higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

INDUSTRIAL ELECTRONICS N5

9 April 2021

This marking guideline consists of 9 pages.

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QUESTION 1: ALTERNATING CURRENT THEORY

1.1 As soon as a perfect square waveform is sent through a faulty circuit,✓ the existence of the error will be indicated as well as what type of error it is.✓ (2)

1.2 $Z_1 = 15 - j3 = 15{,}297 < -11{,}31\ \Omega$

$Z_2 = 10 + j4 = 10{,}77 < 21{,}801\ \Omega$

$Z_3 = 6 + j7 = 9{,}22 < 49{,}4\ \Omega$

$Z_4 = 7 + j8 = 10{,}63 < 48{,}81\ \Omega$

$V_{P1} = I_1 . Z_1$

$= 20 < 0 \times 15{,}297 < -11{,}31$ ✓

$= 305{,}94 < -11{,}31\ V = 300 - j60\ V$ ✓

$I_2 = \frac{V_{P1}}{Z_2}$

$= \frac{305{,}94 < -11{,}31}{10{,}77 < 21{,}801}$ ✓

$= 28{,}41 < -33{,}111\ A = 23{,}8 - j15{,}52\ A$ ✓

$I_3 = I_1 + I_2$

$= 20 + j0 + 23{,}8 - j15{,}52$ ✓

$= 43{,}8 - j15{,}52\ A = 46{,}47 < -19{,}51\ A$ ✓

$V_3 = I_3 . Z_3$

$= 46{,}47 < -19{,}51 \text{ x } 9{,}22 < 49{,}4$ ✓

$= 428{,}45 < -29{,}89\ V = 371{,}46 - j213{,}51\ V$ ✓

$V_T = V_P + V_3$

$= 300 - j60 + 371{,}46 - j213{,}51$ ✓

$= 671{,}46 - j273{,}51\ V = 725{,}03 < -22{,}163\ V$✓

$I_4 = \frac{V_T}{Z_4}$

$= \frac{725{,}03 < -22{,}163}{10{,}63 < 48{,}81}$ ✓

$= 68{,}206 < -70{,}943\ A = 22{,}24 - j64{,}48\ A$ ✓

$I_T = I_4 + I_3$

$= 22{,}24 - j64{,}48 + 43{,}8 - j15{,}52$ ✓

$= 66{,}04 - j80\ A \longrightarrow = 103{,}74 < -50{,}46\ A$ ✓ (14)

[16]

QUESTION 2: POWER SUPPLIES

2.1

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

$$= 20 - \frac{15 \times 10^{-3}}{2 \times 50 \times 470 \times 10^{-6}} \checkmark$$

$$= 19{,}681 \text{ V} \checkmark$$

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

$$= \frac{15\,x\,10^{-3}}{2 \times \sqrt{3} \times 50 \times 470 \times 10^{-6}} \checkmark$$

$$= 0{,}184 \text{ V} \checkmark$$

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

$$\therefore R_L = \frac{V_{dc}}{2\sqrt{3}fCV_{r(rms)}}$$

$$= \frac{19{,}681}{2\,x\sqrt{3} \times 50 \times 470\,x\,10^{-6} \times 0{,}184} \checkmark$$

$$= 1312{,}07\ \Omega \checkmark$$

OR

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

$$= \frac{15\,x\,10^{-3}}{2 \times \sqrt{3} \times 50 \times 470 \times 10^{-6} \times 19{,}681} \checkmark$$

$$= 0{,}009362 \checkmark$$

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

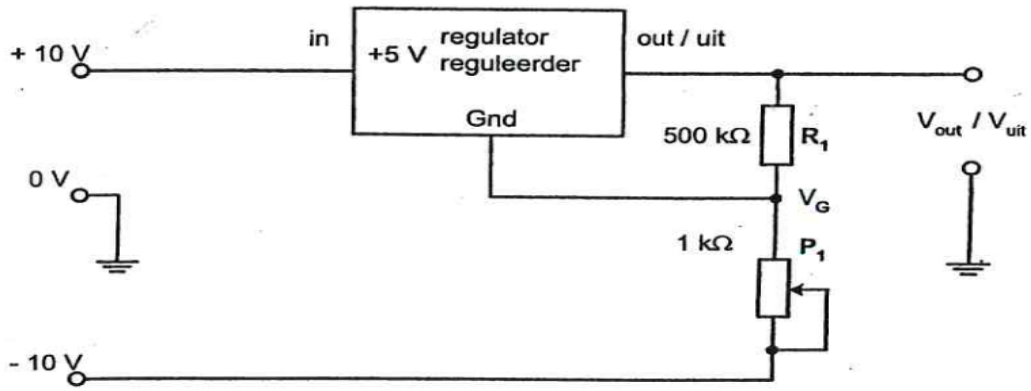
$$\therefore R_{L.} = \frac{1}{2\sqrt{3}\,fC.r}$$

