higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

T310(E)(A9)T
APRIL EXAMINATION

NATIONAL CERTIFICATE

COMMUNICATION-ELECTRONICS N6

(8080246)

9 April 2014 (Y-Paper)
13:00–16:00

Calculators may be used.

This question paper consists of 7 pages and 5 formula sheets.

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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 Study the graph shown in FIGURE 1 below.

The following additional information is given:

$f_C = 3{,}75$ kHz
$f_\infty = 4{,}25$ kHz
$Z_O = 600$ ohms

Design the terminating half-sections for the given information and sketch the completed network. Indicate ALL the relevant values for a T-section only.

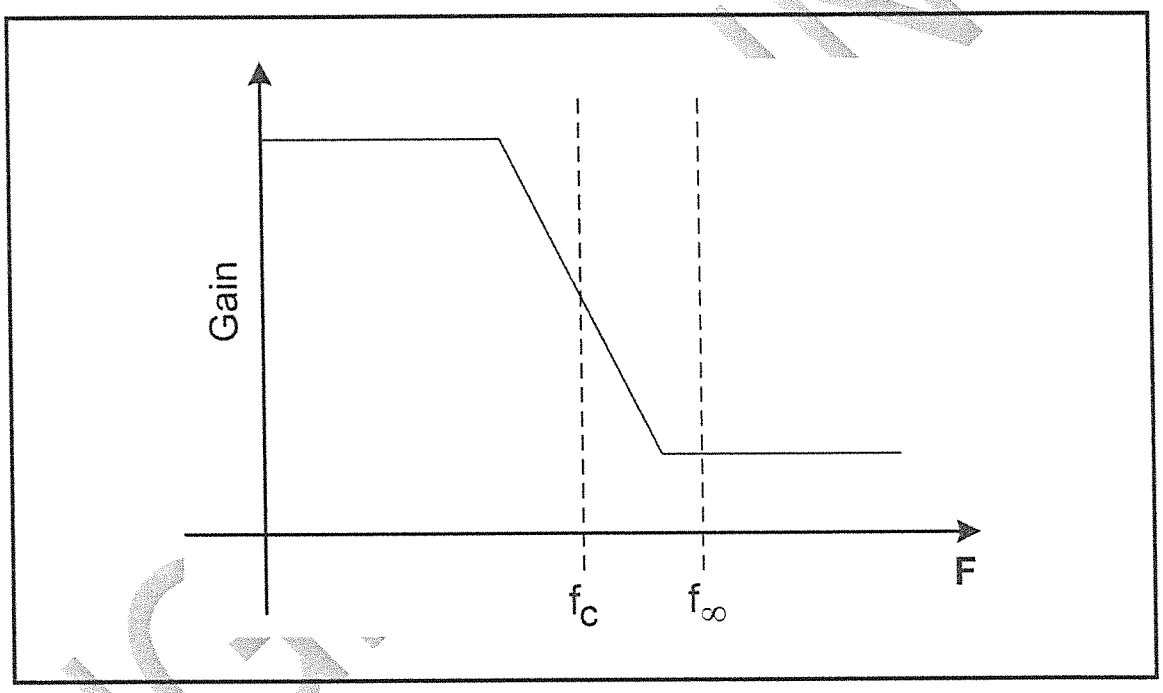


FIGURE 1 (7)

1.2 Study the graph shown in FIGURE 2 below.

The following additional information is given:

$f_C = 5$ kHz
$f_\infty = 4{,}5$ kHz
$Z_O = 600$ ohms

Design an m-derived Pi-section filter which will comply with the above information. Sketch the completed filter and indicate ALL the relevant values.

