higher education & training

Department:
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REPUBLIC OF SOUTH AFRICA

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NATIONAL CERTIFICATE

INDUSTRIAL ELECTRONICS N5

(8080175)

22 July (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. Number the answers correctly according to the numbering system used in this question paper.
4. ALL the calculations MUST be shown.
5. ALL sketches and diagrams MUST be labelled and neat.
6. Keep questions and subsections of questions together.
7. Write neatly and legibly.

QUESTION 1: ALTERNATING CURRENT THEORY

1.1 Which factors determine the capacitance of a capacitor? (3)

1.2 Why is the differentiator called a high-pass filter? (2)

1.3 Refer to FIGURE 1 below and calculate the following:

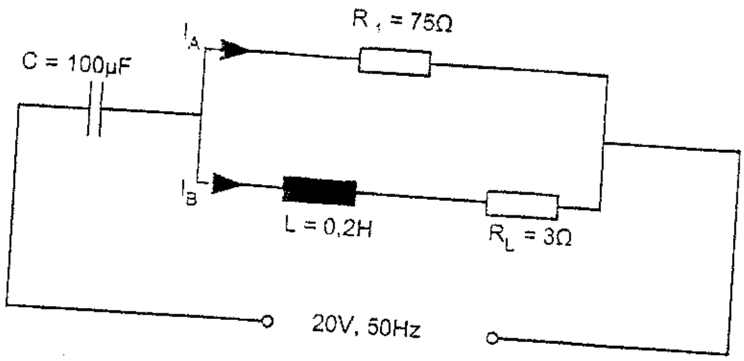

FIGURE 1

1.3.1 The total impedance Z_T (Write the answer in polar form.) (7)

1.3.2 The current value in each branch of the circuit (8)

[20]

QUESTION 2: POWER SUPPLIES

2.1 Calculate the value of a second capacitor in the RC-π-filter circuit, if the following values are known:

f = 50 Hz before full-wave rectification; $V'_{r(rms)}$ = 0,8 V;
$V_{r(rms)}$ = 1,8 V and R = 1,5 kΩ (6)

2.2 Draw a neat, labelled block diagram of a power source, which can supply both positive and negative voltages to operational amplifiers. (6)

2.3 Briefly define the term *voltage regulation.* (1)

[13]

QUESTION 3: TRANSISTOR AMPLIFIERS

3.1 The following values of a fixed voltage biased amplifier are known:

V_{CC} = 12 V; I_C = 5 mA; V_{Ce} = 6 V; V_{BE} = 0,6 V; β= 200

Calculate the following:

3.1.1 R_C (2)

3.1.2 R_B (4)

3.2 A fixed forward biased voltage amplifier has the following information:

h_{ie} = 1,2 kΩ	$h_{re} = 2 \times 10^{-4}$
h_{fe} = 60	h_{oe} = 20 μV/A
R_b = 220 kΩ	R_c = 2 kΩ

Calculate the following, according to the precision method:

3.2.1 The input impedance of the transistor (3)

3.2.2 The current gain of the amplifier (2)

3.2.3 The voltage gain of the amplifier (2)

3.3 Name any TWO types of distortions that can appear in common emitter amplifiers. (2)

[15]

QUESTION 4: OPERATIONAL AMPLIFIERS

4.1 Indicate whether the following statements are TRUE or FALSE. Choose the answer and write only 'true' or 'false' next to the question number (4.1.1 – 4.1.2) in the ANSWER BOOK.

4.1.1 An active filter needs a power supply (1)

4.1.2 An operational amplifier has a high open loop gain (1)

4.2 Draw a neat, labelled circuit diagram of a practical operational amplifier which is connected as a differentiator. (3)

4.3 Calculate the value of the capacitor in QUESTION 4.2 if R_F = 2 kΩ and the frequency (f) = 500 Hz. (4)

[9]

QUESTION 5: INTEGRATED CIRCUITS

5.1 What is the output voltage of a 7812-voltage regulator? (1)

5.2 Show, by means of a neat, labelled sketch, how the terminals of a 7812-voltage regulator should be connected. (3)
[4]

QUESTION 6: TRANSDUCERS

6.1 Make a freehand drawing of the Hall effect displacement transducer. (6)

6.2 Briefly explain the operating principle of a transmitter/receiver system that makes use of an infra-red diode and a photo-diode. (5)
[11]

QUESTION 7: ELECTRONIC PHASE CONTROL

Draw a neatly labelled block diagram of a general closed-loop system and briefly describe how the load condition is kept constant. **[9]**

QUESTION 8: TEST EQUIPMENT

Illustrate by making use of a 4-bit binary code, how a successive approximation A/D-converter would measure an initial unknown voltage of 13 volts. **[5]**

QUESTION 9: OSCILLATORS

9.1 Calculate the frequency of a uni-junction transistor-oscillator if:
R = 15 kΩ and C = 10 µf (2)

9.2 Design a neat, labelled A-stable multivibrator circuit that consists of two resistors, a 200 µf capacitor, a 555-timer, an NPN-transistor and a normally open relay. The relay must be switched on (t_{high}) for 30 seconds and off (t_{low}) for 15 seconds.

Calculate the values of the resistors and draw the circuit diagram. (12)
[14]

TOTAL: 100

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

PTO

INDUSTRIAL ELECTRONICS N5

FORMULA SHEET

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

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

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

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

$$T = RC$$

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

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

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

$$X_L = 2\pi fL$$

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

$$Z = R + jX_L$$

$$Z = R - jX_C$$

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

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

$$V_R = I_TR$$

$$V_L = I_T(jX_L)$$

$$V_C = I_T(-jX_C)$$

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

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

$$BW = f_2 - f_1$$

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

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

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

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

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

$$I_T = I_R - jI_L$$

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

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

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

$$I_T = I_R + jI_C$$

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

PTO

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

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

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

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

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

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

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

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

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

$$V_R = V_i - V_z$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$A_i = h_{fe}$$

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

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

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

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

$$Z_1 = h_{ie}$$

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

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

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

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

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

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

$$Z_1 = R_b \,//\, Z_1$$

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

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

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

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

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

$$Z_L = R_c \,//\, R_L$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$t = R_f C$$

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

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

$$V_0 = V_2 - V_1$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$t = 1,1\ RC$$

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

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

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

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

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

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

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

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

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

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

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

$$T = 273 + °C$$

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

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

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

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

$$V_{Hall} = kIH$$