higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

T730**(E)**(A7)T
APRIL EXAMINATION

NATIONAL CERTIFICATE

INDUSTRIAL ELECTRONICS N5

(8080175)

7 April 2016 (X-Paper)
09:00–12:00

This question paper consists of 5 pages and 1 formula sheet of 6 pages.

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

QUESTION: ALTERNATING-CURRENT THEORY

1.1 Draw the circuit diagram of a RC-coupling and show typical input- and output waveforms of the circuit. (4)

1.2 Low and high frequency disturbances can be observed from different levels of a square test waveform.

Show the levels involved by means of a neat sketch. (3)

1.3 In a parallel RL-circuit $R = 20\ \Omega$; $L = 0{,}01$ mH and $V_T = 20$ V, 100 kHz

Calculate:

1.3.1 Z_T (answer in polar form) (4)

1.3.2 I_T (answer in polar form) (2)

1.3.3 I_L (answer in polar form) (2)

1.3.4 I_R (answer in polar form) (2)
[17]

QUESTION 2: POWER SUPPLIES

2.1 A power supply makes use of a bridge rectifier and a simple capacitor filter.

The following values of the circuit are known:

$V_{DC} = 12$ V
$R_L = 100\ \Omega$
f = 50 Hz before rectification

Calculate:

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

2.1.2 V_m across the bridge rectifier (4)

2.2 A 500 mW, 10 V Zener diode is used in a voltage reference source.

If the maximum supply voltage is 16 V, calculate the value of the series resistor in order to protect the Zener diode. (4)

2.3 Draw a neat, labelled circuit diagram of a high, stable, adjustable power supply. The circuit must make use of a regulator component and an operational amplifier. (5)
[15]

QUESTION 3: TRANSISTOR AMPLIFIERS

3.1 State THREE factors which cause a variation in the collector current of a transistor because of a varying temperature. (3)

3.2 The following values of a common-emitter amplifier is known:

R_{B1} = 15,947 kΩ; R_{B2} = 3 kΩ; R_E = 120 Ω
R_C = 480 Ω; $^{+}V_{CC}$ = 12 V; V_{BE} = 0,7 V and β = 250

Calculate the values of V_e, I_c, I_B, V_{ce} and V_B of the amplifiers (assume the transistor is made from silicon type material). (10)

3.3 Calculate the input impedance Z_i and the output impedance Z_O of the circuit in QUESTION 3.2 by means of the appropriate method if:

h_{ie} = 1,2 kΩ; $h_{re} = 2 \times 10^{-4}$; h_{fe} = 100 and h_{oe} = 20 μA/V (Rs = 0) (5)

[18]

QUESTION 4: OPERATIONAL AMPLIFIERS

4.1 Explain the term *drift* as applicable to operational amplifiers. (2)

4.2 Draw a neat, labelled circuit diagram of an active high-pass filter with unity gain. (3)

4.3 Calculate the $-3d_B$ frequency of the filter in QUESTION 4.2 if both capacitors have values of 0,1 μf while both resistors have values of 1 kΩ. (3)

4.4 Draw a neat, labelled circuit diagram of a practical operational integrator. (3)

[11]

QUESTION 5: INTEGRATED CIRCUITS

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-integrated circuits have higher noise immunity.

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

5.3 When one works on a circuit with CMOS-integrated circuits on it, the power supply to the circuit must be switched off.

(3 x 1) **[3]**

QUESTION 6: TRANSDUCERS

6.1 Draw a neat, labelled circuit diagram of a thermistor control circuit that makes use of an operational amplifier and a DC-Wheatstone bridge. (4)

6.2 If the bridge in QUESTION 6.1 is balanced at 25 °C;

R_t = 10 kΩ at 25 °C
A = 0,2169;
β = 3200 and a 10 V battery is connected across the bridge, calculate:

6.2.1 The value of the thermistor at 30 °C. (2)

6.2.2 The gain of the amplifier with an output of 10 V. (7)
[13]

QUESTION 7: ELECTRONIC PHASE CONTROL

Draw a neat, labelled block diagram of a phase control circuit that makes use of two silicon controlled rectifiers for full-wave AC-control. Also show the trigger and load waveforms for a phase angle of 90°. **[6]**

QUESTION 8: TEST EQUIPMENT

Draw a neat, labelled block diagram of a frequency counter. **[5]**

QUESTION 9: OSCILLATORS

9.1 Draw a neat, labelled circuit diagram of an R-C-phase shift oscillator. (5)

9.2 Calculate the values of the resistors if the oscillating frequency is 50 kHz and the capacitor values are 10 nf. (3)

9.3 Draw a neat, labelled circuit diagram of a Schmidt-trigger. (4)
[12]

TOTAL: 100

INDUSTRIAL ELECTRONICS N5

FORMULA SHEET

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

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

$$V_T = V_1 + V_2 + V_3 + \ldots = I_1R_1 + I_2R_2 + I_3R_3 + \ldots$$

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

$$T = RC$$

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

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

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

$$X_L = 2\pi fL$$

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

$$Z = R + jX_L$$

$$Z = R - jX_C$$

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

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

$$V_R = I_TR$$

$$V_L = I_T(jX_L)$$

$$V_C = I_T(-jX_C)$$

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

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

$$BW = f_2 - f_1$$

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

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

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

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

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

$$I_T = I_R - jI_L$$

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

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

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

$$I_T = I_R + jI_C$$

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

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

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

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

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

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

$$Q = \tan\theta$$

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

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

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

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

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

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

$$PIV = V_m$$

$$PIV = 2\, V_m$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$V_R = V_i - V_z$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$A_i = h_{fe}$$

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

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

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

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

$$Z_1 = h_{ie}$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$t = R_f C$$

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

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

$$V_0 = V_2 - V_1$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$t = 1,1\ RC$$

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

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

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

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

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

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

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

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

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

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

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

$$T = 273 + °C$$

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

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

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

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

$$V_{Hall} = kIH$$