

SULIT

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UNIVERSITI MALAYSIA PERLIS

Peperiksaan Semester Pertama  
Sidang Akademik 2010/2011

22 November 2010

**DMT 231 – Analogue Electronics [Elektronik Analog]**

Masa : 3 jam

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Please make sure that this question paper has **FIFTEEN (15)** printed pages including this front page before you start the examination.

*[Sila pastikan kertas soalan ini mengandungi **LIMA BELAS (15)** muka surat yang bercetak termasuk muka hadapan sebelum anda memulakan peperiksaan ini.]*

This question paper has **SIX (6)** questions in **TWO (2) Sections**. Answer **ALL** questions in **Section A** and **any THREE (3)** questions in **Section B**.

*[Kertas soalan ini mengandungi **ENAM (6)** soalan **DUA (2) Bahagian**. Jawab **SEMUA** soalan dalam **Bahagian A** dan **mana-mana TIGA (3)** soalan dalam **Bahagian B**.]*

List of equations is given in **Appendix A**.

*[Senarai persamaan diberikan pada **Lampiran A**.]*

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## Section A

[Bahagian A]

## Question 1

[Soalan 1]

Figure 1 shows a multistage amplifier. The circuit elements are  $V_{CC} = 10\text{ V}$ ,  $R_1 = 80\text{ k}\Omega$ ,  $R_2 = 20\text{ k}\Omega$ ,  $R_3 = 85\text{ k}\Omega$ ,  $R_4 = 15\text{ k}\Omega$ ,  $R_{C1} = 2\text{ k}\Omega$ ,  $R_{C2} = 4\text{ k}\Omega$ ,  $R_{E1} = 1\text{ k}\Omega$ ,  $R_{E2} = 0.5\text{ k}\Omega$  and  $R_L = 4\text{ k}\Omega$ .

[Rajah 1 menunjukkan sebuah penguat berbilang tahap. Elemen-elemen litar adalah  $V_{CC} = 10\text{ V}$ ,  $R_1 = 80\text{ k}\Omega$ ,  $R_2 = 20\text{ k}\Omega$ ,  $R_3 = 85\text{ k}\Omega$ ,  $R_4 = 15\text{ k}\Omega$ ,  $R_{C1} = 2\text{ k}\Omega$ ,  $R_{C2} = 4\text{ k}\Omega$ ,  $R_{E1} = 1\text{ k}\Omega$ ,  $R_{E2} = 0.5\text{ k}\Omega$  dan  $R_L = 4\text{ k}\Omega$ .]

