higher education & training

Department:
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REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE

INDUSTRIAL ELECTRONICS N5

(8080175)

25 November 2024 (X-paper)
09:00–12:00

Drawing instruments and nonprogrammable calculators may be used.

This question paper consists of 5 pages and a formula sheet of 6 pages.

100Q1E2425

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DEPARTMENT OF HIGHER EDUCATION AND TRAINING
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE
INDUSTRIAL ELECTRONICS N5
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. Start each section on a new page.
5. Use only a black or blue pen.
6. Write neatly and legibly.

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QUESTION 1: ALTERNATING CURRENT THEORY

1.1 Complete the following sentences by filling in the missing word or words. Write only the word or words next to the question number (1.1.1–1.1.4) in the ANSWER BOOK.

An R-C coupling circuit is used to connect one circuit to another when it is desirable to remove or block the … (1.1.1) component while passing the … (1.1.2).

An R-L coupling circuit is used to connect one circuit to another when it is desirable to block the … (1.1.3) component while passing the … (1.1.4) components. (4)

1.2 A circuit consists of the following components:

$Z_1 = 120 - j\,21{,}21\ \Omega$
$Z_2 = 180 - j\,25{,}231\ \Omega$
$Z_3 = 100 + j\,47{,}31\ \Omega$

1.2.1 Calculate the total impedance if Z_1 and Z_2 are connected in series, and then the combination is connected in parallel with Z_3. (5)

1.2.2 Calculate the total impedance if Z_1 is connected across Z_2, and then the combination is connected in series with Z_3. (6)

[15]

QUESTION 2: POWER SUPPLIES

2.1 Calculate the percentage voltage regulation of a power source if the ripple factor and ripple voltage without a load are 3% and 0,5 V, while the full load voltage is 12,7 V. (4)

2.2.1 Draw a neat, labelled block diagram of a series voltage regulator, which provides for protection of the control element. (5)

2.2.2 State the purpose of the circuit. (2)

2.3 Describe the operation of a block diagram for a shunt voltage regulator. (4)

[15]

QUESTION 3: AMPLIFIERS

3.1 A fixed bias common emitter amplifier has the following values:

R_C = 2,4 kΩ; V_{CC} = 11 V; β = 200; V_{CE} = 480 Ω; V_{BE} = 0,6 Ω; F = 100 Hz

Calculate the value of the emitter resistor of the amplifier. (5)

3.2 The h-parameter circuit in QUESTION 3.1 are as follows:

h_{ie} = 12 kΩ; $h_{re} = 2\times10^{-4}$; h_{fe} = 100 and h_{oe} = 20 µA/V (Rs = 0)

Calculate the value of the input impedance (Z_{in}) with the aid of the approximate method. (4)

3.3 A non-inverter amplifier input signal is applied on the non-inverting input, which causes the input and output to be in phase.

3.3.1 Calculate the input voltage if the output voltage is 110 mV, input resistance is 1 kΩ and the feedback resistor is 10 kΩ. (3)

3.3.2 Show the circuit diagram of the non-inverter amplifier. (3)

[15]

QUESTION 4: INTEGRATED CIRCUIT AND TRANSDUCERS

4.1 Draw a neat, labelled circuit diagram of a 7812 voltage regulator. (6)

4.2 List and explain the TWO types of transducers. (4)

4.3 Draw a neat, labelled circuit diagram of an optic fibre and state TWO applications thereof. (5)

[15]

QUESTION 5: ELECTRONIC PHASE CONTROL

5.1 Briefly describe the operation principle of a phase trigger circuit. (4)

5.2 List THREE differences between a basic open loop system and closed loop system. (6)

[10]

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QUESTION 6: MEASURING INTRUMENTS

6.1 Illustrate, by using a 4-bit binary code, how a successive approximation A/D converter would measure an initial unknown voltage of 11 volts. (5)

6.2 Explain the functions of the following amplifiers in a voltage-to-frequency converter.

6.2.1 Comparator (2)

6.2.2 Integrator (3)

[10]

QUESTION 7: OSCILLATORS

7.1 Calculate the value of the resistor for UJT to operate if F = 15 kHz and C = 10 µF. (2)

7.2 Give a name for each pin of a 555-precision timer, in an ascending order (1-8). (8)

[10]

QUESTION 8: LIQUID CRYSTAL DISPLAY

8.1 There are various LCD panel types. Briefly describe the following terms.

8.1.1 Twisted nematic

8.1.2 In-plane switching

8.1.3 Vertical alignment

8.1.4 Advanced fringe field switching

(4 × 2) (8)

