higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

T310(**E**)(A6)T
AUGUST EXAMINATION

NATIONAL CERTIFICATE

COMMUNICATION-ELECTRONICS N6

(8080246)

6 August 2014 (Y-Paper)
13:00–16:00

Calculators may be used.

This question paper consists of 7 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: 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. ALL the sketches and diagrams must be large, clear and neat.
5. Use $\pi = 3,142$.
6. Write neatly and legibly.

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QUESTION 1

1.1 Draw TWO neat, labelled graphs of GAIN versus FREQUENCY for:

1.1.1 A band-pass filter

1.1.2 A band-stop filter

(2 x 2) (4)

1.2 Consider the m-derived filter in FIGURE 1 below.

This section will be used for obtaining the terminating half sections for a composite filter.

Determine, with the available information, the frequency of infinite attenuation for a cut-off frequency of 4,2 kHz.

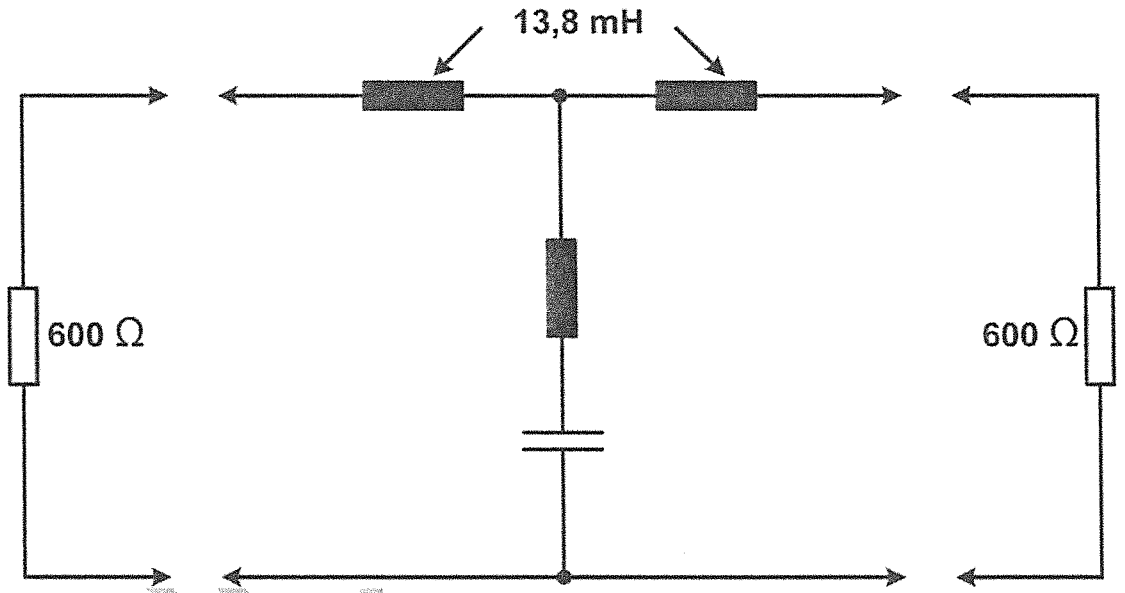


FIGURE 1

(3)

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1.3 Refer to FIGURE 2 below.

1.3.1 Is this a characteristic curve for a low-pass or a high-pass filter? (1)

1.3.2 Design, with the information given, the terminating half-sections for a T-section only. Use 600 ohms for the line impedance.

Sketch the complete filter, as well as the half-sections and insert ALL relevant values. (9)