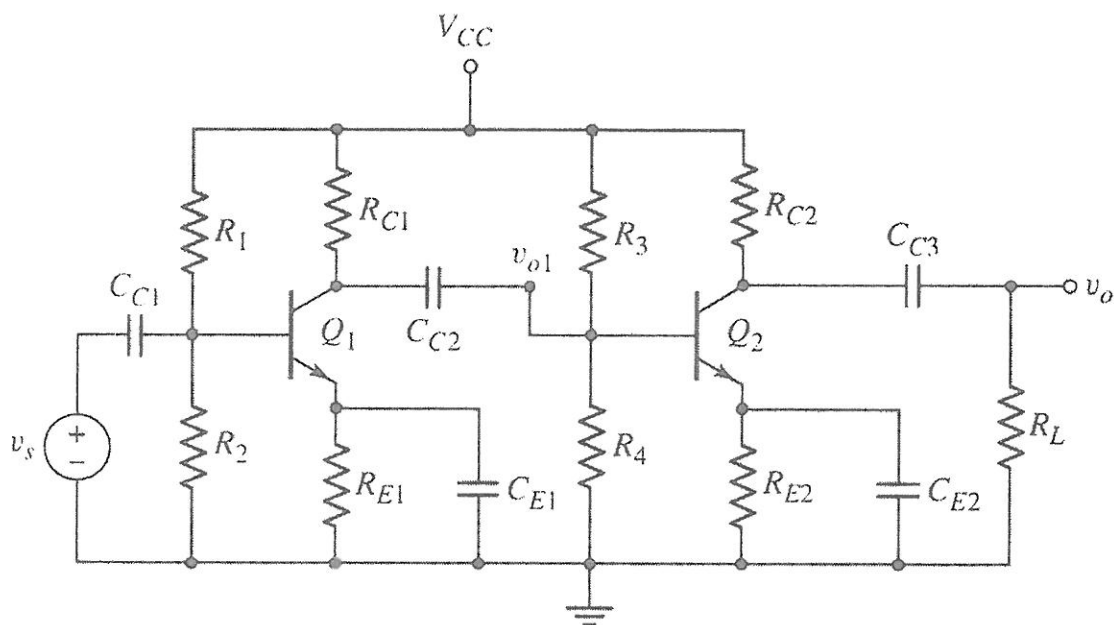


Figure 1  
[Rajah 1]

- (a) State the type of multistage amplifier configuration for the amplifier circuit shown in Figure 1.

[Nyatakan jenis tatarajah penguat berbilang tahap bagi litar penguat yang ditunjukkan dalam Rajah 1.]

(1 Mark / markah)

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- (b) Given that the early voltages,  $V_{A1} = V_{A2} = \infty$ , common-emitter current gains,  $\beta_1 = \beta_2 = 100$ , thermal voltages,  $V_{T1} = V_{T2} = 26$  mV, base-emitter voltages,  $V_{BE(ON)1} = V_{BE(ON)2} = 0.7$  V and the Q-point values of base currents,  $I_{BQ1} = 11.1$   $\mu$ A and  $I_{BQ2} = 12.65$   $\mu$ A. Determine:

[Diberikan voltan-voltan awal,  $V_{A1} = V_{A2} = \infty$ , gandaan-gandaan arus pemancar sepunya,  $\beta_1 = \beta_2 = 100$ , voltan-voltan terma,  $V_{T1} = V_{T2} = 26$  mV, voltan-voltan tapak-pemancar,  $V_{BE(ON)1} = V_{BE(ON)2} = 0.7$  V dan nilai-nilai arus tapak titik-Q,  $I_{BQ1} = 11.1$   $\mu$ A dan  $I_{BQ2} = 12.65$   $\mu$ A. Tentukan.]

- (i) the Q-point values of collector currents,  $I_{CQ1}$  and  $I_{CQ2}$ .

[nilai-nilai arus pemungut titik-Q,  $I_{CQ1}$  dan  $I_{CQ2}$ ]

(2 Marks/ markah)

- (ii) transconductances,  $g_{m1}$  and  $g_{m2}$ .

[trankonduktan-trankonduktan,  $g_{m1}$  dan  $g_{m2}$ ]

(2 Marks/ markah)

- (iii) base-emitter input resistances,  $r_{\pi 1}$  and  $r_{\pi 2}$ .

[rintangan-rintangan masukan tapak-pemancar,  $r_{\pi 1}$  dan  $r_{\pi 2}$ ]

(2 Marks/ markah)

- (c) Sketch and label the AC equivalent circuit for the multistage amplifier circuit in **Figure 1**.

[Lakar dan labelkan litar setara A.U. untuk litar penguat berbilang tahap dalam **Rajah 1**.]

(6 Marks/ markah)

- (d) Derive and determine the value of small-signal voltage gain,  $A_v$  for the multistage amplifier circuit in **Figure 1**.

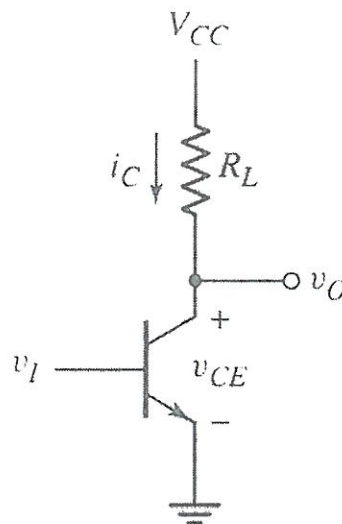
[Terbit dan tentukan nilai gandaan voltan isyarat-kecil,  $A_v$  untuk litar penguat berbilang tahap dalam **Rajah 1**.]

(7 Marks/ markah)

**Question 2***[Soalan 2]*

The four principal classifications of power amplifiers are class A, class B, class AB and Class C. Power amplifiers are generally classified according to the percent of time the output transistors are conducting. **Figure 2.1** shows a standard class A power amplifier.