8.2 List TWO types of LCD displays. (2)

[10]

TOTAL: 100

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FORMULA SHEET

$$I = \frac{V}{R} \qquad P = IV = I^2R = \frac{V^2}{R}$$

$$V_T = V_1 + V_2 + V_3 + ... = I_1R_1 + I_2R_2 + I_3R_3 + ...$$

$$I_T = I_1 + I_2 + I_3 + ... = \frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3} + ...$$

$$T = RC \qquad T = \frac{L}{R}$$

$$V_R = RC\frac{dv}{dt} \qquad V_C = \frac{1}{RC}\int v_i dt$$

$$X_L = 2\pi fL \qquad X_C = \frac{1}{2\pi fC}$$

$$Z = R + jX_L \qquad Z = R - jX_C$$

$$Z = R + j(X_L - X_C) \qquad I_T = \frac{V_T}{Z_T}$$

$$V_R = I_T R \qquad V_L = I_T(jX_L)$$

$$V_C = I_T(-jX_C) \qquad f_r = \frac{1}{2\pi\sqrt{LC}}$$

$$Q = \frac{V_L}{V_T} = \frac{V_C}{V_T} = \frac{X_L}{R} = \frac{X_C}{R} = \frac{1}{R}\sqrt{\frac{L}{C}} = \frac{f_r}{f_2 - f_1}$$

$$BW = f_2 - f_1 \qquad \frac{1}{Z_T} = \frac{1}{Z_1} + \frac{1}{Z_2}$$

$$Z_T = \frac{Z_2Z_2}{Z_1 + Z_2} \qquad I_T = I_1 + I_2 = \frac{V}{Z_1} + \frac{V}{Z_2}$$

$$Z_T = \frac{R(jX_L)}{R + jX_L} \qquad \frac{1}{Z_T} = \frac{1}{R} - \frac{j}{X_L}$$

$$I_T = I_R - jI_L \qquad I_T = \frac{V}{R} - j\frac{V}{X_L}$$

$$Z_T = \frac{R(-jX_C)}{R - jX_C} \qquad \frac{1}{Z_T} = \frac{1}{R} + \frac{j}{X_C}$$

$$I_T = I_R + jI_C \qquad I_T = \frac{V}{R} + j\frac{V}{X_C}$$

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$$\frac{1}{Z_T} = \frac{1}{R} - j\left(\frac{1}{X_L} - \frac{1}{X_C}\right)$$

$$I_T = I_R - j(I_L - I_C) \qquad I_T = \frac{V}{R} - j\left(\frac{V}{X_L} - \frac{V}{X_C}\right)$$

$$a + jb = \sqrt{a^2 + b^2} \,/\, \underline{\tan^{-1}\frac{b}{a}} = r\,/\underline{\theta}$$

$$r/\underline{\theta} = r(\cos\theta + j\sin\theta) \qquad Q = \tan\theta$$

$$f = \frac{1}{2\pi}\sqrt{\frac{1}{LC} - \frac{R^2}{L^2}} \qquad Z_d = \frac{L}{CR_1}$$

$$V_{rms} = \frac{1}{\sqrt{2}}V_m = 0{,}707\,V_m \qquad V_{dc} = \frac{2}{\pi}V_m = 0{,}637\,V_m$$

$$\frac{V_P}{V_S} = \frac{N_P}{N_S} = \frac{I_S}{I_P} \qquad V_{dc} = \frac{1}{\pi}V_m = 0{,}318\,V_m$$

$$PIV = V_m \qquad PIV = 2\,V_m$$

$$R_{r(rms)} = 0{,}385\,V_m \qquad V_{r(rms)} = 0{,}305\,V_m$$

$$r = \frac{V_{r(rms)}}{V_{dc}} \qquad V_{r(rms)} = \frac{V_{r(p-p)}}{2\sqrt{3}}$$

$$V_{dc} = V_m - \frac{V_{r(p-p)}}{2}$$

$$V_{dc} = V_m - \frac{I_{dc}}{2\,fC} \qquad V_{dc} = V_m - \frac{I_{dc}}{4\,fC}$$

$$V_{r(rms)} = \frac{I_{dc}}{2\sqrt{3}\,fC} = \frac{V_{dc}}{2\sqrt{3}\,fCR_L} \qquad V_{r(rms)} = \frac{I_{dc}}{4\sqrt{3}\,fC} = \frac{V_{dc}}{4\sqrt{3}\,fCR_L}$$

