higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

T290**(E)**(N17)T
NOVEMBER EXAMINATION

NATIONAL CERTIFICATE

COMMUNICATION-ELECTRONICS N6

(8080246)

17 November 2016 (X-Paper)
09:00–12:00

This question paper consists of 6 pages and 1 formula sheet of 5 pages.

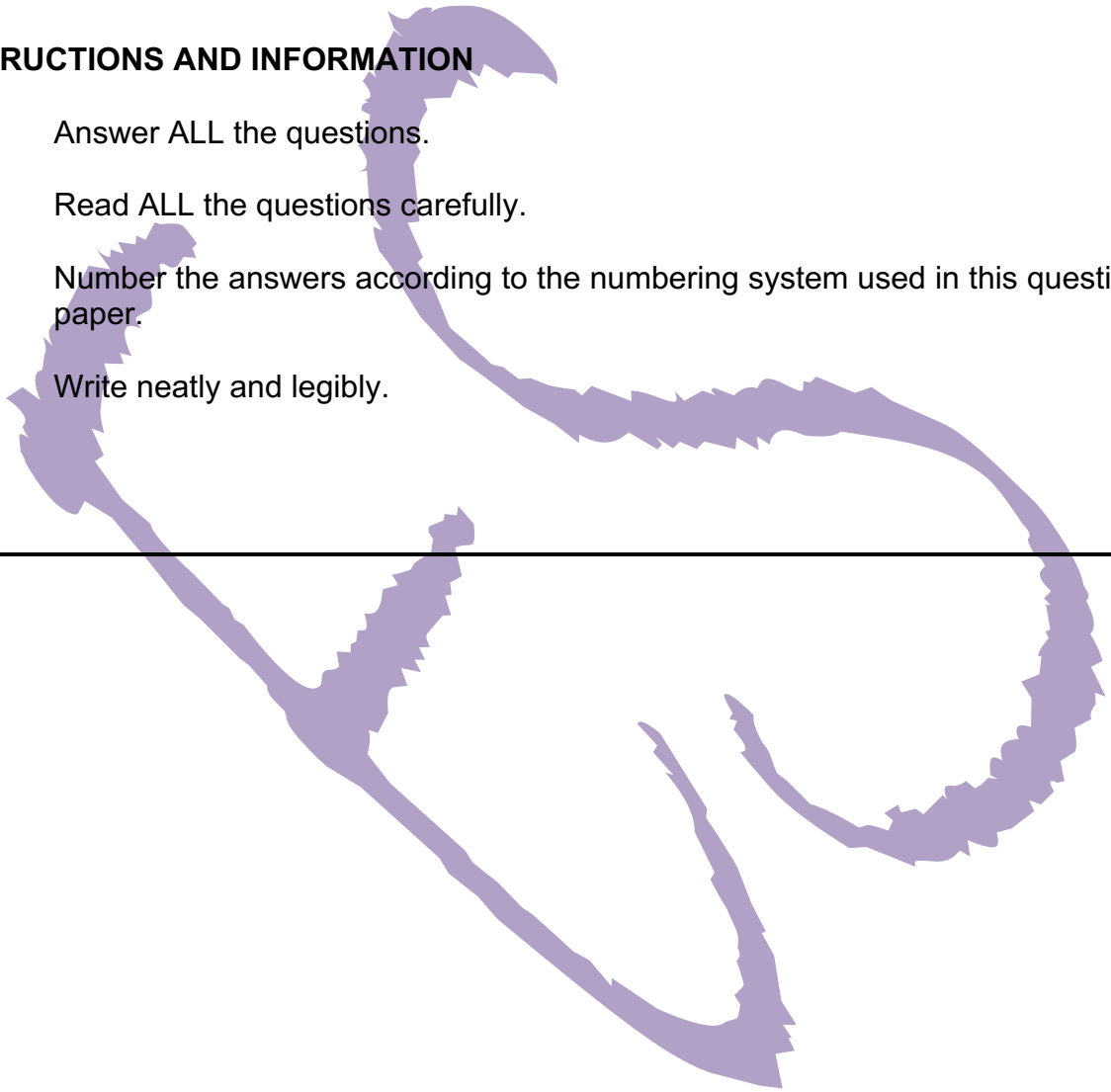
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DEPARTMENT OF HIGHER EDUCATION AND TRAINING
REPUBLIC OF SOUTH AFRICA

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. Write neatly and legibly.



