



higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE INDUSTRIAL ELECTRONICS N5

(8080175)

**30 July 2021 (X-paper)
09:00–12:00**

Drawing instruments and nonprogrammable calculators may be used.

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

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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. Show all calculations.
 5. All sketches and diagrams must be large, clear and neat.
 6. Keep subsections of questions together.
 7. Write neatly and legibly.
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QUESTION 1: ALTERNATING CURRENT THEORY

1.1 Briefly define the term *selectivity*. (2)

1.2 A resistance of $20\ \Omega$ (R_1) is connected in parallel with an unknown resistance (R_2). The combination is connected in series with a third resistance (R_3) of $10\ \Omega$ that draws a current of 15 A. The whole circuit is connected across a 300 V battery.



Calculate the value and current of the unknown resistor. (8)

1.3 A $100\ \mu\text{F}$ capacitor is connected in parallel to a $0,01\ \text{H}$ coil with a DC resistance of $5\ \Omega$. The circuit has a supply of 200 V, 50 Hz.

Calculate the total impedance of the circuit. (5)
[15]

QUESTION 2: POWER SUPPLIES

2.1 The following values of an LC- π -filter circuit are known:
 $V_{\text{DC}} = 40\ \text{V}$ $V'_{\text{DC}} = 5\ \text{V}$ $r = 5\%$ $r' = 3\%$ $L = 0,5\ \text{H}$
 $f = 50\ \text{Hz}$ before full-wave rectification.



Calculate the value of a second capacitor in the LC- π -filter circuit. (6)

2.2 Briefly describe the operation of a shunt voltage regulator. (3)

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)
[14]

QUESTION 3: TRANSISTOR AMPLIFIERS

3.1 The following values of a common-emitter amplifier with silicon transistor are known:



$+V_{\text{CC}} = 20\ \text{V}$	$I_{\text{C}} = 15\ \text{mA}$	$R_{\text{b}} = 480\ \text{k}\Omega$
$R_{\text{e}} = 133,33\ \Omega$	$V_{\text{be}} = 0,7\ \text{V}$	$f = 50\ \text{Hz}$

Calculate the following:

3.1.1 The beta-gain (5)

3.1.2 Emitter capacitor (2)

- 3.2 The following information about a common-base amplifier that uses a PNP transistor is known:

$h_{fb} = -0,95$	$h_{ib} = 50 \Omega$	$R_c = 5 \text{ k}\Omega$	$h_{rb} = 200 \times 10^{-6}$
$h_{ob} = 0,4 \mu\text{A/V}$	$R_e = 1 \text{ k}\Omega$	$R_L = 20 \text{ k}\Omega$	$R_s = 0$

Calculate the following values with the aid of the precision method:

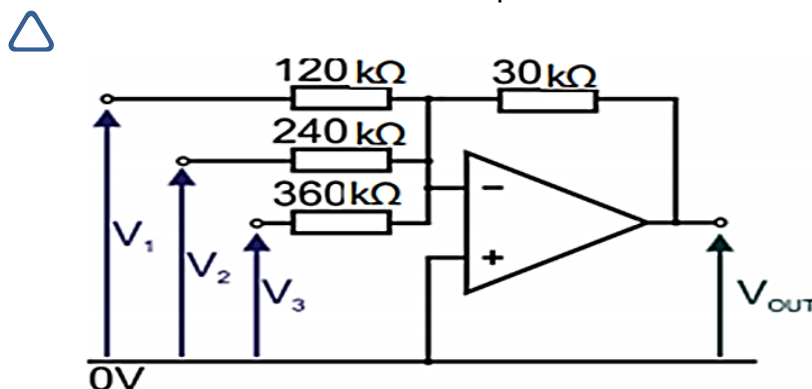
- 3.2.1 The voltage gain A_v (5)

- 3.2.2 The input impedance Z_i (4)

[16]

QUESTION 4: OPERATIONAL AMPLIFIERS

- 4.1 The FIGURE below shows the circuit diagram of a summing amplifier. The input voltages are: $V_1 = V_2 = V_3 = +6 \text{ V}$. The output is not saturated.