*[Empat pengelasan utama bagi penguat-penguat kuasa adalah kelas A, kelas B, kelas AB dan kelas C. Penguat-penguat kuasa dikelaskan secara umum mengikut peratus masa keluaran pengaliran transistor-transistor. Figure 2.1 menunjukkan sebuah penguat kuasa piawai kelas A.]*



**Figure 2.1**  
*[Rajah 2.1]*

- (a) With the aid of a DC load line, state the condition for the power amplifier in **Figure 2.1** to achieve maximum positive and negative swing.

*[Dengan bantuan garis beban A.T., nyatakan keadaan bagi penguat kuasa dalam Rajah 2.1 agar mencapai ayunan maksimum positif dan negatif.]*

(4 Marks/ markah)

- (b) Prove that the maximum efficiency for class A power amplifier is 25%.

*[Buktikan kecekapan maksimum bagi penguat kuasa kelas A adalah 25%.]*

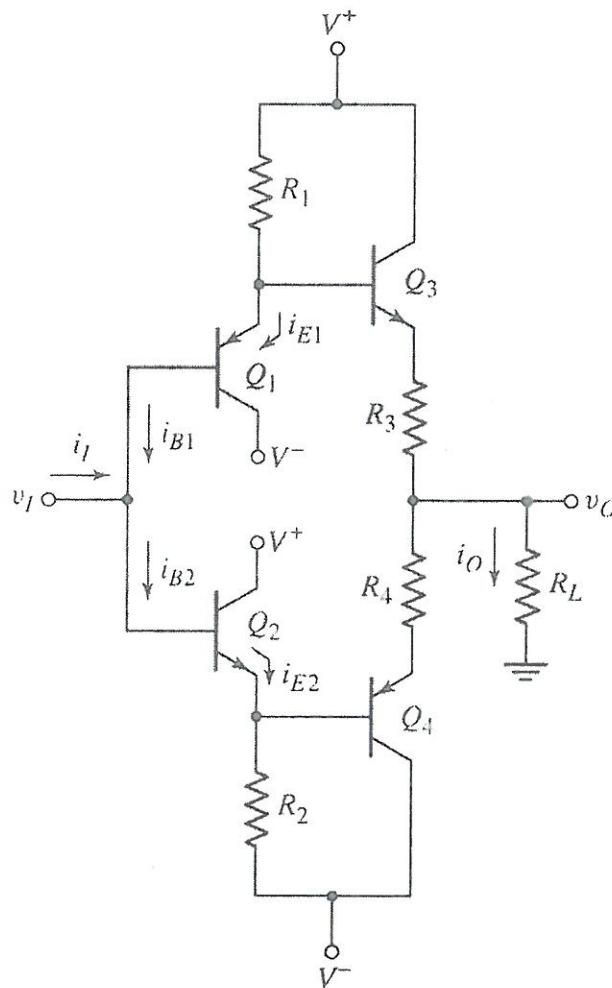
(6 Marks/ markah)

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(c) **Figure 2.2** shows a class AB power amplifier with input buffer transistors.

[Rajah 2.2 menunjukkan sebuah penguat kuasa kelas AB dengan transistor-transistor penimbal masukan.]



**Figure 2.2**  
[Rajah 2.2]

- (i) Identify the functions of the resistors,  $R_1$ ,  $R_2$ ,  $R_3$ ,  $R_4$  and emitter followers,  $Q_1$  and  $Q_2$  in **Figure 2.2**.

[Kenalpastikan fungsi-fungsi perintang,  $R_1$ ,  $R_2$ ,  $R_3$ ,  $R_4$  dan pengikut-pengikut pemancar,  $Q_1$  dan  $Q_2$  dalam **Rajah 2.2**.]

(2 Marks/ markah)

...6/-

- (ii) The circuit elements in **Figure 2.2** are  $V^+ = 15 \text{ V}$ ,  $V^- = -15 \text{ V}$ ,  $R_1 = R_2 = 200 \ \Omega$ ,  $R_L = 8 \ \Omega$  and  $R_3 = R_4 = 0 \ \Omega$ . By assuming that all the transistors are matched with  $\beta = 50$  and  $V_{BE(ON)} = V_{EB(ON)} = 0.7 \text{ V}$ , determine the current gain for the class AB power amplifier in **Figure 2.2** if  $v_i = 5 \text{ V}$ .

