higher education
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Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE

INDUSTRIAL ELECTRONICS N5

(8080175)

21 November 2019 (X-Paper)
09:00–12:00

This question paper consists of 6 pages and a 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 according to the numbering system used in this question paper.
4. Sketches must be large, neat and fully labelled.
5. Write neatly and legibly.

QUESTION 1: ALTERNATING-CURRENT THEORY

1.1 What are coupling capacitors used for? (2)

1.2 Draw a graphical representation of every reactance, resistance and impedance of a series-RLC-circuit versus frequency. (4)

1.3 TWO circuits A and B are connected in parallel to a 200 V, 50 Hz supply. The current taken by the combination is 15 A. Circuit A consists of a 15 Ω resistor and a 200 μf capacitor connected in series. Circuit B consists of a resistor and an inductor in series.

Calculate the following data for circuit B:

1.3.1 The current through A and B (7)

1.3.2 The impedance across B (2)

1.3.3 The reactance and resistance across B (1)
[16]

QUESTION 2: POWER SUPPLIES

2.1 The following values of a RC-filter are known: X_{C2} = 26,526 Ω; R_L = 1,2 kΩ; R = 450 Ω; r' = 1,3% and $V'_{R(RMS)}$ = 0,118 V at C_2 f = 50 Hz. The supply is rectified by a half-wave rectifier.

Calculate:

2.1.1 V_{DC} across the first capacitor (4)

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

2.1.3 r across the first capacitor (2)

2.2 Briefly define the term *voltage regulation.* (2)

2.3 Draw a neat, labelled block diagram of a double power supply, which can supply both positive and negative voltages to operational amplifiers. (6)
[17]

QUESTION 3: TRANSISTOR AMPLIFIERS

3.1 3.1.1 Indicate, using TWO sketches, how the operating point on the load line of a common emitter amplifier can shift due to temperature changes. (4)

3.1.2 Briefly explain how the shifting of the operating point could be minimised. (3)

3.2 In a voltage divider biased amplifier the values of R_{B1} and R_{B2} are 74 kΩ and 7,4 kΩ respectively.

Calculate the values of thermal components R_E and C_E, if the minimum signal frequency is 50 Hz and β = 200. (4)

3.3 A fixed biased voltage amplifier has the following information:

h_{ie} = 1 kΩ	h_{oe} = 25 µA/V	h_{re} = $2{,}5 \times 10^{-4}$
h_{fe} = 50	R_B = 200 kΩ	R_C = 2,2 kΩ

Calculate according to the PRECISION method the following:

3.3.1 Input impedance of the transistor (3)

3.3.2 Voltage gain of the amplifier (2)
[16]

QUESTION 4: OPERATIONAL AMPLIFIERS

4.1 Name TWO common mode signals that may appear in differential amplifiers. (2)

4.2 Draw the pin outlay and functional diagram of a 741-operational amplifier in an 8-pin dual in-line package. (4)

4.3 Calculate the value of the feedback resistor in a practical differentiator for a 2 kHz signal for a chosen capacitor with a value of 2 µf. (3)

4.4 Draw a neat, labelled circuit diagram of an operational amplifier which is used for impedance matching. (2)
[11]

QUESTION 5: INTEGRATED CIRCUITS

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

5.2 What should be done with the unused input of a CMOS integrated circuit when it is connected to a circuit? (2)
[5]

QUESTION 6: ELECTRONIC PHASE CONTROL

6.1 Make a neat, labelled sketch of a trigger circuit of a silicon-controlled rectifier. (2)

6.2 Show, with the aid of a sketch of a waveform, the operation of a phase-triggering circuit that is used in a single-phase controlled circuit. (4)

[6]

QUESTION 7: TEST EQUIPMENT

Complete the following sentences by writing only the missing term next to the question number (7.1–7.6) in the ANSWER BOOK.

The code register is converted to a/an (7.1) … reference voltage V_r which is compared with the (7.2) ... voltage V_u. The (7.3) … then enables the logic programmer to program the register with a certain (7.4) … Initially the most significant bit is set to a 1, while the other bits are 0. The (7.5) … analogue voltage V_r of this code is (7.6) … with Vu. If V_r < Vu this 1 is kept in the code, but if V_r > Vu the 1 is reset to a 0. **[6]**

QUESTION 8: OSCILLATORS

8.1 A piezoelectric crystal may have two resonant frequencies.

Make neat, labelled sketches of these TWO conditions and give a brief explanation. (5)

8.2 Briefly explain the function of the Rozner modification. (2)

8.3 Draw a neat, labelled circuit diagram which can be used to view level discrimination. (4)

[11]

QUESTION 9: TRANSDUCERS

9.1 Calculate the resolutions of a wire-wound potentiometer with 350 turns. (2)

9.2 Choose a term from the following list to complete the sentences below. Write only the answer next to the question number (9.2.1–9.2.10) in the ANSWER BOOK.

greater; indorsed; phase; magnetic flux; size; secondary; displacement; indication; core; difference; oppose; proportional; external; induced

With the core in the centre, equal voltages will be (9.2.1) … in the secondary windings. Because they oppose each other, the output V_O will be 0V. As soon as an (9.2.2) … force moves the core to the left A, more (9.2.3) … develops in the left winding than the right winding (B). Therefore the (9.2.4) … voltage in winding A will be (9.2.5) … than that in winding B. Therefore the (9.2.6) … of the output voltage is equal to the (9.2.7) … between the two (9.2.8) … voltages of winding A. V_O is proportional to the amount of (9.2.9) … and the (9.2.10) … of V_O is an indication of the direction in which it moves. (10 × ½) (5)

9.3 Draw a neat, labelled circuit diagram of a photoelectric transducer that can be used for solar heat devices or satellite generators. (5)

[12]

TOTAL: 100

INDUSTRIAL ELECTRONICS N5

FORMULA SHEET

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

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

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

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

$T = RC$

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

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

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

$X_L = 2\pi fL$

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

$Z = R + jX_L$

$Z = R - jX_C$

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

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

$V_R = I_TR$

$V_L = I_T(jX_L)$

$V_C = I_T(-jX_C)$

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

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

$BW = f_2 - f_1$

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

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

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

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

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

$I_T = I_R - jI_L$

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

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

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

$I_T = I_R + jI_C$

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

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

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

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

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

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

$$Q = \tan\theta$$

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

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

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

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

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

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

$$PIV = V_m$$

$$PIV = 2\,V_m$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$X_C = \frac{1}{4\pi fC}$$

$$r' = \frac{V'_{r(rms)}}{V'_{dc}}$$

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

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

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

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

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

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

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

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

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

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

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

$$V_R = V_i - V_z$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$A_i = h_{fe}$$

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

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

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

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

$$Z_1 = h_{ie}$$

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

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

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

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

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

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

$$Z_1 = R_b // Z_1$$

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

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

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

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

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

$$Z_L = R_c // R_L$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$t = R_f C$$

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

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

$$V_0 = V_2 - V_1$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$t = 1,1\ RC$$

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

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

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

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

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

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

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

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

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

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

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

$$T = 273 + °C$$

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

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

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

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

$$V_{Hall} = kIH$$