Name: MODEL ANSWERS

Student ID Number:

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

Lecturer: Dr Jamaludin/ Dr Azni Wati/ Dr Jehana Ermy/ Prof Md Zaini

Table Number:

UNIVERSITI TENAGA NASIONAL

College of Engineering

Department of Electronics and Communication Engineering

Test 2

SEMESTER 2, ACADEMIC YEAR 2017/2018

Subject Code	:	**EEEB273**
Course Title	:	**Electronics Analysis & Design II**
Date	:	**30 December 2017**
Time Allowed	:	**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.

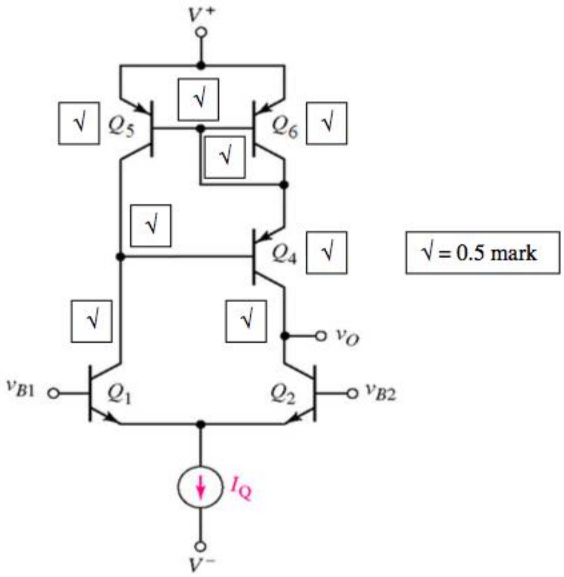
☺ **GOOD LUCK!** ☺

Question Number	Q1a	Q1bc	Q2ad	Q2e	Q3	Q4a	Q4b	Total
Marks								

QUESTION 1 [20 marks]

Answers for Question 1

(a) New diff-amp with BJT Wilson current source as active load drawing



[4]

(b) $A_d = g_{m2}(r_{o2} \| R_{OAL})$ **[2]**

$g_{m2} = I_{CQ}/V_T = (0.23m/2)/0.026 = \underline{4.423 \text{ mA/V}}$ **[1, 1, 1]**

$r_{o2} = V_{A2}/I_{CQ} = 100/(0.23m/2) = \underline{0.8696 \text{ M}\Omega}$ **[1, 1, 1]**

$R_{OAL} = (\beta/2)\, r_{o4} = (\beta/2)\, V_{A4}/\, I_{CQ} = (120/2)*120/(0.23m/2)$

$= \underline{62.609 \text{ M}\Omega}$ **[2]**

So, $A_d = (4.423m)(0.8696M \| 62.609M)$

$= (4.423m)(0.8577M) = \underline{3.793}$ **[2]**

(c) With the 3-transistor current source active load:

$A_d = g_{m2}(r_{o2} \| R_{OAL}) = g_{m2}(r_{o2} \| r_{o4})$

$r_{o4} = V_{A4}/\, I_{CQ} = 120/(0.23m/2) = 1.043 \text{ M}\Omega$

So, $A_d = (4.423m)(0.8696M \| 1.043M) = 2.097$ Calculation **[2]**

Thus, the differential-mode gain with a three-transistor current source active load is reduced approximately 45% because Ro of the 3-transistor current source active load is lower by $\beta/2$ compared to the Ro of the Wilson CS. **[2]**

QUESTION 2 [35 marks]

