higher education & training

Department:
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REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE

COMMUNICATION-ELECTRONICS N6

(8080246)

19 April 2021 (X-paper)
09:00–12:00

Nonprogrammable calculators may be used.

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

235Q1A2119

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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.

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QUESTION 1

1.1 Design a π-section to match impedances of 600 Ω to 125 Ω with an attenuation of 40 dB. Draw the completed section of this attenuator and insert the values. (11)

1.2 Define the term *attenuator*. (2)

1.3 Differentiate between the older design theory of a filter and the modern approach to filters. (2)

1.4 Name TWO important active devices used in the design of RC-active filters to achieve the usual transfer function attainable with passive LC filters. (2)

[17]

QUESTION 2

2.1 Define the term *transmission line*. (2)

2.2 The diagrams in FIGURE 1, together with their formulae, represent transmission-line geometry.

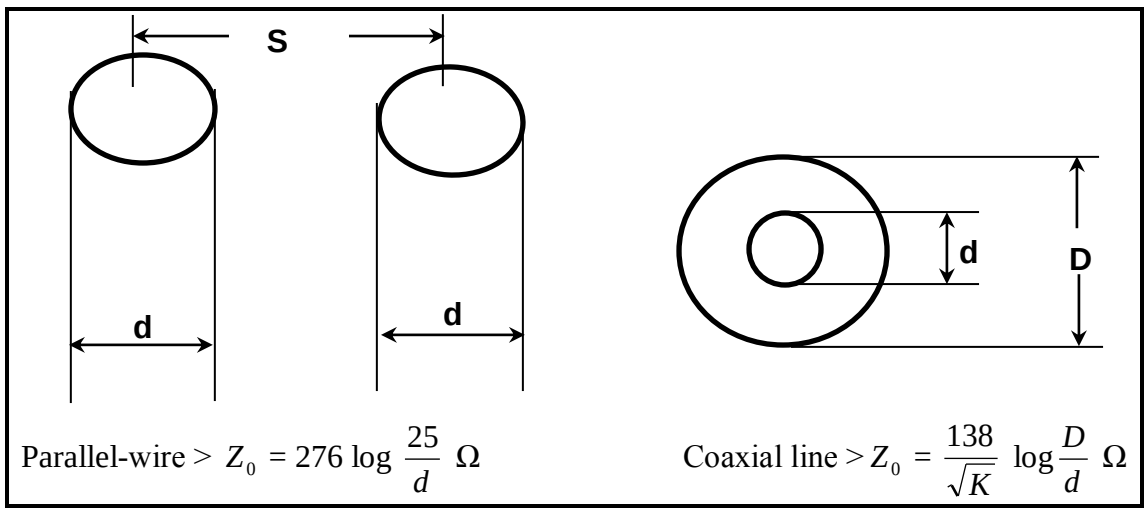


FIGURE 1

2.2.1 A coaxial cable has a 75 Ω characteristic impedance and a nominal capacitance of 64 pf/m.

What is the inductance per meter? (5)

2.2.2 Calculate the outer conductor diameter if the inner conductor has a diameter of 0,584 mm and the dielectric constant of the insulation is 2,23. (2)

2.3 Is an attenuator frequency sensitive? Substantiate the answer. (1 + 2) (3)

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2.4 The information is for a π-type asymmetrical attenuator network:

Attenuation = 10
Output image impedance = 300 Ω
Series resistor = 4 kΩ

Use the information to determine the input image impedance. (4)
[16]

QUESTION 3

3.1 Differentiate between a vertically polarised and a horizontally polarised antenna. (2 × 2) (4)

3.2 A 10 kW, 500 MHz transmitter is used to range a satellite with a surface area of 10 m^2 that is 5 000 km above the earth. The transmitter and the receiver are centrally based and have similar characteristics with gains of 25 dB each.

Calculate:

3.2.1 Field strength at the satellite (4)

3.2.2 Power density at the satellite (2)

3.2.3 Reflected power (2)

3.2.4 Field strength at the receiver (2)

3.2.5 Power density at the receiver (2)

3.2.6 Signal strength of the received signal (5)
[21]

QUESTION 4

4.1 Explain how thermal agitation noise is generated in a receiver. (5)

4.2 A receiver connected to an antenna with a resistance of 50 Ω has an equivalent noise resistance of 30 Ω.

Calculate the noise figure of the receiver in decibels and its equivalent noise temperature. (6)

