Name:
Student ID Number:
Section Number: 01/02/03 A/B
Lecturer: Dr Fazrena Azlee/ Dr Jamaludin/
Dr Ahmad Wafi
Table Number:

UNIVERSITI TENAGA NASIONAL

The National Energy University

College of Engineering

Department of Electrical and Electronics Engineering

Test 1

SEMESTER 1, ACADEMIC YEAR 2019/2020

Subject Code	:	**EEEB2014/EEEB273**
Course Title	:	**Electronics Analysis & Design II**
Date	:	**13 July 2019**
Time Allowed	:	**2 hours**

Instructions to the candidates:

1. Write your Name and Student ID Number. Indicate your Section Number and Lecturerôs 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(a)	Q1(b-d)	Q2(a)	Q2(b)	Q3(a)	Q3(b,c)	Total
Marks							

BASIC FORMULA FOR TRANSISTOR

BJT

$i_C = I_S e^{v_{BE}/V_T}$; npn

$i_C = I_S e^{v_{EB}/V_T}$; pnp

$i_C = \alpha i_E = \beta i_B$

$i_E = i_B + i_C$

$$\alpha = \frac{\beta}{\beta + 1}$$

; Small signal

$\beta = g_m r_\pi$

$$g_m = \frac{I_{CQ}}{V_T}$$

$$r_\pi = \frac{\beta V_T}{I_{CQ}}$$

$$r_o = \frac{V_A}{I_{CQ}}$$

$V_T = 26\,\text{mV}$

MOSFET

; N – MOSFET

$v_{DS}(\text{sat}) = v_{GS} - V_{TN}$

$i_D = K_n[v_{GS} - V_{TN}]^2$

$$K_n = \frac{k_n'}{2} \cdot \frac{W}{L}$$

; P – MOSFET

$v_{SD}(\text{sat}) = v_{SG} + V_{TP}$

$i_D = K_p[v_{SG} + V_{TP}]^2$

$$K_p = \frac{k_p'}{2} \cdot \frac{W}{L}$$

; Small signal

$g_m = 2\sqrt{K_n I_{DQ}}$; N - MOSFET

$g_m = 2\sqrt{K_p I_{DQ}}$; P - MOSFET

$$r_o \cong \frac{1}{\lambda I_{DQ}}$$

Quadratic formula :

$$Ax^2 + Bx + C = 0 \quad \rightarrow \quad x = \frac{-B \pm \sqrt{B^2 - 4AC}}{2A}$$

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

QUESTION 1 [35 marks]

For all BJT current sources in this question, assume that all transistors are matched with parameters β **= 50**, $V_{BE(ON)}$ **= 0.7 V**, and V_A **= 150 V**. Other parameters are: V^+ **= 10 V,** V^- **= -10V and** I_{REF} **= 1mA**

(a) Draw **npn based Three-transistor Current Source, Wilson Current Source and Cascode Current Source**. **Clearly indicate and label all components** for each current sources **[10 marks]**

(b) Calculate the resistor value R_1 in for the **Three-transistor and Wilson current sources ONLY** **[6 marks]**

(c) **Calculate** the **output current (**I_O**)** and **output Resistance (**R_O**)** for the **current mirror given in part (b)** **[12 marks]**

(d) **Find** the change in **output current (**dI_O**)** as the **output voltage** for the two BJT current sources given in **part (b) changes by from 1V to 6V**. **[7 marks]**

Answers for Question 1

Answers for Question 1 (Continued)

QUESTION 2 [30 marks]

(a) **Draw and label** clearly a **Cascode MOSFET** current mirror using **N-MOSFET** devices M_1 to M_4 with additional transistor M_5 is used to establish I_{REF}. The current mirror is powered by $V^+ = +5$ **V** and $V^- = -5$ **V** power supplies. **[5 marks]**

(b) **Figure 1** shows a **two-transistor MOSFET** current mirror with I_{REF} is established using another **MOSFET** M_3. The transistor parameters are: $V_{TP} = -0.4$ **V**, $k'_p = 60$ μ**A/V**^{2}, and $\lambda = 0$. The transistor width-to-length ratios are $(W/L)_1 = 25$, $(W/L)_2 = 15$ and $(W/L)_3 = 5$.

i) **Determine** I_O, I_{REF}, V_{SG1} and V_{SG3}. **[17 marks]**

ii) **Calculate** the maximum value of V_{D2} and the largest value of R such that M_2 remains biased in the saturation region. **[8 marks]**