*[Elemen-elemen litar dalam Rajah 2.2 adalah  $V^+ = 15 \text{ V}$ ,  $V^- = -15 \text{ V}$ ,  $R_1 = R_2 = 200 \ \Omega$ ,  $R_L = 8 \ \Omega$  dan  $R_3 = R_4 = 0 \ \Omega$ . Dengan mengandaikan bahawa semua transistor adalah terpadan dengan  $\beta = 50$  dan  $V_{BE(ON)} = V_{EB(ON)} = 0.7 \text{ V}$ , tentukan gandaan arus bagi penguat kuasa kelas AB dalam Rajah 2.2, jika  $v_i = 5 \text{ V}$ .]*

(8 Marks/ markah)

## Section B

[Bahagian B]

## Question 3

[Soalan 3]

The transistor parameters for the amplifier circuit shown in **Figure 3** are  $\beta = 100$ ,  $V_A = \infty$ ,  $V_T = 26$  mV and  $V_{BE(ON)} = 0.7$  V. The circuit elements are  $R_S = 0$   $\Omega$ ,  $R_C = R_L = 2$  k $\Omega$ ,  $R_E = 4.2$  k $\Omega$ ,  $R_B = 2.4$  k $\Omega$  and  $V_{CC} = V_{EE} = 5$  V.

[Parameter-parameter transistor bagi litar penguat yang ditunjukkan dalam **Rajah 3** adalah  $\beta = 100$ ,  $V_A = \infty$ ,  $V_T = 26$  mV dan  $V_{BE(ON)} = 0.7$  V. Elemen-elemen litar adalah  $R_S = 0$   $\Omega$ ,  $R_C = R_L = 2$  k $\Omega$ ,  $R_E = 4.2$  k $\Omega$ ,  $R_B = 2.4$  k $\Omega$  dan  $V_{CC} = V_{EE} = 5$  V.]

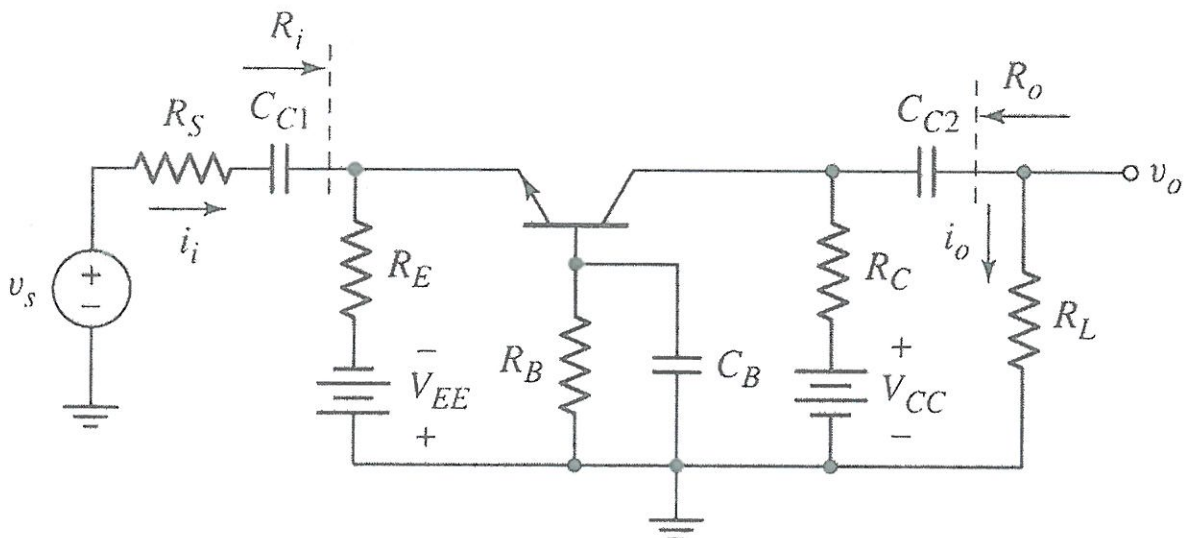


Figure 3  
[Rajah 3]

- (a) State the type of amplifier configuration for the amplifier circuit shown in **Figure 3**.

