Name:

Student ID Number:

Section Number: 01/02/03/04/05/06 A/B

Lecturer: Dr Azni Wati/ Dr Fazrena Azlee/

Dr Jehana Ermy/ Dr Jamaludin

Table Number:

UNIVERSITI TENAGA NASIONAL

College of Engineering

Department of Electronics and Communication Engineering

Test 2 SOLUTION

SEMESTER 1, ACADEMIC YEAR 2017/2018

Subject Code	:	**EEEB273**
Course Title	:	**Electronics Analysis & Design II**
Date	:	**19 August 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!** ☺

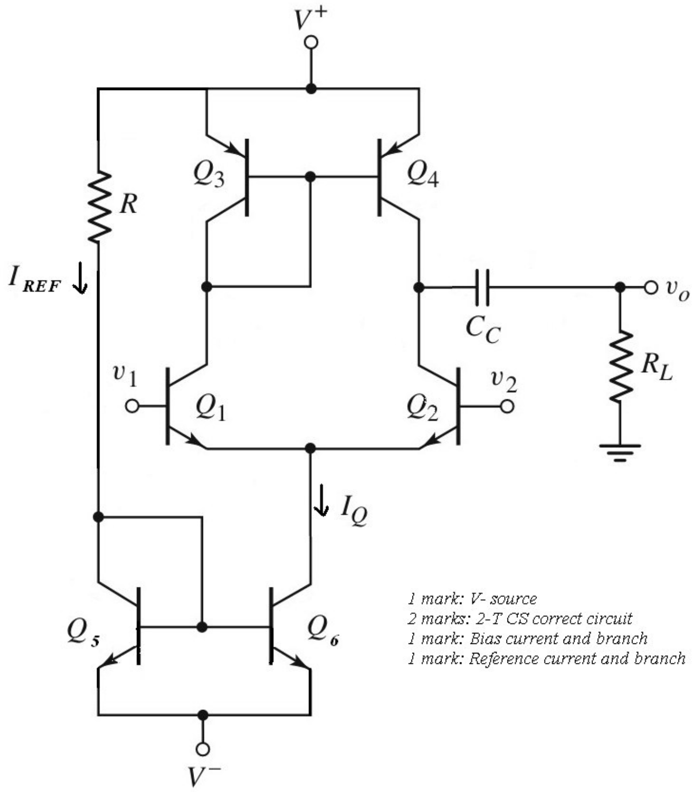
Question Number	Q1	Q2	Q3	Q4	Total
Marks					

QUESTION 1 [20 marks]

Answers for Question 1 (Continued)

Answer Guide:

(a)



1 mark: V- source
2 marks: 2-T CS correct circuit
1 mark: Bias current and branch
1 mark: Reference current and branch

(b)

$v_O = g_m v_d (r_{O2}||r_{O4})$ [1.5]

$A_d = \frac{v_O}{v_d} = g_m (r_{O2}||r_{O4})$ [1]

$g_m = \frac{I_Q/2}{V_T} = \frac{0.25m/2}{0.026} = 4.808 mA/V$ [1.5]

$r_{O2} = \frac{V_{AN}}{I_Q/2} = \frac{120}{0.125m} = 960\ k\Omega$ [2]

$r_{O4} = \frac{V_{AP}}{I_Q/2} = \frac{100}{0.125m} = 800\ k\Omega$ [2]

$r_{O2}||r_{O4} \rightarrow \frac{960k \times 800k}{960k + 800k} = 436.4\ k\Omega$ [1]

$A_d = 4.808\ m\ \times 436.4\ k = 2098$ [1]

(c)

$v_O = g_m v_d (r_{O2}||r_{O4}||R_L)$ [1]

$A_d = \frac{v_O}{v_d} = g_m (r_{O2}||r_{O4}||R_L)$ [1]

$r_{O2}||r_{O4}||R_L \rightarrow \frac{436.4k \times 150k}{436.4k + 150k} = 111.63 k\Omega$ [2]

$A_d = 4.808\ m\ \times 111.63\ k = 536.7$ [1]

QUESTION 2 [35 marks]