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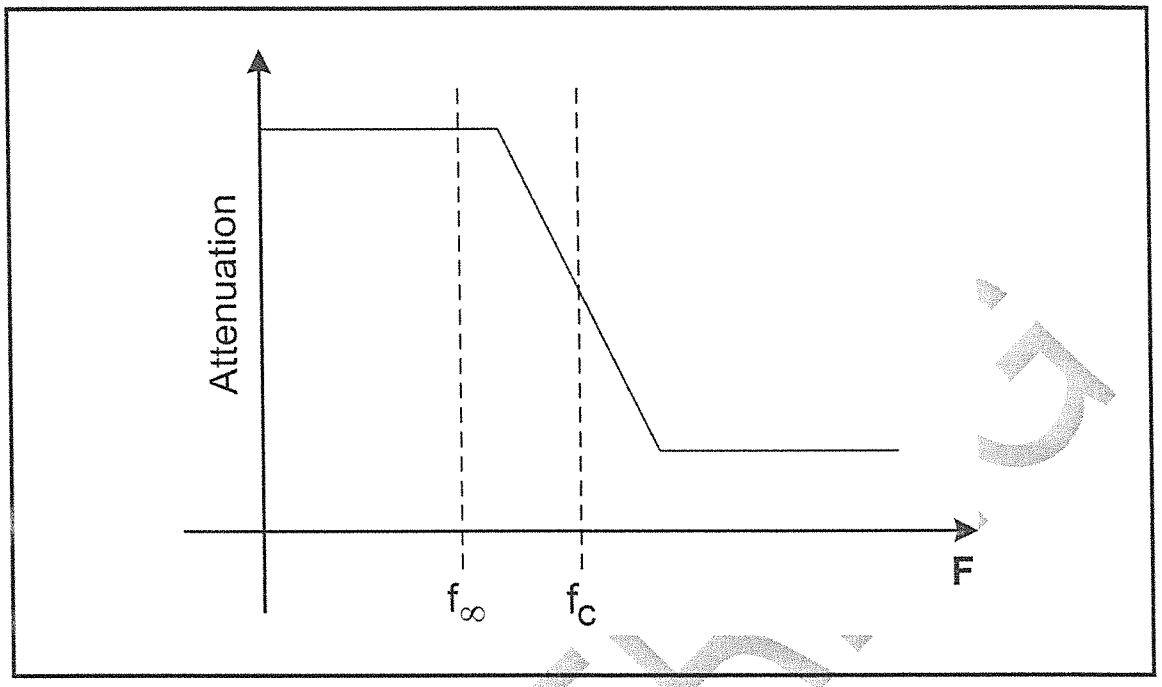


FIGURE 2 (7)

1.3 What is the main disadvantage of a constant-k filter? (2)

1.4 1.4.1 How is the attenuation of a prototype filter improved? (1)

1.4.2 How is the characteristic impedance of a prototype filter improved? (1)

[18]

QUESTION 2

2.1 Consider FIGURE 3 below.

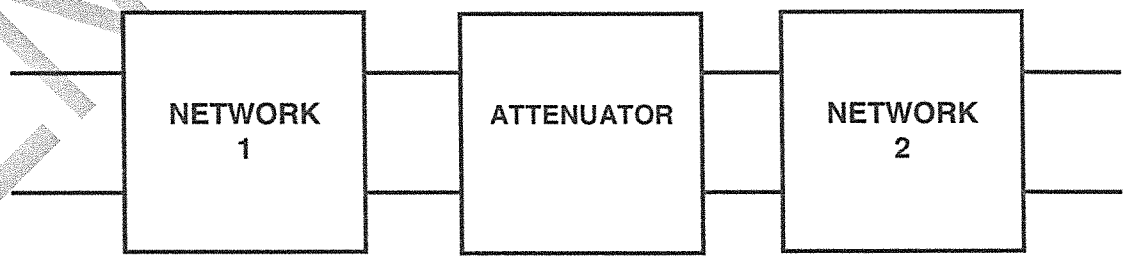


FIGURE 3

Network 1 has an output impedance of 480 ohms and network 2 has an input impedance of 420 ohms.

Design a T-type asymmetrical attenuator that will provide 12 dB attenuation between the two networks.

Draw the completed attenuator network and insert ALL relevant values. (7)

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2.2 Consider FIGURE 4 below.

Determine, with the available information, the input impedance of the network if the power is attenuated by 20 dB. (4)

