higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

T310(E)(N27)T

NOVEMBER EXAMINATION

NATIONAL CERTIFICATE

COMMUNICATION-ELECTRONICS N6

(8080246)

27 November (Y-Paper)
13:00–16:00

Calculators may be used.

This question paper consists of 6 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. ALL the sketches and diagrams MUST be large, clear and neat.
4. Number the answers according to the numbering system used in this question paper.
5. Use $\pi = 3,142$
6. Write neatly and legibly.

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QUESTION 1

1.1 Study FIGURE 1 below and answer the questions.

1.1.1 What type of filter is shown? (1)

1.1.2 Determine the cut-off frequency of the filter. (4)

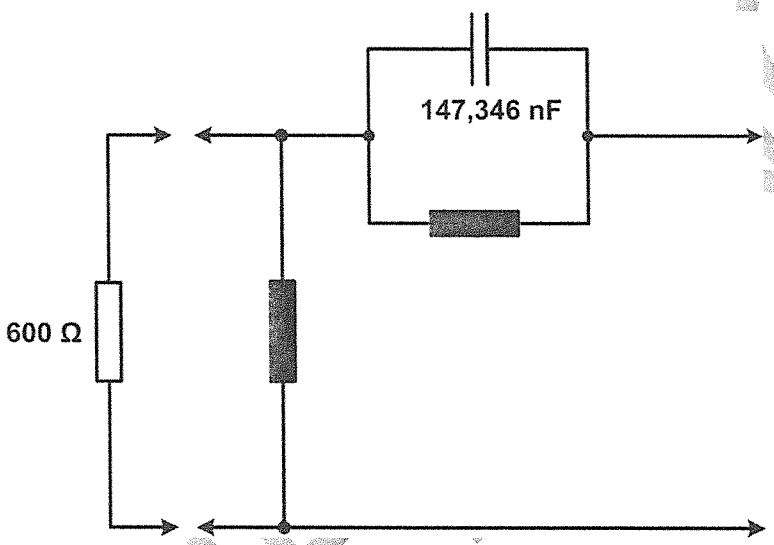


FIGURE 1

1.2 A filter has a cut-off frequency of 7,5 kHz and the frequency of infinite attenuation is 0,5 kHz below cut-off.

Design an m-derived T-section filter for a 600-ohms transmission that will have the above characteristics.

Draw the completed filter and insert ALL relevant values. (8)

1.3 Draw a graph of frequency/attenuation for the filter network in QUESTION 1.2 and indicate ALL relevant values. (4)
[17]

QUESTION 2

2.1 Network 1 has an output impedance of 560 ohms and network 2 has an input impedance of 420 ohms. It was found by calculation that the inserted attenuator caused an insertion loss of 15 dB. The maximum allowable attenuation should however not exceed 6 dB. Design a T-type asymmetrical attenuator to fulfil the above conditions. Sketch the completed attenuator and insert ALL the relevant values. (8)

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2.2 Study FIGURE 2 below.

Z_B is made variable between the values of 200 ohms and 400 ohms.

Calculate, with the available information, the TWO limits of attenuation. (4)