$$= \frac{1}{2 \times \sqrt{3} \times 50 \times 470 \times 10^{-6} \times 0{,}009362} \checkmark$$

$$= 1312{,}07\ \Omega \checkmark$$ (6)

2.2 Potentiometer P_2 is adjusted during a normal load current so that transistor T_2 is not biased forward sufficiently and therefore is off. An increase in load current will cause an increase in voltage drop across P_2.✓ During overload conditions, the increased voltage drop across P_2 will switch transistor T_2 on✓ to conduct a part of the base current of transistor T_1 and limit the increase in load current to a safe value.✓ (3)

2.3



Regulator with voltage lower than fixed voltage (4)

2.4 2.4.1 fixed
2.4.2 control element

(2 × 1) (2)
[15]

QUESTION 3: TRANSISTOR AMPLIFIERS

3.1 3.1.1 $R_C = \frac{V_{cc} - V_{ce}}{I_C}$

$= \frac{13,2 - 6,8}{12,2 \times 10^{-3}}$ ✓

$= 524,59\ \Omega$ ✓ ⟶ (2)

3.1.2 $I_B = \frac{I_C}{\beta}$

$= \frac{12,2 \times 10^{-3}}{300}$

$= 40,67\ \mu A$ ✓

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

$= \frac{13,2 - 0,68}{40,67 \times 10^{-6}}$ ✓

$= 307,844\ k\Omega$ ✓ ⟶ (3)

3.1.3 $Z_1 = h_{ie} - \frac{h_{fe}.h_{re}.Z_L}{1+ h_{oe}.Z_L}$

$= 1300 - \frac{40 \times 2 \times 10^{-4} \times 524,59}{1 + 20 \times 10^{-6} \times 524,59}$ ✓

$= 1295,85\ \Omega$ ✓

$A_i = \left(\frac{h_{fe}}{1 + h_{oe}.Z_L}\right)\left(\frac{R_{BT}}{R_{BT} + Z_1}\right)$

$= \left(\frac{40}{1 + 20 \times 10^{-6} \times 524,59}\right)\left(\frac{307,844 \times 10^3}{307,844 \times 10^3 + 1295,85}\right)$ ✓

$= 39,432$ ✓ ⟶ (4)

3.1.4 $A_V = \frac{-h_{fe}Z_L}{h_{ie} + (h_{ie}h_{oe} - h_{fe}h_{re})Z_L}$

$= \frac{-40 \times 524,59}{1300 + (1300 \times 20 \times 10^{-6} - 40 \times 2 \times 10^{-4}) \times 524,59}$ ✓✓

$= -16,025$ ✓ ⟶ (3)

3.2 $Z_i = \frac{R_b x\, Z_1}{R_b + Z_1}$

$= \frac{307,844 \times 10^3 \times 1295,85}{307,844 \times 10^3 + 1295,85}$ ✓

$= 1290,42\ \Omega$ ✓

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

$= \frac{1}{20 \times 10^{-6}}$

$= 50\ k\Omega$ ✓

$Z_o = \frac{R_c \times Z_2}{R_c + Z_2}$

$= \frac{524,59 \times 50000}{524,59 + 50000}$ ✓

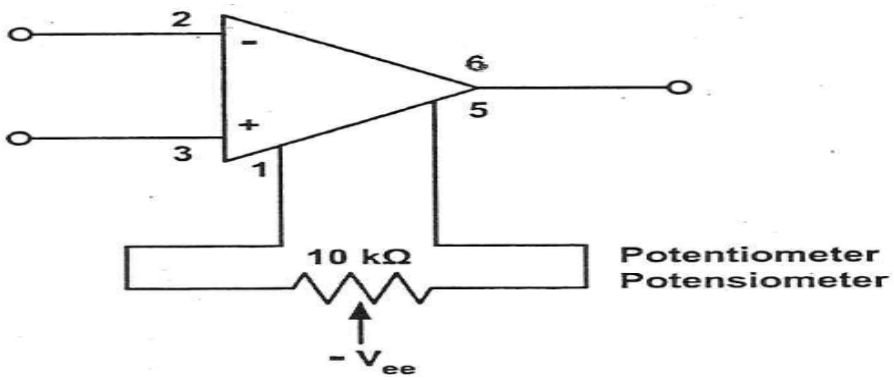
$= 519,43\ \Omega$ ✓ ⟶ (5)

