higher education & training

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T790**(E)**(J30)T

NATIONAL CERTIFICATE

INDUSTRIAL ELECTRONICS N5

(8080175)

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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 Briefly state the advantage of a square waveform over a sine waveform as soon as they are sent through a faulty circuit when testing electronic circuits. (3)

1.2 Draw a graphical representation of the voltage and current, as opposed to frequency, of a series RLC circuit. (3)

1.3 A circuit consists of the following components:

Z_1: 120 – j21,21 Ω

Z_2: 180 + j25,31 Ω

Z_3: 100 + j47,31 Ω

Calculate the total impedance of the circuit if Z_1 and Z_2 are connected in parallel and the combination is connected in series with Z_3 to a 250 V/50 Hz supply. (8)

[14]

QUESTION 2: POWER SUPPLIES

2.1 An LC-π-filter has the following values:

V'_{DC} = 26,4 V
$V'_{R(RMS)}$ = 2,5 V
R_L = 1 kΩ
R_1 = 100 Ω
L = 0,2 H
C_2 = 100 µf
F = 50 Hz before full-wave rectification

Calculate:

2.1.1 V_{DC} across the first capacitor (3)

2.1.2 $V_{R(RMS)}$ across the first capacitor (3)

2.1.3 r across the first capacitor (2)

2.2 What is the main function of a voltage doubler? (2)

2.3 Briefly describe the operation of over-current protection. (3)

2.4 Draw a neat, labelled circuit diagram of a high, stable, adjustable power supply. The circuit must use a regulator component and an operational amplifier. (5)

[18]

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QUESTION 3: TRANSISTOR AMPLIFIERS

3.1 The following values of a common emitter are known:

R_E = 250 Ω
C_E = 20 µf
$I_{C\ (MAX)}$ = 20 mA

Calculate:

3.1.1 The supply voltage (4)

3.1.2 The minimum input frequency for the amplifier (3)

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

h_{ie} = 2,2 kΩ
h_{oe} = 20 µA/V
h_{re} = 2×10^{-4}
h_{fe} = 100
R_{B1} = 65 kΩ
R_{B2} = 6,5 kΩ
R_C = 10 kΩ

Determine with the aid of the precision method each of the following:

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

3.2.2 Z_i (2)

3.3 Define the term *distortion of a common-emitter amplifier*. (2)
[18]

QUESTION 4: OPERATIONAL AMPLIFIERS

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

4.2 Draw a neat, labelled circuit diagram which is used for impedance matching. (2)

4.3 Calculate the output voltage of a differentiator amplifier if all resistor values are 200 kΩ and the input voltages are 4 V and 5 V respectively. (3)

4.4 Draw the circuit diagram of an active low-pass filter with unity gain. (3)
[11]

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QUESTION 5: INTEGRATED CIRCUITS

5.1 Draw the integrated metal can pack outlay of a 741-operational amplifier and label the terminal assignments. (4)

5.2 What is the output voltage of a 7805-voltage regulator? (1)
[5]

QUESTION 6: ELECTRONIC PHASE CONTROL

Show, with the aid of a sketch of a waveform, the operation of a phase-triggering circuit used in single-phase controlled circuits. **[4]**

QUESTION 7: TEST EQUIPMENT

Illustrate, by using a 4-bit binary code, how a successive approximation A/D converter would measure an initial unknown of 14 volts. **[5]**

QUESTION 8: OSCILLATORS

8.1 Give TWO requirements an oscillator must fulfil to maintain its oscillations. (2)

8.2 Indicate the tuned (rank) circuit of the Hartley oscillator and Colpitts oscillator on TWO separate labelled sketches. Do NOT show the amplifier circuit. (4)

8.3 Draw a neat, labelled circuit diagram of a multivibrator which has ONE stable and ONE semistable condition. (4)

8.4 Calculate the oscillation frequency of a stable 555-timer with the following values:

R_A = 100 kΩ; R_B = 80 kΩ and C = 5µF (3)
[13]

QUESTION 9: TRANSDUCERS

9.1 A potentiometer has a resolution of 2%.

Calculate the supply voltage if the voltage drop across TWO adjacent turns is 10 mV. (3)

9.2 Draw a circuit diagram to show how strain gauges must be connected in a Wheatstone bridge, as well as the differential amplifier that observes the displacement equivalent signal. (5)

9.3 A thermistor has values of 12 kΩ at 10 °C and 2 kΩ at 30 °C.

Calculate the value of the constant B. (4)
[12]

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

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

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

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

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

$$Q = \tan\theta$$

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

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

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

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

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

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

$$PIV = V_m$$

$$PIV = 2\,V_m$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$V_R = V_i - V_z$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$A_i = h_{fe}$$

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

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

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

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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 a 'b' in the h-parameters.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$t = R_f C$$

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

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

$$V_0 = V_2 - V_1$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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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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