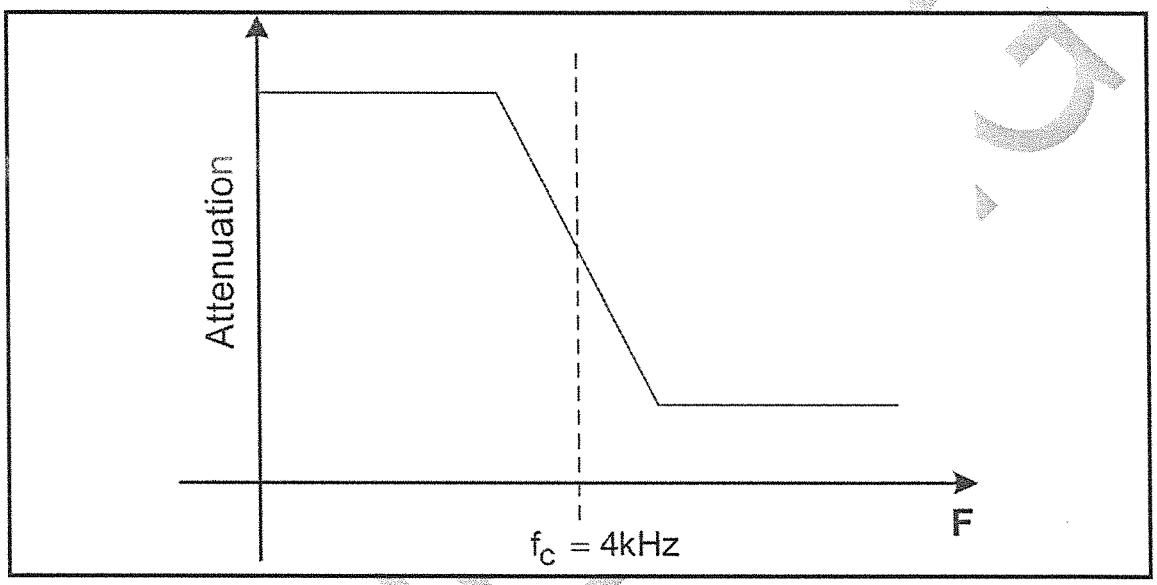


FIGURE 2 **[17]**

QUESTION 2

2.1 Design and draw a T-type attenuator to give an attenuation of 20 dB between a device that has an output impedance of 600 ohms and a device that has an input impedance of 900 ohms. (8)

2.2 Draw a neat labelled balanced network for the attenuator you obtained in QUESTION 2.1

NOTE: NO component values need to be given. (2)

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2.3 Study FIGURE 3 below.

An asymmetrical T-network is inserted between the two image impedances as shown.

Determine, with the aid of the available information, the insertion loss produced by the T-network.

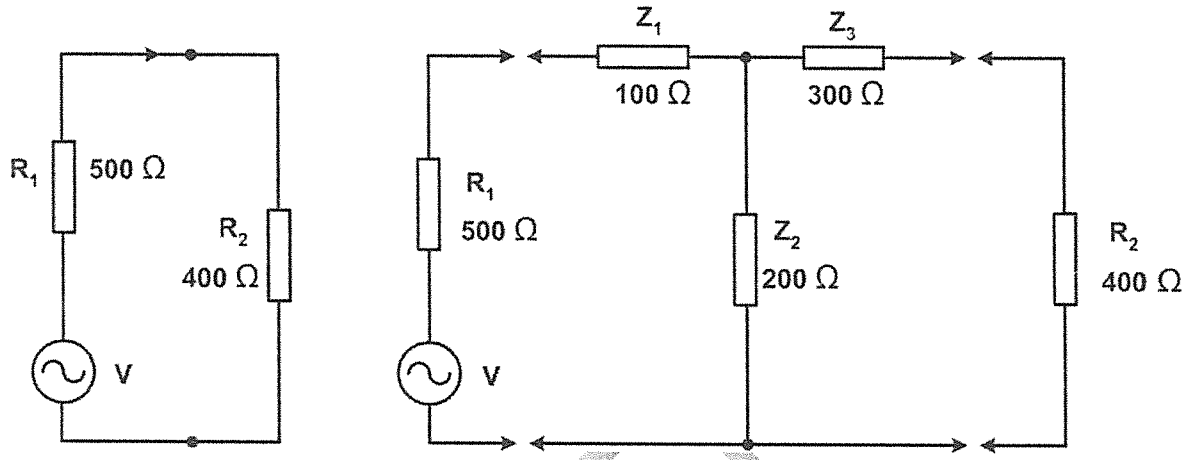


FIGURE 3

(8)
[18]

QUESTION 3

3.1 Transmission line components form an integral part of the communication industry.

Which transmission line components will be used to:

3.1.1 Measure power in a line?

3.1.2 Determine the first voltage maximum from the load?

3.1.3 Tune out any reactive component?

(3 x 1) (3)

3.2 The following information was obtained during a test on a transmission line at a frequency of 1 000 radians/second.

R = 56 ohms/km
G = 15 µ-mhos/km
L = 1,5 mH/km
C = 0,9 pF/km

Calculate the following:

3.2.1 The wavelength of the transmission (5)

3.2.2 The velocity of the transmission (1)

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3.3 Determine for the primary line constants in QUESTION 3.2, the characteristic impedance of the transmission line. (2)

3.4 What conclusion can be drawn from the answer you obtained in QUESTION 3.3? (3)

3.5 Indicate whether the following statement is 'TRUE' or 'FALSE':

'When a load is perfectly matched, the S.W.R. is equal to unity.' (1)
[15]

