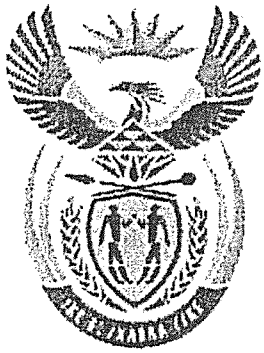
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T360(E)(N11)T
NOVEMBER EXAMINATION

NATIONAL CERTIFICATE

COMMUNICATION-ELECTRONICS N6

(8080246)

11 November 2013 (X-Paper)
09:00–12:00

Calculators may be used.

This question paper consists of 6 pages and a 6-page formula sheet.

UNISA

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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 Draw TWO neat, labelled graphs of ATTENUATION versus FREQUENCY for the following:

1.1.1 A band-stop filter (2)

1.1.2 A band-pass filter (2)

1.2 Consider the graph shown in FIGURE 1 below.
Design, with the available information in FIGURE 1, a filter for a 600 ohm transmission line.
Draw the completed filter and insert ALL the relevant values.

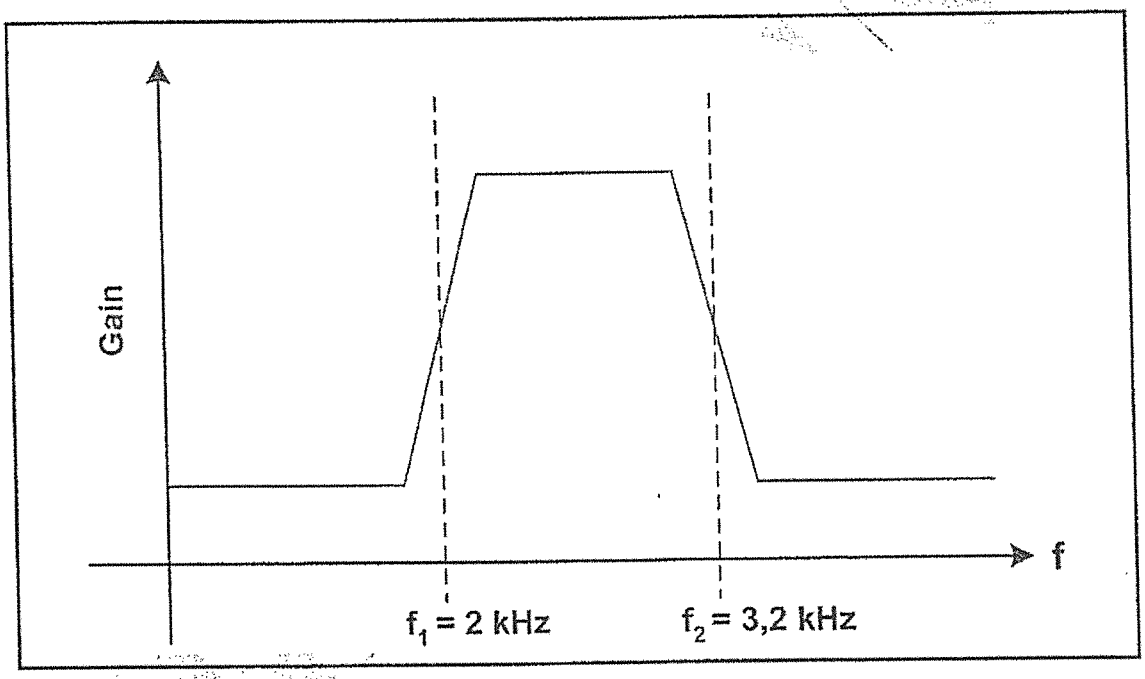


FIGURE 1 (6)

1.3 A high-pass π-section filter has a cut-off frequency of 3 kHz, a frequency of infinite attenuation of 1,8 kHz and is used on a 600 ohm transmission line. Obtain the terminating input and output half sections and draw the completed filter. Show ALL the relevant component values. (8)
[18]

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QUESTION 2

2.1 Draw the following fully labelled balanced attenuator networks:

2.1.1 π-type (2)

2.1.2 L-type (2)

2.1.3 T-type (2)

2.2 A variable bridged T- network is required for a 600 ohms transmission line to give attenuation between the ranges of 3 dB and 5 dB.
Obtain the maximum and minimum values for the potentiometers required then draw the network and insert ALL relevant values. (8)

2.3 Is an attenuator frequency sensitive? Motivate your answer. (3)
[17]

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:

3.2.1 750 ohms (1)

3.2.2 300 + j450 ohms (4)

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

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QUESTION 4

4.1 The following information for a telephone channel is given:

S/N ratio = 15 dB
Bandwidth = 10 kHz

Calculate the following:

4.1.1 The channel capacity. (2)

4.1.2 The channel capacity should the bandwidth double and the S/N ratio halve. (2)

4.2 The input resistor to an amplifier has a value of 27 kΩ and has a frequency range of 21 kHz to 30 kHz at a temperature of 24 °C.
Determine the difference in noise voltage generated, should the temperature be reduced to 18 °C.
Take Boltzmann's constant as $1,38 \times 10^{-23}$ J/K. (3)