Answers for Question 2

(a) $V_{GS5} = V_{GS7}$ {Identical transistors} **[1]**

$V_{GS5} + V_{GS7} = 2\ V_{GS5} = V^+ - V^- = 10 - (-10) = 20$ V **[0.5]**

$V_{GS5} = 10\text{V} = V_{GS7}$ **[0.5]**

$I_1 = K_n\ (V_{GS5} - V_{TN})^2 = K_n\ (V_{GS7} - V_{TN})^2$ **[1]**

$I_1 = (0.2\text{m})(10\text{-}2)^2 = 12.8$ mA **[1]**

$I_Q = I_1 = 12.8$ mA **[1]**

$I_{D1} = ½\ I_Q = 6.4$ mA **[1]**

(b) $v_o = (g_m)v_d\ (r_{o2} \parallel r_{o4} \parallel R_L)$ therefore $A_d = (g_m)(r_{o2} \parallel r_{o4} \parallel R_L)$ **[2]**

$g_m = 2\sqrt{(K_n I_{D1})} = 2\sqrt{[(0.2\text{m})(6.4\text{m})]} = 2.26$ mA/V **[1, 0.5]**

$r_{o2} = 1/(\ \lambda_n I_{D1}) = 1/(0.02)(6.4\text{m}) = 7.812$ kΩ **[1, 0.5]**

$r_{o4} = 1/(\ \lambda_p I_{D1}) = 1/(0.015)(6.4\text{m}) = 10.417$ kΩ **[1, 0.5]**

$(r_{o2} \parallel r_{o4} \parallel R_L) = (7.812\text{k})\|(10.417\text{k})\|(100\text{k}) = 4.273$ kΩ **[1.5]**

$Ad = (2.26$ mA/V) x (4.273 k) = 9.668 **[1]**

(c) $CMRR = 20 \log [A_d / A_{cm}] = 60$ dB **[1, 0.5]**

$Acm = Ad$ / [10^(60/20)] = 9.668x10^(-3) **[1, 0.5]**

(d) Select two answers: **[2 marks]**

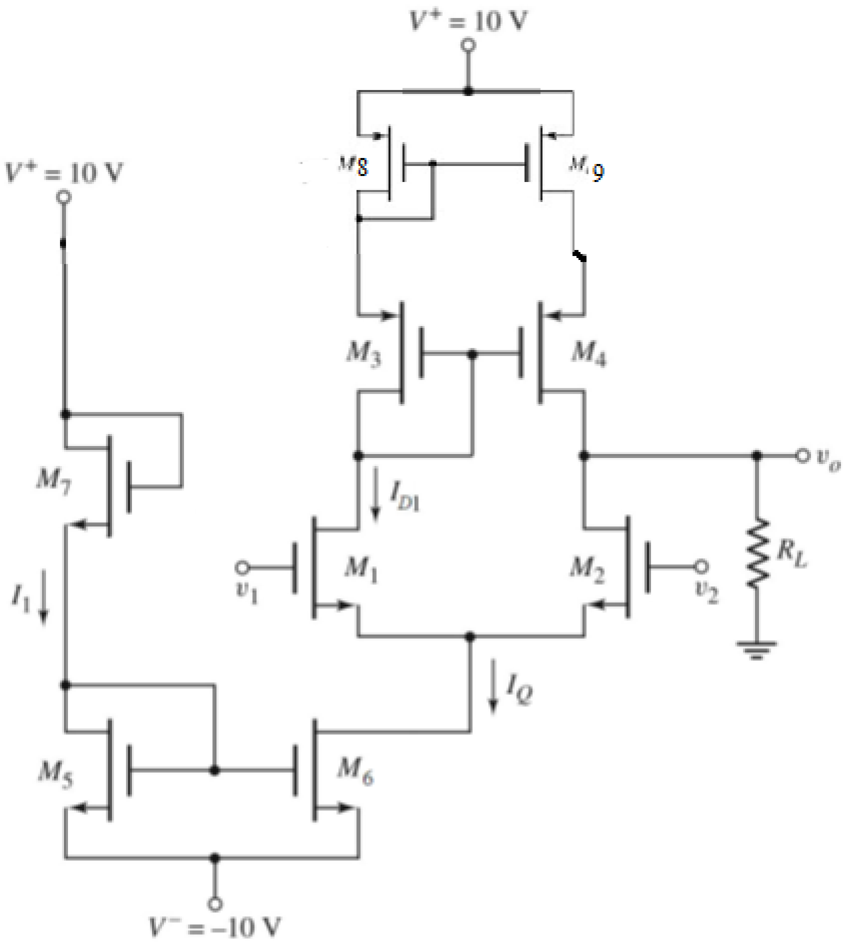
Increase the current source output resistance. **[1]**