QUESTION 4

4.1 Define the following terms with reference to extrinsic noise:

4.1.1 Cosmic noise (2)

4.1.2 Static noise (3)

4.1.3 Solar noise (3)

4.2 An amplifier receives a signal of 21 µV at a frequency of 15 kHz and a temperature of 25°C.

4.2.1 Determine the value of the input resistor to this amplifier. (3)

4.2.2 Determine the magnitude of the received signal should the input resistor be halved.

Take Boltzman's constant as: $1,38\times10^{-23}$ J/K (2)

4.3 An antenna having a resistance of 90 ohms is connected to an amplifier which measures a noise figure of 2,632 dB.

Calculate the following:

4.3.1 The equivalent noise (4)

4.3.2 The equivalent noise temperature
[Take the ambient temperature as 25°C] (1)
[18]

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QUESTION 5

5.1 Determine the bandwidth of a channel that has a channel capacity of 1 000 000 bits/s and a signal-to-noise ratio of 20 dB. (4)

5.2 Five signals each in the range of 0–3 kHz have to be simultaneously transmitted over a 15 kHz channel.

Explain, with the aid of a sketch, the principle of frequency division multiplexing and then draw a neat, labelled block diagram of a frequency division multiplex system to accommodate FIVE signals. (14)
[18]

QUESTION 6

6.1 Two antennae are 75 km apart. The transmitting antenna has a gain of 15 and radiates 30 kW of RF-power. The receiving antenna has a gain of unity and absorbs 18 µW of RF-power into its antenna.

Calculate the following:

6.1.1 The effective aperture of the receiving antenna

6.1.2 The frequency of operation

(4 x 2) (8)

6.2 A receiver antenna received 30×10^{-12} watts at a frequency of 150 MHz.

Determine the gain of the antenna in dB, should the power density at the antenna be 2×10^{-12} watts/m^2. (6)
[14]

TOTAL: 100

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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

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

$$\text{Shunt } C = m \,.\, C$$

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

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

π-section

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

$$\text{Series } L = m \,.\, L$$

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

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

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

T-section

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

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

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

π-section

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

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

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

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

Band-pass sections

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

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

Band-stop sections

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

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

2. *Attenuators*

Symmetrical

Bridged T-type

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

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

$$Z_A = Z_o$$

where/waar $dB = 20 \log N$

Asymmetrical
Asimmetries

L-type

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

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

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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* $S = \sqrt{\frac{R_1}{R_2}}$

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

3. *Transmission lines*

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

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

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

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$$L.G = C.R$$

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

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

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

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

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

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

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

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

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

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

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

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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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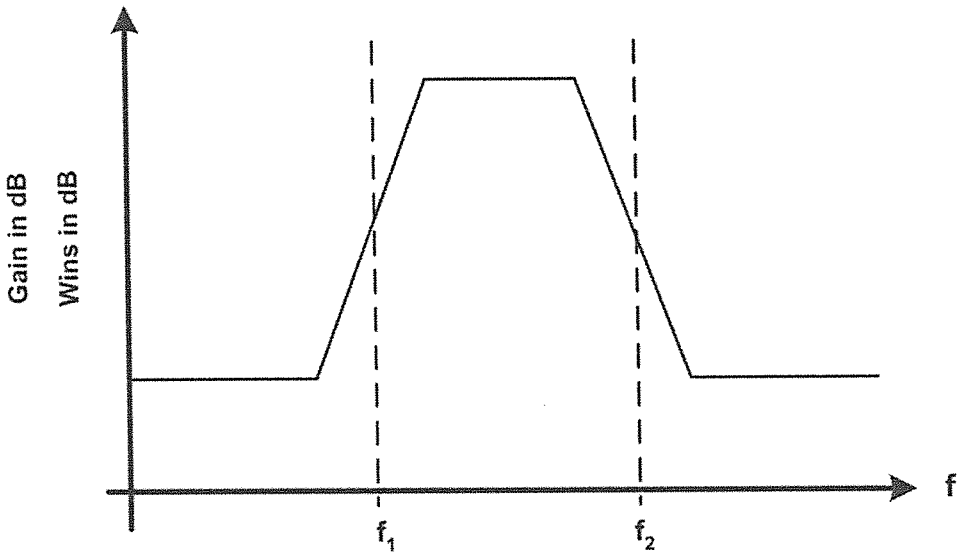
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This marking guideline consists of 14 pages.