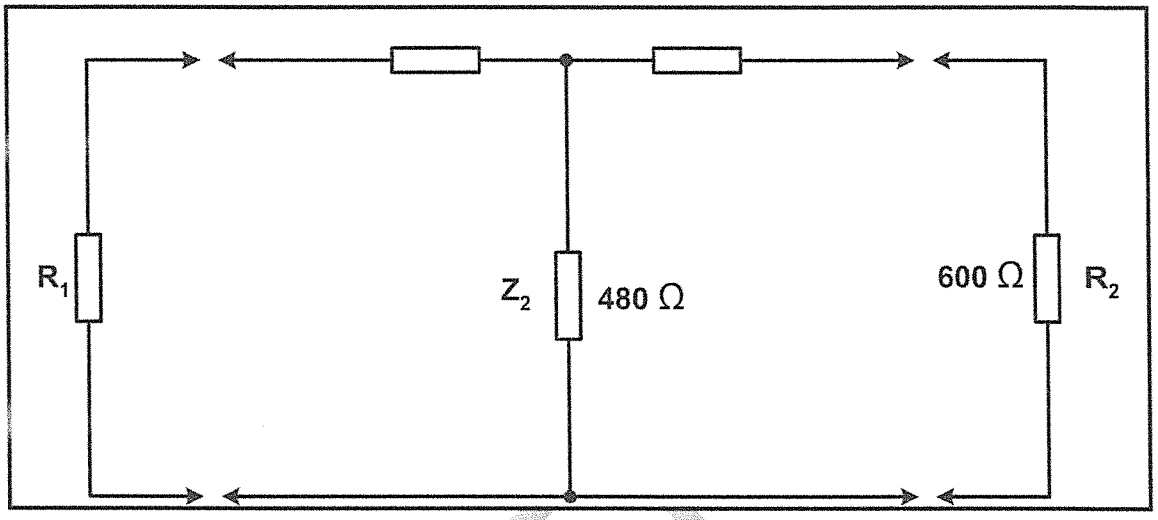


FIGURE 4

2.3 Impedance matching and possible attenuation are important concepts in communication systems. A device has an output impedance of 350 ohms and has to be matched to a device that has an input impedance of 500 ohms.

Design a π-type attenuator of which the attenuation figure may not exceed 15.

Draw the complete network and insert ALL the relevant component values. (5)
[16]

QUESTION 3

3.1 State the purpose of each of the following transmission components:

3.1.1 A stub

3.1.2 A directional coupler

3.1.3 A balun

3.1.4 A slotted line

(4 × 1) (4)

3.2 Determine the open circuit impedance of a transmission line for the following data:

Z_O = 600 ohms
$Z_{S/C}$ = 750 ohms (2)

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3.3 The following information was obtained from a transmission line at a frequency of $\omega = 10\,000$ radians:

R = 30 ohms/km
G = 45 μ-mhos/km
L = 9 mH/km
C = 600 pF/km

Calculate the following:

3.3.1 The impedance of the transmission line (4)

3.3.2 The attenuation constant (3)

3.3.3 The phase constant (1)

3.3.4 The wavelength (1)

3.3.5 The velocity (1)
[16]

QUESTION 4

4.1 Differentiate between the following and give in each instance a mathematical expression to enhance the description:

4.1.1 Noise factor (3)

4.1.2 Signal-to-noise ratio (3)

4.2 An RF amplifier has an input resistance of 3,5 kilo-ohms and an equivalent noise resistance of 4,8 kilo-ohms. The amplifier has a gain of 10 with an output load impedance of 180 kilo-ohms.

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

4.2.1 Determine the noise voltage for a bandwidth of 900 kHz at a temperature of 25 °C. (3)

4.2.2 Determine the noise figure if the RF amplifier is connected to an antenna with an impedance of 50 ohms. (4)

4.3 Determine the value of the input resistor to an amplifier which has a frequency range of 90 kHz to 120 kHz. A noise voltage of 18 μV is generated at a temperature of 25 °C.

Take Boltzmann's constant as $1{,}38 \times 10^{-23}$ J/K (3)

4.4 Name TWO sources of extra-terrestrial noise. (2)
[18]

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QUESTION 5

5.1 What are the advantages and disadvantages of PCM over other methods of communication? (6)

5.2 Draw a neat, labelled block diagram of a phase shift single sideband system.

Indicate on the block diagram ALL the voltage expressions and also the expected outputs. (12)
[18]

QUESTION 6

6.1 Define the following terms with reference to antennae:

6.1.1 Polarisation (2)

6.1.2 An isotrope (2)

6.1.3 Antenna resistance (3)

6.1.4 Aperture (2)

6.2 The antenna of a transmitter station has an effective aperture of 12 m^2 and radiates energy at a frequency of 120 MHz.