Increase the diff amp output resistance by using cascode active loads. **[1]**

Reduce the loading effect by increasing load resistance, R_L. **[1]**

Answers for Question 2 (Continued)

(e)



Biasing [5], Diff Amp [5], Cascode Active Load [5]

Total [15 marks]

QUESTION 3 [20 marks]

Answers for Question 3

$I_Q = 0.307mA$

$I_{C2} = I_{E2} = I_Q / 2 = 0.1531mA$ **[1]**

$I_{C7} = I_Q = 0.307mA$ **[1]**

$I_{C6} = I_{C7} /(1+\beta) = 0.307m/121 = 2.537uA$ **[1, 1]**

$I_{C8} = \dfrac{v_O - V^-}{R_4} = \dfrac{0 - V^-}{R_4} = 10/5k = 2mA$ **[1]**

Calculation for R_i:

$r_{\pi 6} = \dfrac{\beta V_T}{I_{C6}} = \dfrac{(120)(0.026)}{2.537u} = 1.229M\Omega$ **[1]**

$r_{\pi 7} = \dfrac{\beta V_T}{I_{C7}} = \dfrac{(120)(0.026)}{0.307m} = 10.16\text{ k}\Omega$ **[1]**

$R_i = r_{\pi 6} + (1+\beta) r_{\pi 7} = 1.229M + (121)(10.16k) = 2.459M\Omega$ **[1, 1]**

Calculation for R_{c11}:

$r_{\pi 11} = \beta\ V_T / I_Q$ = (120x0.026)/(0.307m) = 10.16 kΩ **[1]**

R'_E = 10.16k ‖ 0.1k = 99 Ω **[1]**

$g_{m11} = I_Q / V_T$ = 0.307m/0.026 = 11.81 mA/V **[1]**

$r_{o11} = V_A / I_Q$ = 100/0.307m = 325.7 kΩ **[1]**

Therefore, $R_{c11} = r_{o11} (1 + g_{m11} R'_E)$ = 706.5 kΩ **[1, 0.5]**

Calculation for R_{b8}:

$r_{\pi 8} = \beta\ V_T / I_{C8}$ = (100)(0.026)/(2m) = 1.3 kΩ **[1]**

$R_{b8} = r_{\pi 8} + (1+\beta) R_4$ = 1.3k+(121)(5k) = 606.3 kΩ **[1, 0.5]**

$R_{L7} = R_{c11} \| R_{b8}$ = 706.5k ‖ 606.3k = 326.3 kΩ **[1]**

$r_{o7} = r_{o11} = V_A / I_Q$ = 100/0.307m = 325.7 kΩ **[1]**

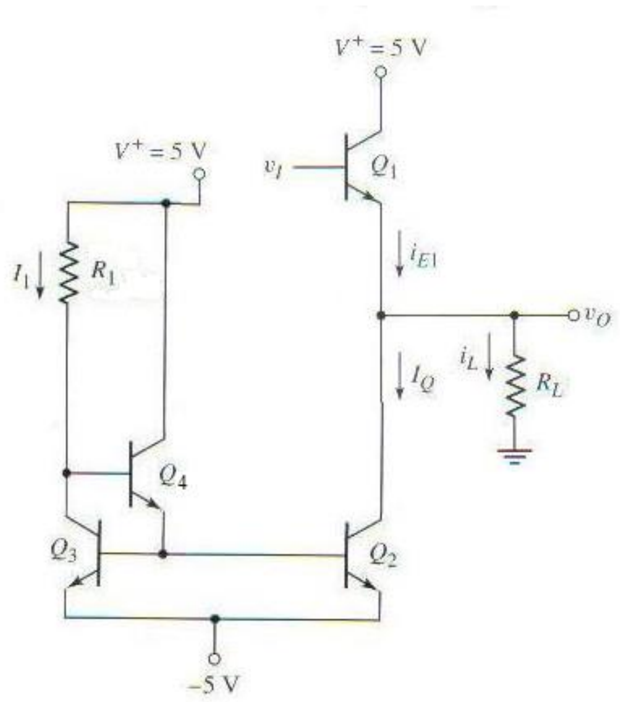
$A_{v2} = [\beta(1+\beta)(r_{o7} \| R_{L7})] / R_i$