4.3 Draw the equivalent input circuit for noise of the amplifier in FIGURE 2 below.

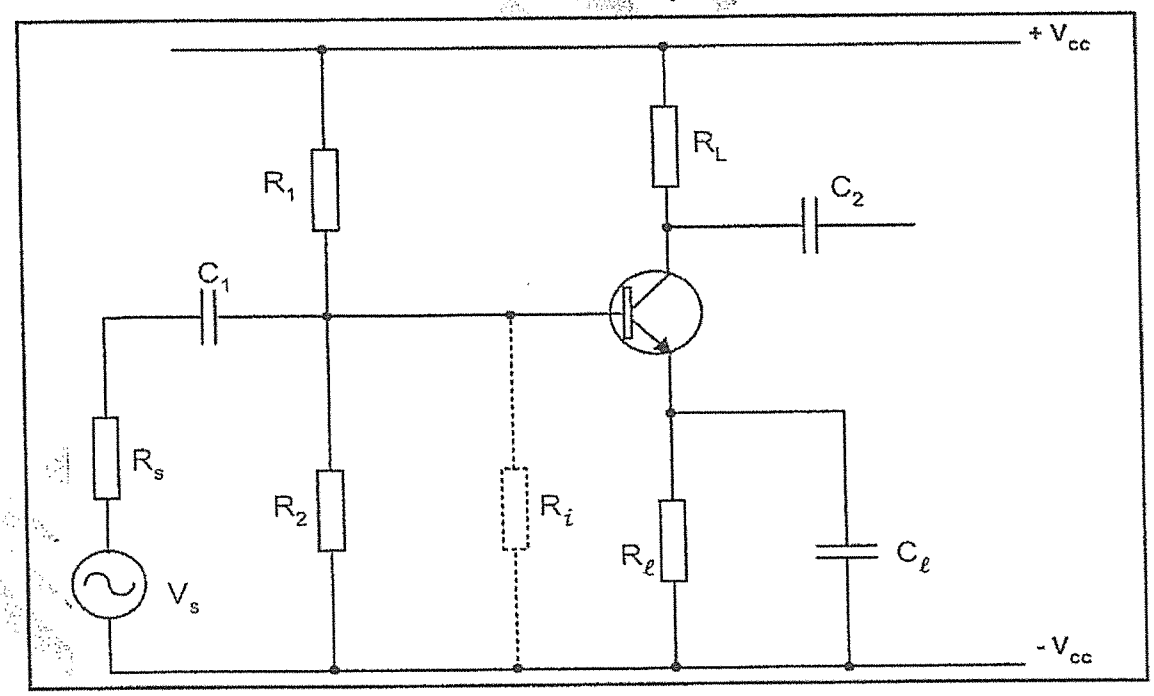


FIGURE 2 (4)

4.4 The following data of a two-stage amplifier are given:

R_{eq} = 9 k-ohms
R_a = 50 ohms
F = 41

Calculate the value of the input resistor to this amplifier. (4)
[15]

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QUESTION 5

5.1 Define, with reference to modulation the following:

5.1.1 PAM (2)

5.1.2 PPM (2)

5.1.3 PWM (2)

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 Indicate if the following statement is TRUE or FALSE:

The gain of an antenna effectively increases the effective aperture of the antenna. (1)

6.2 A satellite transmitter operating at a frequency of 950 MHz radiates 60 kW of RF power and is used to determine the distance of the satellite 150 km away, which has a surface area of 30 m^2. The transmitter and receiver antenna has similar characteristics with gains of 15 dB each.

Determine the following:

6.2.1 The field strength at the satellite (3)

6.2.2 The power density at the satellite (2)

6.2.3 The reflected power from the satellite (2)

6.2.4 The field strength at the receiver (2)

6.2.5 The power density at the receiver (2)

6.2.6 The received power at the receiver. (3)
[15]

TOTAL: 100

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COMMUNICATION-ELECTRONICS

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*	*π-section* *π-seksie*
Series/Serie $L = \frac{m \,.\, L}{2}$	*Shunt/Sjunt* $C = \frac{m \,.\, C}{2}$
Shunt/Sjunt $C = m \,.\, C$	*Series/Serie* $L = m \,.\, L$
Shunt/Sjunt $L = \frac{1 - m^2}{4 \,.\, m} \,.\, L$	*Series/Serie* $C = \frac{1 - m^2}{4 \,.\, m} \,.\, C$
$m = \sqrt{1 - \frac{f_c^2}{f_\infty^2}}$ $L = \frac{Z_o}{\pi \,.\, f_c}$	$C = \frac{1}{\pi \,.\, Z_o \,.\, f_c}$

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

T-section *T-seksie*	*π-section* *π-seksie*
Series/Serie $C = \frac{2 \,.\, C}{m}$	*Series/Serie* $C = \frac{C}{m}$
Shunt/Sjunt $C = \frac{4 \,.\, m}{1 - m^2} \,.\, C$	*Series/Serie* $L = \frac{4 \,.\, m}{1 - m^2} \,.\, L$

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

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

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

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

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

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

$$L.G = C.R$$

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

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

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

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

Normalised impedance/Genormaliseerde impedansie

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

4. *Noise/Geruis*

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

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

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

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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*

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

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

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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