Calculate the following:

6.2.1 The power received for a power density of $1,2 \times 10^{-12}$ watt/m^2 (1)

6.2.2 The gain of the antenna in dB (4)
[14]

TOTAL: 100

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FORMULA SHEET

1. *Filters*

Low-pass

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

High-pass

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

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

T-section

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

$$\text{Shunt } C = m \cdot C$$

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

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

π-section

$$\text{Shunt } C = \frac{m \cdot C}{2}$$

$$\text{Series } L = m \cdot L$$

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

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

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

T-section

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

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

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

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

π-section

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

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

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

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

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Band-pass sections

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

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

Band-stop sections

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

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

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

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

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

T-Type

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

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

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

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*

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

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

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

$$L.G = C.R$$

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

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

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

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

Normalised impedance

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

4. *Noise*

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

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

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

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

$$R_c = R_{2out}$$

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

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

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

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

5. *Modulation*

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

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$$P_{dc} = I_{mean} \times V_{dc}$$

$$P_{\text{mod}} = \frac{P_{SB}}{\eta}$$

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

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

6. *Antennae*

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

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

$P_r = P_d \times A \,.\, G_r$ *where*

$$dB = 10 \log G$$

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

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

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

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

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

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

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

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

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MARKING GUIDELINE

NATIONAL CERTIFICATE

APRIL EXAMINATION

COMMUNICATION-ELECTRONICS N6

9 APRIL 2013

This marking guideline consists of 12 pages.

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QUESTION 1

1.1

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

$$= \frac{600}{3,142 \times 3,75 \times 10^3} \qquad = \frac{1}{3,142 \times 600 \times 3,75 \times 10^3}$$

$$= 50,923 \text{ mH} \qquad = 141,453 \text{ nF}$$

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

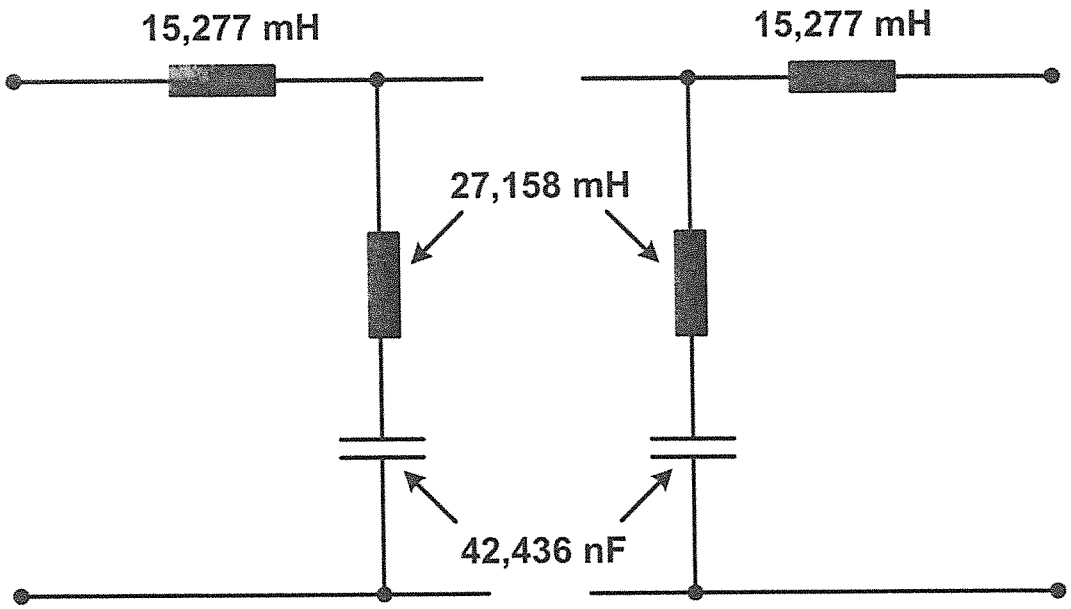
$$= \frac{0,6 \times 50,923 \times 10^{-3}}{2} \qquad = 0,6 \times 141,453 \times 10^{-9}$$

$$= 15,277 \text{ mH} \qquad = 84,872 \text{ nF}$$

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

$$= \frac{1 - 0,6^2}{4 \times 0,6} \times 50,923 \times 10^{-3}$$

$$= 13,579 \text{ mH}$$



(7)

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1.2 $L = \frac{Z_o}{4.\pi.f_c}$ $C = \frac{1}{4.\pi.Z_o.f_c}$

$= \frac{600}{4\times3,142\times5\times10^3}$ $= \frac{1}{4\times3,142\times600\times5\times10^3}$