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QUESTION 1: ATTENUATORS AND FILTERS

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

1.2 Define the term *attenuator.* (2)

1.3 Draw the circuit diagrams of the following types of attenuators.

1.3.1 H-type

1.3.2 Lattice-type

1.3.3 O-type

(3 × 1) (3)

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

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

1.6 Design a multi-section low-pass filter consisting of two terminating half-sections, one prototype section and one m-derived section. The filter must have a cut-off frequency of 1 000 Hz and a frequency of infinite attenuation of 1 200 Hz. It must be designed to operate in a 600 Ω transmission line.

Draw the completed filter to include all relevant components. (10)
[30]

QUESTION 2: TRANSMISSION LINES

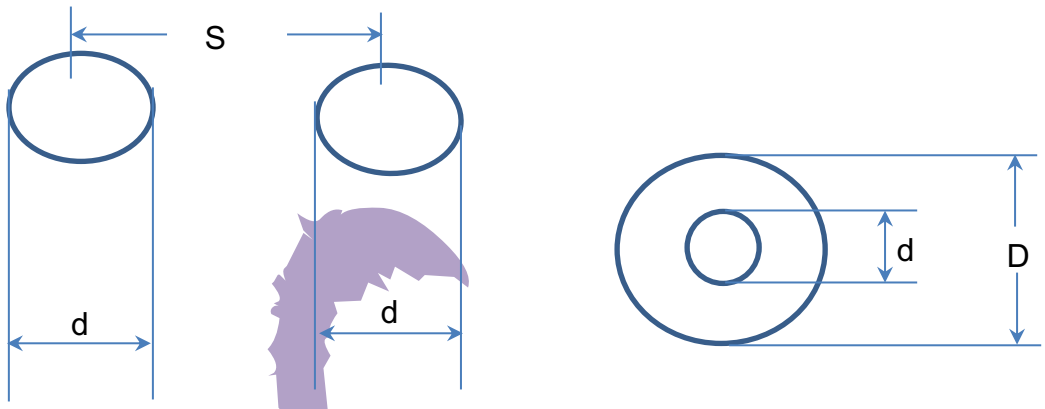
2.1 Define the term *transmission line*. (2)

2.2 Draw the circuit diagram which represents the transmission-line RF equivalent circuit. (2)

2.3 Name THREE elements that determine the characteristic impedance of a transmission line. (3)

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2.4 The TWO diagrams below, together with their formulae, represent the transmission-line geometry. Consider the question to calculate the outer conductor diameter of the coaxial cable.



(a) Parallel-wire > $Z_0 = 276 \log \frac{25}{d}\ \Omega$

(b) Coaxial line > $Z_0 = \frac{138}{\sqrt{K}} \log \frac{D}{d} \Omega$

A coaxial cable has a 75 Ω characteristic impedance and a nominal capacitance of 64 pf/m. What is inductance per meter? If the inner conductor has a diameter of 0,584 mm, and the dielectric constant of the insulation is 2,23, what is the outer conductor diameter. (7)

2.5 Define the term *stub.* (2)
[16]

QUESTION 3: ANTENNAS

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 10 KW, 500 MHz transmitter is used to range a satellite with a surface area of 10 m^2 which is 5 000 km above the earth. The transmitter and the receiver are centrally based and have similar characteristics with gains of 25 $d\beta$ each.

Calculate:

3.3.1 Field strength at the satellite (4)

3.3.2 Power density at the satellite (2)

3.3.3 The reflected power (2)

3.3.4 Field strength at the receiver (2)

3.3.5 Power density at the receiver (2)

3.3.6 Signal strength of the received signal (6)
[24]

QUESTION 4: NOISE

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

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

Calculate the receiver's noise figure in decibels and its equivalent noise temperature. (6)
[19]

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QUESTION 5: MODULATION AND DEMODULATION