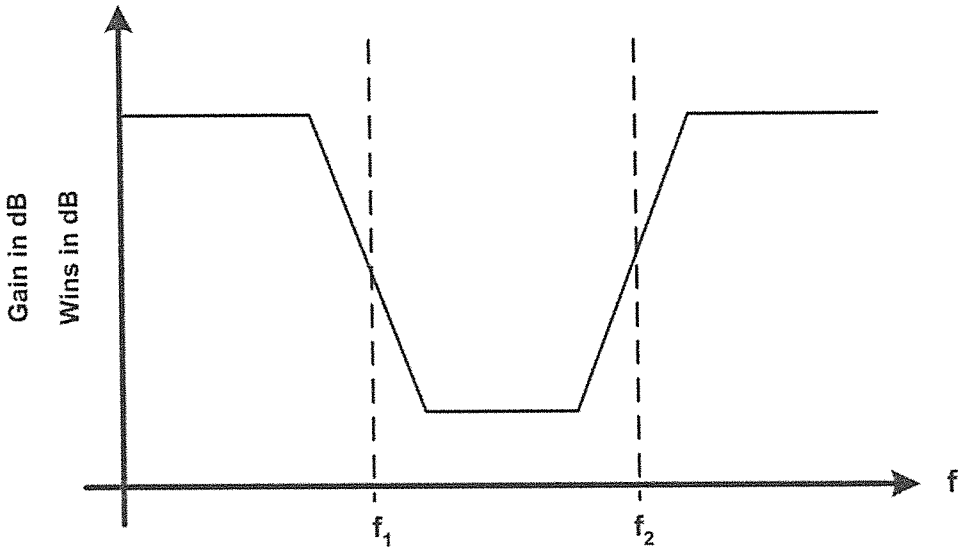
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QUESTION 1

1.1 1.1.1



1.1.2



(2 x 2) (4)

1.2

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

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

$$= \sqrt{\frac{\left(4,2\times10^3\right)^2}{1-0,6^2}}$$

$$= \mathbf{5,25\ kHz}$$

(3)

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1.3 1.3.1 High-pass filter (1)

