higher education & training

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NOVEMBER EXAMINATION

NATIONAL CERTIFICATE

INDUSTRIAL ELECTRONICS N5

(8080175)

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DEPARTMENT OF HIGHER EDUCATION AND TRAINING
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE
INDUSTRIAL ELETRONICS 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. Keep questions and subsections of questions together.
5. ALL sketches and diagrams must be large, clear and neat.
6. Show ALL steps and calculations.
7. Write neatly and legibly.

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QUESTION 1: ALTERNATING CURRENT THEORY

1.1 In a serial RC circuit it takes 1 ms to charge up to 63,2% of the applied voltage V_T.

If R = 100 kΩ and V_T = 6 V, calculate:

1.1.1 Value of C

1.1.1 V_C after 1 ms

(2 × 2) (4)

1.2 Three components are connected in parallel across a 10 V, 50 Hz supply. The values of the components are as follows:

R = 5 Ω; L = 20 mH and C = 100 μf

Calculate:

1.2.1 Total impedance (4)

1.2.2 Total current flow (2)

1.2.3 Current through the three branches (6)

[16]

QUESTION 2: POWER SUPPLIES

2.1 Calculate the value of the load resistor R_L if the following values of a capacitor filter are known:

V_m = 15 V; f = 50 Hz after half-wave rectification; C = 470 μf and I_{dc} = 10 mA (6)

2.2 Calculate the percentage (%) voltage regulation of a power supply if the output voltage is 12,4 V without a load and 11,9 V with a load. (2)

2.3 Sketch a neat, labelled complete block diagram that shows the connection of the 7812-regulator in a power supply. (4)

2.4 What is meant by the term *stabilising factor* of a voltage? (1)

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2.5 Choose the correct word(s) from those given in brackets. Write only the word(s) next to the question number (2.5.1–2.5.2) in the ANSWER BOOK.

2.5.1 Over-current protection protects the (control element/network) against excess current.

2.5.2 The 7812-integrated voltage regulator is a (fixed/adjustable) voltage regulator.

(2 × 1) (2)
[15]

QUESTION 3: TRANSISTOR AMPLIFIERS

3.1 The following values of a common-emitter are known:

R_E = 400 Ω; C_E = 10 µf and $I_{c(max)}$ = 5 mA

Calculate:

3.1.1 Supply voltage (4)

3.1.2 Minimum input frequency for the amplifier (3)

3.2 In a common-emitter with a voltage divider bias, the following information is known:

h_{ie} = 1,2 kΩ; h_{re} = 2 × 10^{-4}; h_{fe} = 60; h_{oe} = 20 µA/V; R_{B1} = 56 kΩ; R_{B2} = 5,6 kΩ and R_C = 5 kΩ

Determine the following with the aid of the precision method:

3.2.1 A_i (according to the current divider rule) (7)

3.2.2 Z_i (3)
[17]

QUESTION 4: OPERATIONAL AMPLIFIERS

4.1 Draw a simplified circuit diagram of an operational amplifier. (4)

4.2 Briefly describe the THREE most important characteristics of operational amplifiers. (3)

4.3 Calculate the value of the equal input resistors that a summing amplifier should have for the following values:

Three input voltages of 1 V, 1,5 V and 3,5 V respectively, an output voltage of 12 V and a feedback resistor of 20 kΩ. (3)

[10]

QUESTION 5: INTEGRATED CIRCUITS

5.1 What should be done with the unused inputs of a CMOS-integrated circuit when it is connected to a circuit? (2)

5.2 Indicate whether the following statements are TRUE or FALSE. Choose the answer and write only 'true' or 'false' next to the question number (5.2.1–5.2.3) in the ANSWER BOOK.

5.2.1 CMOS-integrated circuits have higher noise immunity.

5.2.2 CMOS-integrated circuits are susceptible to static charges because of their low reactive input.

5.2.3 As soon as you work on the circuit of a CMOS-integrated circuit, the power supply to the circuit must be switched off.

(3 × 1) (3)

[5]

QUESTION 6: ELECTRONIC PHASE CONTROL

Draw a neat, labelled block diagram of a typical closed-loop system. **[5]**

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QUESTION 7: TEST EQUIPMENT

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

7.2 Show the output waveform of the D/A converter in the circuit of a staircase voltmeter. (2)
[7]

QUESTION 8: OSCILLATORS

8.1 8.1.1 Draw a neat, labelled circuit diagram of an RC-phase shift oscillator. (4)

8.1.2 Calculate the values of the resistors for the RC-phase shift oscillator if the oscillating frequency is 50 kHz and the capacitor values are 10 nF. (3)

8.2 8.2.1 Draw a neat, labelled circuit diagram of a Schmitt trigger. (4)

8.2.2 Name an application of the circuit in QUESTION 8.2.1. (1)
[12]

QUESTION 9: TRANSDUCERS

9.1 Transducers can be classified into TWO groups.

Name the groups and briefly describe the difference between them. (4)

9.2 Briefly describe the operating principle of an infrared detector. (4)

9.3 Draw the circuit diagram to show how a strain gauge must be connected in a wheatstone bridge, as well as the differential amplifier that observes the displacement equivalent signal. (5)
[13]

TOTAL: 100

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INDUSTRIAL ELECTRONICS N5

FORMULA SHEET

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$I_T = I_R - j(I_L - I_C)$$

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

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

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

$$Q = \tan\theta$$

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

$$Z_d = \frac{L}{CR_1}$$

$$V_{rms} = \frac{1}{\sqrt{2}} V_m = 0{,}707\, V_m$$

$$V_{dc} = \frac{2}{\pi} V_m = 0{,}637\, V_m$$

$$\frac{V_P}{V_S} = \frac{N_P}{N_S} = \frac{I_S}{I_P}$$

$$V_{dc} = \frac{1}{\pi} V_m = 0{,}318\, V_m$$

$$PIV = V_m$$

$$PIV = 2\, V_m$$

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

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

$$r = \frac{V_{r(rms)}}{V_{dc}}$$

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

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

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

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

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

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

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

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

$$V'_{dc} = \frac{R_L}{R + R_L} . V_{dc}$$

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

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

$$V'_{r(rms)} = \frac{X_C}{R} . V_{r(rms)}$$

$$r' = rX_C\left(\frac{R + R_L}{R.R_L}\right)$$

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

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

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

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

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

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

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

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

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

$V_R = V_i - V_z$

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

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

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

$V_o = V_r - V_{be}$

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

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

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

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

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

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

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

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

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

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

$V_b = V_e + V_{be}$

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

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

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

$A_i = h_{fe}$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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$t = \frac{1}{f}$

$A_v = -\frac{R_s}{R_1}$

$R_2 = \frac{R_1 R_s}{R_1 + R_s}$

$f_c = \frac{1}{2\pi R_s C}$

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

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

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

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

$t = R_f C$

$V_0 = A(V_r - V_i)$

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

$V_0 = V_2 - V_1$

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

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

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

$L_T = L_1 + L_2 + 2M$

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

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

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

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

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

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

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

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

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

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

$t = 1{,}1\ RC$

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

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

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

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

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

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

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

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

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

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

$$R_t = Ae^{B/T}$$

$$T = 273 + °C$$

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

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

$$V_{AB} = V_A - V_B$$

$$A_v = \frac{V_0}{V_i}$$

$$V_{Hall} = kIH$$

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