[Nyatakan jenis tatarajah penguat bagi litar penguat yang ditunjukkan dalam **Rajah 3**.]

(1 Mark / markah)

...8/-

- (b) Determine the following small-signal parameters:  
*[Tentukan parameter-parameter isyarat-kecil berikut:]*
- (i) base-emitter input resistance,  $r_{\pi}$ .  
*[rintangan masukan tapak-pemancar,  $r_{\pi}$ .]*  
(2 Marks / markah)
- (ii) transconductance,  $g_m$ .  
*[trankonduktan,  $g_m$ .]*  
(2 Marks / markah)
- (iii) transistor output resistance,  $r_o$ .  
*[rintangan keluaran transistor,  $r_o$ .]*  
(1 Mark / markah)
- (c) Sketch and label the small-signal equivalent circuit for **Figure 3**.  
*[Lakar dan labelkan litar setara isyarat-kecil bagi **Rajah 3**.]*  
(5 Marks / markah)
- (d) Determine the values of input resistance,  $R_i$  and output resistance,  $R_o$  in (c).  
*[Tentukan nilai-nilai rintangan masukan,  $R_i$  dan rintangan keluaran,  $R_o$  dalam (c).]*  
(4 Marks / markah)
- (e) Derive and determine the value of small-signal voltage gain,  $A_v$  in (c).  
*[Terbit dan tentukan nilai gandaan voltan isyarat-kecil,  $A_v$  dalam (c).]*  
(5 Marks / markah)



## Question 4

[Soalan 4]

The transistor parameters for the amplifier circuit shown in **Figure 4** are  $\beta = 150$ ,  $V_A = \infty$ ,  $V_T = 26$  mV and  $V_{BE(ON)} = 0.7$  V. The circuit elements are  $R_S = R_E = 10$  k $\Omega$ ,  $R_L = R_C = 8$  k $\Omega$ ,  $R_B = 85$  k $\Omega$ ,  $V^+ = +12$  V and  $V^- = -12$  V.

[Parameter-parameter transistor bagi litar penguat yang ditunjukkan dalam **Rajah 4** adalah  $\beta = 150$ ,  $V_A = \infty$ ,  $V_T = 26$  mV dan  $V_{BE(ON)} = 0.7$  V. Elemen-elemen litar adalah  $R_S = R_E = 10$  k $\Omega$ ,  $R_L = R_C = 8$  k $\Omega$ ,  $R_B = 85$  k $\Omega$ ,  $V^+ = +12$  V dan  $V^- = -12$  V.]