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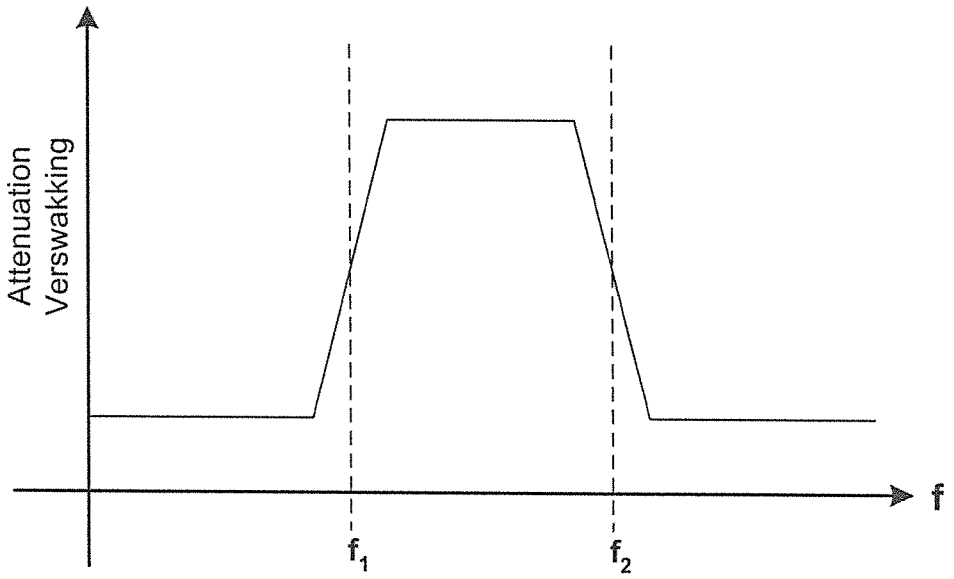
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QUESTION 1

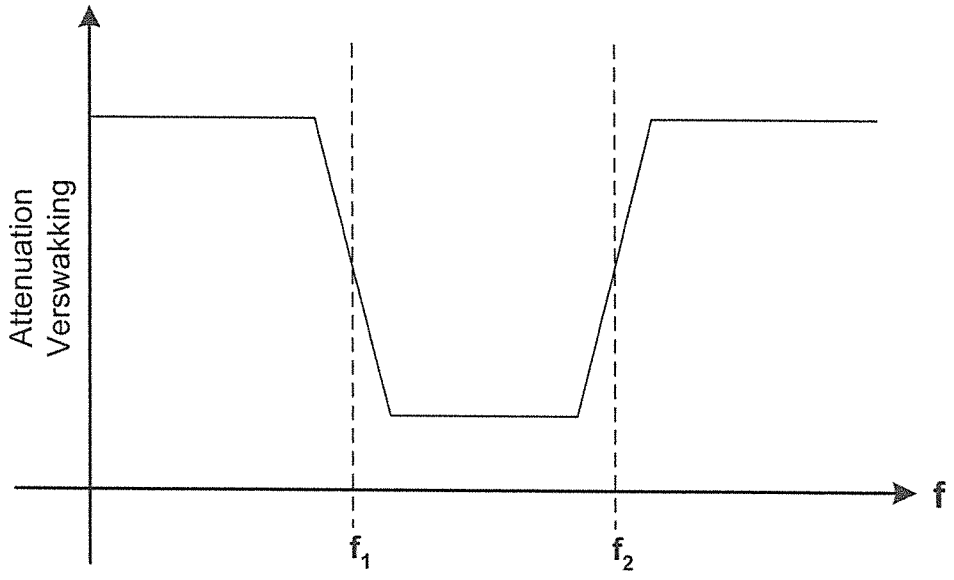
1.1

1.1.1



(2)

1.1.2



(2)

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1.2

Series L $= \dfrac{Z_0}{2\pi[f_2 - f_1]}$

$= \dfrac{600}{2\times3,142\left[3,2\times10^3 - 2\times10^3\right]}$

$=$ **79,567 mH**

Series C $= \dfrac{f_2 - f_1}{2.\pi.Z_0.f_1.f_2}$

$= \dfrac{3,2\times10^3 - 2\times10^3}{2\times3,142\times600\times2\times10^3\times3,2\times10^3}$

