higher education & training

Department:
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NATIONAL CERTIFICATE

INDUSTRIAL ELECTRONICS N5

(8080175)

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09:00–12:00

This question paper consists of 6 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 Briefly state what happens to the following signals when they are sent through reactive components:

1.1.1 A square waveform

1.1.2 A sine waveform

(2 × 1) (2)

1.2 The selectivity of a resonant circuit is a measure of how well a resonant circuit responds to a range of frequencies and separates others.

Make a sketch to indicate the difference in high and low selectivity and bandwidth by means of amplitude versus frequency response curve. (5)

1.3 A network consists of THREE branches in parallel. Branch A is a 10 Ω resistor, branch B is a coil with a resistance of 4 Ω and an inductance of 0,02 H and branch C is an 8 Ω resistor in series with a 200 µf capacitor. The combination is connected to a 100 V, 50 Hz supply.

1.3.1 Calculate the current in each branch. (8)

1.3.2 Draw a phasor diagram showing the relative positions of the various currents. (2)

[17]

QUESTION 2: POWER SUPPLIES

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

$V'_{R(RMS)} = 0,8$ V $V_{R(RMS)} = 1,5$ V R = 20 Ω
f = 50 Hz before full-wave rectification (6)

2.2 Draw a neat, labelled circuit diagram of an over-voltage protection circuit. (3)

2.3 Describe how the protection circuit in QUESTION 2.2 will protect the load of the circuit. (3)

2.4 A 600 mW 12 V Zener diode is used in a voltage reference source.

If the maximum supply voltage is 18 V, calculate the value of the series resistor in order to protect the Zener diode. (4)

[16]

QUESTION 3: TRANSISTOR AMPLIFIERS

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

$^{+}V_{CC} = 30$ V $\beta = 300$ $V_{BE} = 0,7$ V $R_C = 4,7$ kΩ

$R_{B1} = 35,541$ kΩ $R_{B2} = 5$ kΩ $R_E = 2,2$ kΩ

Calculate the values of V_E, I_C, I_B, V_{CE} and V_B of the amplifier. (11)

3.2 The following values of a common-base amplifier are known:

$h_{ib} = 40\ \Omega$ $h_{ob} = 0,4\ \mu A/V$ $h_{rb} = 200 \times 10^{-6}$ $h_{fb} = -0,98$

$R_C = 5$ kΩ $Z_L = 4$ kΩ $R_S = 0$ $R_E = 1$ kΩ

Calculate by means of the PRECISE method:

3.2.1 R_L (3)

3.2.2 Z_1 (2)

3.2.3 Z_i (2)
[18]

QUESTION 4: OPERATIONAL AMPLIFIERS

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

4.2 4.2.1 Draw a neat, labelled circuit diagram of an operational amplifier which causes the input and output signals to be in phase. (3)

4.2.2 Calculate the feedback resistor (R_F) of the circuit mentioned in QUESTION 4.2.1, if $V_1 = 3$ V, $R_1 = 1,5$ kΩ and $V_O = 11$ V. (2)

4.3 Draw a neat, labelled circuit diagram of a band-pass filter. (4)
[12]

QUESTION 5: INTEGRATED CIRCUITS

State FIVE methods of handling CMOS integrated circuits. **[5]**

QUESTION 6: ELECTRONIC PHASE CONTROL

Complete the following sentences by writing only the missing word(s) next to the question number (6.1–6.5) in the ANSWER BOOK.

An open-loop system is a simple on-off system or manually-controlled system with no (6.1) ... The operator must (6.2) … control himself by observing the (6.3) … and that, if the load shows a deviation, the necessary (6.4) … can be applied on the input until the load reaches the required value. This system is (6.5) … than a closed-loop system and is used where precise load conditions are not essential. **[5]**

QUESTION 7: TEST EQUIPMENT

Draw a neat, labelled block diagram of a voltmeter with the following description:

The analogue input voltage produces a charging current V_u/R_1 which charges the capacitor to the reference voltage level V_r. As soon as the value of V_r is reached, the output condition of the comparator changes to trigger the pulse generator. The pulse generator allows the capacitor to discharge immediately during the off-time of the pulse. The rate at which the capacitor charges and discharges, supplies a square with a certain frequency which is supplied by the comparator. This frequency is directly proportional to the input voltage V_U. **[6]**

QUESTION 8: OSCILLATORS

8.1 Make TWO neat, labelled sketches in which you indicate the tuned (tank) circuit of the Colpitts oscillator and the Hartley oscillator. The amplifier circuit needs not be shown. (4)

8.2 Name the number of stable and semistable conditions of the following circuits:

8.2.1 Monostable multivibrator

8.2.2 Bistable multivibrator

8.2.3 A-stable multivibrator

(3 × 1) (3)

8.3 Briefly explain the operation of a multivibrator that can be used where a certain time is required. (3)

[10]

QUESTION 9: TRANSDUCERS

9.1 Calculate the resolution of a potentiometer which has 2 500 turns. (2)

9.2 Draw a neat, labelled circuit diagram of a linear potentiometer in a Wheatstone bridge. (4)

9.3 Briefly describe the operating principle of a precision light switch circuit that makes use of a light-dependent resistor and an operational amplifier. (5)
[11]

TOTAL: 100

INDUSTRIAL ELECTRONICS N5

FORMULA SHEET

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

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

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

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

$$T = RC$$

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

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

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

$$X_L = 2\pi fL$$

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

$$Z = R + jX_L$$

$$Z = R - jX_C$$

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

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

$$V_R = I_T R$$

$$V_L = I_T(jX_L)$$

$$V_C = I_T(-jX_C)$$

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

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

$$BW = f_2 - f_1$$

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

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

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

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

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

$$I_T = I_R - jI_L$$

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

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

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

$$I_T = I_R + jI_C$$

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

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

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

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

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

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

$$Q = \tan\theta$$

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

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

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

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

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

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

$$PIV = V_m$$

$$PIV = 2\,V_m$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$V_R = V_i - V_z$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$A_i = h_{fe}$$

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

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

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

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

$$Z_1 = h_{ie}$$

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

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

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

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

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

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

$$Z_1 = R_b // Z_1$$

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

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

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

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

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

$$Z_L = R_c // R_L$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$t = R_f C$$

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

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

$$V_0 = V_2 - V_1$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$t = 1,1\ RC$$

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

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

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

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

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

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

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

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

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

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

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

$$T = 273 + °C$$

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

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

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

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

$$V_{Hall} = kIH$$