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4.3

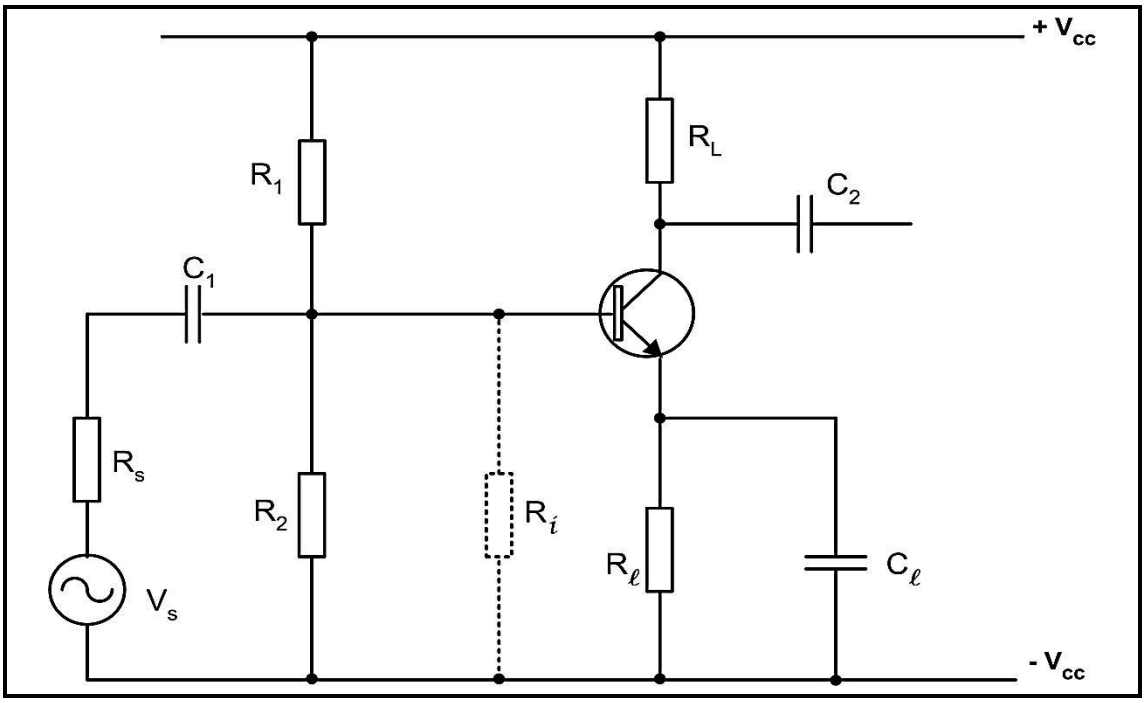


FIGURE 2

Draw the equivalent input circuit for noise of the amplifier shown in FIGURE 2. (4)

4.4 The following data apply to a two-stage amplifier:

R_{eq} = 9 kΩ
R_a = 50 Ω
F = 41

Calculate the value of the input resistor to this amplifier. (4)
[19]

QUESTION 5

5.1 Differentiate between:

5.1.1 Pulse amplitude modulation (PAM) (1)

5.1.2 Pulse position modulation (PPM) (2)

5.2 Draw a neat, fully labelled block diagram of a single-channel PCM system. (10)
[13]

QUESTION 6

A satellite transmitter operating at a frequency of 950 MHz radiates 60 kW of RF power and is used to determine the distance of the satellite 150 km away which has a surface area of 30 m^2. The transmitter and receiver antenna have similar characteristics with gains of 15 dB each.

Determine the:

6.1	Field strength at the satellite	(3)
6.2	Power density at the satellite	(2)
6.3	Reflected power from the satellite	(2)
6.4	Field strength at the receiver	(2)
6.5	Power density at the receiver	(2)
6.6	Received power at the receiver	(3)
		[14]

TOTAL: 100

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FORMULA SHEET

1. Filters

Low-pass

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

High-pass

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

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

T-section	π-section
Series $L = \frac{m \,.\, L}{2}$	Shunt $C = \frac{m \,.\, C}{2}$
Shunt $C = m \,.\, C$	Series $L = m \,.\, L$
Shunt $L = \frac{1 - m^2}{4 \,.\, m} \,.\, L$	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	π-section
Series $C = \frac{2 \,.\, C}{m}$	Series $C = \frac{C}{m}$
Shunt $C = \frac{4 \,.\, m}{1 - m^2} \,.\, C$	Series $L = \frac{4 \,.\, m}{1 - m^2} \,.\, L$
Shunt $L = \frac{L}{m}$	Shunt $L = \frac{2 \,.\, L}{m}$

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

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Band-pass section

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

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

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

$Z_A = Z_o$

where $dB = 20 \log N$

Asymmetrical

L-type

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

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

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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

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

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

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

LG = CR

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

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

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

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

Normalised impedance

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

4. Noise

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

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

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

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

$$R_c = R_{2out}$$

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

$$F = \frac{S/N_{(in)}}{S/N_{(out)}} \qquad F = 1 + \frac{T_{eq}}{T_o}$$

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

where $dB = 10 \log S/N$

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5. Modulation

$$m = \frac{V_m}{V_c} \qquad \eta = \frac{P_{dc}}{P_c} \times 100\%$$

$$P_{dc} = I_{mean} \times V_{dc} \qquad P_{\text{mod}} = \frac{P_{SB}}{\eta}$$

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

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

6. Antennae

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

$$P_r = P_d \times A \,.\, G_r \qquad \text{where } dB = 10 \log G$$

$$P_d = \frac{E^2}{120 \,.\, \pi} \qquad P_d = \frac{P_t \,.\, G_t}{4 \,.\, \pi \,.\, d^2}$$

$$P_d = \frac{30 \,.\, G \,.\, P_t}{120 \,.\, \pi \,.\, d^2} \qquad P_t = \frac{[4 \,.\, \pi]^3 \,.\, d^4 \,.\, P_r}{G_t \,.\, G_r \,.\, Q \,.\, \lambda^2}$$

$$P_r = \frac{10 \,.\, P_t \,.\, G_t}{4 \,.\, \pi \,.\, d^2} \qquad E_r = \frac{\sqrt{30 \,.\, P_r}}{d}$$

$$E_S = \frac{\sqrt{30 \,.\, P_t \,.\, G_t}}{d} \qquad A = \frac{G \,.\, \lambda^2}{4 \,.\, \pi}$$

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