$=$ **49,729 nF**

Shunt L $= \dfrac{Z_0\,[f_2 - f_1]}{4.\pi.f_1.f_2}$

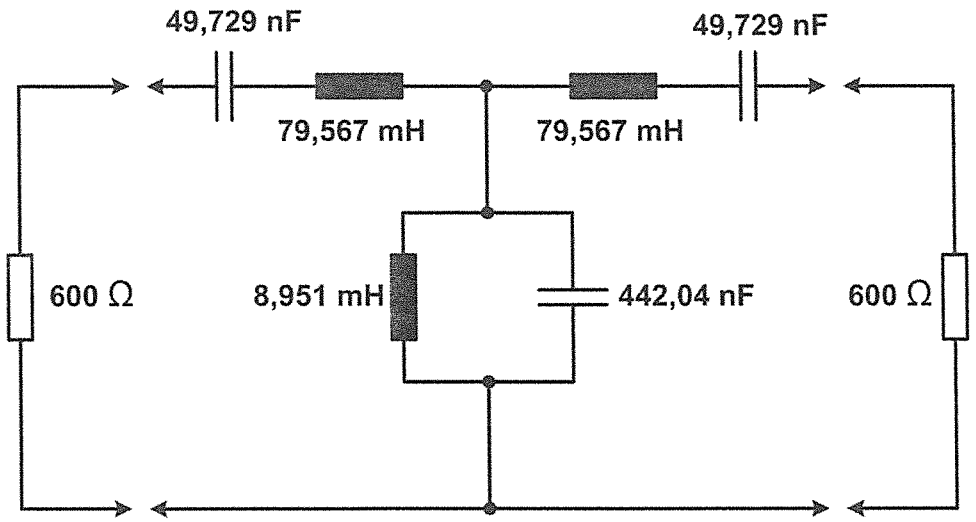
$= \dfrac{600\left[3,2\times10^3 - 2\times10^3\right]}{4\times3,142\times2\times10^3\times3,2\times10^3}$

$=$ **8,951 mH**

Shunt C $= \dfrac{1}{\pi.Z_0[f_2 - f_1]}$

$= \dfrac{1}{3,142\times600\times\left[3,2\times10^3 - 2\times10^3\right]}$

$=$ **442,04 nF**



(6)

1.3

$$L = \frac{Z_o}{4.\pi.fc}$$

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

$$= \mathbf{15,913\ mH}$$

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

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

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

$$\textbf{Serie C} = \frac{C}{m}$$

$$= \frac{44,204\times10^{-9}}{0,6}$$

$$= \mathbf{73,673\ nF}$$

$$\textbf{Shunt L} = \frac{2.L}{m}$$

$$= \frac{2\times15,913\times10^{-3}}{0,6}$$

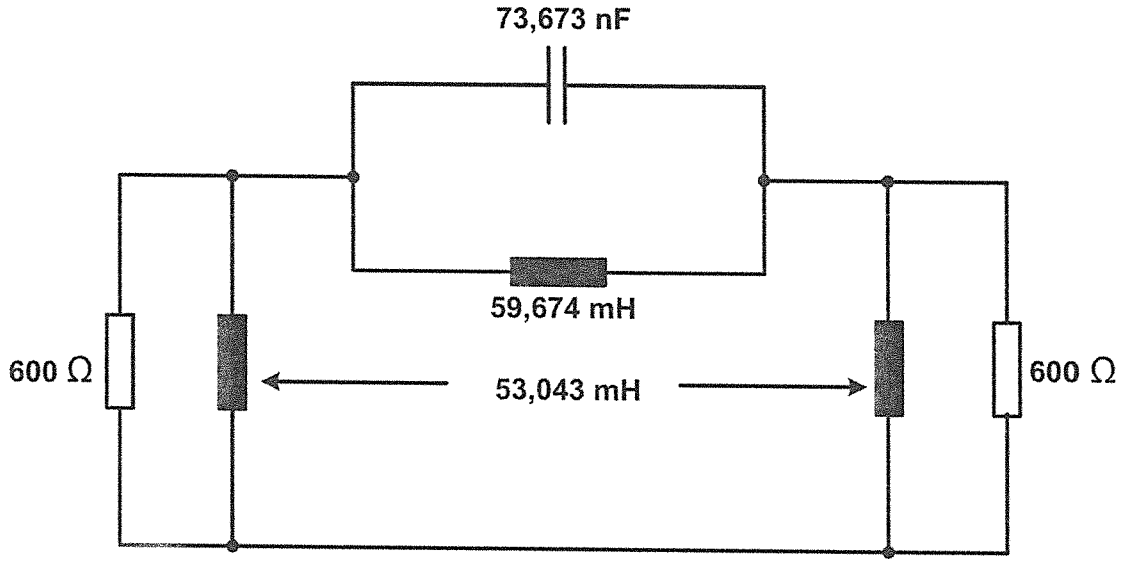
$$= \mathbf{53,043\ mH}$$

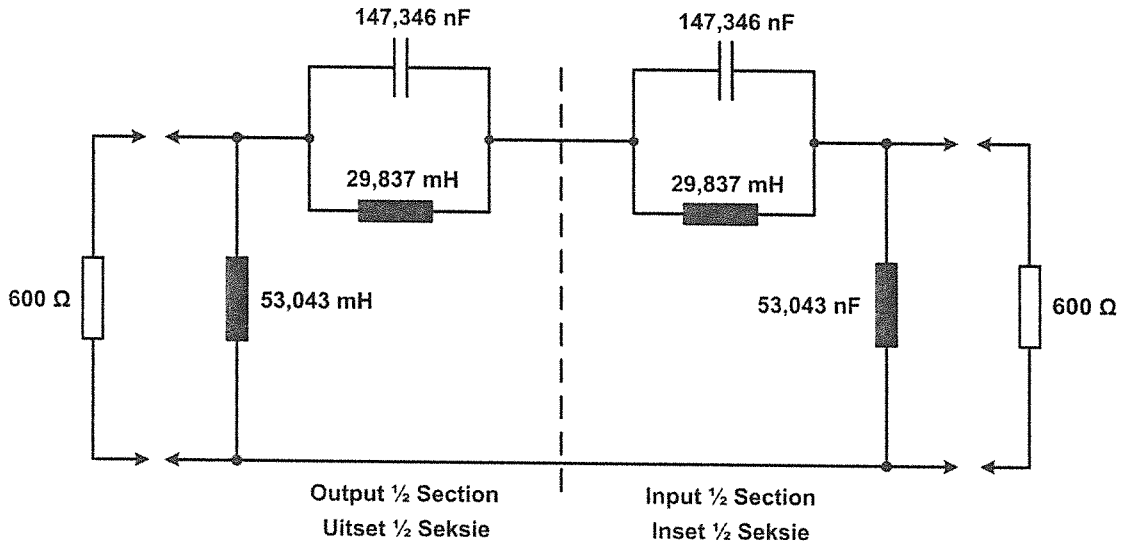
$$\textbf{Serie L} = \frac{4.m}{1-m^{2}}\times L$$

