higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

T710(E)(N21)T

NOVEMBER EXAMINATION

NATIONAL CERTIFICATE

INDUSTRIAL ELECTRONICS N5

(8080175)

21 November 2014 (Y-Paper)
13:00–16:00

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

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QUESTION 1: ALTERNATING-CURRENT THEORY

1.1 Which factors determine the charging rate of a capacitor?

1.2 Draw a neat, labelled *gain versus frequency response curve* of each of the following: (2)

1.2.1 A simple differentiator

1.2.2 A simple integrator

(2 x 2) (4)

1.3 In a parallel LC-circuit both of the reactances X_L and X_C equal 31,62 Ω at a frequency of 503,29 Hz.

If the coil has a DC-resistance of 5 Ω and the supply voltage is 40 V, calculate the following:

1.3.1 The dynamic impedance (6)

1.3.2 The current through each branch (4)

[16]

QUESTION 2: POWER SUPPLIES

2.1 A power supply uses a bridge rectifier and a simple capacitor filter.

The following values of the circuit are known:

V_{DC} = 12V; R_L = 100 Ω and f = 50 Hz before rectification

Calculate the following:

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

2.1.2 V_m across the bridge rectifier (4)

2.2 A Zener diode reference source is supplied by a 15 V ±1 V DC supply.

If a minimum load current of 100 mA must be delivered to a 120 Ω load, calculate the minimum value for the series resistor. (5)

2.3 Draw a neat, labelled circuit diagram of an overvoltage protection circuit. (3)

2.4 Describe how the protection circuit in QUESTION 2.3 will protect the load of the circuit. (3)

[17]

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QUESTION 3: TRANSISTOR AMPLIFIERS

3.1 The following values of a fixed biased amplifier is known:

$V_{CC} = 12$ V $\quad V_{ce} = 6$ V $\quad \beta = 200$ $\quad f_{in(min)} = 50$ Hz
$I_C = 10$ mA $\quad V_{BE} = 0{,}6$ V $\quad h_{ie} = 1{,}3$ kΩ $\quad h_{oe} = 20$ µA/V
$h_{re} = 2 \times 10^{-4}$ $\quad h_{fe} = 60$

Calculate the following:

3.1.1 R_C (2)

3.1.2 R_B (3)

3.1.3 Z_i (according to the precise method) (2)

3.1.4 A_i the current divider rule may be used (according to the precise method) (3)

3.1.5 A_V (according to the precise method) (3)

3.2 Describe, with the aid of sketches, the following distortions:

3.2.1 Non-linear

3.2.2 Amplitude

3.2.3 Frequency

(3 x 2) (6)
[19]

QUESTION 4: OPERATIONAL AMPLIFIERS

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

4.2 Draw the 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 the circuit diagram of a practical operational integrator. (3)
[11]

QUESTION 5: INTEGRATED CIRCUITS

Name THREE methods (not storage methods) for the handling of CMOS integrated circuits.
[3]

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QUESTION 6: TRANSDUCERS

6.1 Calculate the percentage resolution of a potentiometer that has 1000 turns. (2)

6.2 Draw a neat, labelled block diagram of a closed-loop system that uses a self-balancing potentiometer in order to control a cannon. (6)

6.3 Draw a neat, labelled circuit diagram of a transmitter/receiver system that uses an infrared diode and a photodiode. (6)
[14]

QUESTION 7: ELECTRONIC PHASE CONTROL

Make a neat, labelled sketch of a trigger circuit for a silicon-controlled rectifier. **[3]**

QUESTION 8: TEST EQUIPMENT

Illustrate, by making use of a 4-bit binary code how a successive approximation A/D-converter would measure an initial unknown voltage of 13 volts. **[5]**

QUESTION 9: OSCILLATORS

9.1 Calculate the frequency of the Collpitts-oscillator if:

C_1 = 10 nf; C_2 = 20 nf and L = 100 µH (4)

9.2 Choose the correct word from those given in brackets. Write only the word next to the question number (9.2.1–9.2.2) in the ANSWER BOOK.

9.2.1 A bistable multivibrator has (one/two) stable condition(s).

9.2.2 The 555-timer delivers a (square/sine) waveform on the output.

(2 × 1) (2)

9.3 Why is Rozner-modification used in some cases? Draw a circuit diagram that shows Rozner-modification and explain its operation. (6)
[12]

TOTAL: 100

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FORMULA SHEET

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

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

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

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

$$T = RC$$

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

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

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

$$X_L = 2\pi fL$$

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

$$Z = R + jX_L$$

$$Z = R - jX_C$$

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

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

$$V_R = I_TR$$

$$V_L = I_T(jX_L)$$

$$V_C = I_T(-jX_C)$$

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

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

$$BW = f_2 - f_1$$

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

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

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

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

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

$$I_T = I_R - jI_L$$

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

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

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

$$I_T = I_R + jI_C$$

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

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

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

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

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

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

$$Q = \tan\theta$$

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

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

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

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

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

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

$$PIV = V_m$$

$$PIV = 2\, V_m$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$V_R = V_i - V_z$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$A_i = h_{fe}$$

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

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

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

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

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

$$A_p = \frac{A_i^2 R_L}{R_1} = -A_v A_i \qquad A_p = \frac{h_{fe}{}^2 R_L}{h_{ie}}$$

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

$$Z_0 = R_C // Z_2 = Z_L // Z_2 \qquad Z_1 = R_b // Z_1$$

$$Z_i = R_{b1} // R_{b2} // Z_1 \qquad I_1 = \frac{R_{bT} I_i}{R_{bT} = Z_1}$$

$$I_0 = h_{fe} I_b = h_{fe} \left(\frac{R_{b2}(I_i)}{R_{b2} + h_{ie}} \right) \qquad A_i = \frac{I_0}{I_1}$$

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

$$Z_L = R_c // R_L \qquad I_1 = \frac{R_e I_i}{R_e + Z_1}$$

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

$$I_e = \frac{V_e}{R_e} \qquad I_c = \frac{I_e}{2}$$

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

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

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

$$V_0 = -(V_1 + V_2 + V_3) \qquad V_0 = -(I_1 + I_2 + I_3)\, R_f$$

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

$$t = \frac{1}{f} \qquad A_v = -\frac{R_s}{R_1}$$

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

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

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

$$t = R_f C$$

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

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

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

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

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

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

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

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

$$t = 1,1\ RC$$

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

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

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

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

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

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

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

$$V_0 = V_2 - V_1$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$T = 273 + °C$$

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

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

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

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

$$V_{Hall} = kIH$$

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