1.3.2

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

$$= \frac{600}{4\times3,142\times4\times10^{3}}$$

$$= \mathbf{11,935\ mH}$$

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

$$= \frac{1}{4\times3,142\times600\times4\times10^{3}}$$

$$= \mathbf{33,153\ nF}$$

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

$$= \frac{2\times33,153\times10^{-9}}{0,6}$$

$$= \mathbf{110,51\ nF}$$

1.3.2

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

$$= \frac{11,935\times10^{-3}}{0,6}$$

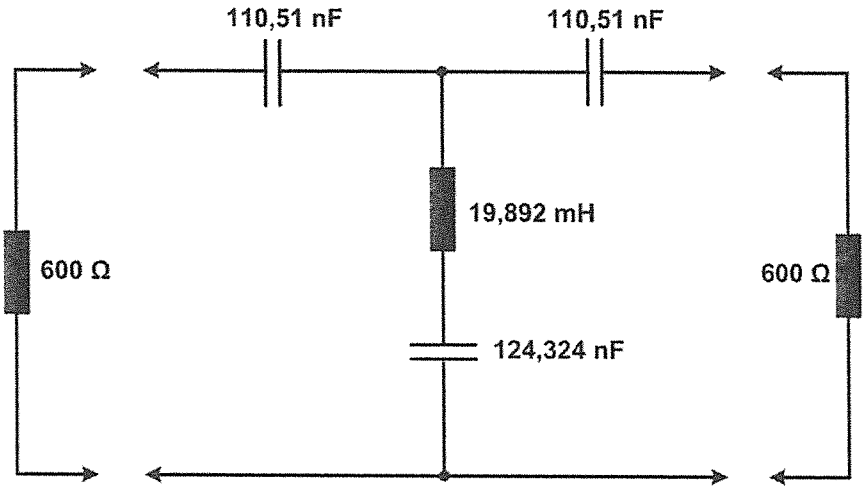
$$= \mathbf{19,892\ mH}$$

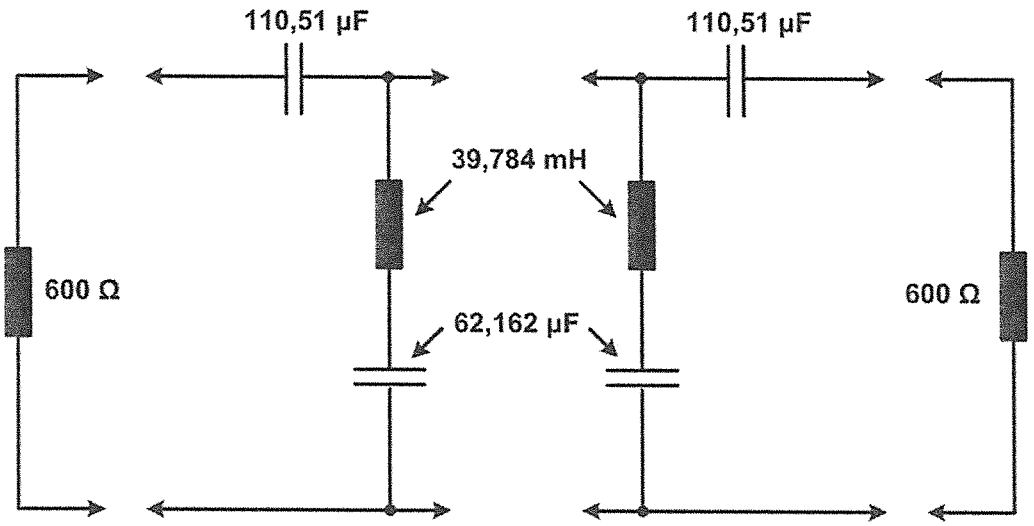
$$\mathbf{Shunt\ C} = \frac{4.m}{1-m^2} \times C$$

$$= \frac{4\times0,6}{1-0,6^2} \times 33,153\times10^{-9}$$

$$= \mathbf{124,324\ nF}$$

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110,51 nF
110,51 nF
19,892 mH
600 Ω
600 Ω
124,324 nF


110,51 µF
110,51 µF
39,784 mH
600 Ω
600 Ω
62,162 µF

(9)
[17]

QUESTION 2

2.1

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

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

$$= \mathbf{10}$$

$$Z_1 = R_1\left(\frac{N^2+1}{N^2-1}\right) - 2\sqrt{R_1.R_2}\left(\frac{N}{N^2-1}\right)$$

$$= 600\left(\frac{10^2+1}{10^2-1}\right) - 2\sqrt{600 \times 900}\left(\frac{10}{10^2-1}\right)$$

$$= \mathbf{463{,}667\ ohm}$$

$$Z_2 = 2\sqrt{R_1.R_2}\left(\frac{N}{N^2-1}\right)$$

$$= 2\sqrt{600 \times 900}\left(\frac{10}{10^2-1}\right)$$

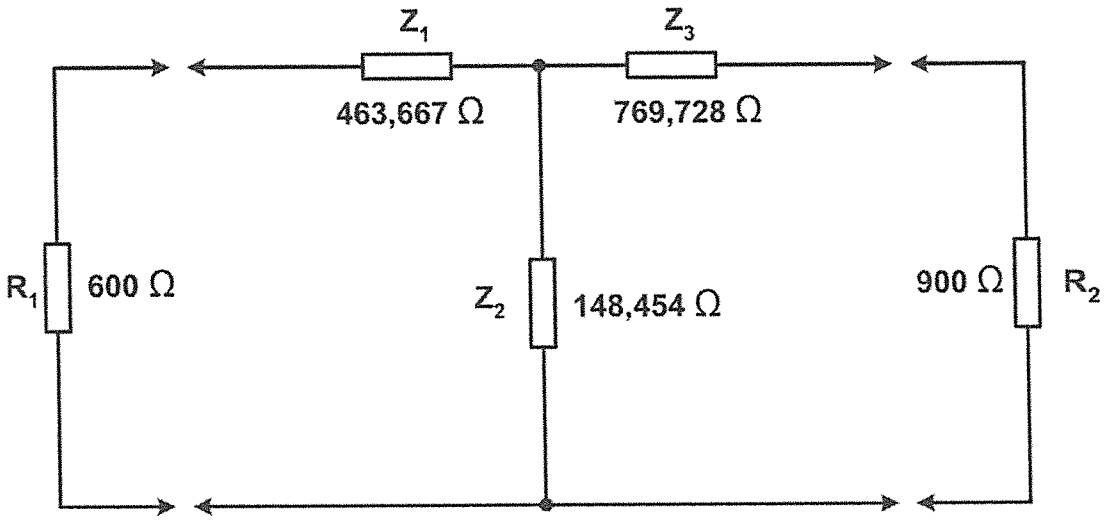
$$= \mathbf{148{,}454\ ohm}$$

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

$$= 900\left(\frac{10^2+1}{10^2-1}\right) - 2\sqrt{600 \times 900}\left(\frac{10}{10^2-1}\right)$$