[17]

QUESTION 4: OPERATIONAL AMPLIFIERS

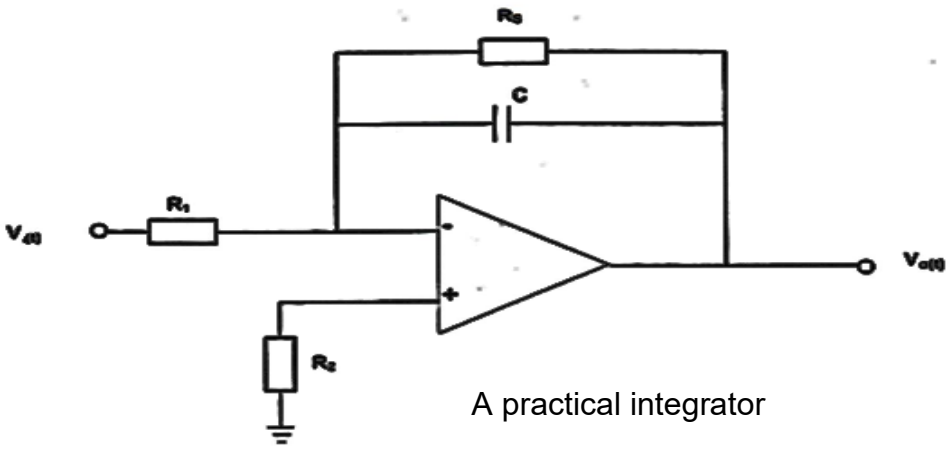
4.1 It is the ability of an amplifier to reject common-mode signals. (2)

4.2



Null balance adjustment of the 741 operational amplifier (3)

4.3



A practical integrator

(3)

4.4 $V_o = -\frac{R_f}{R_1} \times V_{in}$

$\therefore R_f = \frac{V_o x R_1}{V_{in}}$ ✓

$= \frac{20000 \times 20}{2}$ ✓

$= 200\ k\Omega$ ✓ ⟶ (3)

[11]

QUESTION 5: INTEGRATED CIRCUITS

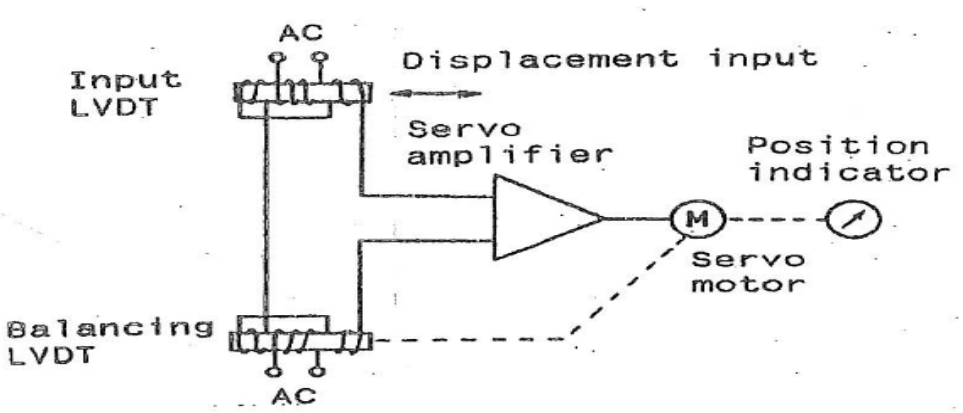
5.1 5 V (1)

5.2 Because of high noise immunity and high reactive input (2)

[3]