Answers for Question 2

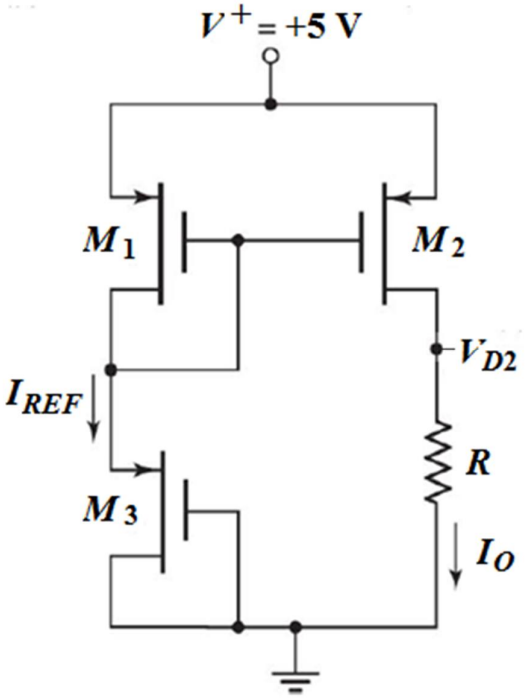

Figure 1

Answers for Question 2 (Continued)

QUESTION 3 [35 marks]

(a) Draw a complete circuit diagram for a **PNP** differential amplifier with resistive load biased by a **Widlar** current source. **Label the diagram clearly**, showing all necessary currents, resistors, and **PNP** BJTs used in the circuit. Explain why the Widlar current source has an **advantage** over the basic two transistor current source. **[10 marks]**

(b) Figure 2 shows a basic BJT differential pair, biased by a constant current source I_Q. Assume that $\mathbf{Q_1}$ and $\mathbf{Q_2}$ are matched pair and operating at the same temperature.

(i) By defining $v_d = v_{BE1} - v_{BE2}$

Show that $i_{C1} = \dfrac{I_Q}{1+e^{-v_d/V_T}}$ and $i_{C2} = \dfrac{I_Q}{1+e^{+v_d/V_T}}$ **[6 marks]**

(ii) What happen when differential-mode input voltage (v_d) is zero? Show how the answer is obtained and explain your answer. **[4 marks]**

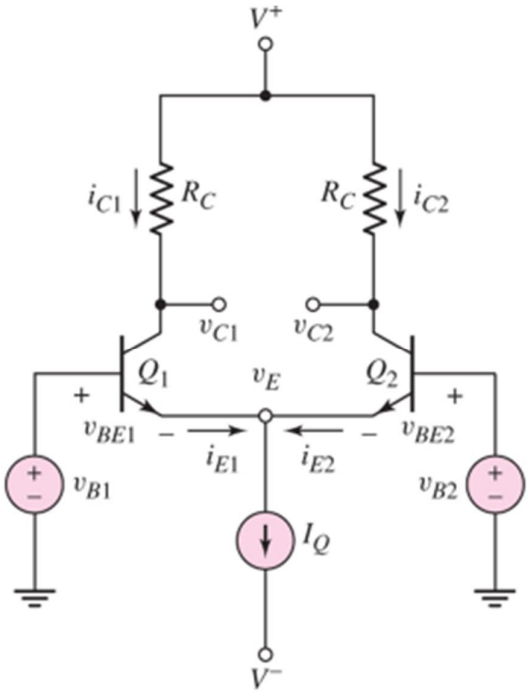

Figure 2

(c) For the differential amplifier shown in **Figure 2**, the circuit parameters are V^+ **= 5 V,** V^- **= -5 V** and R_C **= 15 kΩ**. For all transistors: **β = 100** and $\mathbf{V_A = 200V}$. The constant-current source $\mathbf{I_Q}$ is a **cascode** current source with output current of **2 mA**.

(i) **Calculate** the one-sided differential-mode gain (A_d). **[5 marks]**

(ii) **Determine** the differential-mode input resistance (R_{id}) and the common-mode input resistance (R_{icm}). **[6 marks]**

(iii) It is given for the inputs, $v_1 = 200 \times 10^{-6} \sin \omega t$ **V** and $v_2 = -200 \times 10^{-6} \sin \omega t$ **V**. **Calculate** the output voltage v_o. **[4 marks]**

Answers for Question 3

Answers for Question 3 (Continued)

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