$= 9,548$ mH $= 26,522$ nF

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

$= \sqrt{1-\frac{\left(4,5\times10^3\right)^2}{\left(5\times10^3\right)^2}}$ $=$

$\frac{26,522\times10^{-9}}{0,436}$

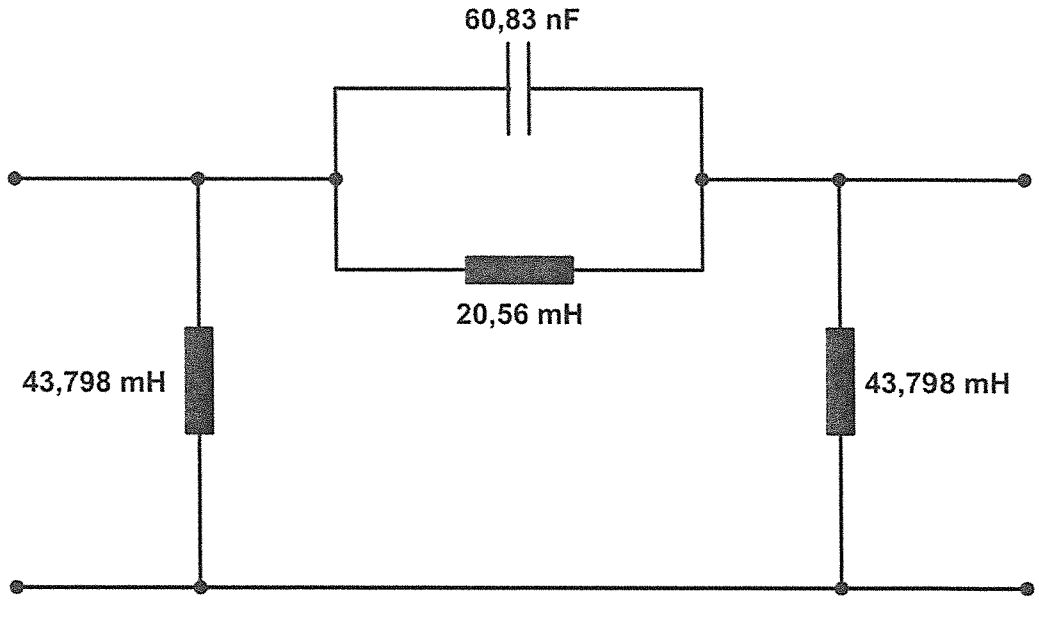
$= 0,436$ $= 60,83$ nF

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

$= \frac{4\times0,436}{1-0,436^2}\times 9,548\times10^{-3}$ $=$

$\frac{2\times9,548\times10^{-3}}{0,436}$

$= 20,56$ mH $= 43,798$ mH



(7)

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1.3
- Attenuation does not rise sharply at cut-off
- The characteristic impedance is not constant over the pass band (2)

1.4 1.4.1 Design and make use of m-derived sections (1)

1.4.2 Design and make use of half-sections (1)
[18]

QUESTION 2

2.1 $dB = 20 \log N$

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

$= \text{anti-log } \frac{12}{20}$

$= 3,981$

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

$= 480\left[\frac{3,981^2+1}{3,981^2-1}\right] - 2\sqrt{480\times 420}\left[\frac{3,981}{3,981^2-1}\right]$