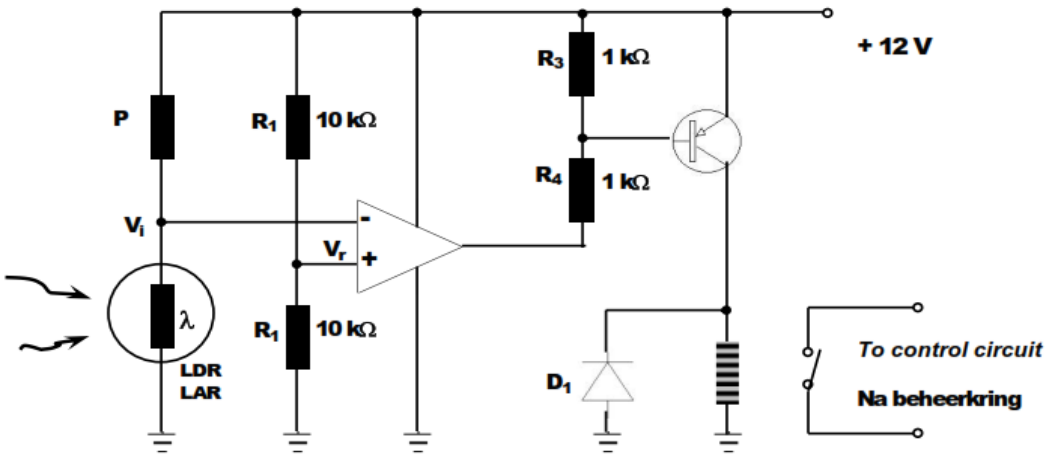
QUESTION 6: TRANSDUCERS

6.1



LVDT in a closed-loop servo-system (4)

6.2

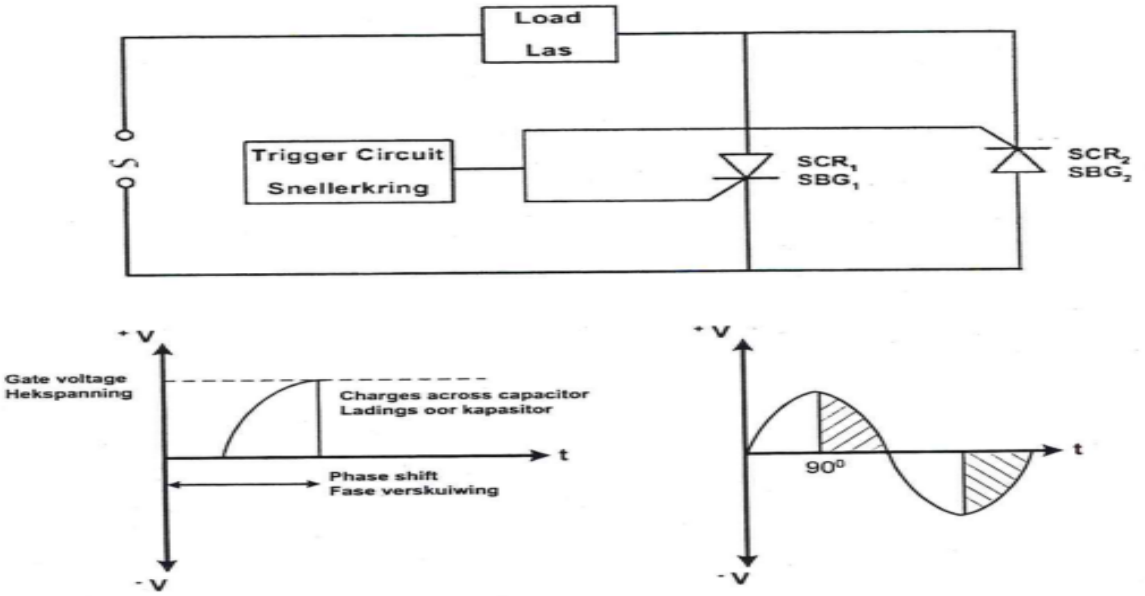


Precision light switch (5)

6.3 The slider of the feedback potentiometer can be adjusted mechanically by the axle of the cannon turret and sends a feedback signal to the comparator. The comparator compares the feedback signal with the reference signal, which is adjusted manually. If there is a difference, the error signal is given and applied to the motor. The motor rotates the gearbox and cannon respectively, which rotates the axle of the feedback potentiometer in return. As the cannon nears its required position, the error signal becomes smaller. As soon as the cannon reaches its required position, the error signal is zero and the motor will stop. (5)