$$r = \frac{I_{dc}}{2\sqrt{3}\,fCV_{dc}} = \frac{1}{2\sqrt{3}\,fCR_L} \qquad r = \frac{I_{dc}}{4\sqrt{3}\,fCV_{dc}} = \frac{1}{4\sqrt{3}\,fCR_L}$$

$$V'_{dc} = \frac{R_L}{R + R_L}\cdot V_{dc} \qquad V'_{r(rms)} = \frac{X_C}{\sqrt{R^2 + X_C^2}}\cdot V_{r(rms)}$$

$$X_C = \frac{1}{2\pi fC} \qquad X_C = \frac{1}{4\pi fC} \qquad r' = \frac{V'_{r(rms)}}{V'_{dc}}$$

$$V'_{r(rms)} = \frac{X_C}{R}\cdot V_{r(rms)} \qquad r' = rX_C\left(\frac{R + R_L}{R.R_L}\right)$$

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$$V'_{dc} = V_{dc} - I_{dc}R_1$$

$$V'_{dc} = \frac{R_L}{R_L + R_1} \cdot V_{dc}$$

$$V'_{r(rms)} = \frac{V_{r(rms)}}{(2\pi f)^2 LC}$$

$$V'_{r(rms)} = \frac{V_{r(rm)}}{(4\pi f)^2 LC}$$

$$VR = \frac{V_{NL} - V_{FL}}{V_{FL}}$$

$$\%VR = \frac{V_{NL} - V_{FL}}{V_{FL}} \times 100$$

$$2V_m = V_{c2} = V_m + V_{c1}$$

$$3V_m = V_{c1} + V_{c3} = V_m + 2V_m$$

$$S = \frac{\Delta V_o}{\Delta V_i}$$

$$V_R = V_i - V_z$$

$$R_{s(\min)} = \frac{V_{i(\max)} - V_z}{I_{z(\max)}}$$

$$I_z = \frac{P_z}{V_z}$$

$$R_{L(\min)} = \frac{V_Z}{V_{i(\max)} - V_Z} \cdot R_S$$

$$V_o = V_r - V_{be}$$

$$R_c = \frac{V_{cc} - V_{ce}}{I_c}$$

$$R_b = \frac{V_{cc} - V_{be}}{I_b}$$

$$\beta = \frac{I_c}{I_b}$$

$$C_e \geq \frac{10}{2\pi f R_e}$$

$$V_e = \frac{V_{cc}}{10}$$

$$R_e = \frac{V_e}{I_e} \simeq \frac{V_e}{I_c}$$

$$R_c = \frac{V_{cc} - V_{ce} - V_e}{I_c}$$

$$R_b = \frac{V_{cc} - V_{be} - V_e}{I_b}$$

$$R_{b1} = \frac{R_{b2}(V_{cc} - V_b)}{V_b}$$

$$R_{b2} = \frac{1}{10}\beta R_e$$

$$V_b = V_e + V_{be}$$

$$V_{be} = h_{ie} i_b + h_{re} V_{ce}$$

$$i_c = i_{fe} i_b + h_{oe} V_{ce}$$

$$A_i = \frac{h_{fe}}{1 + h_{oe} Z_L}$$

$$A_i = h_{fe}$$

$$A_i = \left(\frac{h_{fe}}{1 + h_{oe} Z_L}\right)\left(\frac{R_b T}{R_{bT} + Z_1}\right)\left(\frac{R_c}{R_c + R_L}\right)$$

$$A_v = \frac{-h_{fe} Z_L}{h_{ie} + (h_{ie} h_{oe} - h_{fe} h_{re}) Z_L}$$

$$A_v = \frac{-h_{fe} Z_L}{h_{ie}}$$

$$Z_1 = h_{ie} - \frac{h_{fe} h_{re} Z_L}{1 + h_{oe} Z_L}$$

$$Z_1 = h_{ie}$$

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$$Z_2 = \frac{1}{h_{oe} - \frac{h_{fe}h_{re}}{h_{ie} + R_s}} \qquad Z_2 = \frac{1}{h_{oe}}$$

$$A_p = \frac{A_i^2 R_L}{R_1} = -A_v A_i \qquad A_p = \frac{h_{fe}{}^2 R_L}{h_{ie}}$$

$$Z_0 = R_C // R_L // Z_2 = Z_L // Z_2$$

$$Z_0 = R_C // Z_2 = Z_L // Z_2 \qquad Z_1 = R_b // Z_1$$

$$Z_i = R_{b1} // R_{b2} // Z_1 \qquad I_1 = \frac{R_{bT} I_i}{R_{bT} = Z_1}$$

$$I_0 = h_{fe} I_b = h_{fe} \left(\frac{R_{b2}(I_i)}{R_{b2} + h_{ie}} \right) \qquad A_i = \frac{I_0}{I_1}$$