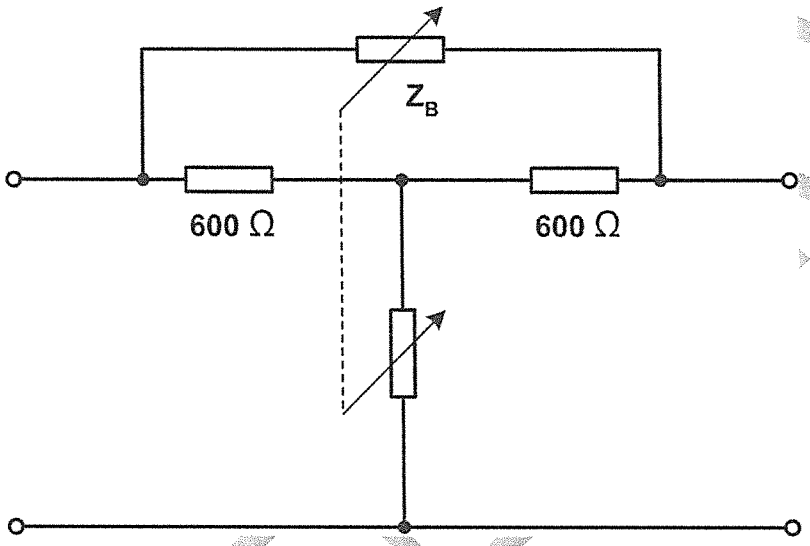


FIGURE 2

2.3 Design an attenuator network that will match an output impedance of 500 ohms to an input impedance of 350 ohms.

Sketch the completed network and insert ALL relevant values. (4)
[16]

QUESTION 3

3.1 The propagation constant of a transmission line is given by:
$\gamma = \alpha + j\beta$

3.1.1 What quantity is represented by α? Name the unit it is measured in. (2)

3.1.2 What quantity is represented by β? Name the unit it is measured in. (2)

3.2 Calculate the standing wave ratio for the following loads connected to a 600 ohms transmission line:

3.2.1 900 ohms (1)

3.2.2 200 + j100 ohms (4)

3.3 Make a neat, labelled sketch of a two-hole directional coupler. (8)
[17]

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QUESTION 4

4.1 Differentiate between the following:

4.1.1 Intrinsic noise (2)

4.1.2 Extrinsic noise (2)

4.2 An FM-radio has an equivalent resistance of 400 ohms and an input resistance of 650 ohms to the RF-amplifier. A RMS voltage of 9 μV is developed at 24 °C.

What is the bandwidth of this RF-amplifier?

Take Boltzmann's constant as $1{,}38 \times 10^{-23}$ J/K (2)

4.3 A 3 mega-ohm resistor generates a noise voltage of 24,416 μV at a frequency of 12 kHz.

Determine the temperature in °C and take Boltzmann's constant as $1{,}38 \times 10^{-23}$ J/K. (4)

4.4 A standard telephone channel has a bandwidth of 10 kHz and a signal-to-noise ratio of 20 dB.

Determine the channel capacity. (4)

4.5 Define the *Shannon-Hartley theorem*. (3)
[17]

QUESTION 5

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

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

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

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

5.1.4 PCM requires a (narrow/wide) bandwidth.

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)

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5.2 Draw a neat, fully labelled block diagram of a pulse-code modulation system. (10)

5.3 What are the main reasons for using double-sideband AM for broadcasting purposes? (2)
[18]

QUESTION 6

6.1 Define with reference to antennae:

6.1.1 Directive gain

6.1.2 A receiver antenna

6.1.3 A transmitter antenna

(3 × 2) (6)

6.2 Determine the minimum power needed to detect a target of 25 m^2 at a distance of 200 km if the following information is given:

Operating frequency	=	1,5 GHz
Received power	=	$0,75 \times 10^{-15}$ watts
Antenna gain	=	10 dB
Atmospheric attenuation	=	0,005 dB/km

(9)
[15]

TOTAL: 100

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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 $L = \frac{2 \cdot L}{m}$

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

$C = \frac{1}{4 \cdot \pi \cdot Z_o \cdot f_c}$

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

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

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

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

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

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

$$E_r = \frac{\sqrt{30 \cdot P_r}}{d}$$

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

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

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MARKING GUIDELINE

NATIONAL CERTIFICATE

NOVEMBER EXAMINATION

COMMUNICATION-ELECTRONICS N6

27 NOVEMBER 2014

This marking guideline consists of 11 pages.