[14]

QUESTION 7: ELECTRONIC PHASE CONTROL



1 mark for each wave
4 marks for diagram **[6]**

QUESTION 8: TEST EQUIPMENT

8.1 Presume that the unknown voltage V_u = 15 V of a 4-bit code is used:

Start : 0000 ✓

Step1 : 1000 (8V) $V_r < V_u$: Sets 1 ✓

Step 2 : 1110 (14V) $V_r < V_u$: Sets 1 ✓

Step 3 : 1101 (13V) $V_r < V_u$: Sets 1 ✓

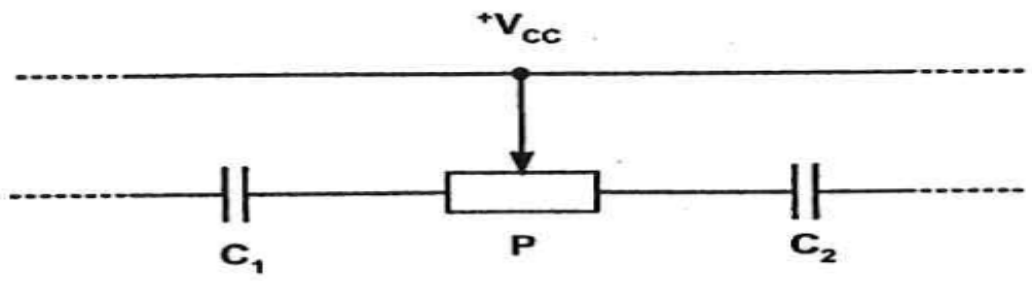
Step 4 : 1111 (15V) $V_r = V_u$: Sets 1 ✓ (5)

8.2 The A/D converter invokes a reference voltage which is equivalent to the digital code in the digital counter. A reading may now be obtained from the display.

(2)
[7]

QUESTION 9: OSCLLATORS

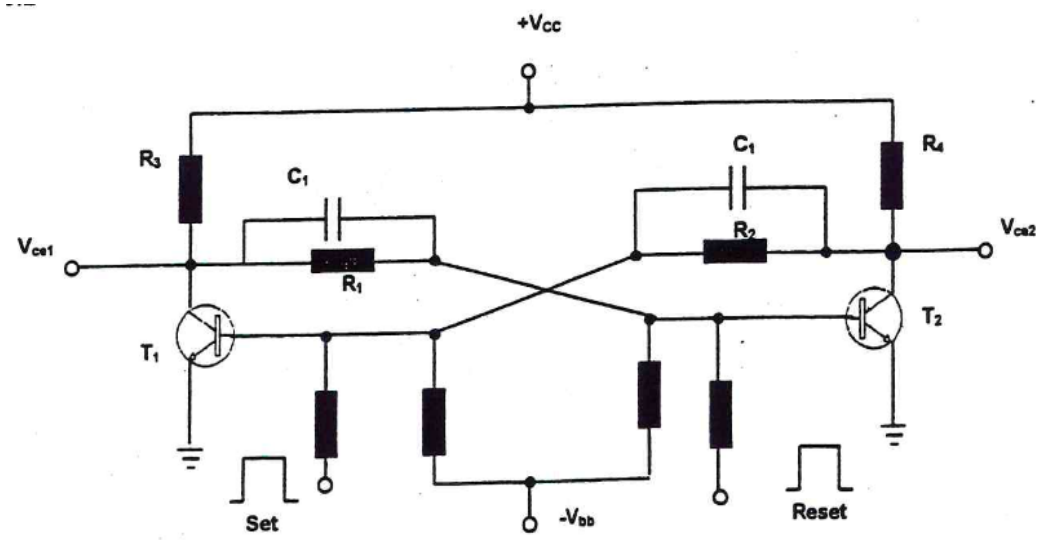
9.1



Adjustment of the relation between t_1 and t_2

(4)

9.2



Bi-stable multivibrator (4)

9.2 $f_o = \dfrac{1{,}443}{(R_A + 2R_B)C}$

$= \dfrac{1{,}443}{(80 \times 10^3 + 2 \times 70 \times 10^3) \times 1 \times 10^{-6}}$ ✓✓

$= 6{,}56 \text{ Hz}$ ✓ ⟶

(3)
[11]

TOTAL: 100

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