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Department:
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NATIONAL CERTIFICATE

INDUSTRIAL ELECTRONICS N5

(8080175)

12 November (X-Paper)
09:00 – 12:00

Calculators may be used.

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

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. ALL the calculations must be shown.
4. ALL sketches and diagrams must be labelled and neat.
5. Keep questions and sub-sections of questions together.
6. Number the answers correctly according to the numbering system used in this question paper.
7. Write neatly and legibly.

QUESTION 1: ALTERNATING CURRENT THEORY

1.1 A serial RC circuit 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 the following:

1.1.1 The value of C (2)

1.1.2 V_c after 1 ms (2)

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

$R = 5\ \Omega$; $L = 20$ mH and $C = 100\ \mu f$

Calculate the following:

1.2.1 The total impedance (6)

1.2.2 The total current flow (2)

1.2.3 The current through the three branches (6)
[18]

QUESTION 2: POWER SUPPLIES

2.1 An RC-π-filter delivers an output voltage of 12 V. If

$X_{C2} = 8\ \Omega$; $R = 10\ \Omega$; $R_L = 300\ \Omega$ and $V'_{r(rms)} = 0{,}8$ V, calculate the following:

2.1.1 V_{DC} across the first capacitor (2)

2.1.2 $V'_{r(rms)}$ across the first capacitor (2)

2.1.3 r' across the second capacitor (2)

2.2 Draw a neatly labelled circuit diagram that provides over-voltage protection in a power supply and briefly describe how the circuit operates. (6)
[12]

QUESTION 3: TRANSISTOR AMPLIFIERS

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

$I_{C(MAX)} = 10$ mA; $R_E = 120\ \Omega$; $\beta = 250$ and $V_B = 1{,}8$ V

Calculate the following:

3.1.1 V_{CC} (4)

3.1.2 R_{B2} (2)

3.1.3 R_{B1} (2)

3.2 Use the values of QUESTION 3.1 and determine the following values according to the precise method:

3.2.1 Z_1 (2)

3.2.2 Z_I (3)

3.2.3 A_i (4)

Given: R_C = 2 kΩ

h_{ie} = 1,2 kΩ

h_{re} = 2×10^{-4}

h_{fe} = 100

h_{oe} = 20 µA/v **[17]**

QUESTION 4: OPERATIONAL AMPLIFIERS

4.1 Explain the following terms as applied to the operational amplifiers:

4.1.1 Input-offset voltage (2)

4.1.2 Inverting input (2)

4.2 4.2.1 Draw the circuit diagram of an inverting operational amplifier. (3)

4.2.2 The input signal to an operational amplifier in the inverting mode is –2V and the input resistance is 20 kΩ. If the output voltage is 20 V, calculate the feedback resistor. (2)

4.3 Draw a neat, labelled circuit diagram of an operational band-reject filter. (7) **[16]**

QUESTION 5: TRANSDUCERS

Indicate whether the following statements are TRUE or FALSE. Choose the answer and write only 'true' or 'false' next to the question number (5.1 – 5.3) in the ANSWER BOOK.

5.1 CMOS-intergrated circuits have a higher noise immunity. (1)

5.2 CMOS-integrated circuits are susceptible to static charges because of their low reactive input. (1)

5.3 As soon as you work on the CMOS-integrated circuits, the power supply to the circuits must be switched off. (1) **[3]**

PTO

QUESTION 6: TRANSDUCERS

6.1 If a potentiometer has a resolution of 2%, what will the supply voltage be if the voltage drop across two adjacent turns is 10 mV? (3)

6.2 Explain, with the aid of a neat sketch and brief descriptions, how an optic fibre as a communication medium can transfer signals. (5)

6.3 State ONE application of optic fibre. (1)
[9]

QUESTION 7: ELECTRONIC PHASE CONTROL

Show, with the aid of a sketch, what is meant by a half-controlled bridge rectifier circuit. Indicate the output wave form. **[5]**

QUESTION 8: TEST EQUIPMENT

8.1 Briefly describe the principle of operation of a successive approximation A/D-converter. (6)

8.2 What is the function of the comparator in the staircase-A/D-voltmeter? (2)
[8]

QUESTION 9: OSCILLATORS

9.1 Design a switching circuit that will switch a lamp on for one minute when an infrared ray is interrupted. The circuit must include an infrared diode, an operational amplifier and a 555 precision timer. (10)