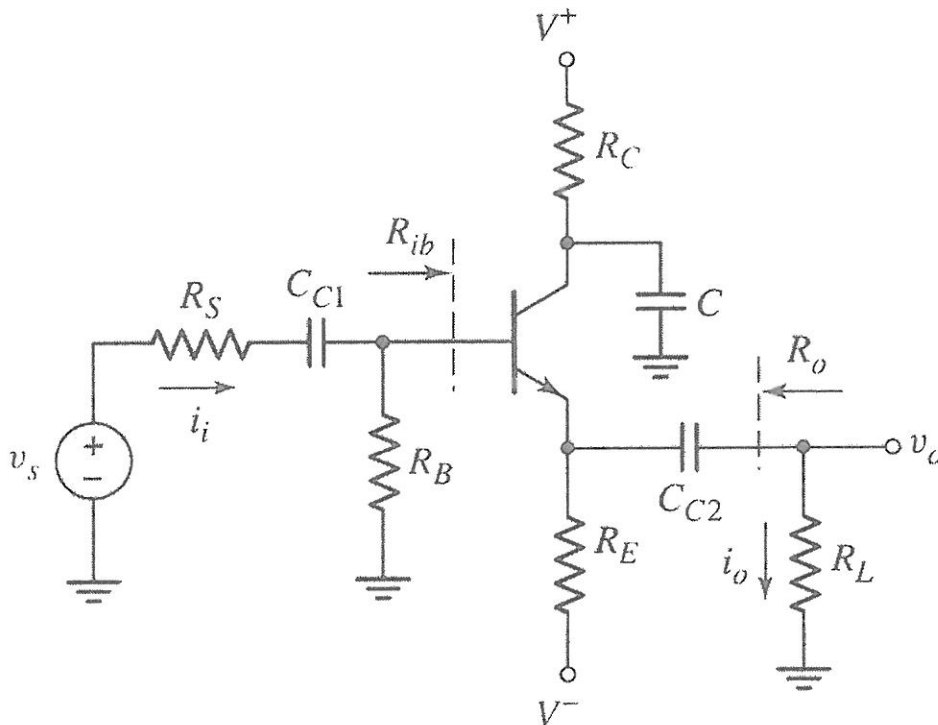


Figure 4

[Rajah 4]

- (a) State the type of amplifier configuration in **Figure 4**.

[Nyatakan jenis tatarajah penguat dalam **Rajah 4**.]

(1 Mark / markah)

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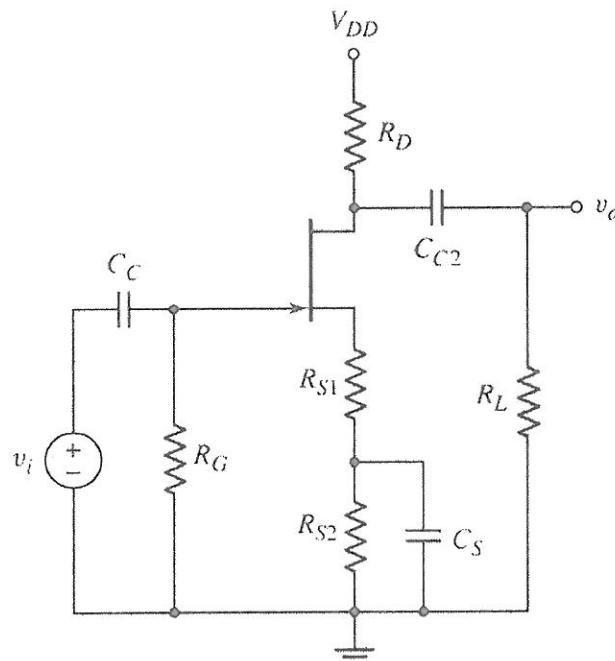
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- (b) Determine the following large-signal Q–point values:  
*[Tentukan nilai-nilai titik-Q isyarat-besar berikut:]*
- (i) base current,  $I_{BQ}$ .  
*[arus tapak,  $I_{BQ}$ .]* (3 Marks / markah)
- (ii) collector current,  $I_{CQ}$ .  
*[arus pemungut,  $I_{CQ}$ .]* (1 Mark / markah)
- (c) Determine the following small – signal parameter values:  
*[Tentukan nilai-nilai parameter isyarat – kecil berikut:]*
- (i) base – emitter input resistance,  $r_{\pi}$ .  
*[rintangan masukan tapak – pemancar,  $r_{\pi}$ .]* (2 Marks / markah)
- (ii) transconductance,  $g_m$ .  
*[trankonduktan,  $g_m$ .]* (2 Marks / markah)
- (d) Sketch and label the small-signal equivalent circuit for **Figure 4**.  
*[Lakar dan labelkan litar setara isyarat-kecil bagi **Rajah 4**.]* (5 Marks / markah)
- (e) Determine the input resistance,  $R_i$  in (d).  
*[Tentukan rintangan masukan,  $R_i$  dalam (d).]* (2 Marks / markah)
- (f) Derive and determine the value of small-signal voltage gain,  $A_v$  in (d).  
*[Terbit dan tentukan nilai gandaan voltan isyarat-kecil,  $A_v$  dalam (d).]* (4 Marks / markah)

**Question 5***[Soalan 5]*

The transistor in **Figure 5** has the following parameters;  $I_{DSS} = 2 \text{ mA}$ ,  $V_p = -2 \text{ V}$  and  $\lambda = 0.005 \text{ V}^{-1}$ . The circuit elements are;  $V_{DD} = 15 \text{ V}$ ,  $R_G = 75 \text{ k}\Omega$ ,  $R_{S1} = 85 \Omega$ ,  $R_{S2} = 225 \Omega$ ,  $R_D = 10 \text{ k}\Omega$  and  $R_L = 5 \text{ k}\Omega$ .

