higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

T400(**E**)(A10)T

NATIONAL CERTIFICATE

COMMUNICATION-ELECTRONICS N6

(8080246)

10 April 2018 (X-Paper)
09:00–12:00

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

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QUESTION 1: ATTENUATORS AND FILTERS

1.1 Define an *attenuator*. (2)

1.2 Name FIVE types of unbalanced attenuators. (5)

1.3 Determine ALL the component values for a π-type attenuator pad which will provide a 40 dB attenuation, to match two networks with impedances of 600 Ω and 125 Ω respectively. (10)

1.4 Explain the TWO main disadvantages of a prototype filter. (2)

1.5 Name FOUR of the most common types of filters which are mostly used in communication circuits. (4)

1.6 Determine ALL the component values for a multisection low-pass filter consisting of a terminating prototype half section and a terminating m-derived half section. The filter has a cut-off frequency of 1 000 Hz and a frequency of infinite attenuation of 1 200 Hz to be able to operate in a 600 Ω transmission line. (12)
[35]

QUESTION 2: TRANSMISSION LINES

2.1 Define a *transmission line*. (2)

2.2 State THREE elements that determine the characteristic impedance of a transmission line. (3)

2.3 A field quad cable has the following primary constants:

R = 78 ohms per km loop
G = 62 micromhos per km loop
L = 1,75 millihenries per km loop
C = 0,0945 microfarads per km
Frequency = 1,6 kHz $\left(\omega \times 10000\, radians/_{\sec ond}\right)$

Determine the following:

2.3.1 The characteristic impedance (3)

2.3.2 The attenuation constant, in nepers and decibels per km (2)

2.3.3 The phase constant, in radians and degrees per km (1)

2.3.4 The wavelength in km (1)

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2.3.5 Velocity in km per second (1)

2.3.6 Time in milliseconds, for a wave to travel 100 km along the line (2)
[15]

QUESTION 3: ANTENNAS

3.1 Explain each of the following terms regarding an antenna:

3.1.1 Beam width

3.1.2 Bandwidth

3.1.3 Aperture

(3 × 2) (6)

3.2 Explain each of the following terms with reference to an antenna:

3.2.1 Polarisation

3.2.2 Capture area

3.2.3 Effective electrical length

(3 × 3) (9)

3.3 Determine the minimum peak transmitter power needed in a pulsed radar which is required to detect a target 10 m² echoing at a range of 120 km.

The following system parameters are given:

Operating frequency = 1,3 GHz
Received power = $10^{-13,5}$ *watts*
Aerial gain = 34 dB
Atmospheric attenuation = 0,008 dB/km

(5)
[20]

QUESTION 4: NOISE

4.1 Explain why pulse-duration modulation gives a better signal-to-noise performance in radio communication systems. (4)

4.2 Determine the noise voltage at the input of a television radio-frequency amplifier with a bandwidth of 6 MHz at a temperature of 17 °C, connected to a device that has a 200 Ω equivalent noise resistance and a 300 Ω input resistor. (3)

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4.3 A receiver with a rated equivalent noise resistance of 2 000 Ω and an input impedance of 1 000 Ω, is connected to a sine-wave generator with an internal impedance of 200 Ω.

Calculate:

4.3.1 The noise figure in dB (5)

4.3.2 The equivalent noise temperature at 25 °C (3)

[15]

QUESTION 5: MODULATION AND DEMODULATION

5.1 Explain why a frequency-modulation system is preferred rather than an amplitude-modulation system in radio communication systems. (3)

5.2 State why most radio-communication systems use angle modulation. (3)

5.3 Name FOUR alternative methods of modulation that use a digital carrier. (4)

5.4 Define the term *multiplexing*. (2)

5.5 Name THREE practical radio-communication systems which favour the use of frequency modulation rather than phase modulation. (3)

[15]

TOTAL: 100

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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

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

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

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

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

π-section
π-seksie

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

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

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

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

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

T-section
T-seksie

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

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

π-section
π-seksie

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

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

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

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

Band-pass sections
Banddeurlaatseksies

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

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

Band-stop sections
Bandsperseksies

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

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

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

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

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

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

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3. Transmission lines
Transmissielyne

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

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

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

$$L.G = C.R$$

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

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

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

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

Normalised impedance/Genormaliseerde impedansie

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

4. Noise/Geruis

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

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

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

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

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

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

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

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

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

5. *Modulation*
Modulasie

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

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

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

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

6. *Antennae/Antennas*

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

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

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

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

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

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

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

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

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

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

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