higher education & training

Department:
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REPUBLIC OF SOUTH AFRICA

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AUGUST EXAMINATION

NATIONAL CERTIFICATE

INDUSTRIAL ELECTRONICS N5

(8080175)

31 July 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. 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 Why is the differentiator called a high-pass filter? (2)

1.3

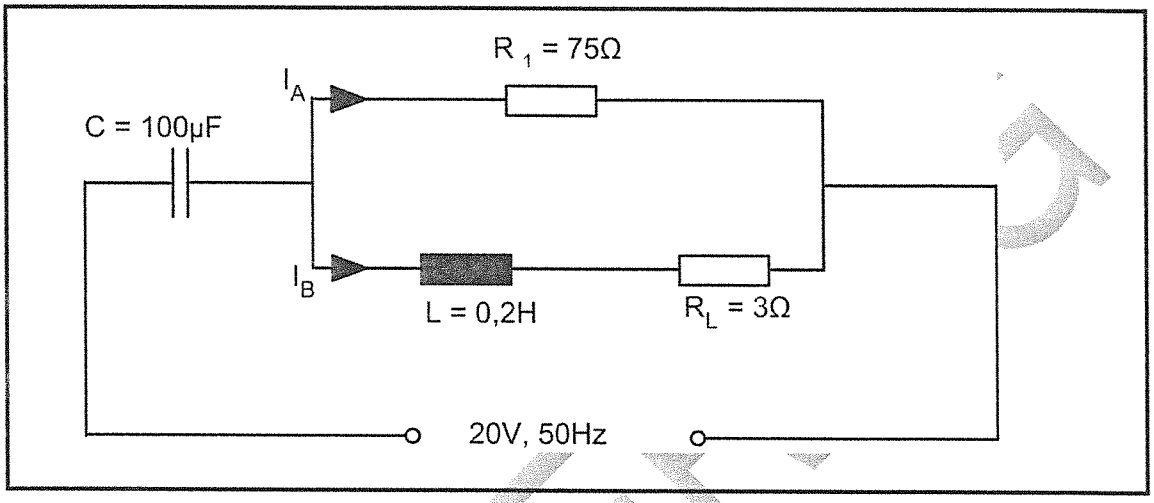


FIGURE 1

Refer to FIGURE 1 and calculate the following:

1.3.1 The total impedance ZT (write the answer in polar form) (7)

1.3.2 The current value in each branch of the circuit (6)

[18]

QUESTION 2: POWER SUPPLIES

2.1 An LC-π-filter has a 0,5 H inductor with a DC resistance of 12 Ω. The value of the second capacitor is 100 µf and the value of a load resistor is 2 kΩ. The voltage across the first capacitor is 12 V and the ripple voltage 1,5 V and f = 50 Hz before full-wave rectification.

Calculate the following:

2.1.1 The output voltage across the load

2.1.2 The output ripple voltage across the second capacitor

2.1.3 The output ripple factor across the second capacitor

(3 × 2) (6)

2.2 Briefly describe how the total voltage drop across a half-wave voltage trippler is obtained. (4)

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2.3 Show with the aid of a neat, labelled circuit diagram, how a 5 V fixed voltage regulator can be used to produce a voltage lower than a fixed voltage regulator. (5)
[15]

QUESTION 3: TRANSISTOR AMPLIFIERS

3.1 The following values of a common emitter amplifier are known:

$R_E = 400\ \Omega$; $C_E = 10\ \mu f$ and $I_C(max) = 5\ mA$

Calculate the following:

3.1.1 supply voltage (4)

3.1.2 minimum input frequency for the amplifier (3)

3.2 In a common emitter amplifier, with a voltage divider bias, the following information is known:

$h_{ie} = 1{,}2\ k\Omega$ $h_{re} = 2 \times 10^{-4}$ $h_{fe} = 60$
$h_{oe} = 20\ \mu A/V$ $R_{B1} = 56\ k\Omega$ $R_{B2} = 5{,}6\ k\Omega$ and $R_C = 5\ k\Omega$

Determine with the aid of the precision method:

3.2.1 A_i according to the current divider rule (7)

3.2.2 Z_i (3)
[17]

QUESTION 4: OPERATIONAL AMPLIFIERS

4.1 Name THREE causes of 'drift' that appear in amplifiers. (3)

4.2 Draw a neat, labelled circuit diagram of a practical operational amplifier connected as a differentiator. (4)

4.3 Calculate the value of the capacitor in QUESTION 4.2 if $R_F = 2\ k\Omega$ and the work frequency (f) = 500 Hz. (4)
[11]

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QUESTION 5: INTEGRATED CIRCUITS

5.1 What is the output voltage of a 7812-voltage regulator? (1)

5.2 Show by means of a neat labelled sketch, how the terminals of a 7812-voltage regulator should be connected. (4)
[5]

QUESTION 6: TRANSDUCERS

6.1 Draw a neat labelled diagram of the Hall-effect displacement transducer. (6)

6.2 Briefly explain the operating principle of a transmitter/receiver system that makes use of an infrared diode and a photo-diode. (6)
[12]

QUESTION 7: ELECTRONIC PHASE CONTROL

Draw a neat, labelled block diagram of a phase controlled circuit that makes use of two silicon controlled rectifiers and two diodes for full wave DC control. Indicate also the trigger-and-load waveforms of a phase angle of 90°. **[6]**

QUESTION 8: TEST EQUIPMENT

Briefly describe the operating principles of a staircase A/D voltmeter. **[6]**

QUESTION 9: OSCILLATORS

9.1 Explain the difference between the tuned (tank) circuit of the Hartley-oscillator and Collpits-oscillator. (4)

9.2 Describe the feedback phase displacement in the RC-network of an RC-phase displacement oscillator. (6)
[10]

TOTAL: 100

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INDUSTRIAL ELECTRONICS N5

FORMULA SHEET

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

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

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

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

$$T = RC$$

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

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

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

$$X_L = 2\pi fL$$

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

$$Z = R + jX_L$$

$$Z = R - jX_C$$

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

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

$$V_R = I_TR$$

$$V_L = I_T(jX_L)$$

$$V_C = I_T(-jX_C)$$

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

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

$$BW = f_2 - f_1$$

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

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

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

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

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

$$I_T = I_R - jI_L$$

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

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

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

$$I_T = I_R + jI_C$$

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

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

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

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

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

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

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

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

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

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

$$V_R = V_i - V_z$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$A_i = h_{fe}$$

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

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

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

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

$$Z_1 = h_{ie}$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$R_2 = \frac{R_1 R_s}{R_1 + R_s} \qquad f_c = \frac{1}{2\pi R_s C}$$

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

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

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

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

$$t = R_f C$$

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

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

$$V_0 = V_2 - V_1$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$t = 1,1\ RC$$

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

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

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

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

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

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

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

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

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

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

$R_t = Ae^{B/T}$ $\quad T = 273 + °C$

$V_A = \frac{R_2}{R_1 + R_2} . V_T$ $\quad V_B = \frac{R_t}{R_t + R_3} . V_T$

$V_{AB} = V_A - V_B$ $\quad A_v = \frac{V_0}{V_i}$

$V_{Hall} = kIH$

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