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:

UNIVERSITI TENAGA NASIONAL

The National Energy University

College of Engineering

Department of Electronics and Communication Engineering

Test 1

SEMESTER 1, ACADEMIC YEAR 2018/2019

Subject Code	:	**EEEB273**
Course Title	:	**Electronics Analysis & Design II**
Date	:	**7 July 2018**
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 (a)	Q1 (b)	Q2 (a)	Q2 (b)	Q3 (a)	Q3 (b)	Q4 (a-c)	Q4 (d)	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

$i_C = \alpha i_E = \beta i_B$

$i_E = i_B + i_C$

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

; Small signal

$\beta = g_m r_\pi$

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

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

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

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

MOSFET

; N – MOSFET

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

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

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

; P – MOSFET

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

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

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

; Small signal

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

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

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

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]

(a) **List the advantage(s)** of:

(i) A basic **three-transistor** BJT current source as compared to a **two-transistor** BJT current source. **[2 marks]**

(ii) A **Wilson** BJT current source as compared to a basic **three-transistor** BJT current source. **[2 marks]**

(iii) A **cascode** BJT current source as compared to a **Wilson** BJT current source. **[2 marks]**

(iv) A **Widlar** current source as compared to a **two-transistor** BJT current source. **[4 marks]**

(b) Consider a **modified three-transistor BJT current source** as in **Figure 1**. Transistor parameters are V_{BE}**(on) = 0.7 V,** $V_A = \infty$, and β **= 80**. *Hint: Please take note of the current directions given in the* **Figure 1**.

(i) **Show** that

$$I_{REF} - \frac{V_{BE}}{(1+\beta)R_2} = I_O\left(1 + \frac{2}{\beta(1+\beta)}\right)$$ **[15 marks]**

(ii) For R_2 **= 10 kΩ**, V^+ **= 10 V**, and I_O **= 0.70 mA**, find I_{REF} and R_1. **[10 marks]**

Answers for Question 1

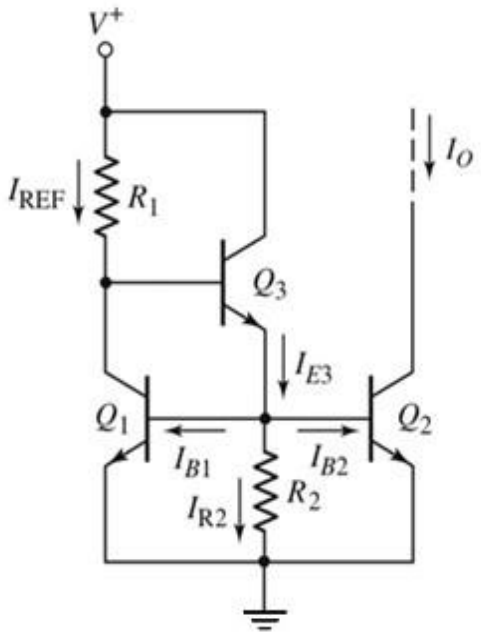

Figure 1

Answers for Question 1 (Continued)

QUESTION 2 [20 marks]

For a **MOSFET** current source the bias voltages are $V^+ = 2.5$ **V** and $V^- = 0$ **V**. Transistors are available with the parameters: $k'_n = 120\ \mu$**A** /**V**^{2}, $V_{TN} = 0.4$ **V**, and $\lambda = 0$.

(a) **Draw and label** completely a NMOS current source, M_1 and M_2, with M_3 acting as a physical resistor. **[10 marks]**

(b) **Design** the circuit such that $I_{REF} = 100\ \mu$**A**, $I_O = 50\ \mu$**A**, and V_{DS2}**(sat) = 0.6 V**.

[10 marks]

Answers for Question 2

Answers for Question 2 (Continued)

QUESTION 3 [25 marks]

(a) **Draw** a complete circuit diagram for an **NPN** differential amplifier with resistive load biased by a **cascode** current source. Transistors Q_1 and Q_2 are used in the differential amplifier while transistors Q_3 until Q_6 are used in the **cascode** current source. **Label the diagram clearly**, showing all necessary currents, resistors, and **NPN** BJTs used in the circuit.