A_{v2} = [(120)(121)(326.3k‖325.7k)] / 2.459M = 958.49 **[1]**

QUESTION 4 [25 marks]

Answers for Question 4

4(a)



3-transistor current source	**[2]**
Emitter follower with VI, VO and RL	**[2]**
Correct connection between EF & CS	**[1]**

Answers for Question 4 (Continued)

Answers to QUESTION 4(b) [20 marks]

(i) **Calculation of i_L, i_{Cp}, i_{Cn},** and v_I. **[12 marks]**

$v_O = -4\text{ V} = i_L R_L$

➔ $i_L = v_O / R_L = (-4\text{V})/(1\text{k}\Omega) = -4\text{ mA}$ **[1]**

Therefore, Q_p is conducting and Q_n is OFF.

Approximate value $i_L \approx i_{Cp} = I_S \exp(V_{EBP}/V_T) = 4\text{ mA}$ **[1]**

$V_{EBP} = V_T \ln(i_{Cp}/I_S) = (26\text{m}) \ln(4\text{m}/2\text{x}10^{-15}) = 0.7364\text{ V}$ **[1]**

$V_{BEN} = V_{BB} - V_{EBP} = 1.4 - 0.7364 = 0.6636\text{ V}$ **[1]**

➔ $i_{Cn} = I_S \exp(V_{BEN}/V_T) = (2\text{x}10^{-15}) \exp(0.6636/0.026) = 0.2429\text{ mA}$ **[1]**

$i_{Cn} = i_{Cp} + i_L$ **[1]**

Actual value of $i_{Cp} = i_{Cn} - i_L = 0.2429\text{m} - (-4\text{m}) = 4.2429\text{ mA}$ **[1]**

$V_{EBP} = V_T \ln(i_{Cp}/I_S) = (26\text{m}) \ln(4.2429\text{ m}/2\text{x}10^{-15}) = 0.73796\text{ V}$ **[1]**

$V_{BEN} = V_{BB} - V_{EBP} = 1.4 - 0.73796 = 0.66204\text{ V}$ **[1]**

➔ $i_{Cn} = I_S \exp(V_{BEN}/V_T) = (2\text{x}10^{-15}) \exp(0.66204/0.026) = 0.2288\text{ mA}$ **[1]**

$v_I = v_O + V_{BEN} - V_{BB}/2 = -4 + 0.66204 - 0.7 = -4.03796\text{ V}$

OR $v_I = v_O - V_{EBP} + V_{BB}/2 = -4 - 0.73796 + 0.7 = -4.03796\text{ V}$ **[2]**

(ii) Calculation of power dissipation in transistor Q_n and Q_p: **[8 marks]**

$P_{Qn} = i_{Cn} V_{CEn}$ **[2]**

$V_{CEn} = +V_{CC} - v_O = +6 - (-4) = 10\text{ V}$ **[1]**

➔ $P_{Qn} = (0.2288\text{ mA})(10\text{ V}) = 2.288\text{ mW}$ **[1]**

$P_{Qp} = i_{Cp} V_{ECp}$ **[2]**

$V_{ECp} = v_O - (-V_{CC}) = -4 - (-6) = 2\text{ V}$ **[1]**

➔ $P_{Qp} = (4.2429\text{ mA})(2\text{ V}) = 8.4858\text{ mW}$ **[1]**