Answers for Question 2 (Continued)
2a) 12 marks

$I_{set} = I_{DF} = \frac{V^+ - V^- - V_{SGF}}{R_{set}} = \frac{5-(-5)-V_{SGF}}{15k}$ [1]

$I_{DF} = K_{pF}(V_{SGF} + V_{TP})^2$ = 0.5(20u)(10)(VSGF -2)^2 [1]

Simulataneous equation: 10-VSGF = (15k)(0.5)(20u)(10)(VSGF -2)^2
= > VSGF = 4V, -0.67V. [2]

Choose VSGF = 4V, since > |VTP| [1]
Iset = (10-4)/15k = 0.4mA [1]
Iset = IQ since W/L for ME and MF are the same [1]

IDA = IDC = IQ/2 = 0.4m /2 = 0.2mA [1]

IDA = KPA(VSGA+VTP)^2 =0.2mA
⇨ VSGA = -2 + SQRT(0.2m/(10u)(20)) = 3V [2]

IDC = KNC(VGSC-VTN)^2 =0.2mA
⇨ VGSC = 2 + SQRT(0.2m/(20u)(15)) = 2.82V [2]

2b) 8 marks

$A_d = g_{mA}\left(r_{oB} \| r_{oD}\right)$ [2]

$g_{mA} = 2\sqrt{K_{PA} I_{DA}} = 2\sqrt{\left(\frac{k_p'}{2}\right)\left(\frac{W}{L}\right)_A I_{DA}} = 2\sqrt{\left(\frac{20\mu}{2}\right)(20)(0.4m)} = 0.4mA/V$ [1]

$r_{oB} = \frac{1}{\lambda_p I_{DB}} = \frac{1}{(0.02)(0.2m)} = 250\Omega$ [2]

$r_{oD} = \frac{1}{\lambda_n I_{DD}} = \frac{1}{(0.01)(0.2m)} = 500k\Omega$ [2]

$A_d = (0.4m)(250k \| 500k) = 66.67V/V$ [1]

2c) 5 marks

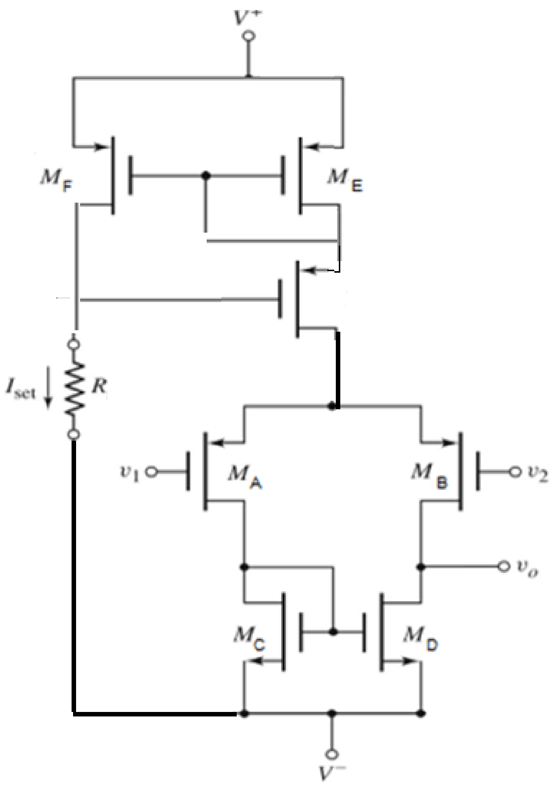
$A_{dnew} = g_{mA}\left(r_{oB} \| r_{oD} \| R_{in2}\right)$ [2]

$A_{dnew} = (0.4m)(167.7k \| 200M) \approx 66.67V/V$ [1]

Av = AdxAv2 = 66.67 x 80 = 5330 V/V [2]

2d) 5 marks

3rd transistor between ME and diff-pair [2]
Correct connection for Wilson current source [2]
Correction connection between Wilson output node and diff pair [1]



2e) 5 marks

Advantage of Wilson over 2T:
Increased Ro, [2] hence CMRR of diff –amp will increase [1]