FIGURE

- 4.1 Calculate the output voltage of the summing amplifier in FIGURE 1. (3)
- 4.2 Draw a neat, labelled circuit diagram of a differential amplifier used to monitor the difference between two voltage levels. (3)
- 4.3 Name ONE application of a voltage adder. (1)
- 4.4 Draw the circuit diagram of an active high-pass filter with unity gain. (3)

[10]

QUESTION 5: INTEGRATED CIRCUITS

Name FIVE precautions to take when working with a CMOS integrated circuit so that it is not damaged by electrostatic discharge.

**[5]****QUESTION 6: TRANSDUCERS**

6.1 Explain the term *resolution of a potentiometer*. (2)

6.2 Draw a diagram to show how strain gauges must be connected in a Wheatstone bridge and in the differential amplifier that observes the displacement equivalent signal. (5)



6.3 Sketch a neat, labelled circuit diagram of a thermistor temperature control circuit that uses an alternating current excited bridge circuit. (5)

6.4 Determine the value of the thermistor be at 24 °C if the constants are:

$$A = 7 \times 10^{-12} \quad \text{and} \quad b = 8972$$

[14]**QUESTION 7: ELECTRONIC PHASE CONTROL**

Draw a neat, labelled block diagram of a general loop system that will keep the load condition constant and briefly describe its operation.

**[8]****QUESTION 8: TEST EQUIPMENT**

8.1 Briefly explain the function of the binary counter in a voltmeter. (4)

8.2 Explain why a Schmitt trigger is used in a frequency counter. (2)

[6]**QUESTION 9: OSCILLATORS**

9.1 Draw a neat, labelled circuit diagram of a Colpitts oscillator. (4)



9.2 Explain, with the aid of a neat circuit diagram and brief description, the operation of a monostable multivibrator. (8)

[12]**TOTAL: 100**

FORMULA SHEET

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

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

$$V_T = V_1 + V_2 + V_3 + \dots = I_1 R_1 + I_2 R_2 + I_3 R_3 + \dots$$

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

$$T = RC$$

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

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

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

$$X_L = 2\pi f L$$

$$X_C = \frac{1}{2\pi f C}$$

$$Z = R + jX_L$$

$$Z = R - jX_C$$

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

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

$$V_R = I_T R$$

$$V_L = I_T (jX_L)$$

$$V_C = I_T (-jX_C)$$

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

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

$$BW = f_2 - f_1$$

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

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

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

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

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

$$I_T = I_R - jI_L$$

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

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

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

$$I_T = I_R + jI_C$$

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

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

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

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

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

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

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

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

$$PIV = V_m$$

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

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

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

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

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

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

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

$$X_C = \frac{1}{2\pi fC} \quad X_C = \frac{1}{4\pi fC}$$

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

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

$$Q = \tan \theta$$

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

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

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

$$PIV = 2 V_m$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$V_R = V_i - V_z$$

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

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

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

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

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

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

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

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

$$A_i = h_{fe}$$

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

$$Z_1 = h_{ie}$$

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

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

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

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

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

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

$$Z_1 = R_b // Z_1$$

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

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

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

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

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

$$Z_L = R_c // R_L$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$t = R_f C$$

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

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

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

$$f_0 = \frac{1}{2\pi\sqrt{L C_T}}$$

$$f_0 = \frac{1}{2\pi\sqrt{L C_2}}$$

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

$$t_1 = 0,7 R_2 C_1$$

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

$$t = 1,1 RC$$

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

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

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

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

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

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

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

$$V_0 = V_2 - V_1$$

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

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

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

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

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

$$t_2 = 0,7 R_1 C_2$$

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

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

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

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

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

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

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

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

$$T = 273 + ^\circ\text{C}$$

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

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

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

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

$$V_{Hall} = kIH$$