5.1 Define the term *angle modulation.* (2)

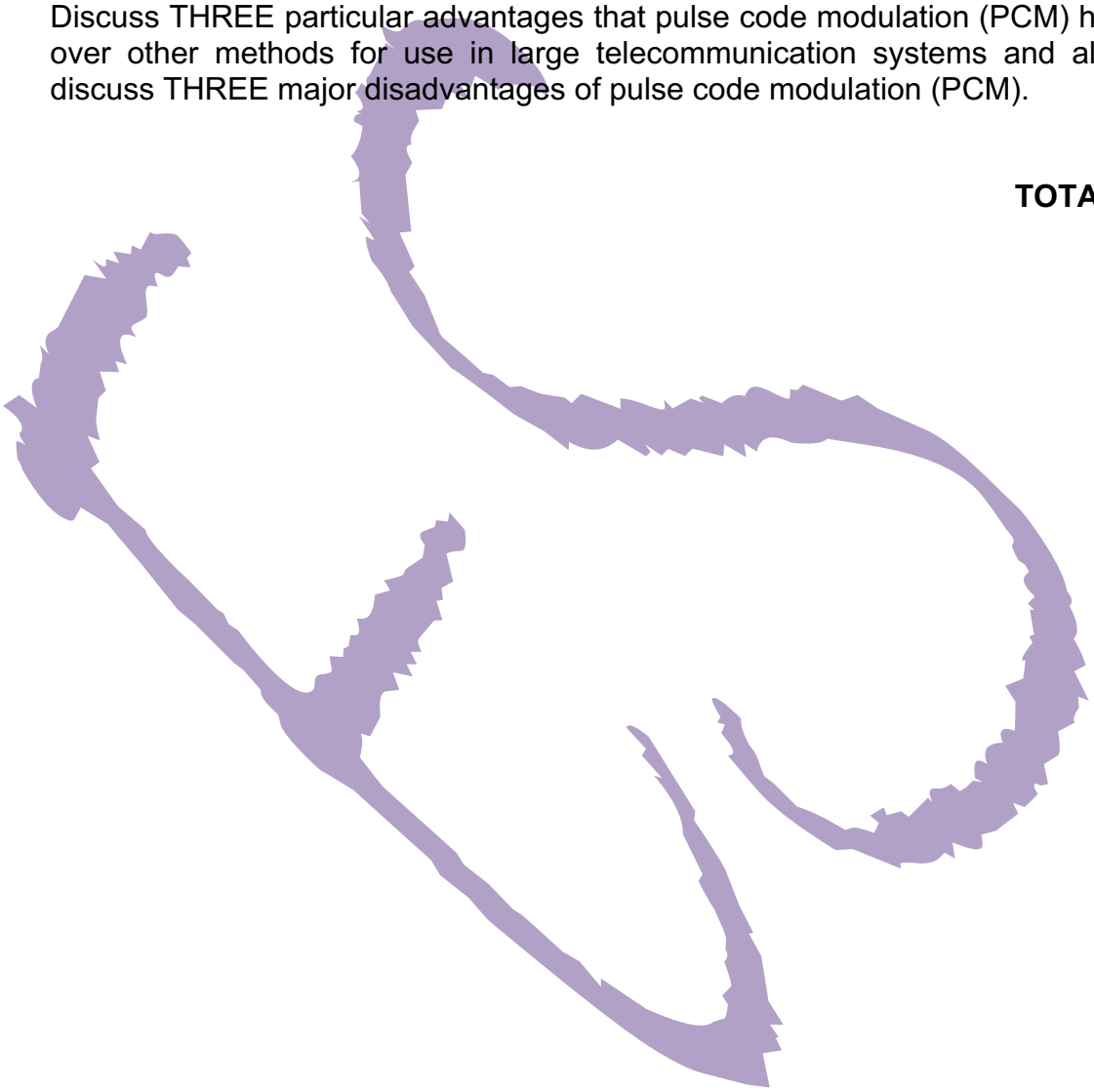
5.2 Differentiate between the following:

5.2.1 Pulse amplitude modulation (PAM) (1)

5.2.2 Pulse position modulation (PPM) (2)

5.3 Discuss THREE particular advantages that pulse code modulation (PCM) has over other methods for use in large telecommunication systems and also discuss THREE major disadvantages of pulse code modulation (PCM). (6)
[11]

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*

$$\text{Series } L = \frac{m \,.\, L}{2} \qquad \text{Shunt } C = \frac{m \,.\, C}{2}$$

$$\text{Shunt } C = m \,.\, C \qquad \text{Series } L = m \,.\, L$$

$$\text{Shunt } L = \frac{1 - m^2}{4 \,.\, m} \,.\, L \qquad \text{Series } C = \frac{1 - m^2}{4 \,.\, m} \,.\, C$$

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

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

T-section *π-section*

$$\text{Series } C = \frac{2 \,.\, C}{m} \qquad \text{Series } C = \frac{C}{m}$$

$$\text{Shunt } C = \frac{4 \,.\, m}{1 - m^2} \,.\, C \qquad \text{Series } L = \frac{4 \,.\, m}{1 - m^2} \,.\, L$$

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

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

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Band-pass sections

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

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

Band-stop sections

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

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

2. *Attenuators* *Symmetrical*

Bridged T-type

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

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

$$Z_A = Z_o$$

where $dB = 20 \log N$

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

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

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

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

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*

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

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

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

$$L.G = C.R$$

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

$$Alos \;\; VSWR = \frac{1+\rho}{1-\rho}$$

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

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

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 $dB = 10 \log S/N$

5. Modulation

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

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

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

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

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6. Antennae

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

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

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

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

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

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

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