Disadvantage of Wilson over 2T:
Since additional transistor, decreased input and/or output voltage swing [2]

QUESTION 3 [20 marks]

(i) $v_{o(min)} = V^{-} + C_{E2(\text{sat})}$ = -5 + 0.38 = -4.62 V [2]

$v_{o(max)} = V^{+} - C_{E1(\text{sat})}$ = 7 – 0.38 = 6.62 V

BUT for symmetrical swing of class-A, $v_{o(max)} = |\, v_{o(min)}|$ = +4.62 V [2]

(ii) $I_Q = |\, v_{o(min)}/R_L|$ = 4.62/1k = 4.62 mA [2]

(iii) iE1 = IQ +IL [1]

iE1 (max) = IQ + Vo(max)/RL = 2IQ = 9.24mA [1.5]

iE1 (min) = IQ + Vo(min)/RL = 0 [1.5]

(iv) $v_{I(max)} = v_{o(max)} + V_{BE}$ = 4.62 + 0.7 = 5.32 V [1.5]

$v_{I(min)} = v_{o(min)} + V_{BE}$ = -4.62 + 0.7 = -3.92 V [1.5]

(v) $\eta = (\overline{P_L}) / (\overline{P_S})$ x 100 % [1]

$(\overline{P_L}) = Vp^2/2R_L = (4.62)^2/(2)(1k)$ = 10.67 mW [3]

$(\overline{P_S}) = (\overline{P_S}^{+} + \overline{P_S}^{-}) = (7)\, I_Q + 2\,(5) I_Q$ = 2[(0-(-5)](4.62m) = 78.54mW [2]

η = 10.67/78.54 x 100% = 13.6% [1]

QUESTION 4 [25 marks]

Answers for Question 4

$$I_{C6} = \frac{\beta}{1+\beta} I_{E6} = \frac{\beta}{1+\beta} I_{B7} = \frac{\beta}{1+\beta}\frac{I_{C7}}{\beta} = \frac{I_{C7}}{1+\beta} \quad [3]$$

$$I_{C6} = \frac{0.2\text{m}}{101} = 0.00198\,\text{mA} = 1.98\,\mu\text{A} \quad [2]$$

$$R_i = r_{\pi 6} + r_{\pi 7}(1+\beta) \quad [2]$$

$$r_{\pi 7} = \frac{\beta V_T}{I_{C7}} = \frac{100(26\text{m})}{0.2\text{m}} = 1.3\text{k}\Omega \quad [2]$$

$$r_{\pi 6} = \frac{\beta V_T}{I_{C6}} = \frac{(1+\beta)\beta V_T}{I_{C7}} = \frac{(101)100(26\text{m})}{0.2\text{m}} = 1.313\text{M}\Omega \quad [2]$$

$$R_i = \frac{2(1+\beta)\beta V_T}{I_{C7}} = \frac{2(101)(100)(26\text{m})}{0.2\text{m}} = 2.626\,\text{M}\Omega \quad [1]$$

$$R_{L7} = R_{c11} \parallel R_{b8} \quad [2]$$

$$R_{c11} = r_{o11} = V_{A11} / I_{C11} = 100 / 0.2\text{m} = 500\,\text{k}\Omega \quad [3]$$

$$R_{b8} = r_{\pi 8} + (1+\beta)R_2 \quad [2]$$

$$r_{\pi 8} = \frac{\beta V_T}{I_{C8}} = \frac{100(26\text{m})}{1.3\text{m}} = 2\,\text{k}\Omega \quad [2]$$

$$R_{b8} = 2\text{k} + 101(12\text{k}) = 1.214\,\text{M}\Omega \quad [1]$$

$$R_{L7} = 500\text{k} \parallel 1.214\text{M} = 354.14\,\text{k}\Omega = 0.35414\,\text{M}\Omega \quad [1]$$

$$A_v = \frac{\beta(1+\beta)R_{L7}}{R_i} = \frac{100(101)(0.35414\text{M})}{2.626\text{M}} = 1362.077 \quad [2]$$