9.2 Calculate the value of the resistor in the timer if a capacitor value of 470 µf is used. (2)
[12]

TOTAL: 100

INDUSTRIAL ELECTRONICS N5

FORMULA SHEET

$$I = \frac{V}{R}$$

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

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

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

$$T = RC$$

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

$$V_R = RC\frac{dv}{dt}$$

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

$$X_L = 2\pi fL$$

$$X_C = \frac{1}{2\pi fC}$$

$$Z = R + jX_L$$

$$Z = R - jX_C$$

$$Z = R + j(X_L - X_C)$$

$$I_T = \frac{V_T}{Z_T}$$

$$V_R = I_T R$$

$$V_L = I_T(jX_L)$$

$$V_C = I_T(-jX_C)$$

$$f_r = \frac{1}{2\pi\sqrt{LC}}$$

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

$$BW = f_2 - f_1$$

$$\frac{1}{Z_T} = \frac{1}{Z_1} + \frac{1}{Z_2}$$

$$Z_T = \frac{Z_2Z_2}{Z_1 + Z_2}$$

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

$$Z_T = \frac{R(jX_L)}{R + jX_L}$$

$$\frac{1}{Z_T} = \frac{1}{R} - \frac{j}{X_L}$$

$$I_T = I_R - jI_L$$

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

$$Z_T = \frac{R(-jX_C)}{R - jX_C}$$

$$\frac{1}{Z_T} = \frac{1}{R} + \frac{j}{X_C}$$

$$I_T = I_R + jI_C$$

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

PTO

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

PTO

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

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

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

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

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

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

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

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

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

$V_R = V_i - V_z$

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

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

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

$V_o = V_r - V_{be}$

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

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

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

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

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

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

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

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

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

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

$V_b = V_e + V_{be}$

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

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

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

$A_i = h_{fe}$

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

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

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

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

$Z_1 = h_{ie}$

PTO

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

$$Z_2 = \frac{1}{h_{oe}}$$

$$A_p = \frac{A_i^2 R_L}{R_1} = -A_v A_i$$

$$A_p = \frac{h_{fe}{}^2 R_L}{h_{ie}}$$

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

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

$$Z_1 = R_b // Z_1$$

$$Z_i = R_{b1} // R_{b2} // Z_1$$

$$I_1 = \frac{R_{bT} I_i}{R_{bT} = Z_1}$$

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

$$A_i = \frac{I_0}{I_1}$$

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

$$Z_L = R_c // R_L$$

$$I_1 = \frac{R_e I_i}{R_e + Z_1}$$

$$CMRR = \frac{A_{dm}}{A_{cm}}$$

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

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

$$I_c = \frac{I_e}{2}$$

$$R_L = \frac{V_{R_L}}{I_C}$$

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

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

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

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

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

$$V_0 = -(V_1 + V_2 + V_3)$$

$$V_0 = -(I_1 + I_2 + I_3)\,R_f$$

$$V_0(t) = -\frac{1}{RC}\int V_i(t)$$

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

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

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

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

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

PTO

$V_0(t) = -RC\frac{dV_i(t)}{dt}$	$A = \frac{R_f}{X_c}$
$A = -\frac{R_f}{R_s}$	$V_0(t) = -R_f C\frac{d}{dt}.v_i \sin\omega t$
$t = R_f C$	$V_0 = A(V_r - V_i)$
$V_0 = \frac{R_f}{R_s}(V_2 - V_1)$	$V_0 = V_2 - V_1$
$f_0 = \frac{1}{2\pi\sqrt{C_1 C_2 R_1 R_2}}$	$f_0 = \frac{1}{2\pi RC}$
$f_0 = \frac{1}{2\pi\sqrt{L_T C_1}}$	$L_T = L_1 + L_2 + 2M$
$f_0 = \frac{1}{2\pi\sqrt{LC_T}}$	$C_T = \frac{C_1 C_2}{C_1 + C_2}$
$f_0 = \frac{1}{2\pi\sqrt{LC_2}}$	$f = \frac{1}{2\pi RC\sqrt{6}}$
$f_0 = \frac{1,5}{RC}$	$f_0 = \frac{1}{t} = \frac{1}{t_1 + t_2}$
$t_1 = 0,7\ R_2 C_1$	$t_2 = 0,7\ R_1 C_2$
$f_0 = \frac{1}{1,4RC}$	$V_i = I_{c2}R_e + V_{be(ON)}$
$t = 1,1\ RC$	$f_0 = \frac{1,443}{(R_A + 2R_B)C}$
$t_{low} = 0,693\ (R_B)C$	$t_{high} = 0,693\ (R_A + R_B)C$
$t_T = t_{low} + t_{high}$	$K = \frac{\Delta R / R}{\Delta l / l}$
$\sigma = \Delta l / l$	$R = \rho\frac{1}{\pi d^2 / 4}$
$\sigma = \frac{S}{E}$	$Resolution = \frac{1}{amount\ of\ turns}$

PTO

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

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

$$T = 273 + °C$$

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

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

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

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

$$V_{Hall} = kIH$$