$$= \frac{4\times0,6}{1-0,6^{2}}\times15,913\times10^{-3}$$

$$= \mathbf{59,674\ mH}$$

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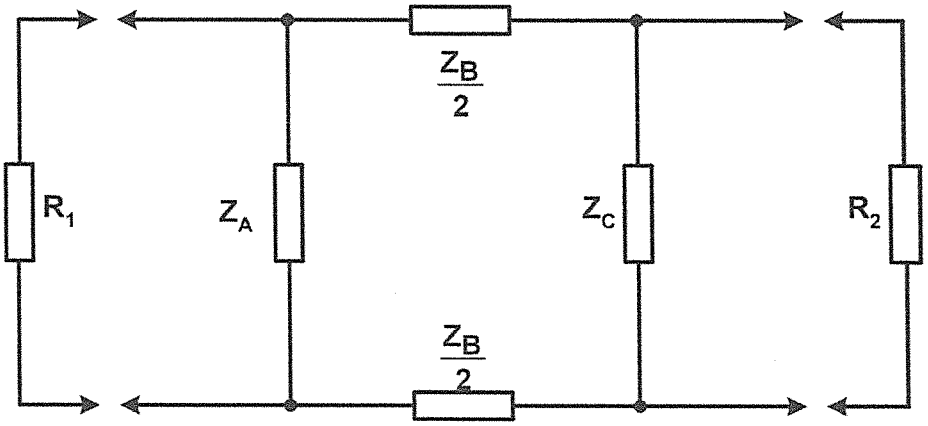


(8)
[18]

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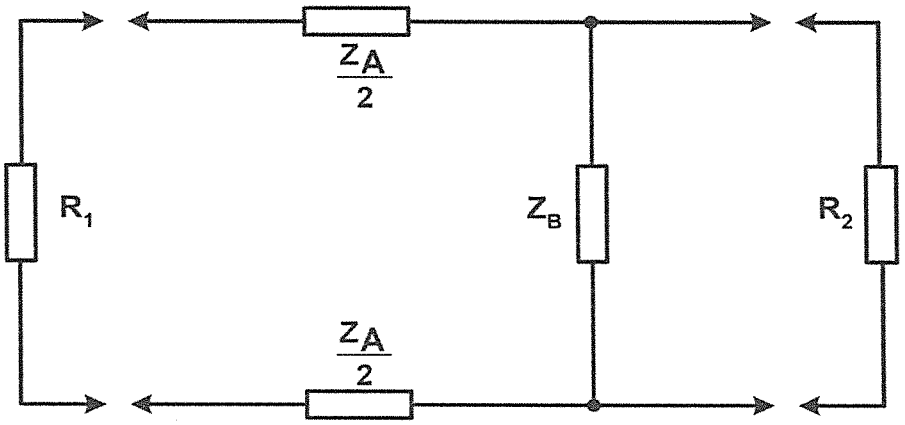
QUESTION 2

2.1 2.1.1



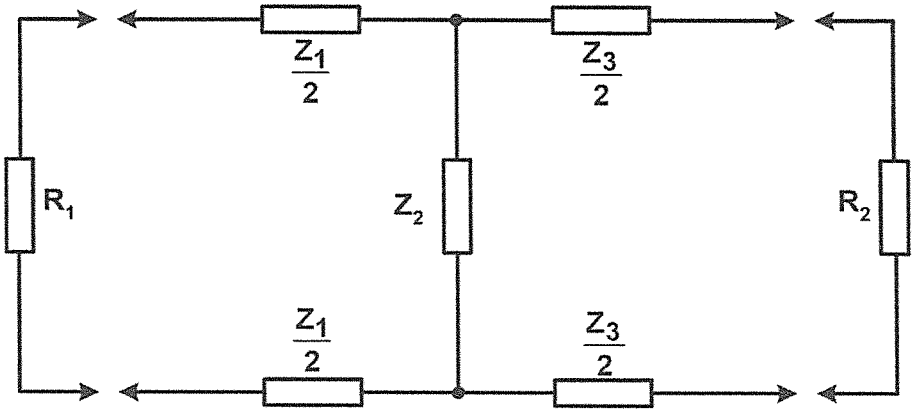
(2)

2.1.2



(2)

2.1.3



(2)