For common base, substitute all the 'e' subscripts with a 'b' in the h-parameters.

$$Z_L = R_c // R_L \qquad I_1 = \frac{R_e I_i}{R_e + Z_1}$$

$$CMRR = \frac{A_{dm}}{A_{cm}} \qquad CMRR\ (dB) = 20log \frac{A_{dm}}{A_{cm}}$$

$$I_e = \frac{V_e}{R_e} \qquad I_c = \frac{I_e}{2}$$

$$R_L = \frac{V_{R_L}}{I_C} \qquad g_m R_L = \frac{h_{fe}}{h_{ie}} . R_L$$

$$V_0 = -\left(\frac{R_f}{R_1} \right) . V_i \qquad V_0 = \left(\frac{R_f}{R_1} + 1 \right) . V_i$$

$$V_0 = -\left(\frac{R_f}{R_1} . V_1 + \frac{R_f}{R_2} . V_2 + \frac{R_f}{R_3} . V_3 \right) \qquad V_0 = -\left(\frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3} \right) R_f$$

$$V_0 = -(V_1 + V_2 + V_3) \qquad V_0 = -(I_1 + I_2 + I_3)\, R_f$$

$$V_0(t) = -\frac{1}{RC} \int V_i(t) \qquad V_0(t_b) = -\frac{1}{RC} \int_{t_a}^{t_b} V_i(t_b) + V_c(t_a)$$

$$t = \frac{1}{f} \qquad A_v = -\frac{R_s}{R_1}$$

$$R_2 = \frac{R_1 R_s}{R_1 + R_s} \qquad f_c = \frac{1}{2\pi R_s C}$$

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$$V_0(t) = -RC\frac{dV_i(t)}{dt}$$

$$A = \frac{R_f}{X_c}$$

$$A = -\frac{R_f}{R_s}$$

$$V_0(t) = -R_f C\frac{d}{dt}.v_i \sin \omega t$$

$$t = R_f C$$

$$V_0 = A(V_r - V_i)$$

$$V_0 = \frac{R_f}{R_s}(V_2 - V_1)$$

$$V_0 = V_2 - V_1$$

$$f_0 = \frac{1}{2\pi\sqrt{C_1 C_2 R_1 R_2}}$$

$$f_0 = \frac{1}{2\pi RC}$$

$$f_0 = \frac{1}{2\pi\sqrt{L_T C_1}}$$

$$L_T = L_1 + L_2 + 2M$$

$$f_0 = \frac{1}{2\pi\sqrt{LC_T}}$$

$$C_T = \frac{C_1 C_2}{C_1 + C_2}$$

$$f_0 = \frac{1}{2\pi\sqrt{LC_2}}$$

$$f = \frac{1}{2\pi RC\sqrt{6}}$$

$$f_0 = \frac{1,5}{RC}$$

$$f_0 = \frac{1}{t} = \frac{1}{t_1 + t_2}$$

$$t_1 = 0,7\ R_2 C_1$$

$$t_2 = 0,7\ R_1 C_2$$

$$f_0 = \frac{1}{1,4RC}$$

$$V_i = I_{c2}R_e + V_{be(ON)}$$

$$t = 1,1\ RC$$

$$f_0 = \frac{1,443}{(R_A + 2R_B)C}$$

$$t_{low} = 0,693(R_B)C$$

$$t_{high} = 0,693(R_A + R_B)C$$

$$t_T = t_{low} + t_{high}$$

$$K = \frac{\Delta R / R}{\Delta l / l}$$

$$\sigma = \Delta l / l$$

$$R = \rho\frac{1}{\pi d^2 / 4}$$

$$\sigma = \frac{S}{E}$$

$$Resolution = \frac{1}{amount\ of\ turns}$$

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$$Resolution = \frac{voltage\,drop\,across\,adjacent\,turns}{total\,voltage\,drop}$$

$R_t = Ae^{B/T}$ $T = 273 + °C$

$V_A = \frac{R_2}{R_1 + R_2} . V_T$ $V_B = \frac{R_t}{R_t + R_3} . V_T$

$V_{AB} = V_A - V_B$ $A_v = \frac{V_0}{V_i}$

$V_{Hall} = kIH$

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