot m}{1 - m^2} \cdot L$$

$$\text{Shunt } L = \frac{2 \cdot L}{m}$$

$$C = \frac{1}{4 \cdot \pi \cdot Z_o \cdot f_c}$$

Band-pass sections

$$\text{Series } L = \frac{Z_o}{2 \cdot \pi [f_2 - f_1]}$$

$$\text{Series } C = \frac{f_2 - f_1}{2 \cdot \pi \cdot Z_o \cdot f_1 \cdot f_2}$$

$$\text{Shunt } L = \frac{Z_o [f_2 - f_1]}{4 \cdot \pi \cdot f_1 \cdot f_2}$$

$$\text{Shunt } C = \frac{1}{\pi \cdot Z_o [f_2 - f_1]}$$

Band-stop sections

$$\text{Series } L = \frac{Z_o [f_2 - f_1]}{2 \cdot \pi \cdot f_1 \cdot f_2}$$

$$\text{Series } C = \frac{1}{2 \cdot \pi \cdot Z_o [f_2 - f_1]}$$

$$\text{Shunt } L = \frac{Z_o}{4 \cdot \pi \cdot [f_2 - f_1]}$$

$$\text{Shunt } C = \frac{f_2 - f_1}{\pi \cdot Z_o \cdot f_1 \cdot f_2}$$

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**

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

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

T-type

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

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

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

where $dB = 20 \log N$

 π -type

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

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

$$Z_C = R_2 \left[\frac{N^2 - 1}{N^2 - 2 \cdot N/S + 1} \right]$$

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

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

3. Transmission lines

$$Z_o = \sqrt{Z_{o/c} \cdot Z_{s/c}}$$

$$Z_o = \sqrt{\frac{R + j\omega L}{G + j\omega C}}$$

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

$$\gamma = \alpha + j\beta$$

$$\lambda = \frac{2 \cdot \pi}{\beta} \quad V = \frac{\omega}{\beta}$$

$$t = \frac{d}{v}$$

L.G = C.R

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

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

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

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

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

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

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

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

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

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

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

6. Antennae

$$P_r = P_d \times A \quad A = \frac{\lambda^2}{4 \cdot \pi}$$

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

$$P_r = P_d \times A \cdot G_r$$

where

$$dB = 10 \log G$$

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

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

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

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

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

$$E_r = \frac{\sqrt{30 \cdot P_r}}{d}$$

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

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