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2.2

N_A for 3 dB:

$$dB = 20 \log N_A$$

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

$$= \text{anti-log}\frac{3}{20}$$

$$= \textbf{\textit{1,413}}$$

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

$$= 600(1{,}413 - 1)$$

$$= \textbf{247,8 Ω}$$

$$Z_C = \frac{Z_0}{N_A - 1}$$

$$= \frac{600}{1{,}413 - 1}$$

$$= \textbf{1,453 kΩ}$$

N_B for 5 dB:

$$dB = 20 \log N_B$$

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

$$= \text{anti-log}\frac{5}{20}$$

$$= \textbf{1,778}$$

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

$$= 600(1{,}778 - 1)$$

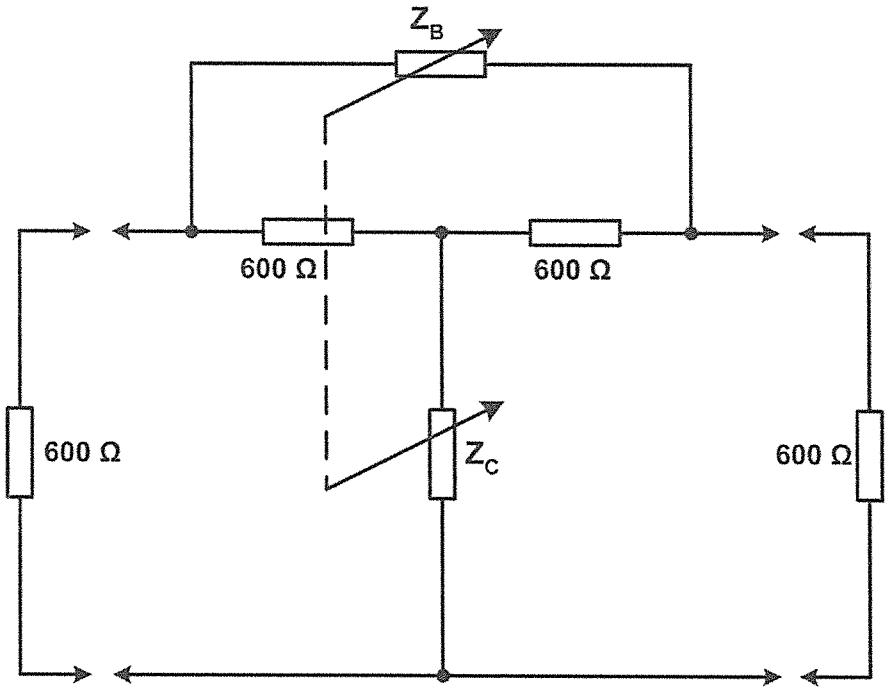
$$= \textbf{466,8 Ω}$$

$$Z_C = \frac{Z_0}{N_B - 1}$$

$$= \frac{600}{1{,}778 - 1}$$

$$= \textbf{771,208 Ω}$$

∴ Z_B should be variable between 247,8 Ω to 466,8 Ω
∴ Z_C should be variable between 771,208 Ω to 1,453 kΩ



(8)

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2.3 Attenuator frequency - sensitive:

No

An attenuator only consists of resistive components, which are not frequency sensitive. (3)
[17]

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 $$\textbf{SWR} = \frac{Z_L}{Z_o}$$

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

$$= \mathbf{1,25}$$ (1)

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

3.2.2 $$= \frac{300 + j450 - 600 - j0}{300 + j450 + 600 + j0}$$

$$= \frac{-300 + j450}{900 + j450}$$

$$= \frac{540,833\angle 123,7^0}{1006,231\angle 26,6^0}$$

$$= 0,537\angle 97,1^0$$

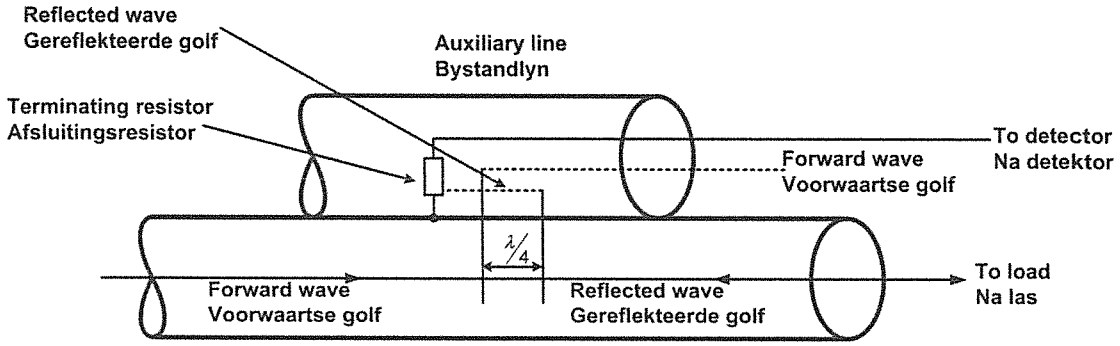
$$\therefore \textbf{SWR} = \frac{1+\rho}{1-\rho}$$

$$= \frac{1+0,537}{1-0,537}$$

$$= \mathbf{3,32}$$ (4)

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3.3



(8)
[17]