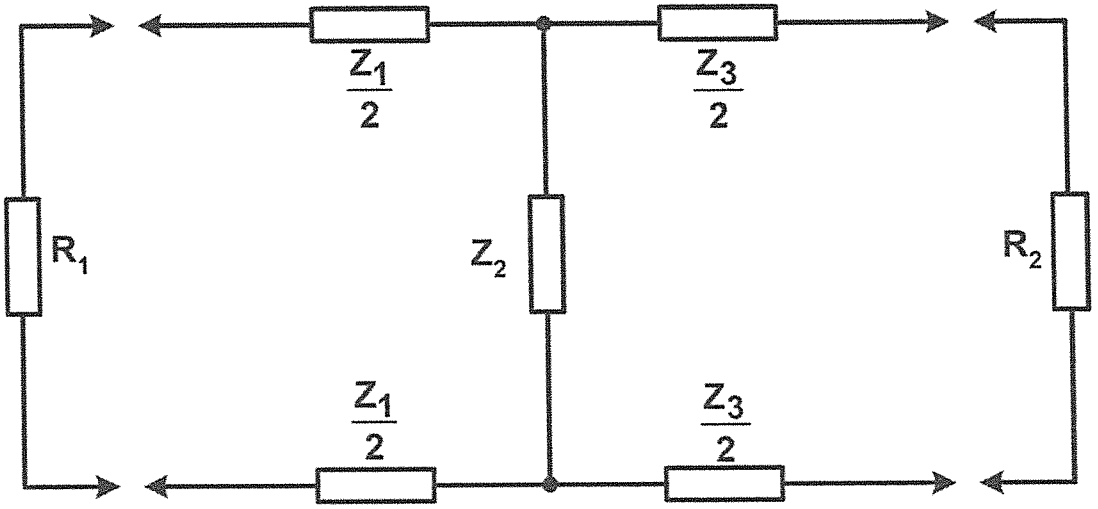
$$= \mathbf{769{,}728\ ohm}$$

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(8)

2.2



(2)

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2.3

Insertion loss: **Tussenskakelverlies:**

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

Without the network: **Sonder die network:**

$$I_1 = \frac{V}{R_1 + R_2}$$

$$= \frac{V}{500 + 400}$$

$$= \frac{V}{900}$$

$$I_s = \frac{V}{R_1 + Z_1 + \left[\frac{Z_2 (Z_3 + R_2)}{Z_2 + Z_3 + R_2}\right]}$$

$$= \frac{V}{500 + 100 + \left[\frac{200(300 + 400)}{200 + 300 + 400}\right]}$$

$$= \frac{V}{755{,}556}$$

$$\therefore I_2 = \frac{Z_2}{Z_2 + Z_3 + R_2} \cdot I_s$$

$$= \frac{200}{200 + 300 + 400} \times \frac{V}{755{,}556}$$

$\therefore$ Insertion loss: $= \frac{200V}{680000}$ $\therefore$ Tussenskakelverlies:

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∴ Insertion loss: **∴ Tussenskakelverlies:**

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

$$= 20 \log \times \frac{\frac{V}{900}}{\frac{200V}{680000}}$$

$$= 20 \log \times \frac{680000V}{180000V}$$

$$= \mathbf{11,545\ dB} \qquad (8)$$

[18]

QUESTION 3

3.1 3.1.1 Directional coupler
3.1.2 Slotted line
3.1.3 Stub

(3 x 1) (3)

3.2 3.2.1 $\mathbf{R + j.\omega.L} = 56 + j1000 \times 1,5 \times 10^{-3}$

$$= 56 + j1,5$$

$$= \mathbf{56\angle 1,53^0}$$

$$\mathbf{G + j.\omega.C} = 15 \times 10^{-6} + j1000 \times 0,9 \times 10^{-12}$$

$$= 15 \times 10^{-6} + j900 \times 10^{-12}$$

$$= \mathbf{15 \times 10^{-6} \angle \left(3,44 \times 10^{-3}\right)^0}$$

$$\gamma = \sqrt{(R + j.\omega L)(G + j.\omega C)}$$

$$= \sqrt{\left(56\angle 1,53^0\right)\left(15 \times 10^{-6} \angle \left(3,44 \times 10^{-3}\right)^0\right)}$$

$$= 28,983 \times 10^{-3} \angle 0,77^0$$

$$= \mathbf{28,98 \times 10^{-3} + j389,492 \times 10^{-6}}$$

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$$\gamma = \alpha + j\beta$$

$$\gamma = \frac{2.\pi}{\beta}$$

$$= \frac{2\times 3,142}{389,492\times 10^{-6}}$$

$$= \mathbf{16,134\ km}$$ (5)

