higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

T400**(E)**(A3)T

NATIONAL CERTIFICATE

COMMUNICATION-ELECTRONICS N6

(8080246)

3 August 2018 (X-Paper)
09:00–12:00

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

Copyright reserved

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. Write neatly and legibly.

Copyright reserved

QUESTION 1: ATTENUATORS AND FILTERS

1.1 Determine ALL component values for an m-derived low-pass T-type filter, given the following specifications:

Z_0 = 600 ohms
f_c = 7,5 kHz
mL = 9 mH (4)

1.2 Determine the input impedance of an asymmetrical T-type network with the aid of the information given below, if the power is attenuated by 15 dB:

Z_2 = 350 ohms
R_2 = 500 ohms (6)

1.3 Explain in detail the effect of an insertion loss on a network. (5)

1.4 Determine ALL the component values for a T-type filter network, which will prevent all frequencies between the ranges of 3,5 kHz and 6 kHz to pass and which is needed for a 600 ohm transmission line. (4)

1.5 Determine ALL the component values for an m-derived, high-pass, T-type filter, given the following specifications:

Z_0 = 600 ohms
f_c = 4,25 kHz
f_∞ = 3,75 kHz (6)
[25]

QUESTION 2: TRANSMISSION LINES

2.1 Discuss the term *standing-wave ratio.* (2)

2.2 Consider the primary constants given below which were obtained during the test on a transmission line taken at a frequency of ω = 9 000 radians/second.

Primary constants:

R = 22 ohms/km
G = 18 x 10^{-6}
C = 12 x 10^{-9}
L = 35 mH/km

Determine:

2.2.1 The wavelength of the transmission (8)

2.2.2 The velocity of the transmission (2)

Copyright reserved

2.3 Determine the open-circuit impedance of a transmission line given the following data:

Z_0 = 600 ohms
$Z_{s/c}$ = 600 ohms (2)

2.4 The impedance of a transmission line is 400 – j 200 ohms and is terminated by a load with an impedance of 300∟45° ohms.

Determine the reflected voltage for an incident voltage of 0,6300∟30° ohms. (6)
[20]

QUESTION 3: ANTENNAS

3.1 Define the following terms with reference to antennas:

3.1.1 Beam width (1)

3.1.2 Bandwidth (1)

3.1.3 Aperture (2)

3.2 An antenna receives 12×10^{-9} watts at a frequency of 100 MHz with a power density of $0,6 \times 10^{-9}$ watts/m².

Determine the gain of the antenna in dB. (9)

3.3 An earth station receives information from a satellite 180 km away from earth at a frequency of 90 MHz which supplies 30 watts from the antenna with a gain of 15. The receiver antenna has a gain of 12.

Determine the signal power received by the earth station. (7)
[20]

QUESTION 4: NOISE

4.1 What causes the following noise:

4.1.1 Atmospheric (1)

4.1.2 Man-made (1)

4.1.3 Thermal agitation (2)

4.1.4 Cosmic (2)

Copyright reserved

4.2 A receiver has an antenna with a resistance of 180 ohms and an equivalent noise resistance of 75 ohms.

Determine:

4.2.1 The noise figure in dB

4.2.2 The ambient temperature for a 100 K and the equivalent temperature

(2 × 4) (8)

4.3 Define the *Shannon-Hartley theorem.* (2)

4.4 Calculate the Baud rate of a telephone channel with a bandwidth of 15 kHz and a signal-to-noise ratio of 20 dB. (5)

4.5 The Boltzmann's constant is $1,38 \times 10^{-3}$ J/K.

You are required to determine the temperature in °C when a 4,5 megohm resistor generates a noise voltage of 26,112 µV at a frequency of 9 kHz. (4)

[25]

QUESTION 5: MODULATION AND DEMODULATION

5.1 Explain why single-sideband transmission is commonly used for multi-channel line telephony and point-to-point radio circuits.

5.2 Discuss why independent single-sideband transmission is preferred to other systems for communication.

(2 × 5) **[10]**

TOTAL: 100

Copyright reserved

COMMUNICATION-ELECTRONICS N6

FORMULA SHEET

1. Filters

Low-pass/Laedeurlaat

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

High-pass/Hoëdeurlaat

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

Low-pass m-derived sections (also for half-sections)
Laedeurlaat, m-afgeleide seksies (ook vir halfseksies)

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

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

High-pass m-derived sections (also for half-sections)
Hoëdeurlaat, m-afgeleide seksies (ook vir halfseksies)

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

Copyright reserved

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

Shunt/Sjunt $L = \frac{2 \cdot L}{m}$

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

Band-pass sections
Banddeurlaatseksies

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

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

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

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

Band-stop sections
Bandsperseksies

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

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

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

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

2. *Attenuators*
Verswakkers

Symmetrical
Simmetries

Bridged T-type
Gebrugde T-tipe

$Z_B = Z_o [N - 1]$

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

$Z_A = Z_o$

where/waar $dB = 20 \log N$

Asymmetrical
Asimmetries

L-type
L-tipe

Copyright reserved

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

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

T-Type
T-Tipe

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

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

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

where/waar $dB = 20 \log N$

π-type
π-tipe

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

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

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

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

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

Copyright reserved

3. Transmission lines
Transmissielyne

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

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

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

$$L.G = C.R$$

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

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

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

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

Normalised impedance/Genormaliseerde impedansie

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

4. Noise/Geruis

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

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

$$\text{where/ waar } R_A = R_{1in} + R_{1eq}$$

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

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

Copyright reserved

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

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

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

where/waar $dB = 10 \log S/N$

5. *Modulation*
Modulasie

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

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

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

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

6. *Antennae/Antennas*

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

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

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

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

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

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

Copyright reserved