Name:
Student ID Number:
Section Number: 01A
Lecturer: Prof Md Zaini & Dr Jamaludin
Table Number:

UNIVERSITI TENAGA NASIONAL

The National Energy University

College of Engineering

Department of Electrical Engineering

Midterm Test

SEMESTER 3, ACADEMIC YEAR 2018/2019

Subject Code	:	**EEEB273**
Course Title	:	**Electronics Analysis & Design II**
Date	:	**5 April 2019**
Duration	:	**2 hours**

Instructions to the candidates:

1. Write your **Name** and **Student ID 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 (bcd)	Q2 (abc)	Q3 (ab)	Q4 (ab)	Total
Marks						
CO	9	1	3	1	2	

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 [25 marks]

You are required to **design** a **Widlar** current source using **NPN** transistors such that $\boldsymbol{I_{REF}}$ **= 2 mA** and $\boldsymbol{I_O}$ **= 50 µA.** Let $\boldsymbol{V^+}$ **= 15 V** and $\boldsymbol{V^-}$ **= 0 V**. The transistor are matched and $\boldsymbol{V_{BE}}$ **= 0.7 V** at **1 mA.**

(a) **Draw** the circuit and **clearly label** all the resistors and transistors. **[4 marks]**

(b) **Derive** the $\boldsymbol{I_{REF}}$ and $\boldsymbol{I_O}$ relationship of the circuit, showing all your steps is getting the relationship. **[6 marks]**

(c) **Design** the circuits and **clearly show all calculations** as marks are given according to this. **[10 marks]**

(d) Given $\boldsymbol{V_A}$ and $\boldsymbol{\beta}$ for $\boldsymbol{Q_2}$ is **100 V** and **50** respectively, **determine** the output resistance, $\boldsymbol{R_O}$, of the **Widlar** current source. **[5 marks]**

Answers for Question 1

Answers for Question 1 (Continued)

QUESTION 2 [25 marks]

Figure 1 shows a differential amplifier has a pair of **PNP** bipolar as **input devices** and a pair of **NPN** bipolar connected as an **active load**. The circuit has $\boldsymbol{I_Q}$ **= 0.2 mA** bias current and the transistor parameters are $\boldsymbol{\beta}$ **= 100** and $\boldsymbol{V_A}$ **= 100 V**.

(a) **Calculate $\boldsymbol{I_O}$** such that the **DC currents** in the diff-amp **are balanced**. **[6 marks]**

(b) **Determine** the **open-circuit** differential-mode voltage gain, $\boldsymbol{A_d}$. **[12 marks]**

(c) **Find** the differential-mode voltage gain if a load resistance $\boldsymbol{R_L}$ **= 250 kΩ** is connected to the output. **[7 marks]**

Answers for Question 2

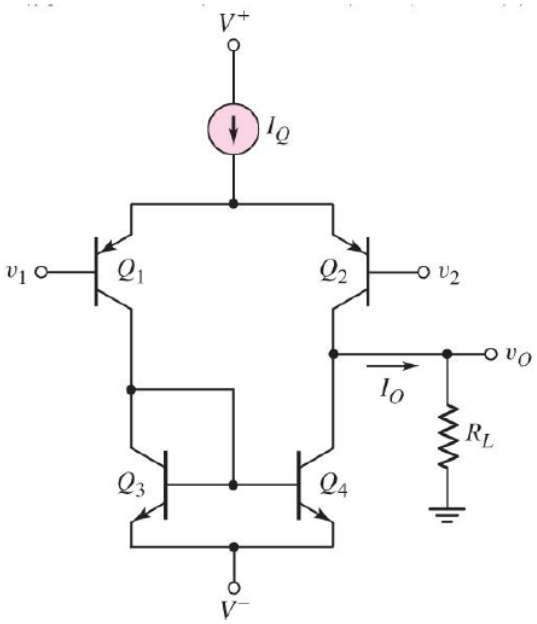

Figure 1

Answers for Question 2 (Continued)

QUESTION 3 [25 marks]

For a **MOSFET current source** circuit shown in **Figure 2**, transistor parameters are V_{TN} **= 0.7 V,** k'_n **= 70 μA/V^2**, and λ **= 0.015 V^{-1}**. The transistor aspect ratios are $(W/L)_1$ **= 20,** $(W/L)_2$ **= 12.5,** and $(W/L)_3$ **= 3**.