3.2.2 $$v = \frac{\omega}{\beta}$$

$$= \frac{1000}{389,492\times 10^{-6}}$$

$$= \mathbf{2567,445\ km/s}$$ (1)

3.3 $$Z_o = \sqrt{\frac{R + j\omega L}{G + j\omega C}}$$

$$= \sqrt{\frac{56\angle 1,53^0}{15\times 10^{-6}\angle\left(3,44\times 10^{-3}\right)^0}}$$

$$= \mathbf{1932,184\angle 0,76^0}$$ (2)

3.4 Since the angle in the impedance is zero, it means that the line is purely resistive and that no distortion will occur and that LG = CR. (3)

3.5 True (1)
[15]

QUESTION 4

4.1 4.1.1 Cosmic noise is a noise radiated by stars, sun and planets and is also known as 'blackbody' noise. (2)

4.1.2 Static noise is caused by spurious radio waves which induce voltages in an antenna and are caused by natural disturbances such as: lightning and electrical disturbances (3)

4.1.3 Solar noise is a constant radiation from the sun and undergoes cycles at the peak of which electrical disturbances erupt, which include: corona flares, sunspots. (3)

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4.2 4.2.1 $E_n = \sqrt{4.K.T.\Delta f.R}$

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

$$= \frac{\left(21\times10^{-6}\right)^2}{4\times1,38\times10^{-23}\times298\times15\times10^3}$$

$$= \mathbf{1,787\ M\Omega}$$ (3)

4.2.2 $E_n = \sqrt{4\ .\ K\ .\ T\ .\ \Delta f\ .\ R}$

$$= \sqrt{4\times1,38\times10^{-23}\times298\times15\times10^3\times893,5\times10^3}$$

$$= \mathbf{14,848\ \mu V}$$ (2)

4.3 4.3.1 $\mathbf{dB} = 10 \log F$

$$\therefore \mathbf{F} = \text{anti-log}\frac{dB}{10}$$

$$= \text{anti-log}\frac{2,632}{10}$$

$$= \mathbf{1,833}$$

$$\mathbf{F} = 1 + \frac{R'_{eq}}{R_a}$$

$$\therefore R'_{eq} = R_a(F - 1)$$

$$= 90(1,833 - 1)$$

$$= \mathbf{75\ ohm}$$ (4)

4.3.2 $T_{eq} = T_O(F - 1)$

$$= 298(1,833 - 1)$$

$$= 248\ K$$

$$\therefore t = \mathbf{-25\ ^0C}$$ (1)

[18]

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QUESTION 5

5.1 $\mathbf{dB} = 10 \log \frac{S}{N}$

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

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

$= \mathbf{100}$

$c = \Delta f \times \log_2 \left(1 + \frac{S}{N}\right)$

$\therefore \Delta f = \frac{c}{\log_2 \left(1 + \frac{S}{N}\right)}$

$= \frac{1000000}{\log_2 (1 + 100)}$

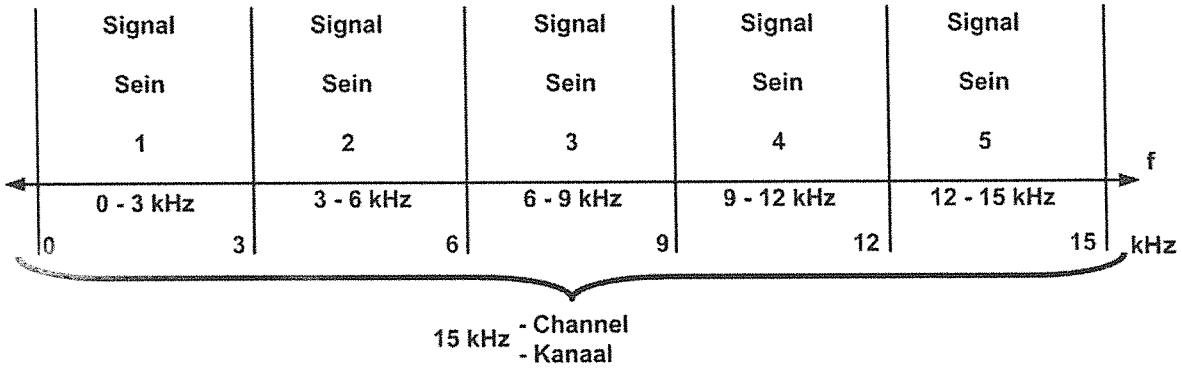
$= \frac{1000000}{\frac{\log 101}{\log 2}}$