$= 303,891\ \Omega$

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

$= 2\sqrt{480\times 420}\left[\frac{3,981}{3,981^2-1}\right]$

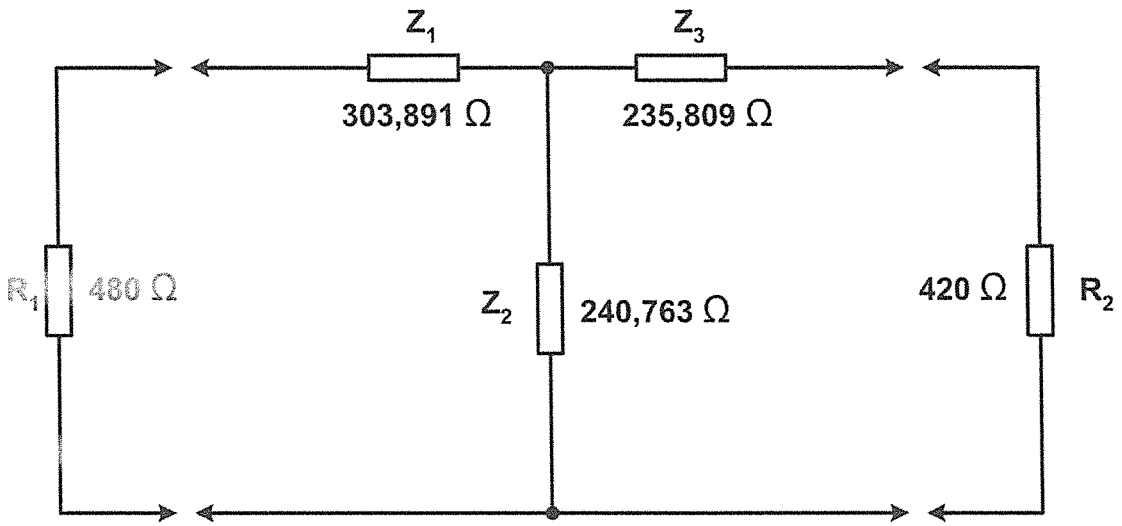
$= 240,763\ \Omega$

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

$= 420\left[\frac{3,981^2+1}{3,981^2-1}\right] - 2\sqrt{480\times 420}\left[\frac{3,981}{3,981^2-1}\right]$

$= 235,809\ \Omega$

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(7)

2.2 $dB = 20 \log N$

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

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

$= 10$

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

$= 2\sqrt{R_1 \times 600} \times \left[\frac{10}{10^2-1}\right]$

$480 = 2\sqrt{600 \times R_1} \times \left[101{,}01 \times 10^{-3}\right]$

$2\sqrt{600 \times R_1} = \frac{480}{101{,}01 \times 10^{-3}}$

$\sqrt{600 \times R_1} = 2376$

$\therefore R_1 = 9{,}409\ k\Omega$ (4)

2.3 $S = \sqrt{\frac{R_1}{R_2}}$

$= \sqrt{\frac{350}{500}}$

$= 0,837$

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

$= 350\left[\frac{15^2 - 1}{15^2 - (2 \times 15 \times 0,837) + 1}\right]$

$= 390,263 \text{ ohm}$

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

$= \frac{\sqrt{350 \times 500}}{2} \times \left[\frac{15^2 - 1}{15}\right]$

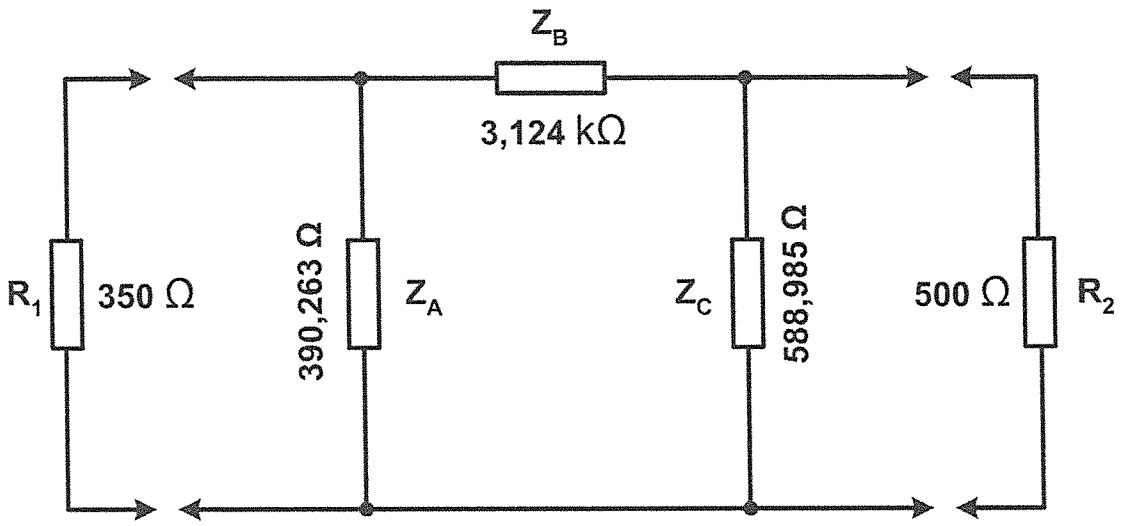
$= 3,124 \text{ k-ohm}$

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

$= 500\left[\frac{15^2 - 1}{15^2 - \left(2 \times \frac{15}{0,837}\right) + 1}\right]$

$= 588,985 \text{ ohm}$

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(5)
[16]

QUESTION 3

3.1 3.1.1 To tune out reactive components.