(a) **Determine** V_{GS1}, V_{GS3}, I_{REF}, I_O, and V_{DS2} **[15 marks]**

(b) **Find** I_O at V_{DS2} **= 2.5 V** **[10 marks]**

Answers for Question 3

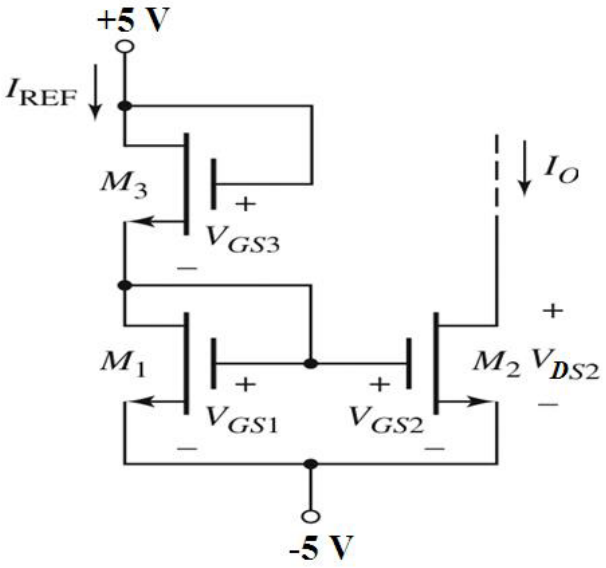

Figure 2

Answers for Question 3 (Continued)

QUESTION 4 [25 marks]

Consider the diff-amp shown in **Figure 3**. The transistor parameters are: $K_{n1} = K_{n2} = 0.1$ **mA/V**^{2} and $K_{n3} = K_{n4} = 0.3$ **mA/V**^{2}. Other parameters for all transistors are $\lambda = 0$ and $V_{TN} = 1$ **V.**

(a) **Find** the values of I_1, I_Q, V_{GS4}, V_{GS2}, v_{O1}, and v_{O2}. **[15 marks]**

(b) **Determine** the maximum range of the common-mode input voltage, i.e. find the values for v_{CM} **(max)** and v_{CM} **(min)**. **[10 marks]**

Answers for Question 4

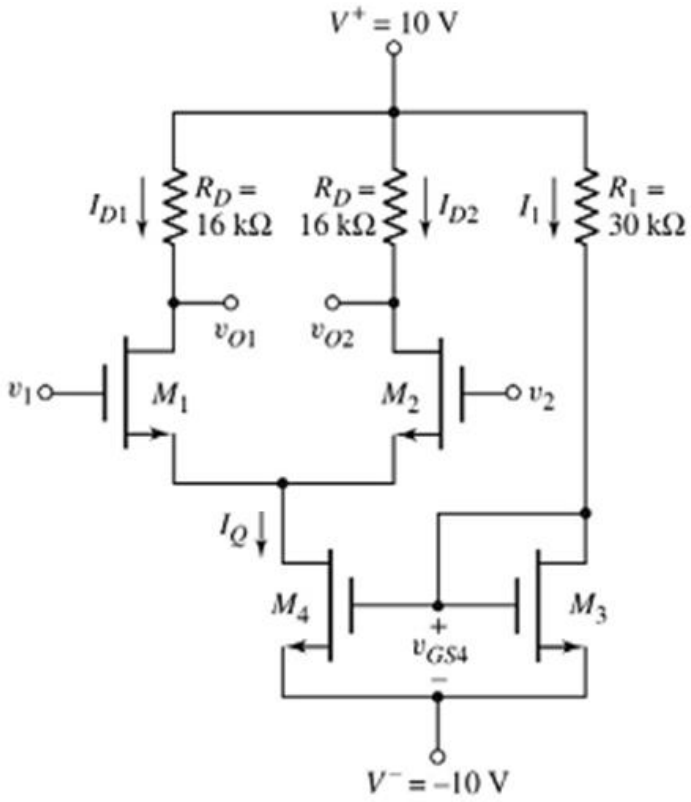

Figure 3

Answers for Question 4 (Continued)

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