higher education
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Department:
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REPUBLIC OF SOUTH AFRICA

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NATIONAL CERTIFICATE

INDUSTRIAL ELECTRONICS N5

(8080175)

3 April 2019 (X-Paper)
09:00–12:00

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

DEPARTMENT OF HIGHER EDUCATION AND TRAINING
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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 Draw a circuit diagram of an RC circuit that can isolate DC signal from AC signal and which is similar to a high-pass filter. Show the typical input and output waveforms of this circuit (4)

1.2 Briefly state the advantage of a square waveform over a sine waveform as soon as it is sent through a faulty circuit when testing electronic circuits. (2)

1.3 A circuit consists of the following components:

$Z_1 = 150 + j399\ \Omega$
$Z_2 = 250 - j159\ \Omega$
$Z_3 = 100 + j257\ \Omega$

Calculate the voltage drop across the parallel circuit if Z_1 and Z_2 are connected in parallel and this combination is connected in series with Z_3 to a 250/50 Hz supply. (9)

[15]

QUESTION 2: POWER SUPPLIES

2.1 The output voltage across the first capacitor of a LC-π-filter half-wave rectifier is 150 V DC with a 10 V ripple at a frequency of 110 Hz.

Calculate the output ripple factor of the filter if L = 2 H, R = 250 Ω and C_2 = 6 µf. The filter is connected to a 5 kΩ load. (7)

2.2 Draw a neat, labelled block diagram of a serial voltage regulator and describe the function of each block. (10)

[17]

QUESTION 3: TRANSISTOR AMPLIFIERS

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

R_C = 1,2 kΩ
V_{CE} = 5 V
I_B = 26 µA
β = 300
R_B = 525,385 kΩ

Calculate:

3.1.1 The supply voltage (5)

3.1.2 The base emitter voltage (V_{BE}) (3)

3.2 Use the values of QUESTION 3.1 and determine the following according to the precise method:

3.2.1 The current gain A_i (without current divider rule) (4)

3.2.2 The voltage gain A_V (3)

Given: h_{ie} = 1,7 kΩ; h_{oe} = 6 µA/V; R_L = 6 kΩ

h_{re} = $1{,}3 \times 10^{-4}$; h_{fe} = 38

3.3 Define the term *distortion* regarding a common emitter amplifier. (2)
[17]

QUESTION 4: OPERATIONAL AMPLIFIERS

4.1 Briefly describe the THREE most important properties of operational amplifiers. (3)

4.2 Draw a neat, labelled circuit diagram to indicate how null-balance adjustment of a 741-operational amplifier can be done with a potentiometer. (3)

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

4.4 Calculate the value of the capacitor of a high pass filter if R = 10 kΩ and f_O = 150 kHz. (2)
[11]

QUESTION 5: INTEGRATED CIRCUITS

Complete the following paragraph by writing the missing word or words next to the question number (5.1–5.5) in the ANSWER BOOK.

Some (5.1) … use diodes on the inputs to protect the circuits. The (5.2) … are connected in a (5.3) … configuration between the input (gate) and the positive supply. In other cases two (5.4) … are connected. Voltage pulses which exceed ± (5.5) … are chopped. (5 × 1) **[5]**

QUESTION 6: ELECTRONIC PHASE CONTROL

Draw a neat, labelled block diagram of a manually controlled open-loop system with no feedback. **[5]**

QUESTION 7: TEST EQUIPMENT

Illustrate, by using a 4-bit binary code, how a successive approximation A/D converter would measure an initial unknown voltage of 10 volts. **[5]**

QUESTION 8: OSCILLATORS

8.1 Draw a neat, labelled circuit diagram of a multivibrator which has TWO stable conditions. (4)

8.2 Calculate the value of the capacitor for a unijunction transistor to operate if $R = 15\ k\Omega$ and $f = 10\ Hz$. (2)

8.3 Indicate whether the following statements are TRUE or FALSE. Choose the answer and write only 'True' or 'False' next to the question number (8.3.1–8.3.6) in the ANSWER BOOK.

8.3.1 Pin 2 is the reset input for the flip-flop.

8.3.2 Pin 4 discharges the external capacitor.

8.3.3 Pin 7 conveys a trigger pulse to the bottom comparator.

8.3.4 Pin 3 produces the output pulse to other circuits.

8.3.5 Pin 5 is the control voltage input or frequency modulator input.

8.3.6 Pin 8 is the positive voltage supply pin which is connected to a power source.

(6 × 1) (6)
[12]

QUESTION 9: TRANSDUCERS

9.1 Briefly define the term *resolution* regarding a potentiometer. (2)

9.2 Briefly describe the operating principle of a closed-loop system that uses TWO potentiometers to control a cannon. (5)

9.3 Briefly explain the operating principle of a resistive transducer. (2)

9.4 Draw a neat, labelled circuit diagram of a thermistor-controlled system which is used to control the temperature of an oven. The circuit must use an AC amplifier and the relay amongst other things. (4)
[13]

TOTAL: 100

FORMULA SHEET

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

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

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

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

$$T = RC$$

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

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

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

$$X_L = 2\pi f L$$

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

$$Z = R + jX_L$$

$$Z = R - jX_C$$

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

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

$$V_R = I_T R$$

$$V_L = I_T (jX_L)$$

$$V_C = I_T(-jX_C)$$

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

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

$$BW = f_2 - f_1$$

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

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

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

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

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

$$I_T = I_R - jI_L$$

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

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

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

$$I_T = I_R + jI_C$$

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

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

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

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

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

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

$$Q = \tan\theta$$

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

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

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

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

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

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

$$PIV = V_m$$

$$PIV = 2\,V_m$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$V_R = V_i - V_z$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$A_i = h_{fe}$$

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

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

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

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

$$Z_1 = h_{ie}$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$t = R_f C$$

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

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

$$V_0 = V_2 - V_1$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$t = 1,1\ RC$$

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

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

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

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

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

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

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

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

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

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

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

$$T = 273 + °C$$

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

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

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

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

$$V_{Hall} = kIH$$