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QUESTION 1

1.1 1.1.1 Pi-type, high-pass, half-section filter (1)

1.1.2

$m = 0,6$

$\text{Serie C} = \frac{2C}{m}$

$\therefore C = \frac{m \times Serie\ C}{2}$

$= \frac{0,6 \times 147,346 \times 10^{9}}{2}$

$= \mathbf{44,204\ nF}$

$C = \frac{1}{4.\pi.Z_o.fc}$

$\therefore fc = \frac{1}{4.\pi.Z_o.C}$

$= \frac{1}{4 \times 3,142 \times 600 \times 44,204 \times 10^{-9}}$

$= \mathbf{3\ kHz}$ (4)

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1.2 $L = \frac{Z_o}{4.\pi.f_c}$

$= \frac{600}{4\times3,142\times7,5\times10^3}$

$=$ **6,365 mH**

$C = \frac{1}{4.\pi.Z_o.f_c}$

$= \frac{1}{4\times3,142\times600\times7,5\times10^3}$

$=$ **17,682 nF**

$m = \sqrt{1-\frac{f_\infty{}^2}{f_c{}^2}}$

$= \sqrt{1-\frac{\left(7\times10^3\right)^2}{\left(7,5\times10^3\right)^2}}$

$=$ **0,359**

Series C $= \frac{2C}{m}$

$= \frac{2\times17,682\times10^{-9}}{0,359}$

$=$ **98,507 nF**

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

$= \frac{4\times0,359}{1-0,359^2}\times17,682\times10^{-9}$

