higher education & training

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REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE

COMMUNICATION ELECTRONICS N6

(8080246)

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09:00–12:00

Drawing instruments and nonprogrammable calculators may be used.

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: 150

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 section on a new page.
5. Use only a black or a blue pen.
6. Write neatly and legibly.

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QUESTION 1

1.1 Indicate whether the following statements are TRUE or FALSE by writing only 'True' or 'False' next to the question number (1.1.1–1.1.2) in the ANSWER BOOK.

1.1.1 The main disadvantages of prototype filter sections are firstly that the attenuation does not rise rapidly at the cut-off frequency.

1.1.2 The most obvious way to increase the attenuation beyond cut-off is by connecting one section only.

(2 × 1) (2)

1.2 A T-filter network, which will prevent all frequencies between the ranges of 5 kHz and 7,5 kHz to pass, is needed for a 600-ohm transmission line.

Design and draw the completed network indicating ALL the component values. (10)

1.3 Draw a neat, labelled graph of attenuation against frequency for the filter referred to in QUESTION 1.2 (2)

1.4 Design the terminating half-sections for a high-pass T-filter given the following specifications:

f_c = 3,75 kHz
f_∞ = 2,5 kHz
Z_o = 600 ohms (6)

[20]

QUESTION 2

2.1 An asymmetrical T-network is inserted between the two image impedances as shown in FIGURE 1 below. Determine, with the aid of the available information, the insertion loss produced by the T-network.

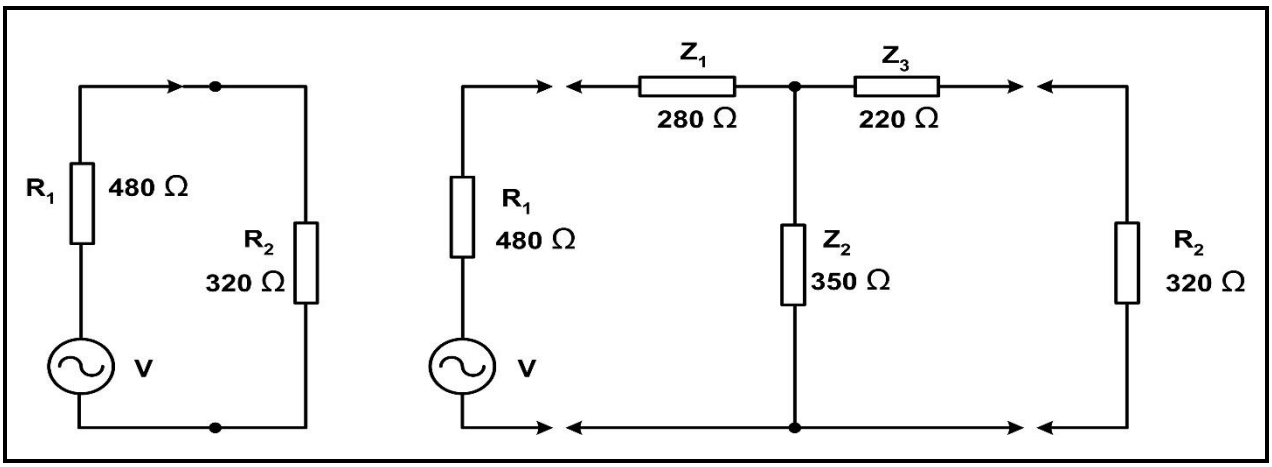


FIGURE 1

(10)

2.2 A variable bridged T-network is required for a 600-ohm transmission line to give attenuation between the ranges of 5 dB and 10 dB. Obtain the maximum and minimum values for the potentiometers required then draw the network and insert all relevant values. (10)
[20]

QUESTION 3

3.1 Explain what theoretical antenna is used as a basis for comparison between antennas. (2)

3.2 Differentiate between the following antennas:

3.2.1 Vertically polarised

3.2.2 Horizontally polarised

(2 × 2) (4)

3.3 A certain transmission line has the following primary line constants:

R_l; C_l and L_l

Derive, from first principles, the formula for the characteristic impedance for this transmission line. (9)
[15]

QUESTION 4

4.1 Explain how thermal agitation noise is generated in a receiver. (4)

4.2 Explain the equivalent noise resistance of an amplifier or receiver according to noise figure. (3)

4.3 Draw a fully labelled circuit diagram of a diode noise generator which is used to determine the noise figure of a receiver under test when it is not practical to calculate the equivalent noise resistance under transit-time conditions. (5)

4.4 A two-stage amplifier has the following information:

AMPLIFIER	GAIN	INPUT RESISTANCE	OUTPUT RESISTANCE	EQUIVALENT RESISTANCE
STAGE 1	12	6,8 kΩ	15 kΩ	9 kΩ
STAGE 2	20	18 kΩ	20 MΩ	12 kΩ

Determine the following:

4.4.1 Equivalent noise resistance (10)

4.4.2 Output noise voltage for a band width of 7,5 MHz and a temperature of 24 °C (3)
[25]

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QUESTION 5

5.1 Choose the correct word from those given in brackets. Write only the word next to the question number (5.1.1–5.1.6) in the ANSWER BOOK.

5.1.1 PCM has a (better/worse) S/N ratio.

5.1.2 PCM requires a (narrow/wide) bandwidth.

5.1.3 A non-linear modulator normally uses a component such as a (transistor/valve).

5.1.4 A linear modulator normally uses a component such as a (transistor/valve).

5.1.5 PAM has a very (good/poor) S/N ratio.

5.1.6 PWM has a (poor/better) S/N ratio compared to PAM.

(6 × 1) (6)

5.2 Explain the design and operation of an AM linear modulator used in large power transmitters requiring good linearity. (4)

5.3 With reference to antennae, define:

5.3.1 Directive gain

5.3.2 A receiver antenna

5.3.3 A transmitter antenna

(3 × 2) (6)

5.4 An antenna has a gain of 12 and receives 5×10^{-13} watts at a frequency of 120 MHz.

Determine the power density around the antenna in W/m^2. (4)

[20]

TOTAL: 100

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COMMUNICATION-ELECTRONICS N6

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

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

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

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

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

Band-pass sections

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

Shunt $L = \frac{Z_o \,[f_2 - f_1]}{4 \,.\, \pi \,.\, f_1 \,.\, f_2}$ *Shunt* $C = \frac{1}{\pi \,.\, Z_o \,[f_2 - f_1]}$

Band-stop sections

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

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

2. *Attenuators* *Symmetrical*

Bridged T-type

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

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

$Z_A = Z_o$

where $dB = 20 \log N$

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

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3. Transmission lines

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

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

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

$$L.G = C.R$$

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

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

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

$$R_c = R_{2out/uit}$$

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

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

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

Where $dB = 10 \log S/N$

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

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

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

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

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

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

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

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