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NATIONAL CERTIFICATE

COMMUNICATION-ELECTRONICS N6

(8080246)

7 August 2019 (X-Paper)
09:00–12:00

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. Write neatly and legibly.

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QUESTION 1

1.1 Draw a neat, labelled graph of attenuation versus frequency, of each of the following:

1.1.1 A band-pass filter

1.1.2 A band-stop filter

(2 × 2) (4)

1.2 Study the graph in FIGURE 1. Additional information given for the graph is:

f_C = 5 kHz

f_∞ = 4,5 kHz

Z_O = 600 ohms

Use the given information and design and make a sketch of a completed m-derived Pi-section π filter. Indicate ALL the relevant values.

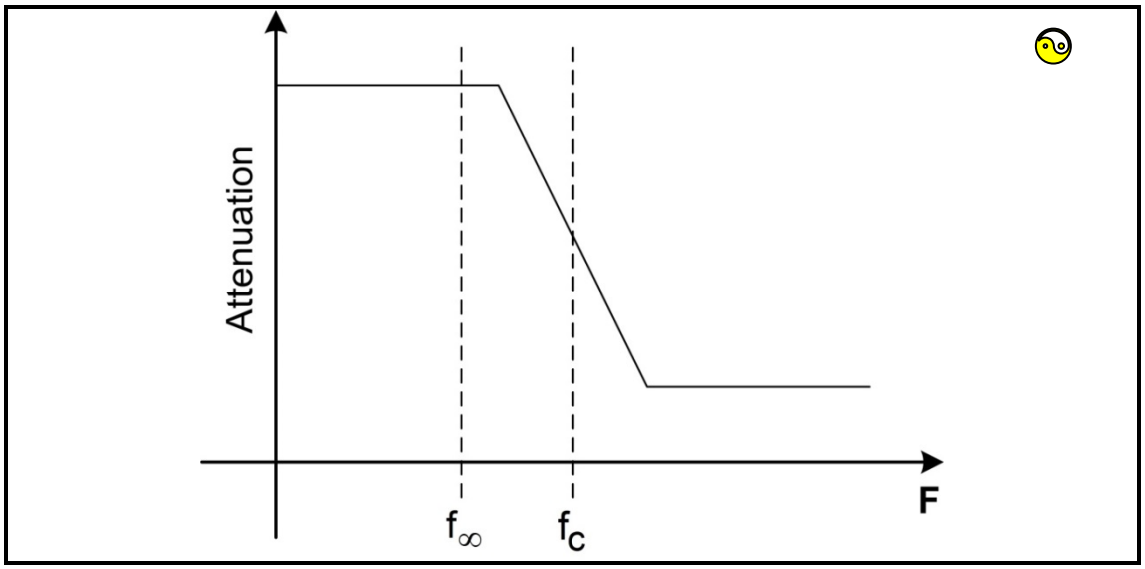


FIGURE 1 (7)

1.3 Study FIGURE 2 and select the correct word between brackets in each of the following statements. Write only the word next to the question number (1.3.1–1.3.2) in the ANSWER BOOK.

1.3.1 FIGURE 2 shows the (input/output) half section for a composite filter.

1.3.2 FIGURE 2 shows a graph of a (high/low)-pass filter.

(2 × 1) (2)

1.4 Determine the cut-off frequency for the filter in FIGURE 2.

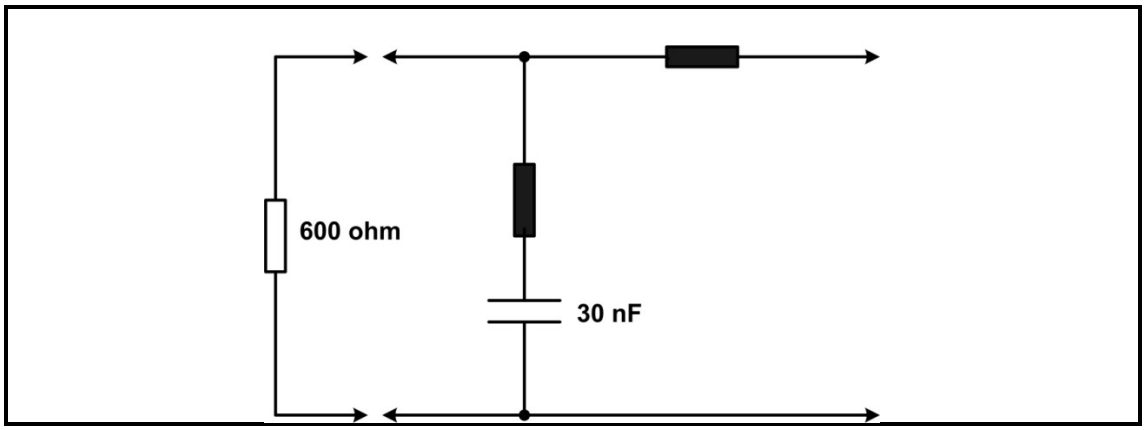


FIGURE 2 (4)

[17]