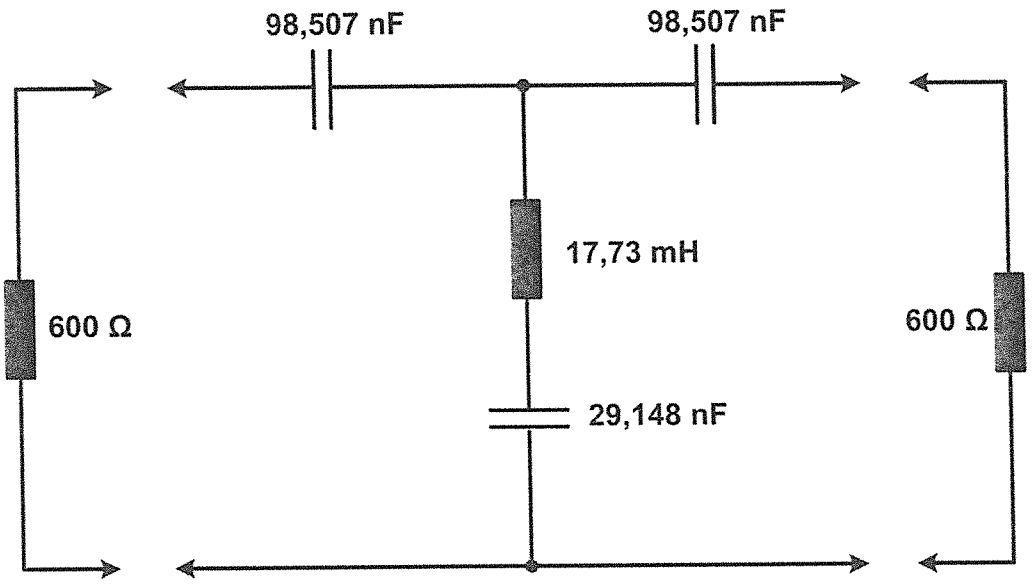
$=$ **29,148 nF**

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

$= \frac{6,365\times10^{-3}}{0,359}$

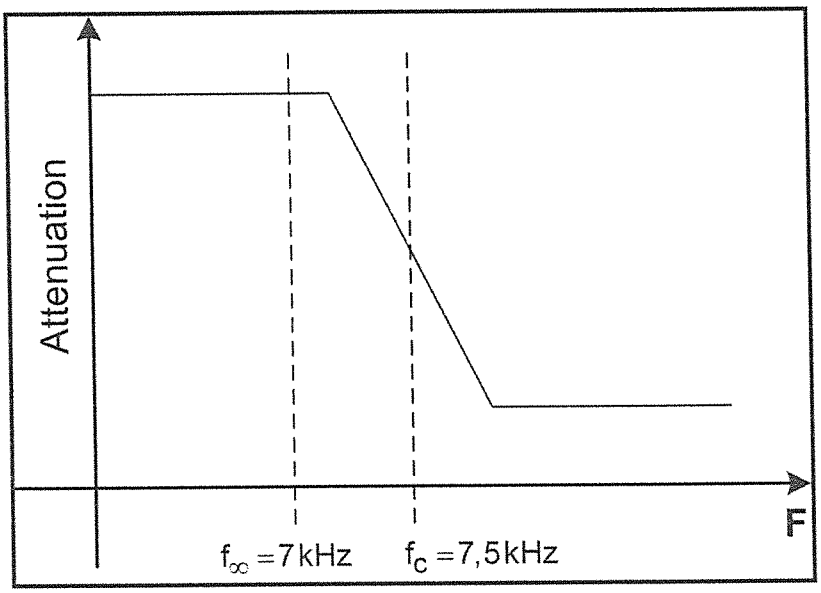
$=$ **17,73 mH**

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(8)

1.3



(4)

[17]

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QUESTION 2

2.1

Loss = Total loss – Insertion loss

$\therefore$ **Loss** = 15 - 6

= **9 dB**

dB = 20 log N

$\therefore$ **N** = anti-log $\frac{dB}{20}$

= anti-log $\frac{9}{20}$

= **2,818**

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

$= 560\left[\frac{2,818^2+1}{2,818^2-1}\right] - 2\sqrt{560\times420}\left[\frac{2,818}{2,818^2-1}\right]$

= **327,571 ohm**

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

$= 2\sqrt{560\times420}\times\left[\frac{2,818}{2,818^2-1}\right]$

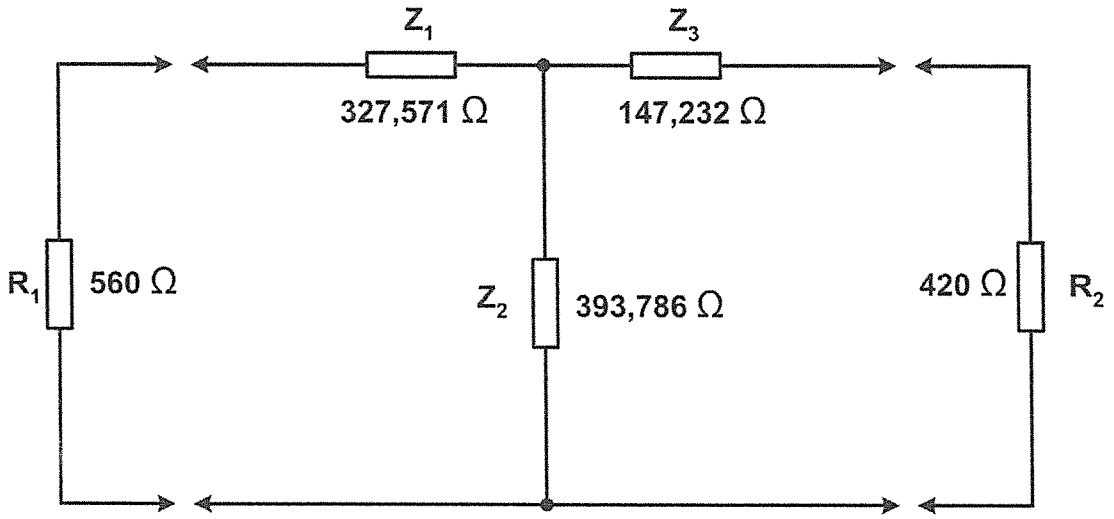
= **393,786 ohm**

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

$= 420\left[\frac{2,818^2+1}{2,818^2-1}\right] - 2\sqrt{560\times420}\times\left[\frac{2,818}{2,818^2-1}\right]$