[5 marks]

Answers for Question 3(a)

(b) The differential amplifier in **Figure 2** is biased with a three-transistor current source as shown. The transistor parameters are: $\boldsymbol{\beta}$ **= 40,** $\boldsymbol{V_{BE}}$**(on) = 0.7 V, and** $\boldsymbol{V_{A4}} = \boldsymbol{V_{A5}} = \infty$. **Determine** $\boldsymbol{R_1}$ if $\boldsymbol{V_{CE4}}$ **= 1.8 V**. **[20 marks]**

Answers for Question 3(b)

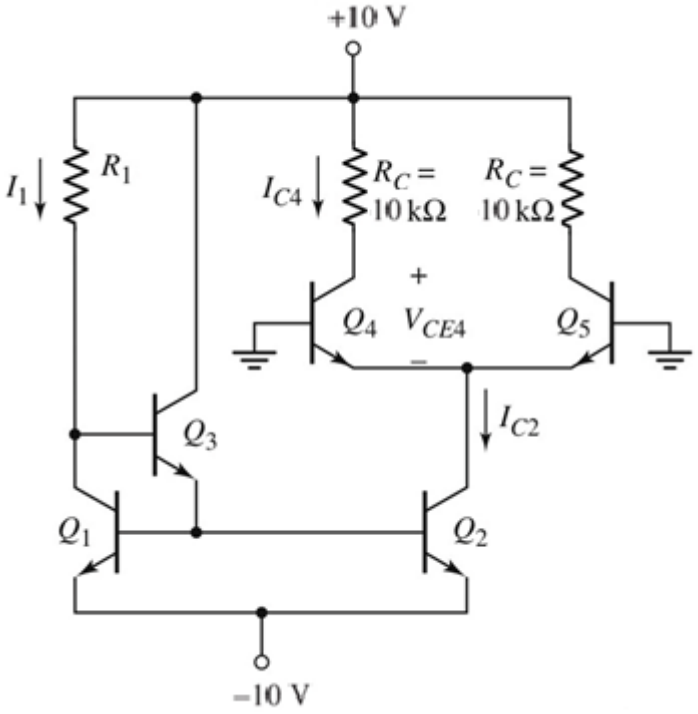

Figure 2

QUESTION 4 [20 marks]

Consider a **BJT differential amplifier** biased with a **Widlar** current source, as shown in **Figure 3**. The transistor parameters are $\beta_1 = 200$ for Q_1 and Q_2, and $\beta_3 = 500$ for Q_3 and Q_4. $V_{A1} = \infty$ for Q_1 and Q_2, and $V_{A3} = 200$ V for Q_3 and Q_4.

From analysis, it is determined that $I_Q = 200$ µA, $v_{O2} = 5$ V, and $CMRR$(dB) = 85 dB.

Given $R_2 = 2$ kΩ.

(a) **Calculate** the value of resistor R_C. **[3 marks]**

(b) **Find** the differential voltage gain (A_d) and common-mode voltage gain (A_{cm}) for one-sided output. **[10 marks]**

(c) **Determine** the differential-mode input resistance (R_{id}) and the common-mode input resistance (R_{icm}). **[5 marks]**

(d) If the circuit is modified such that resistor R_2 **is zero**, will this improve the common mode rejection performance of the differential amplifier? **Justify** your answer. **[2 marks]**

Answers for Question 4

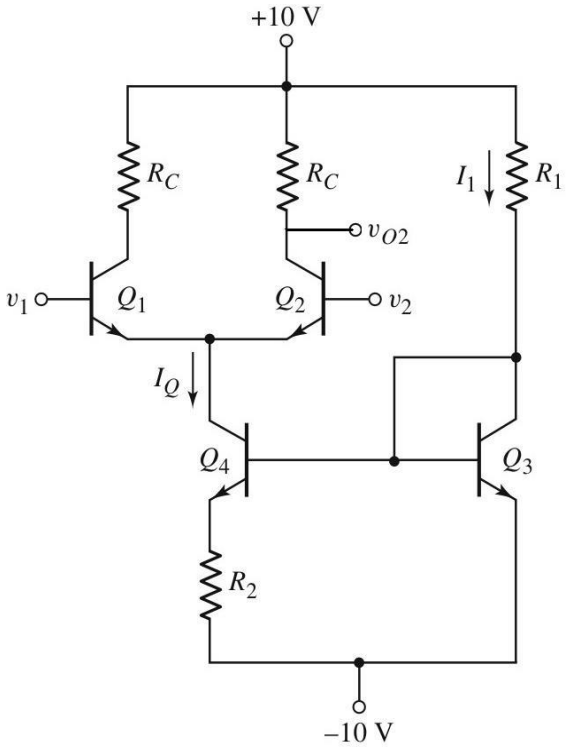

Figure 3

Answers for Question 4 (Continued)

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