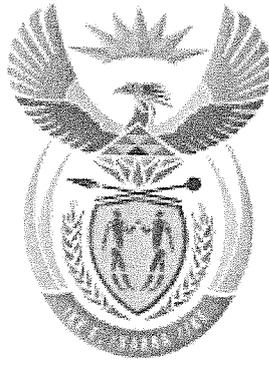


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# higher education & training

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Department:  
Higher Education and Training  
**REPUBLIC OF SOUTH AFRICA**

**T770(E)(A2)T  
APRIL EXAMINATION**

**NATIONAL CERTIFICATE**

**INDUSTRIAL ELECTRONICS N5**

**(8080175)**

**2 April 2013 (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**

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

- 1.1 Which factors determine the capacitance of a capacitor? (3)
- 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 Briefly indicate why square waves are suitable for testing certain electronic circuits. (2)
- 1.4 A circuit consists of the following components:

$$Z_1 = 120 - j 21,21 \Omega$$

$$Z_2 = 180 + j 25,31 \Omega$$

$$Z_3 = 100 + j 47,31 \Omega$$

If  $Z_1$  and  $Z_2$  are connected in parallel and this combination is connected in series with  $Z_3$  to a 250 V/50 Hz supply, calculate the following:

- 1.4.1 The total impedance of the circuit (7)
- 1.4.2 The total current flow through the circuit (2)
- [17]

**QUESTION 2: POWER SUPPLIES**

- 2.1 A RC- $\pi$ -filter delivers an output voltage of 12 V. If  $X_{C2} = 8 \Omega$ ;  $R = 10 \Omega$ ;  $R_L = 300 \Omega$  and  $V_{R(RMS)} = 0,8$  V, calculate the following:
- 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 second capacitor (2)
- 2.2 Draw a neatly labelled circuit diagram that provides overvoltage protection in a power supply and briefly describe how the circuit operates. (6)
- [14]

**QUESTION 3 TRANSISTOR AMPLIFIERS**

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

$$V_{CC} = 12 \text{ V}; I_C = 5 \text{ mA}; V_{C_e} = 6 \text{ V}; V_{BE} = 0,6 \text{ V}; \beta = 200$$

Calculate the following:

3.1.1  $R_C$  (2)

3.1.2  $R_B$  (3)

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

$$h_{ie} = 1,2 \text{ k}\Omega$$

$$h_{re} = 2 \times 10^{-4}$$

$$h_{fe} = 60$$

$$h_{oe} = 20 \text{ }\mu\text{V/A}$$

$$R_b = 220 \text{ k}\Omega$$

$$R_c = 2 \text{ k}\Omega$$

Calculate, according to the precision method, the following:

3.2.1 Input impedance of the transistor (3)

3.2.2 Current gain of the amplifier (2)

3.2.3 Voltage gain of the amplifier (2)

3.3 Name any THREE types of distortions that can appear in common emitter amplifiers.

(3)  
[15]

**QUESTION 4: OPERATIONAL AMPLIFIERS**

4.1 Explain the following terms as applied to the operational amplifiers:

4.1.1 Input offset voltage (2)

4.1.2 Inverting input (2)

4.2 4.2.1 Draw the circuit diagram of an inverting operational amplifier. (3)

4.2.2 The input signal to a operational amplifier in the inverting mode is  $-2\text{V}$  and the input resistance is  $20 \text{ k}\Omega$ . If the output voltage is  $20 \text{ V}$ , calculate the feedback resistor. (3)

- 4.3 Draw a neat, labelled circuit diagram of an operational band-reject filter. (4)  
[14]

### QUESTION 5: INTEGRATED CIRCUITS

- Name THREE methods of handling CMOS-integrated circuits. [3]

### QUESTION 6: TRANSDUCERS

- 6.1 Transducers can be classified into TWO groups.  
Name them and briefly describe the difference between them. (4)
- 6.2 Briefly describe the operating principle of an infrared detector. (4)
- 6.3 Draw the 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)  
[13]

### QUESTION 7: ELECTRONIC PHASE CONTROL

- Draw a neat, labelled circuit diagram of a light dimmer which makes use of a triac. [6]

### QUESTION 8: TEST EQUIPMENT

- Draw a neat, labelled block diagram of a successive approximation A/D voltmeter. [5]

### QUESTION 9: OSCILLATORS

- 9.1 Name THREE factors that may destabilise the frequency of an oscillator. (3)
- 9.2 Draw a neat, labelled circuit diagram of a unijunction transistor oscillator. (4)
- 9.3 Name THREE common types of waveform, as well as an application of each. (6)  
[13]

**TOTAL: 100**

## INDUSTRIAL ELECTRONICS N5

## FORMULA SHEET

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

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

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

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

$$T = RC$$

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

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

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

$$X_L = 2\pi fL$$

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

$$Z = R + jX_L$$

$$Z = R - jX_C$$

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

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

$$V_R = I_T R$$

$$V_L = I_T (jX_L)$$

$$V_C = I_T (-jX_C)$$

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

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

$$BW = f_2 - f_1$$

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

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

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

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

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

$$I_T = I_R - jI_L$$

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

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

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

$$I_T = I_R + jI_C$$

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

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

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

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

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

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

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

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

$$PIV = V_m$$

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

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

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

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

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

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

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

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

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

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

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

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

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

$$Q = \tan \theta$$

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

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

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

$$PIV = 2 V_m$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$V_R = V_i - V_z$$

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

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

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

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

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

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

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

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

$$A_i = h_{fe}$$

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

$$Z_1 = h_{ie}$$

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

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

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

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

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

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

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

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

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

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

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

$$Z_L = R_c // R_L$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$t = R_f C$$

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

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

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

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

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

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

$$t_1 = 0,7 R_2 C_1$$

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

$$t = 1,1 RC$$

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

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

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

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

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

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

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

$$V_0 = V_2 - V_1$$

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

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

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

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

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

$$t_2 = 0,7 R_1 C_2$$

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

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

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

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

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

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

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

$$R_t = Ae^{BIT}$$

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

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

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

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

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

$$V_{\text{Hall}} = kIH$$