= **147,232 ohm**

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(8)

2.2 **For 200 ohm**

$$Z_B = Z_o(N-1)$$

$$\therefore N = \frac{Z_B}{Z_o} + 1$$

$$= \frac{200}{600} + 1$$

$$= \mathbf{1,333}$$

$$\mathbf{dB} = 20 \log N$$

$$= 20 \log 1,333$$

$$= \mathbf{2,5}$$ (2)

For 400 ohm

$$Z_B = Z_o(N-1)$$

$$\therefore N = \frac{Z_B}{Z_o} + 1$$

$$= \frac{400}{600} + 1$$

$$= \mathbf{1,667}$$

$$\mathbf{dB} = 20 \log N$$

$$= 20 \log 1,667$$

$$= \mathbf{4,44}$$ (2)

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2.3 $Z_A = \sqrt{R_1(R_1 - R_2)}$

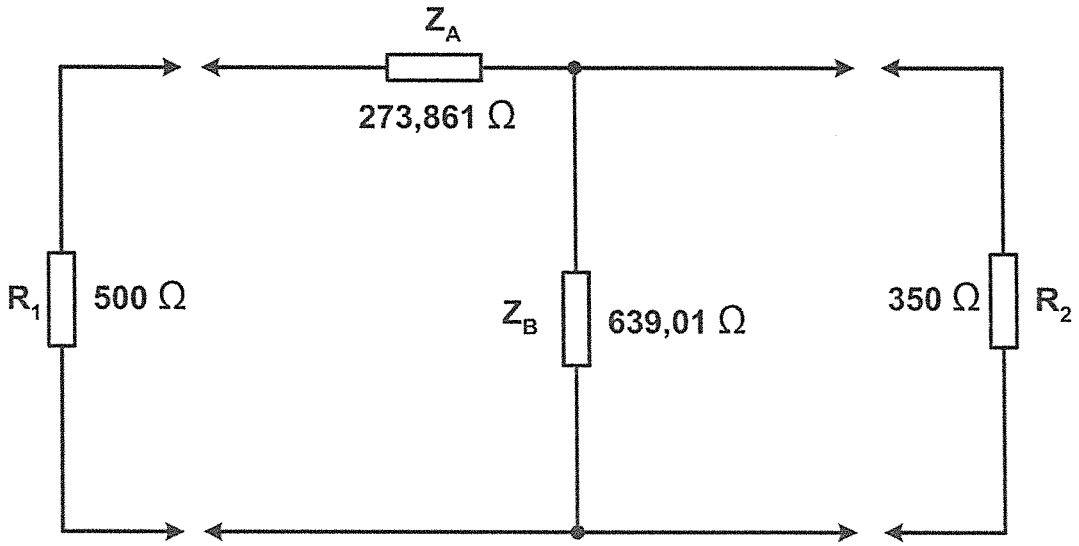
$= \sqrt{500(500 - 350)}$

$=$ **273,861 ohm**

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

$= \sqrt{\frac{500 \times 350^2}{(500 - 350)}}$

$=$ **639,01 ohm**



(4)
[16]

QUESTION 3

3.1 3.1.1 α is the attenuation constant and is measured in nepers/km (2)

3.1.2 β is the phase constant and is measured in radians/km (2)

3.2 3.2.1 **SWR** $= \frac{Z_L}{Z_o}$

$= \frac{900}{600}$

$=$ **1,5** (1)

