**Name:**

**Student ID Number:**

**Section Number:** 01/02/03/04 A/B

**Lecturer:** Dr Jamaludin/ Dr Fazrena Azlee/ Dr Jehana Ermy/ Prof Md Zaini

**Table Number:**

# College of Engineering

## Department of Electronics and Communication Engineering

# Test 2 – Model Answers

## SEMESTER 1, ACADEMIC YEAR 2018/2019

| | | |
|---|---|---|
| Subject Code | : | **EEEB273** |
| Course Title | : | **Electronics Analysis & Design II** |
| Date | : | **11 August 2018** |
| Duration | : | **2 hours** |

## Instructions to the candidates:

1. Write your **Name** and **Student ID Number**. Indicate your **Section Number** and **Lecturer**'s Name. Write also your **Table Number**.
2. **Write all your answers using pen**. **DO NOT USE PENCIL** except for the diagram.
3. **ANSWER ALL QUESTIONS. Show clearly** all your calculations. Every value **must** be written with its correct Unit.
4. **WRITE YOUR ANSWER ON THIS QUESTION PAPER.**

**NOTE: DO NOT OPEN THE QUESTION PAPER UNTIL INSTRUCTED TO DO SO.**

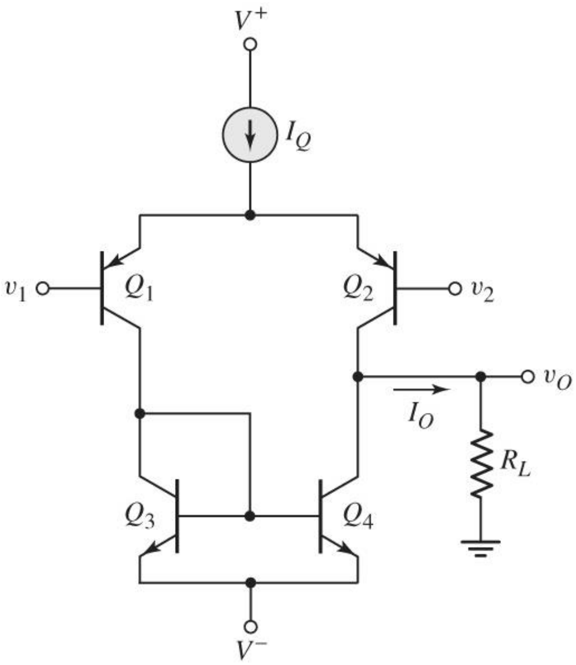
☺ **GOOD LUCK!** ☺

| Question Number | Q1a | Q1bc | Q2a | Q2b | Q3a | Q3b | Q4a | Q4b | Total |
|---|---|---|---|---|---|---|---|---|---|
| Marks | | | | | | | | | |

**QUESTION 1 [20 marks]**

**Answers for Question 1 (Continued)**

Q1(a)




3 marks: correct label
3 marks: correct placement

Q1(b) $r_{02} = V_A/I_{CQ2} = V_A/(I_Q/2) = 100/(0.15m/2) = 1.33M\Omega$ [2]

$r_{04} = V_A/I_{CQ2} = V_A/(I_Q/2) = 100/(0.15m/2) = 1.33M\Omega$ [2]

$g_{m2} = I_{CQ2}/V_T = I_Q/2V_T = 0.15m/[2(26m)] = 2.885mA/V$ [2]

$A_d = g_{m2}\,(r_{02}//\ r_{04}) = 2.885m\ (1.33M//1.33M) = 1923\ V/V$ [2]

Q1(c) $A_d = g_{m2}\,(r_{02}\ //\ r_{04}\ //\ R_L)$ [2]

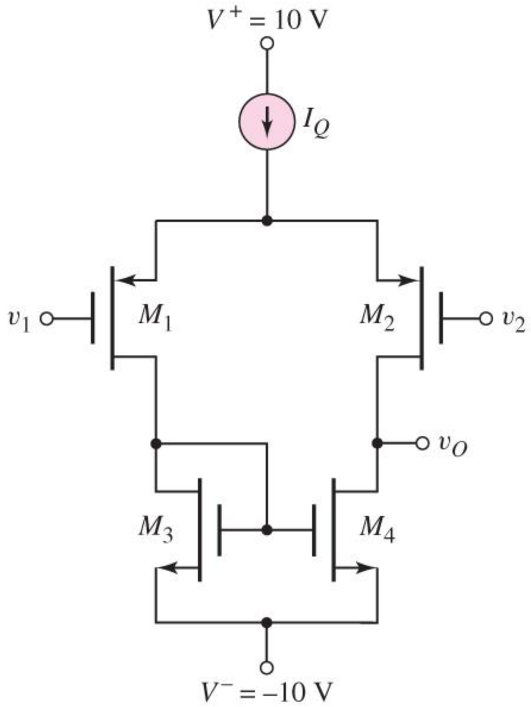
$524 = 2.885m\ (1.33M\ //\ 1.33M\ //\ R_L)$ [2]