*[Transistor dalam Rajah 5 mempunyai parameter-parameter berikut;  $I_{DSS} = 2 \text{ mA}$ ,  $V_p = -2 \text{ V}$  dan  $\lambda = 0.005 \text{ V}^{-1}$ . Elemen-elemen litar adalah;  $V_{DD} = 15 \text{ V}$ ,  $R_G = 75 \text{ k}\Omega$ ,  $R_{S1} = 85 \Omega$ ,  $R_{S2} = 225 \Omega$ ,  $R_D = 10 \text{ k}\Omega$  dan  $R_L = 5 \text{ k}\Omega$ .]*



**Figure 5**  
*[Rajah 5]*

- (a) State the amplifier configuration in **Figure 5**.

*[Nyatakan tatarajah penguat dalam Rajah 5.]*

(1 Mark/markah)

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- (b) Determine the Q-point values of the following parameters:

[Tentukan nilai parameter-parameter titik-Q berikut:]

- (i) gate-source voltage,  $V_{GSQ}$ .

[voltan get-punca,  $V_{GSQ}$ ]

(4 Marks/markah)

- (ii) drain current,  $I_{DQ}$ .

[arus saluran,  $I_{DQ}$ ]

(2 Marks/markah)

- (c) Sketch and label the small-signal equivalent circuit for **Figure 5**.

[Lakar dan labelkan litar setara isyarat-keci bagi **Rajah 5**.]

(5 Marks/markah)

- (d) Prove that the equation of the small-signal voltage gain,  $A_v$  for the circuit in **Figure 5** is equal to:

[Buktikan bahawa persamaan untuk gandaan voltan isyarat-kecil,  $A_v$  dalam **Rajah 5** adalah bersamaan dengan:]

$$A_v = \frac{-g_m(R_D \parallel R_L \parallel r_o)}{1 + g_m R_{S1}}$$

(3 Marks/markah)

- (e) Determine the value of the small signal voltage gain,  $A_v$ .

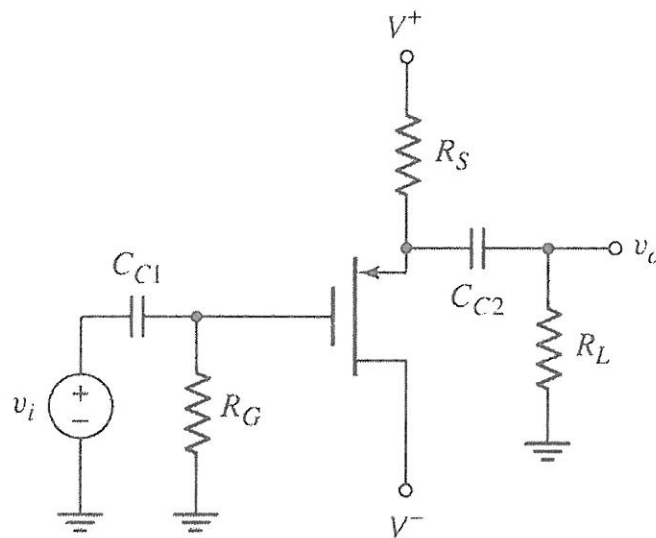
[Tentukan nilai gandaan voltan isyarat-kecil,  $A_v$ .]

(5 Marks/markah)

**Question 6***[Soalan 6]*

For the amplifier circuit in **Figure 6**, the transistor parameters are;  $V_{TP} = -2.5$  V,  $K_p = 2$  mA / V<sup>2</sup> and  $\lambda = 0.002$  V<sup>-1</sup>. The circuit elements are;  $V^+ = +6$  V,  $V^- = -6$  V,  $R_G = 460$  k $\Omega$ ,  $R_S = 0.5$  k $\Omega$  and  $R_L = 1.5$  k $\Omega$ .

*[Bagi litar penguat dalam **Rajah 6**, parameter-parameter transistor adalah;  $V_{TP} = -2.5$  V,  $K_p = 2$  mA / V<sup>2</sup> dan  $\lambda = 0.002$  V<sup>-1</sup>. Elemen-elemen litar adalah;  $V^+ = +6$  V,  $V^- = -6$  V,  $R_G = 460$  k $\Omega$ ,  $R_S = 0.5$  k $\Omega$ , dan  $R_L = 1.5$  k $\Omega$ .]*



**Figure 6**  
*[Rajah 6]*

- (a) State the type of DC biasing in **Figure 6**.