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3.2.2

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

$$= \frac{200 + j100 - 600 - j0}{200 + j100 + 600 + j0}$$

$$= \frac{-400 + j100}{800 + j100}$$

$$= \frac{412{,}311 \angle 166^0}{806{,}226 \angle 7{,}1^0}$$

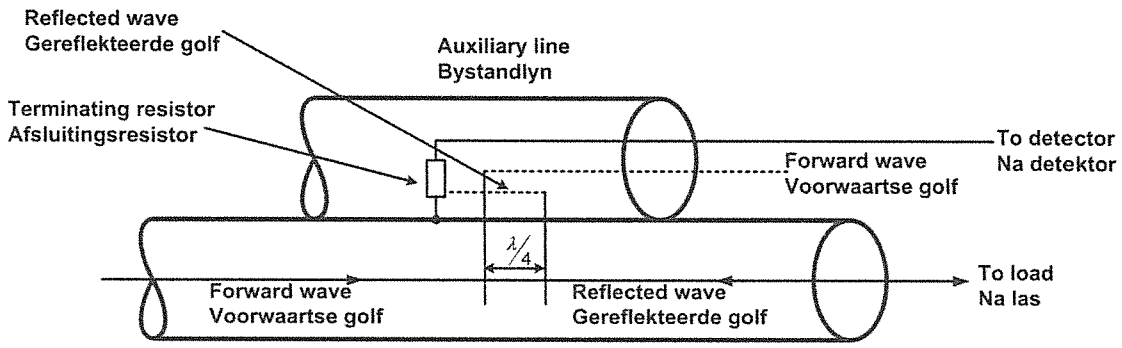
$$= 0{,}511 \angle 158{,}9^0$$

$$\therefore \text{SWR} = \frac{1+\rho}{1-\rho}$$

$$= \frac{1+0{,}511}{1-0{,}511}$$

$$= \mathbf{3{,}09} \quad (4)$$

3.3



(8)
[17]

QUESTION 4

4.1 4.1.1 Intrinsic noise is generated within the receiver itself. (2)

4.1.2 Extrinsic noise enters the receiver from outside the receiver. (2)

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4.2 $\mathbf{E_n} = \sqrt{4.K.T.\Delta f.(R_1 + R_2)}$

$\therefore \mathbf{\Delta f} = \dfrac{E_n^2}{4.K.T.(R_1 + R_2)}$

$= \dfrac{\left[9\times10^{-6}\right]^2}{4\times1{,}38\times10^{-23}\times(273+24)\times[650+400]}$

$=$ **4,705 MHz** (2)

4.3 $E_n = \sqrt{4.K.T.\Delta f.R}$

$\therefore \mathbf{T} = \dfrac{E_n^{\,2}}{4.K.\Delta f.R}$

$= \dfrac{\left[24{,}416\times10^{-6}\right]^2}{4\times1{,}38\times10^{-23}\times12\times10^{3}\times3\times10^{6}}$

$=$ **300 Kelvin**

$\therefore {}^{0}\mathbf{C} = 300 - 273$

$=$ **27 ^{0}C** (4)

4.4 **dB** $= 10 \log \dfrac{S}{N}$

$\therefore \dfrac{S}{N} = \text{antilog}\ \dfrac{dB}{10}$

$= \text{antilog}\ \dfrac{20}{10}$

$= \text{antilog}\ 2$

$=$ **100**

C $= \Delta f\ .\ \log_2 (1 + \dfrac{S}{N})$

$= 10\times10^{3}\times\log_2 (1 + 100)$

$= 10\times10^{3}\times\dfrac{\log101}{\log2}$

$=$ **66582 bits/sec** (4)