QUESTION 2

2.1 Is an attenuator frequency sensitive? Motivate your answer. (3)

2.2 Consider FIGURE 3, where 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 the relevant values.

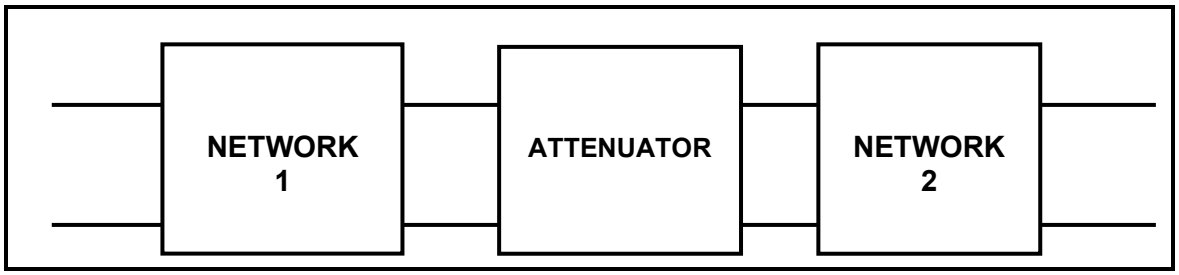


FIGURE 3 (7)

2.3 The following information for a Pi-type-π asymmetrical attenuator network is given:

Attenuation	= 10 dB
Output image impedance	= 300 ohms
Series resistor	= 4 kilohms

Use the available information to determine the input image impedance. (4)

2.4 Study FIGURE 4 with Z_B made variable between the values of 200 ohms and 400 ohms respectively.

Calculate the TWO limits of the attenuation.

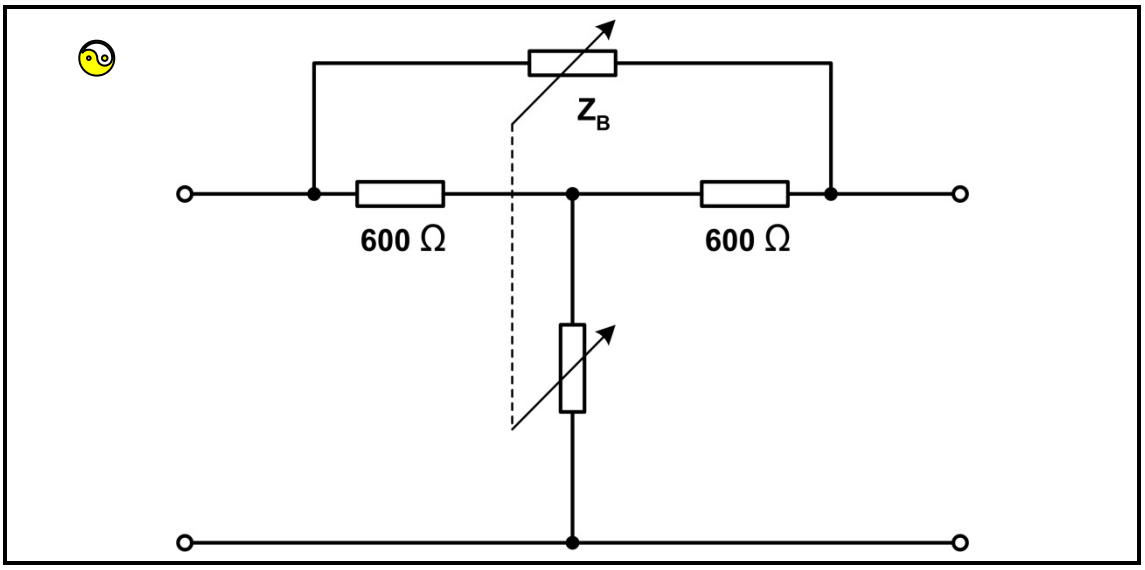


FIGURE 4 (4)
[18]

QUESTION 3

3.1 Draw a neat, labelled sketch of a two-hole directional coupler. (8)

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

3.2.1 A stub

3.2.2 A directional coupler

3.2.3 A balun

3.2.4 A slotted line

(4 × 1) (4)

3.3 Explain how the reactive component can be tuned out of a transmission line. Make use of a simple sketch to support your description. (4)

3.4 The following resistive loads are connected to a 600 ohm transmission line. Calculate the SWR in each instance.

3.4.1 750 ohms

3.4.2 900 ohms

(2 × 1) (2)
[18]

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

4.1.2 The channel capacity for double the bandwidth and halve the S/N ratio

(2 × 2) (4)

4.2 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)

4.3 What is the cause of the following?

4.3.1 Atmospheric noise (1)

4.3.2 Man-made noise (1)

4.3.3 Thermal noise (2)

4.4 An antenna having a resistance of 85 ohms is connected to an amplifier which measures a noise figure of 2,755 dB.

Calculate the following:

4.4.1 The equivalent noise resistance (4)

4.4.2 The equivalent noise temperature (Take the ambient temperature as 24°C.) (1)
[16]

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QUESTION 5

5.1 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)

5.2 Discuss sampling with reference to TDM. Make use of neat sketches to support the answer. (6)
[18]

QUESTION 6

6.1 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:

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

6.1.2 The gain of the antenna in dB (4)

6.2 Define the following with reference to antennae:

6.2.1 A receiver antenna

6.2.2 A transmitter antenna

6.2.3 Directive gain

(3 × 2) (6)

6.3 Define the term *angle modulation.* (2)
[13]

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*

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

$$Shunt\, C = m \,.\, C \qquad Series\ L = m \,.\, L$$

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

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

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

T-section *π-section*

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

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

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

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

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

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

3. Transmission lines

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

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

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

$L.G = C.R$

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

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

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

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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

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

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

$$P_r = P_d \times A \,.\, G_r \quad \textit{where}$$

$$dB = 10 \log G$$

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

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

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

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

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

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

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

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

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