higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

T790**(E)**(A4)T

NATIONAL CERTIFICATE

INDUSTRIAL ELECTRONICS N5

(8080175)

4 April 2018 (X-Paper)
09:00–12:00

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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. Sketches must be large, neat and fully labelled.
5. Write neatly and legibly.

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QUESTION 1: ALTERNATING CURRENT THEORY

1.1 Complete the following paragraph by writing down the missing word or words next to the question number (1.1.1–1.1.4) in the ANSWER BOOK.

The time constant of an RL circuit is the (1.1.1) ... the circuit takes to reach a value of 63,2% of the total (1.1.2) ... value. As soon as a (1.1.3) ... is sent through a faulty circuit the existence of an error as well as an indication of the type of (1.1.4) ... that exists will be indicated. (4 × 1) (4)

1.2 In a parallel LC-circuit X_L and X_C equal 18 849,56 Ω respectively at a frequency of 200 kHz. The circuit has a DC-resistance of 10 Ω and the supply voltage is $60\angle 0^\circ$ V .

Calculate each of the following:

1.2.1 Dynamic impedance (6)

1.2.2 Current through each branch (4)

[14]

QUESTION 2: POWER SUPPLIES

2.1 A power supply uses a half-wave rectifier and a simple capacitor filter. The following values of the circuit are known before rectification:

V_{DC} = 15 V; C = 100 µf; f = 50 Hz

Calculate each of the following:

2.1.1 R_L if the ripple factor is 3% (2)

2.1.2 V_M across a half-wave rectifier (6)

2.2 Calculate the voltage regulation of a power supply if the no-load voltage is 13,8 V and the full-load voltage is 12,2 V. (2)

2.3 Define the *stabilising factor* of a voltage. (1)

2.4 Draw a neat, labelled circuit diagram that provides overcurrent protection in a power supply. Briefly describe how the circuit operates. (6)

[17]

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QUESTION 3: TRANSISTOR AMPLIFIERS

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

$^{+}V_{CC}$ = 12 V; V_{CE} = 8 V; β = 250;

R_C = 2,6 kΩ; V_{BE} = 0,7 V; f = 100 Hz

Calculate each of the following:

3.1.1 R_E (6)

3.1.2 C_E (2)

3.1.3 R_B (4)

3.2 Calculate the input impedance Z_i and output impedance Z_o of the circuit in QUESTION 3.1 by means of the approximate method given the following:

h_{ie} = 1,8 kΩ; h_{oe} = 20 µA/V

$h_{re} = 2,5 \times 10^{-4}$; h_{fe} = 120 (5)

[17]

QUESTION 4: OPERATIONAL AMPLIFIERS

4.1 Draw a neat, labelled circuit diagram of a simplified operational amplifier. (5)

4.2 Explain each of the following terms as applied to operational amplifiers:

4.2.1 Input offset voltage

4.2.2 Inverting input

(2 × 2) (4)

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

- THREE input voltages of 1 V; 1,5 V and 3,5 V
- An output voltage of 20 V
- A feedback resistor of 20 kV (3)

[12]

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QUESTION 5: INTEGRATED CIRCUITS

Some integrated circuits use Zener diodes on the inputs to protect the circuits against overvoltages.

Draw a neat, labelled circuit diagram and include typical wave forms in order to illustrate the protection of CMOS-integrated circuits. **[4]**

QUESTION 6: ELECTRONIC PHASE CONTROL

Draw TWO separate circuit diagrams to show how TWO silicon-controlled rectifiers can be used to control voltage across the loads below. The load and control circuits can be shown in block diagrams. Indicate the wave forms that appear across the loads.

6.1 Full-wave DC load

6.2 Full-wave AC load

(2 × 4) **[8]**

QUESTION 7: TEST EQUIPMENT

Briefly describe the principle of operation of a staircase or slope A/D voltmeter. **[6]**

QUESTION 8: OSCILLATORS

8.1 State THREE factors that could influence the stability of an oscillator. (3)

8.2 Draw a neat, labelled circuit diagram of a bistable device used for pulse detecting. (4)

8.3 What is the value of a capacitor in a tuned circuit if the total inductance of the Hartley-tuned circuit is 20 mH and the oscillating frequency is 250 kHz? (3)

[10]

QUESTION 9: TRANSDUCERS

9.1 Name the TWO groups into which transducers can be classified and briefly describe the difference between them. (2 × 2) (4)

9.2 Briefly explain the operating principle of a resistive transducer. (2)

9.3 Draw a neat, labelled circuit diagram of a Schmitt-trigger which includes a phototransistor that switches a relay on and off. (6)

[12]

TOTAL: 100

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INDUSTRIAL ELECTRONICS N5

FORMULA SHEET

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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$I_T = I_R + jI_C$

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

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

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

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

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

$r\angle\theta = r(\cos\theta + j\sin\theta)$

$Q = \tan\theta$

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

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

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

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

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

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

$PIV = V_m$

$PIV = 2\,V_m$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$V_R = V_i - V_z$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$A_i = h_{fe}$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$t = R_f C$

$V_0 = A(V_r - V_i)$

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

$V_0 = V_2 - V_1$

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

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

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

$L_T = L_1 + L_2 + 2M$

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

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

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

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

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

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

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

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

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

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

$t = 1{,}1\, RC$

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

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

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

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

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

$\sigma = \Delta l / l$

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

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

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

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

$R_t = Ae^{B/T}$

$T = 273 + °C$

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

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

$V_{AB} = V_A - V_B$

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

$V_{Hall} = kIH$

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