*[Nyatakan jenis pincang A.T dalam **Rajah 6**.]*

(1 Mark/markah)

- (b) State the function of coupling capacitor,  $C_{C1}$  in **Figure 6**.

*[Nyatakan fungsi pemuat gandingan,  $C_{C1}$  dalam **Rajah 6**.]*

(1 Mark/markah)

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(c) By performing DC analysis, determine the following Q-point values:

*[Dengan melakukan analisa A.T, tentukan nilai-nilai titik-Q berikut:]*

(i) gate-source voltage,  $V_{GSQ}$ .

*[voltan pintu-sumber,  $V_{GSQ}$ ]*

(4 Marks/markah)

(ii) drain current,  $I_{DQ}$ .

*[urus saliran,  $I_{DQ}$ ]*

(2 Marks/markah)

(d) Sketch and label the small-signal equivalent circuit for **Figure 6**.

*[Lakar dan labelkan litar setara isyarat-kecil bagi **Rajah 6**.]*

(5 Marks/markah)

(e) Determine the input resistance,  $R_i$  in (d).

*[Tentukan rintangan masukan,  $R_i$ , dalam (d)]*

(2 Marks / markah)

(f) Derive and determine the value of small-signal voltage gain,  $A_v$  in (d).

*[Terbit dan tentukan nilai gandaan voltan isyarat-kecil,  $A_v$ , dalam (d).]*

(5 Marks/markah)

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## Appendix A

[Lampiran A]

$$1. \quad g_m = \frac{I_{CQ}}{V_T}$$

$$2. \quad g_m = 2K_n(V_{GS} - V_{TN})$$

$$3. \quad g_m = \frac{2I_{DSS}}{|V_p|} \left( 1 - \frac{V_{GS}}{V_p} \right)$$

$$4. \quad A_v = -g_m R_c \left( \frac{r_\pi}{r_\pi + R_D} \right)$$

$$5. \quad A_v = -g_m \left( \frac{R_1 \parallel R_2 \parallel r_\pi}{(R_1 \parallel R_2 \parallel r_\pi) + R_S} \right) (R_c \parallel r_o)$$

$$6. \quad A_v = \frac{\beta R_c}{r_\pi + (1 + \beta) R_E} \left( \frac{R_i}{R_i + R_S} \right)$$

$$7. \quad A_v = \frac{(1 + \beta)(r_o \parallel R_E)}{r_\pi + (1 + \beta)(r_o \parallel R_E)} \left( \frac{R_i}{R_i + R_S} \right)$$

$$8. \quad A_v = g_m \left( \frac{R_c \parallel R_L}{R_S} \right) \left( \frac{r_\pi}{1 + \beta} \parallel R_E \parallel R_S \right)$$

$$9. \quad A_v = -g_m (r_o \parallel R_D)$$

$$10. \quad A_v = \frac{-g_m (r_o \parallel R_D \parallel R_L)}{1 + g_m R_S}$$

$$11. \quad A_v = -g_m (r_o \parallel R_D \parallel R_L) \left( \frac{R_i}{R_i + R_{Si}} \right)$$

$$12. \quad A_v = \frac{g_m (r_o \parallel R_S \parallel R_L)}{1 + g_m (r_o \parallel R_S \parallel R_L)} \left( \frac{R_i}{R_i + R_{Si}} \right)$$

$$13. \quad A_v = \frac{g_m (r_o \parallel R_D \parallel R_L)}{1 + g_m R_{Si}}$$

$$14. \quad A_v = -g_m (r_o \parallel R_D \parallel R_L)$$

$$15. \quad A_v = \frac{g_m (r_o \parallel R_S \parallel R_L)}{1 + g_m (r_o \parallel R_S \parallel R_L)}$$

$$16. \quad I_D = I_{DSS} \left( 1 - \frac{V_{GS}}{V_p} \right)^2$$

$$17. \quad I_D = K_n (V_{GS} - V_{TN})^2$$

$$18. \quad V_{DS(sat)} = V_{GS} - V_{TN}$$