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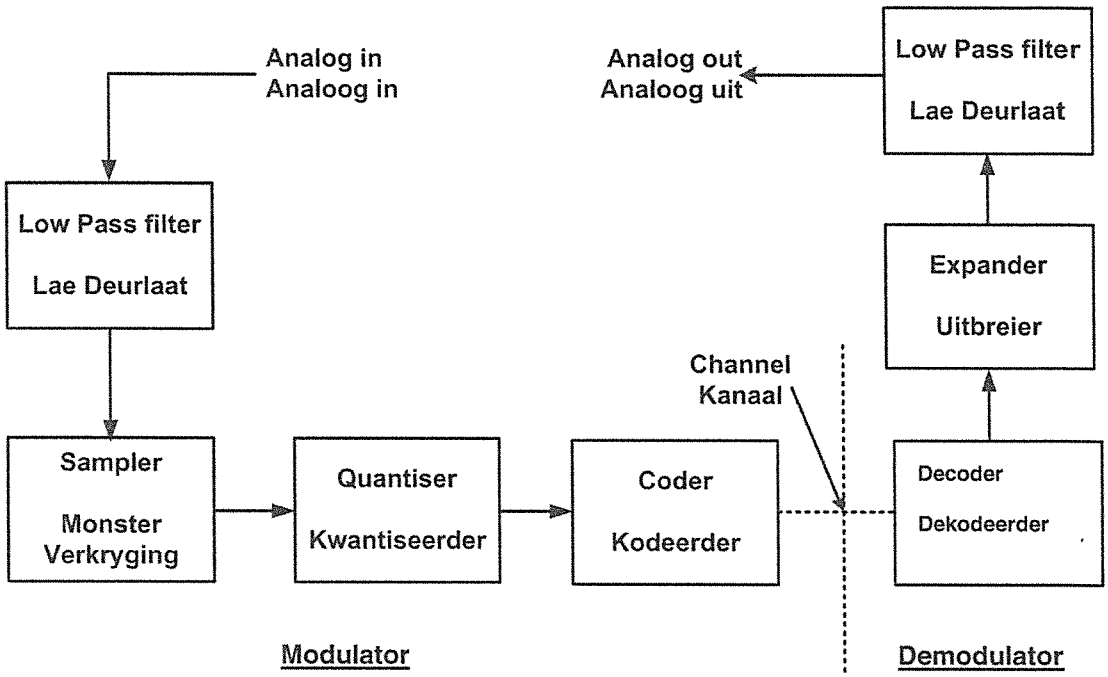
4.5 This theorem specifies the maximum signaling speed or channel capacity, which may not be exceeded for a given bandwidth and noise level without the error rate. (3)
[17]

QUESTION 5

5.1
5.1.1 Transistor
5.1.2 Valve
5.1.3 Better
5.1.4 Wide
5.1.5 Poor
5.1.6 Better

(6 × 1) (6)

5.2



(10)

5.3 (a) Use of simplified equipment at transmitter and receiver and thereby reducing costs.
(b) An amplitude detector can be used at the receiver end. (2)
[18]

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QUESTION 6

6.1 6.1.1 It is the ratio of power density radiated in a specific direction to the power density by an isotropic antenna. (2)

6.1.2 It is device that will convert an electro-magnetic quantity into a corresponding electrical current. (2)

6.1.3 It is device that will convert an electrical current into a corresponding electro-magnetic quantity. (2)

6.2 $G_t = G_r = \text{anti-log}\frac{dB}{10}$

$= \text{anti-log}\frac{10}{10}$

$= \mathbf{10}$

Path loss $= 2 \times 200 \times 0{,}005$

$= \mathbf{2\ dB}$

∴ dB $=$ 10 log Path loss

∴ Path loss $= \text{anti-log}\frac{2}{10}$

$= \mathbf{1{,}585}$

$\lambda = \frac{c}{f}$

$= \frac{3 \times 10^8}{1{,}5 \times 10^9}$

$= \mathbf{0{,}2\ m}$

$\therefore P_t = \frac{(4\pi)^3 \cdot d^4 \cdot P_r}{G_t \cdot G_r \cdot Q \cdot \lambda^2} \times$ Path loss

$= \frac{(4 \times 3{,}142)^3 \times \left(200 \times 10^3\right)^4 \times 0{,}75 \times 10^{-15}}{10 \times 10 \times 25 \times 0{,}2^2} \times 1{,}585$

$= \mathbf{37{,}758\ MW}$ (9)
[15]

TOTAL: 100

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