$= \mathbf{150{,}19\ kHz}$ (4)

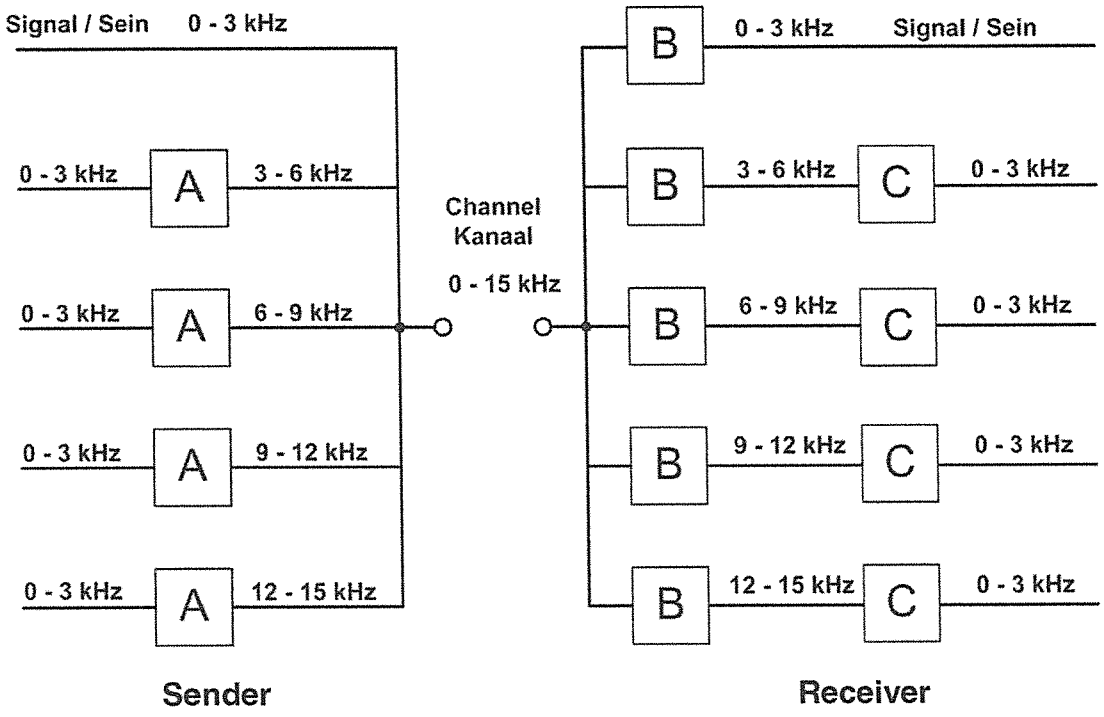
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5.2 **Principle of frequency division multiplexing:**

Frequency multiplexing is a technique of shifting the frequency spectrum of various signals to be transmitted over the same channel so that they occupy different frequency bands that do not overlap. (3)



(2)



A = Modulators / Moduleerders B = Filter C = Demodulators / Demoduleerders (9)

[18]

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QUESTION 6

6.1 6.1.1 $\mathbf{P_d} = \frac{P_t.G_t}{4.\pi.d^2}$

$= \frac{30\times10^3\times15}{4\times3,142\times\left(75\times10^3\right)^2}$

$= \mathbf{6,365\ \mu Watt/m^2}$

$\therefore \mathbf{P_r} = P_d.\ A$

$\therefore \mathbf{A} = \frac{P_r}{P_d}$

$= \frac{18\times10^{-6}}{6,365\times10^{-6}}$

$= \mathbf{2,828\ m^2}$ (4)

6.1.2 $\mathbf{A} = \frac{G.\lambda^2}{4.\pi}$

$\therefore \lambda = \sqrt{\frac{A.4.\pi}{G}}$

$= \sqrt{\frac{2,828\times4\times3,142}{15}}$

$= \mathbf{1,539\ m}$

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

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

$= \frac{3\times10^8}{1,539}$

$= \mathbf{194,932\ MHz}$ (4)

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6.2 $P_r = P_d . A$

$\therefore$ **A** $= \frac{P_r}{P_d}$

$= \frac{30\times10^{-12}}{2\times10^{-12}}$

$=$ **15 m²**

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

$= \frac{3\times10^{8}}{150\times10^{6}}$

$=$ **2 m**

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

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

$= \frac{15\times4\times3,142}{2^2}$

$=$ **47,13**

$\therefore$ **dB** $=$ 10 log G

$=$ 10 log 47,13

$=$ 16,733

$=$ **17 dB** (6)
[14]

TOTAL: 100

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