QUESTION 4

4.1 4.1.1

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

$$\therefore S/N = \text{anti-log}\frac{dB}{10}$$

$$= \text{antilog}\frac{15}{10}$$

$$= \mathbf{31,623}$$

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

$$= 10 \times 10^3 \log_2[1 + 31,623]$$

$$= 10 \times 10^3 \log_2[32,623]$$

$$= 10 \times 10^3 \left[\frac{\log 32,623}{\log 2}\right]$$

$$= \mathbf{50278,18\ bits/sec}$$

(2)

4.1.2

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

$$\therefore S/N = \text{anti-log}\frac{dB}{10}$$

$$= \text{antilog}\frac{7,5}{10}$$

$$= \mathbf{5,623}$$

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

$$= 20 \times 10^3 \log_2[1 + 5,623]$$

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$= \quad 20 \times 10^3 \log_2[6,623]$

$= \quad 20 \times 10^3 \left[\frac{\log 6,623}{\log 2}\right]$

$= \quad$ **54549,7 bits/sec** (2)

4.2

$\mathbf{En_1} = \sqrt{4.K.T.\Delta f.R}$

$= \sqrt{4 \times 1,38\times10^{-23} \times (273+24) \times \left(30\times10^3 - 21\times10^3\right) \times 27\times10^3}$

$=$ **1,996 µV**

$\mathbf{En_2} = \sqrt{4.K.T.\Delta f.R}$

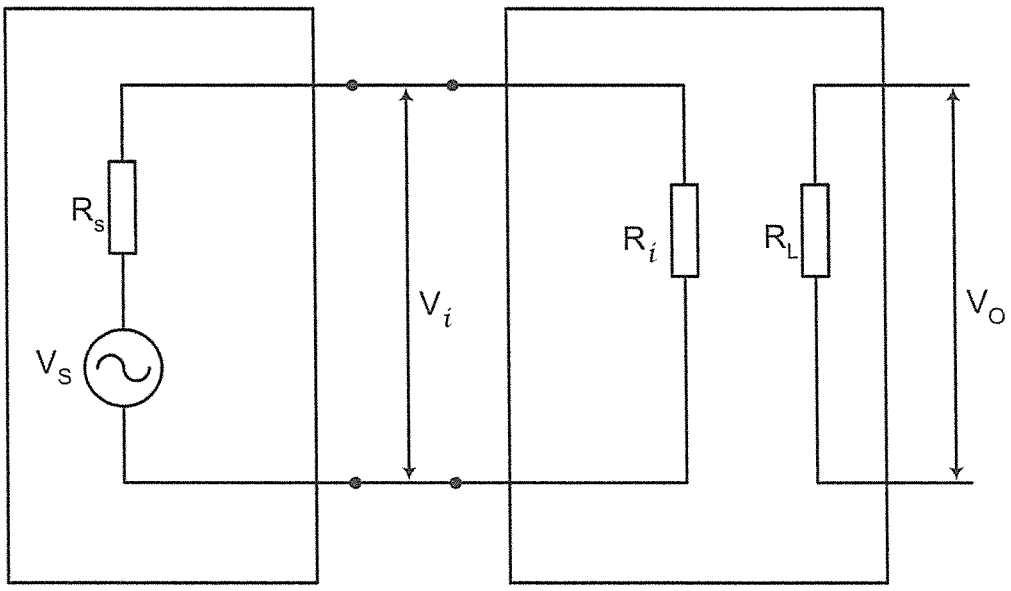
$= \sqrt{4 \times 1,38\times10^{-23} \times (273+18) \times 9\times10^3 \times 27\times10^3}$

$=$ **1,976 µV**

The difference in noise voltage $=$ $\mathbf{En_1 - En_2}$

$=$ **20 nV** (3)

4.3



(4)

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4.4

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

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

$$= 50 (41 - 1)$$

$$= \textbf{2 k-ohm}$$

$$R'_{eq} = R_{eq} - R_t$$

$$\therefore R_t = R_{eq} - R'_{eq}$$

$$= 9\times10^3 - 2\times10^3$$

$$= \textbf{7 k-ohm}$$ (4)

[15]