3.1.2 To measure power along a transmission line.

3.1.3 To match an unbalanced device to balanced device.

3.1.4 To determine the position and size of the first voltage maximum from the load.

(4 × 1) (4)

3.2 $Z_0 = \sqrt{Z_{o/c} . Z_{s/c}}$

$\therefore Z_{o/c} = \frac{Z_o^2}{Z_{s/c}}$

$= \frac{600^2}{750}$

$= 480\ \Omega$ (2)

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3.3 3.3.1 $Z_O = \sqrt{\frac{R + j\omega L}{G + j\omega C}}$

$= \sqrt{\frac{30 + j\ 10000\times9\times10^{-3}}{45\times10^{-6} + j\ 10000\times600\times10^{-12}}}$

$= \sqrt{\frac{30 + j\ 90}{45\times10^{-6} + j\ 6\times10^{-6}}}$

$= \sqrt{\frac{94,868\angle 71,6^0}{45,398\times10^{-6}\angle 7,6^0}}$

$= 1,446\text{x}10^3\angle 32^0$ ohm

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

$= \sqrt{(94,868\angle 71,6^0)(45,398\times10^{-6}\angle 7,6^0)}$ (4)

3.3.2 $= \sqrt{4,307\times10^{-3}\angle 79,2^0}$

$= 65,626\times10^{-3}\angle 39,6^0$

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

$= 50,566\times10^{-3} + j41,832\times10^{-3}$

$\therefore \alpha = 50,566\times10^{-3}$ nepers/km

$\beta = 41,832\times10^{-3}$ radians/km

$\lambda = \frac{2.\pi}{\beta}$ (3)

3.3.3 $= \frac{2\times3,142}{41,832\times10^{-3}}$ (1)

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3.3.4 = 150,22 km

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

$$= \frac{10000}{41,832\times10^{-3}} \quad (1)$$

3.3.5 = 239,051 km/s (1)
[16]

QUESTION 4

4.1 4.1.1 It is the ratio of signal power to noise power at the same point in a circuit.

$$S/N = \frac{E_s^2}{E_N^2} \quad (3)$$

4.1.2 It is the ratio of signal-to-noise at the input to signal-to-noise at the output

$$F = \frac{S/N_{IN}}{S/N_{OUT}} \quad (3)$$

4.2 4.2.1 $E_n = \sqrt{4.K.T.\Delta f\,(R_1 + R_2)}$

$$= \sqrt{4 \times 1,38\times10^{-23} \times 298 \times \left(3,5\times10^3 + 4,8\times10^3\right) \times 900\times10^3}$$

$$= 11,085\ \mu V \quad (3)$$

4.2.2 $$\therefore R_{eq} = \left(R_{eq} - R_t\right) + \frac{R_{out/uit}}{A^2}$$

$$= \left(4,8\times10^3 - 3,5\times10^3\right) + \frac{180\times10^3}{10^2}$$

$$= 3,1\ k\Omega$$

$$F = 1 + \frac{R_{eq}}{R_a}$$

$$= 1 + \frac{3,1\times10^3}{50}$$

$$= 63 \quad (4)$$

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4.3 $En = \sqrt{4.K.T.\Delta F.R}$

$$\therefore R = \frac{E\,n^2}{4.K.T.\Delta F}$$

$$= \frac{\left(18\times10^{-6}\right)^2}{4\times1,38\times10^{-23}\times298\times30\times10^{3}}$$

$= 656,551\ k\Omega$ (3)

4.4
- Solar noise
- Cosmic noise

(2)
[18]

