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education

Department:
Education
REPUBLIC OF SOUTH AFRICA

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NATIONAL CERTIFICATE

INDUSTRIAL ELECTRONICS N5

(8080175)

6 April (X-Paper)
09:00 – 12:00

Calculators may be used.

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

DEPARTMENT OF EDUCATION
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 correctly according to the numbering system used in this question paper.
4. ALL the calculations must be shown.
5. ALL sketches and diagrams must be labelled and neat.
6. Keep questions and subsections of questions together.
7. Write neatly and legibly.

QUESTION 1: ALTERNATING CURRENT THEORY

1.1 The selectivity of a resonant circuit is a measure of how well a resonant circuit responds to a range of frequencies and separates others. Indicate the difference in high and low selectivity and bandwidth by means of an amplitude-versus frequency response curve. (5)

1.2 In a series RL circuit, under what circumstances would the phase angle be 0° or 90°? (2)

1.3 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, then calculate the following:

1.3.1 The total impendance of the circuit (7)
1.3.2 The total current flow through the circuit (2)
[16]

QUESTION 2: POWER SUPPLIES

2.1 The following information in connection with an RC-π-filter is known:

$R_L = 1{,}5\ k\Omega$	$C_1 = 470\ \mu f$	$C_2 = 47\ \mu f$	$R = 10\ \Omega$
$V_{dc} = 16\ V$	$V_{r(rms)}$ 1,8 V by C_1	f = 50 Hz	

The supply is rectified by a bridge rectifier.

Calculate the following:

2.1.1 The DC-voltage across the load R_L (2)
2.1.2 The ripple voltage across the second capacitor (4)
2.1.3 The ripple factor across the first capacitor (1)
2.1.4 The ripple factor across the second capacitor (1)

2.2 A zener diode reference source is supplied by a 15 V ± 1 V DC-supply. If a maximum load current of 100 mA must be delivered to a 120 Ω load, calculate the minimum value for the series resistor. (4)
[12]

QUESTION 3: TRANSISTOR AMPLIFIERS

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

$^+V_{cc} = 12\ V$	$I_c = 10\ mA$	$V_{ce} = 6\ V$
$\beta = 250$	$R_e = 120\ \Omega$	$V_{be} = 0{,}6\ V$

Calculate the values of the following components:

3.1.1 R_c (collector resistor) (4)
3.1.2 R_{b1} and R_{b2} (6)

3.2 Calculate the input impedance Z_i and the output impedance Z_o of the circuit in QUESTION 3.1 by means of the approximate method if:

$h_{ie} = 1{,}2\ k\Omega$ $h_{re} = 2 \times 10^{-4}$
$h_{fe} = 100$ $h_{oe} = 20\ \mu A/V\ (R_s = 0)$ (5)

3.3 What effect does a temperature rise have upon the following:

3.3.1 The collector current I_{CO} (2)
3.3.2 The base-emitter voltage V_{be} (2)
[19]

QUESTION 4: OPERATIONAL AMPLIFIERS

4.1 State FIVE characteristics of an ideal operational amplifier. (5)

4.2 4.2.1 Draw the circuit diagram of an active low-pass filter. (4)

4.2.2 Calculate the resistor values of a low-pass filter if the cut-off frequency must be 20 kHz and a capacitor value of 22 nf is used. (2)
[11]

QUESTION 5: INTEGRATED CIRCUITS

5.1 What should be done with the unused inputs of a CMOS-integrated circuit when it is connected to a circuit? (2)

5.2 Indicate whether the following statements are TRUE or FALSE. Choose the answer and write only 'true' or 'false' next to the question number (5.2.1 – 5.2.3) in the ANSWER BOOK.

5.2.1 CMOS-integrated circuits have higher noise immunity. (1)

5.2.2 CMOS-integrated circuits are susceptible to static charges because of their low reactive input. (1)

5.2.3 As soon as you work on the circuit of CMOS-integrated circuits, the power supply to the circuit must be switched off. (1)
[5]

QUESTION 6: TRANSDUCERS

6.1 Calculate the percentage resolution of a potentiometer that has 1 000 turns. (2)

6.2 Draw a neat, labelled block diagram of a closed loop system that makes use of two potentiometers in order to control cannon. (6)

6.3 Draw a neat, labelled circuit diagram of a transmitter/receiver system that makes use of an infra-red diode and a photo diode. (7)

[15]

QUESTION 7: ELECTONIC PHASE CONTROL

7.1 Make a neat, labelled sketch of a trigger circuit for a silicon-controlled rectifier. (2)

7.2 Draw a neat, labelled block diagram of a basic open loop control system. (5)

[7]

QUESTION 8: TEST EQUIPMENT

Draw a neat, labelled block diagram of a frequency counter. **[5]**

QUESTION 9: OSCILLATORS

9.1 If the total inductance of the Hartley tuned circuit is 10 mH and the oscillating frequency is 200 kHz, what is the value of the capacitor in the tuned circuit? (3)

9.2 Draw a neat, labelled circuit diagram of a 555-timer in a A-stable operation. Indicate the input and output waveforms. (5)

9.3 Calculate the oscillation frequency of an A-stable 555-timer with the following values:

$R_A = 90\ k\Omega$
$R_B = 60\ k\Omega$
c = 1 μf (2)

[10]

TOTAL: 100

INDUSTRIAL ELECTRONICS N5

FORMULA SHEET

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

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

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

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

$$T = RC$$

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

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

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

$$X_L = 2\pi fL$$

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

$$Z = R + jX_L$$

$$Z = R - jX_C$$

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

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

$$V_R = I_TR$$

$$V_L = I_T(jX_L)$$

$$V_C = I_T(-jX_C)$$

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

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

$$BW = f_2 - f_1$$

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

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

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

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

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

$$I_T = I_R - jI_L$$

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

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

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

$$I_T = I_R + jI_C$$

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

PTO

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

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

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

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

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

$$Q = \tan\theta$$

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

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

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

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

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

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

$$PIV = V_m$$

$$PIV = 2\,V_m$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

PTO

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

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

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

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

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

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

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

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

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

$$V_R = V_i - V_z$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$A_i = h_{fe}$$

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

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

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

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

$$Z_1 = h_{ie}$$

PTO

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$t = R_f C$$

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

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

$$V_0 = V_2 - V_1$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$t = 1,1\, RC$$

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

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

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

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

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

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

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

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

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

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

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

$$T = 273 + °C$$

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

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

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

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

$$V_{Hall} = kIH$$