$RL = 250k\Omega$ [2]

**QUESTION 2 [35 marks]**

**Answers for Question 2 (Continued)**

Q2(a) Placements of $M_1$ and $M_2$ [5]
Current source $M_3$ and $M_4$ [5]
Correct label for MOSFET and power supplies [5]




(b) (i) $R_O = r_{o2} \| r_{o4}$ [1]
$I_{D2} = I_{D4} = I_Q/2 = (0.4\text{m})/2 = 0.2$ mA [1]
$r_{o2} = 1/(\lambda_p I_{D2}) = 1/(0.01 \times 0.2\text{m}) = 500$ kΩ [1]
$r_{o4} = 1/(\lambda_n I_{D4}) = 1/(0.02 \times 0.2\text{m}) = 250$ kΩ [1]
$R_O = (500\text{k} \| 250\text{k}) = 166.7$ kΩ [1]

(ii) $A_d = g_{m2}(r_{o2} \| r_{o4}) = g_{m2}(R_O)$ [2]
$g_{m2} = 2\sqrt{K_p\, I_{D2}} = 2\sqrt{(60\mu)(0.2\text{m})} = 0.219$ mA/V [2]
$A_d = (0.219\text{m})(166.67\text{k}) = \underline{36.515 \text{ V/V}}$ [1]

(iii) $v_O = A_d\, v_d = (36.515) \times 20 \sin(\omega t) = \underline{730 \sin(\omega t) \text{ V}}$ [2, 2, 1]

(iv) The $A_d$ calculation is changed to $A_d = g_{m2}(r_{o2} \| R_{O4c})$ [2]
where $R_{O4c} = g_{m4} ro_4 r_{o6}$ by approximation [2]
and higher than the ordinary $R_O$. [1]

## QUESTION 3 [20 marks]

## Answers for Question 3

Q3(a) Derive formula $I_O = I_Q / \beta$ and use it **[5 marks]**

$I_{B3} + I_{B4} = I_{C3} / \beta + I_{C4} / \beta = (I_{C3} + I_{C4}) / \beta$ **[1]**

Assuming base currents for transistors in the diff-amp and $I_O$ are small, then

$I_{C3} + I_{C4} \approx I_{C1} + I_{C2} \approx I_{E1} + I_{E2} = I_Q$ **[1]**

Then $I_{B3} + I_{B4} = I_Q / \beta$ **[1]**

For the DC currents in the diff-amp to be **balanced**

$I_O = I_{B6} = I_{B3} + I_{B4} = I_Q / \beta$ **[1]**

$I_O = I_Q / \beta$ = 0.307 mA / 120 = 0.002558 mA = **2.558 μA** **[1]**

Q3(b) Calculation for $A_{v2}$: **[15 marks]**

$I_Q$ **= 0.307 mA,** $I_{B6} = I_O$ **= 2.558 μA**

$$I_{C6} = \beta I_{B6} = 120 \times 2.558\mu = 0.307\ mA$$ **[1]**

$$I_{C7} = \beta I_{B7} = \beta I_{E6} = \beta(1+\beta)I_{B6}$$ **[1]**

$$I_{C7} = 120(121)(2.558\mu) = 37.142\ mA$$ **[0.5]**

$$I_{C8} = \frac{v_O - V^-}{R_2} = \frac{0-(-10)}{5k} = 2\ mA$$ **[1]**

Calculation for $R_i$:

$$r_{\pi 6} = \frac{\beta V_T}{I_{C6}} = \frac{120 \times 0.026}{0.307m} = 10.16\ k\Omega$$ **[1]**

$$r_{\pi 7} = \frac{\beta V_T}{I_{C7}} = \frac{120 \times 0.026}{37.142m} = 0.084\ k\Omega$$ **[1]**

$$R_i = r_{\pi 6} + (1+\beta) r_{\pi 7}$$ **[1]**

$$R_i = 10.16k + (121)(0.084k) = 20.32\ k\Omega$$ **[0.5]**

Calculation for $R_{c11}$:

$r_{o11} = V_A / I_{C7}$ **= 100/37.142m = 2.692 kΩ** **[1]**

Therefore, $R_{c11} = r_{o11}$ **= 2.692 kΩ** **[1, 0.5]**

Calculation for $R_{b8}$:

$r_{\pi 8} = \beta\ V_T / I_{C8}$ **= (120 x 0.026)/(2m) = 1.56 kΩ** **[1]**

$R_{b8} = r_{\pi 8} + (1+\beta) R_2$ **= 1.56k+(121)(5k) = 606.56 kΩ** **[1, 0.5]**

$R_{L7} = R_{c11} \| R_{b8}$ **= 2.692k ‖ 606.56k = 2.68 kΩ** **[1]**

$r_{o7} = r_{o11} = V_A / I_{C7}$ **= 100/37.142m = 2.692 kΩ** **[1]**

$r_{o7} \| R_{L7}$ **= 2.692k ||2.68k = 1.343 kΩ**

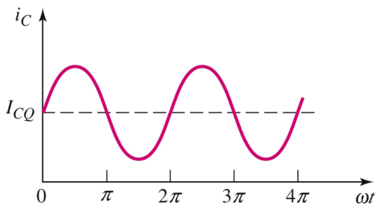
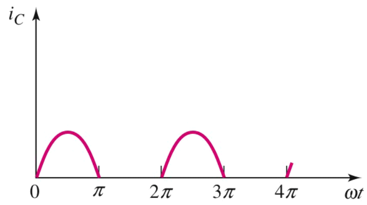
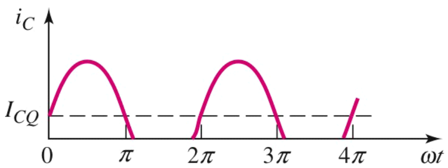
$$A_{v2} = \frac{\beta(1+\beta)(r_{o7} || R_{L7})}{R_i}$$

$A_{v2}$ **= [(120x121)(2.692k ||2.68k)] / 20.32k = 959.66** **[1]**

**QUESTION 4 [25 marks]**

**Answers for Question 4 (Continued)**

**Answers to Question 4(a) [5 marks]**

| **Output Stage** | **Output current waveform** | **Explanation** |
|---|---|---|
| **Class A** | <br>**[1 mark]** | output transistor is ***biased*** *at a quiescent current* $I_Q$ **[½ mark]**<br>and conducts for the ***entire cycle*** *of the input signal*. **[½ mark]** |
| **Class B** | <br>**[½ mark]** | output transistor conducts for only ***one-half*** *of each sine-wave input cycle*. **[½ mark]** |
| **Class AB** | <br>**[1 mark]** | output transistor **biased** *at a small quiescent current* $I_Q$, **[½ mark]**<br>and conducts for ***slightly more than half*** *a cycle* **[½ mark]** |

**This is extra page for answers. Please indicate question number clearly.**

**Answers to QUESTION 4(b) [20 marks]**

(i) VO(max) = Vcc – VCE1(sat)
= 10 – 0.3 = 9.7V [2]

VO(min) = -Vcc + VCE2(sat)
= -10 + 0.3 = -9.7V [2]

IQ = | IL(Min) |
= | VO(min) / RL | = | -9.7 / 1k | = 9.7 mA [2]

IR = IQ = 9.7mA [1]

R = (Vbias = VBE(on) - - Vcc)/IR [2]
= (2-0.65-(-10)) / 9.7m
= 1.17kΩ [1]

(ii) η = PL(ave) / Ps(ave) x 100% [1]

PL(ave) = ½ $Vo(max)^2$/RL
= ½ $(9.7)^2$/1k = 47.045 mW [2]

PS(ave) = (Vcc - (-Vcc))xIQ + (Vbias – (-Vcc))xIR [2]
= (10 - -10)(9.7m) + (2- -10)(9.7m) = 310.4mW [1]

η = 47.045m / 310.4m x 100% = 15.16% [1]

(iii) PQ1 = VCE1xIC1 = (Vcc-Vo) x (IQ+IL) [2]
= (10-5) x (9.7m + 5/1k) = (5)(14.7m) = 73.5mW [1]