QUESTION 5

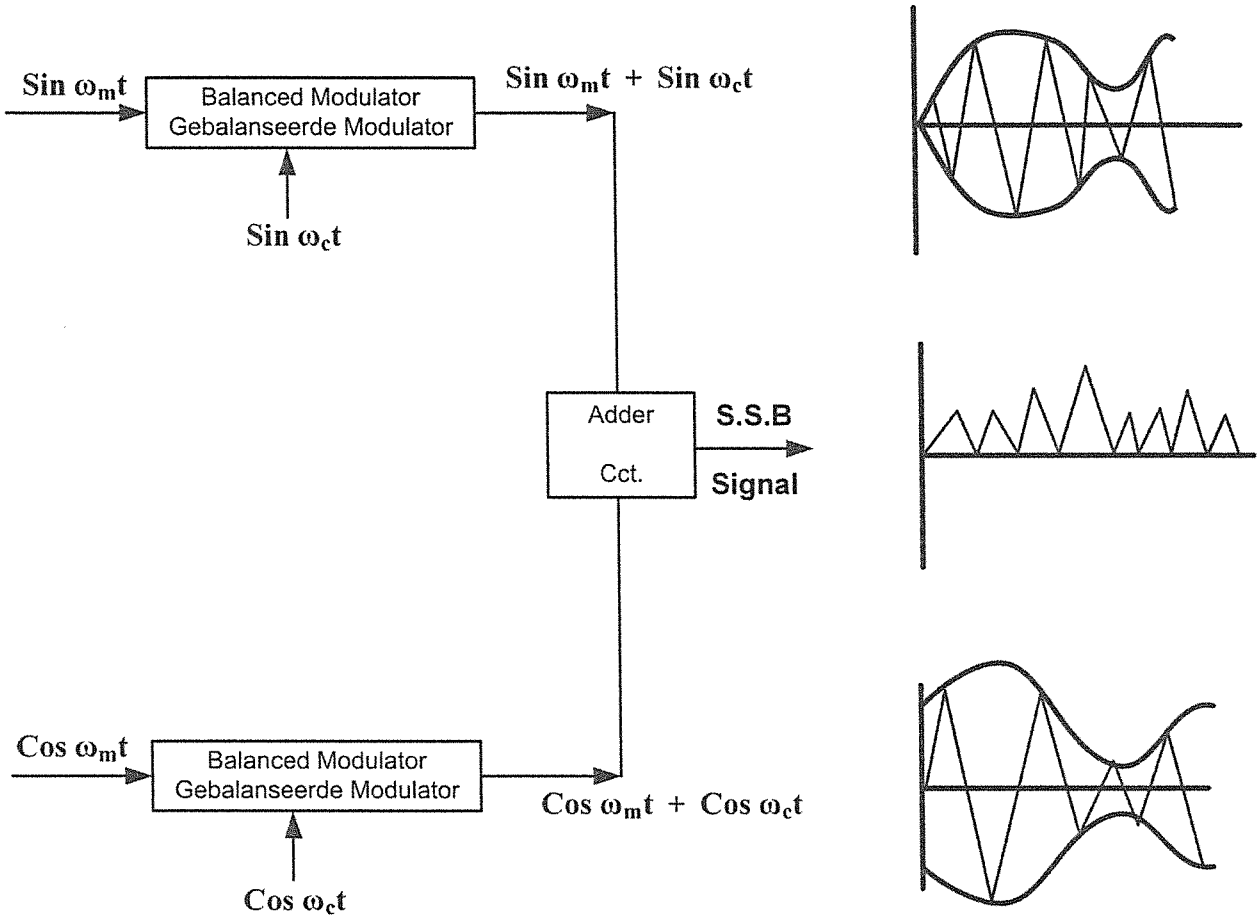
5.1 5.1.1 The amplitude of the pulse is varied in proportion to the amplitude of the modulating signal. (2)

5.1.2 The position of the pulse is varied in proportion to the amplitude of the modulating signal. (2)

5.1.3 The width of the pulse is varied in proportion to the amplitude of the modulating signal. (2)

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5.2


Sin $\omega_m t$
Balanced Modulator
Gebalanseerde Modulator
Sin $\omega_m t$ + Sin $\omega_c t$
Sin $\omega_c t$
Adder
Cct.
S.S.B
Signal
Cos $\omega_m t$
Balanced Modulator
Gebalanseerde Modulator
Cos $\omega_m t$ + Cos $\omega_c t$
Cos $\omega_c t$

(12)
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QUESTION 6

6.1 True (1)

6.2 6.2.1

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

$$= \frac{\sqrt{30 \times 60\times10^3 \times 15}}{150\times10^3}$$

$$= \mathbf{34{,}641 \times 10^{-3}\ volt/m^2}$$ (3)

6.2.2 $$P_d' = \frac{E_s^2}{120.\pi}$$

$$= \frac{\left(34{,}641\times10^{-3}\right)^2}{120\times3{,}142}$$

$$= \mathbf{3{,}183 \times 10^{-6}\ watt/m^2}$$ (2)

6.2.3 $$P_{reflected} = \frac{10.P_t.G}{4\pi d^2}$$

$$= \frac{10 \times 60\times10^3 \times 15}{4 \times 3{,}142 \times \left(150\times10^3\right)^2}$$

$$= \mathbf{31{,}827 \times 10^{-6}\ watt}$$ (2)

6.2.4 $$E_r = \sqrt{\frac{30.P_{reflected}}{d}}$$

$$= \sqrt{\frac{30 \times 31{,}827\times10^{-6}}{150\times10^3}}$$

$$= \mathbf{79{,}783 \times 10^{-6}\ volt/m^2}$$ (2)

6.2.5 $$P_d = \frac{E_r^2}{120.\pi}$$

$$= \frac{\left(79{,}783\times10^{-6}\right)^2}{120\times3{,}142}$$

$$= \mathbf{16{,}882 \times 10^{-12}\ watt/m^2}$$ (2)

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6.2.6 $\lambda = \frac{C}{f}$

$= \frac{3\times10^8}{950\times10^6}$

$=$ **0,316 m**

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

$= \frac{0,316\times15}{4\times3,142}$

$=$ **0,377 m²**

$\mathbf{P_r} = Pd \,.\, A$

$= 16,882 \times 10^{-12} \times 0,377$

$=$ **$6,365 \times 10^{-12}$ watt** (3)
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TOTAL: 100

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