higher education
& training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

T710(E)(A3)T

APRIL EXAMINATION

NATIONAL CERTIFICATE

INDUSTRIAL ELECTRONICS N5

(8080175)

3 April 2014 (Y-Paper)
13:00–16:00

Calculators may be used.

This question paper consists of 5 pages and 1 formula sheet of 6 pages.

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.

QUESTION 1: ALTERNATING CURRENT THEORY

1.1 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)

1.2 In a parallel RL circuit $R = 20\ \Omega$; $L = 0{,}01$ mH and $VT = 20$ V, 100 kHz.

Calculate:

1.2.1 Z_T (answer in polar form) (4)

1.2.2 I_T (answer in polar form) (2)

1.2.3 I_L (answer in polar form) (2)

1.2.4 I_R (answer in polar form) (2)

[13]

QUESTION 2: POWER SUPPLIES

2.1 Calculate the value of a second capacitor in the RC-π-filter circuit if the following values are known:

$f = 50$Hz before full-wave rectification; $V'_{r(rms)} = 0{,}8$V;
$V_{r(rms)} = 1{,}8$V and $R = 1{,}5\text{k}\Omega$ (6)

2.2 Draw a neat, labelled block diagram of a power source, which can supply both positive and negative voltages to operational amplifiers. (7)

[13]

QUESTION 3: TRANSISTOR AMPLIFIERS

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

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

Calculate:

3.1.1 R_C (2)

3.1.2 R_B (3)

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

$h_{ie} = 1{,}2k\Omega$
$h_{re} = 2 \times 10^{-4}$
$h_{fe} = 60$
$h_{oe} = 20\mu V/A$
$R_b = 220k\Omega$
$R_c = 2k\Omega$

Calculate, according to the precision method, the:

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 Differential mode (2)

4.1.2 Common mode (2)

4.2 4.2.1 Draw the circuit diagram of a non-inverting operational amplifier. (3)

4.2.2 Calculate the voltage gain of a non-inverting amplifier if $V_1 = 2V$; $R_1 = 1k\Omega$ and $R_f = 10k\Omega$. (3)

4.3 Draw a neat, labelled circuit diagram of an operational band pass filter. (4)

[14]

QUESTION 5: INTEGRATED CIRCUITS

Draw the integrated metal can pack outlay of a 741 operational amplifier and table ALL terminal assignments.

[4]

QUESTION 6: TRANSDUCERS

6.1 6.1.1 Draw a neat, labelled circuit diagram of a closed-loop system which makes use of synchronous motors in order to control a radar antenna. (5)

6.1.2 Briefly describe what happens as soon as the transmitter rotor moves through an angle θ. (4)

6.2 Draw a neat, labelled circuit diagram of a precision switch that makes use of a light dependant resistor and an operational amplifier. (5)

[14]

QUESTION 7: ELECTRONIC PHASE CONTROL

Draw a neatly labelled block diagram of a general closed-loop system and briefly describe how the load condition is kept constant.

[8]

QUESTION 8: TEST EQUIPMENT

Draw a neat labelled block diagram of a frequency counter.

[5]

QUESTION 9: OSCILLATORS

9.1 Calculate the frequency of a uni-junction transistor oscillator if:

$R = 15\ k\Omega$ and $C = 10\ \mu f$ (2)

9.2 Design, a neat, labelled A-stable multivibrator circuit that consists of two resistors, a 200 μf capacitor, a 555-timer, an NPN-transistor and a normally open relay. The relay must be switched on (t_{high}) for 30 seconds and off (t_{low}) for 15 seconds.

Calculate the values of the resistors and draw the circuit diagram. (12)

[14]

TOTAL: 100

FORMULA SHEET

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

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

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

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

$$T = RC$$

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

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

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

$$X_L = 2\pi fL$$

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

$$Z = R + jX_L$$

$$Z = R - jX_C$$

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

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

$$V_R = I_T R$$

$$V_L = I_T(jX_L)$$

$$V_C = I_T(-jX_C)$$

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

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

$$BW = f_2 - f_1$$

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

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

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

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

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

$$I_T = I_R - jI_L$$

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

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

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

$$I_T = I_R + jI_C$$

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

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

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

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

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

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

$$Q = \tan\theta$$

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

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

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

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

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

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

$$PIV = V_m$$

$$PIV = 2\, V_m$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$V_R = V_i - V_z$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$A_i = h_{fe}$$

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

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

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

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

$$Z_1 = h_{ie}$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$t = R_f C$$

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

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

$$V_0 = V_2 - V_1$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$t = 1,1\ RC$$

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

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

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

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

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

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

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

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

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

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

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

$$T = 273 + °C$$

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

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

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

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

$$V_{Hall} = kIH$$