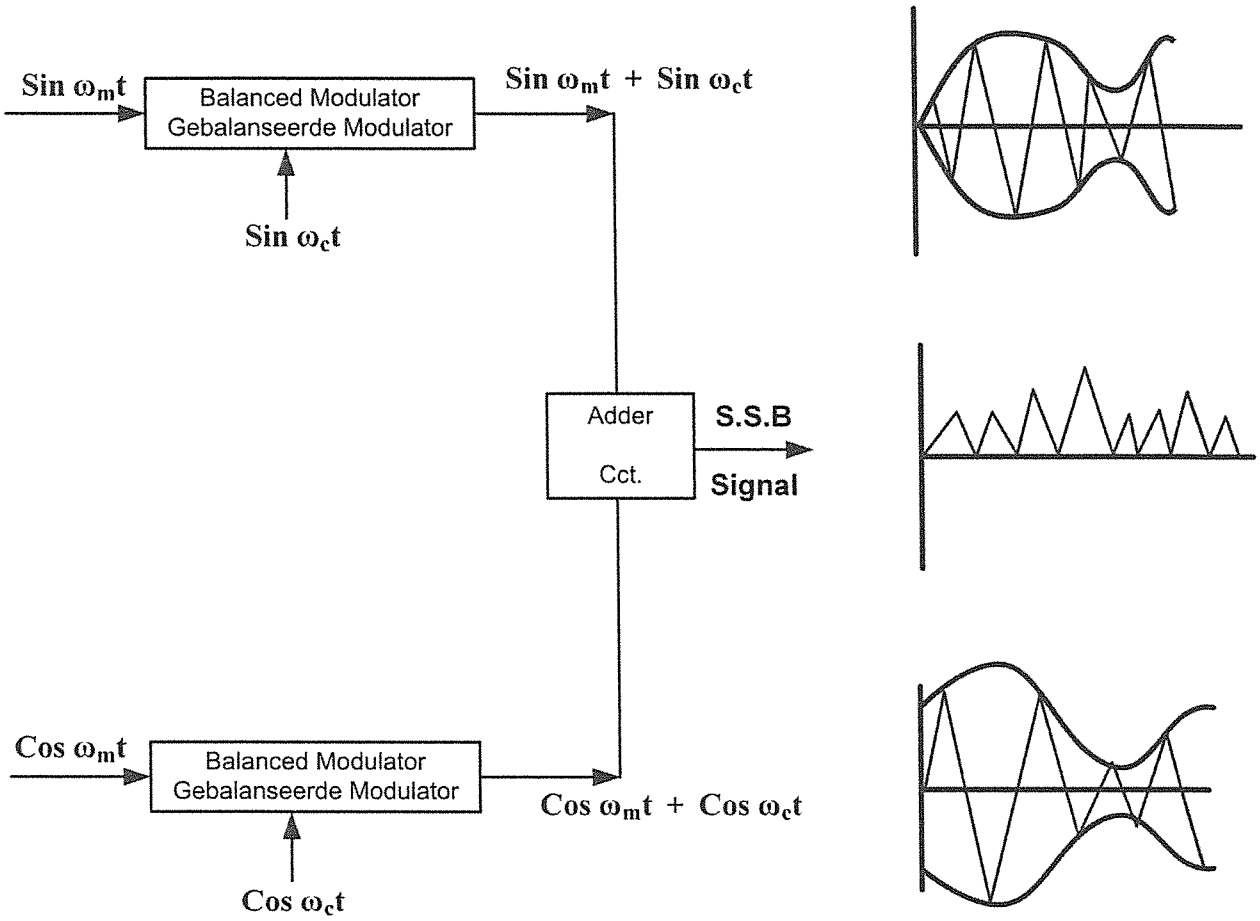
QUESTION 5

5.1 ADVANTAGES OF PCM OVER OTHERS:
- Better S/N characteristics for a given bandwidth.
- Well suited for long distance communications since S/N does not deteriorate.
- Compatible to other digital systems.

DISADVANTAGES OF PCM OVER OTHERS:
- Requires a large bandwidth.
- Requires complex and expensive equipment, which have to be duplicated in several repeaters.
- Not economical for short distance communication. (6)

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5.2



(12)
[18]

QUESTION 6

6.1 6.1.1 Polarisation refers to the plane in which the electrical field is radiated from the antenna. (2)

6.1.2 It is a theoretical antenna that radiates equal energy in all directions. (2)

6.1.3 It is the ratio of power radiated by an antenna to the square of the current at the feed point. (3)

6.1.4 This is the effective area of an antenna when a signal is received. (2)

6.2 6.2.1 $P_R = Pd.A$

$= 1,2\times10^{-12}\times12$

$= 14,4\times10^{-12}$ Watt (1)

6.2.3 $A = \frac{G.\lambda^2}{4.\pi}$ $\lambda = \frac{c}{f}$

$\frac{A.4.\pi}{\lambda^2}\lambda = \frac{3\times10^8}{120\times10^6}$

$= \frac{12\times4\times3,142}{2,5^2} = 2,5$ m

$= 24,131$

$\therefore dB = 10 \log G$

$= 10 \log 24,131$

$= 13,826$ dB

(4)
[14]

TOTAL: 100

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