Seat Number:

Name:

Student ID Number:

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

Lecturer: **Dr Fazrena / Dr Jamaludin / Dr Azni Wati / Dr Jehana / Ms Zarrin**

UNIVERSITI TENAGA NASIONAL

College of Engineering

Department of Electronics and Communication Engineering

Test 1

SEMESTER 1, ACADEMIC YEAR 2016/2017

Subject Code	:	**EEEB273**
Course Title	:	**Electronics Analysis & Design II**
Date	:	**15 July 2016**
Time Allowed	:	**1½ hour**

Instructions to the candidates:

1. Write your Name and Student ID number. Circle your section number.
2. Write all your answers using pen. **DO NOT USE PENCIL** except for the diagram.
3. **ANSWER ALL QUESTIONS.**
4. **WRITE YOUR ANSWER ON THIS QUESTION PAPER.** Use both sides of the question paper to write your answers.
5. For all calculations, assume that V_T **= 26 mV**.

NOTE: DO NOT OPEN THE QUESTION PAPER UNTIL INSTRUCTED TO DO SO.

☺ **GOOD LUCK!** ☺

Question No.	1	2	3	Total
Marks				

FORMULA FOR TRANSISTORS

BJT

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

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

$$i_C = \alpha i_E = \beta i_B$$

$$i_E = i_B + i_C$$

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

;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

$$g_m = 2\sqrt{K_? I_{DQ}}$$

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

Question 1 **[40 marks]**

(a) The Widlar current source is shown in **Figure 1**. It is given that $\boldsymbol{V^+}$ **= 12V** , $\boldsymbol{V^-}$ **= -12V**, $\boldsymbol{R_1}$ **= 50kΩ** and $\boldsymbol{V_{BE1}}$ **= 0.68V at 1mA.**

i) **By clearly stating any assumptions, derive** the relationship between I_o and I_{REF} for a Widlar current source to achieve the equation below:

[8 marks]

$$I_O R_E = V_T \ln(\frac{I_{REF}}{I_O})$$

ii) **Design** the current source to provide output current of **3μA** by determining I_{REF}, I_{C1}, I_{C2}, V_{BE2} and R_E. [12 marks]

Answers for Question 1(a)

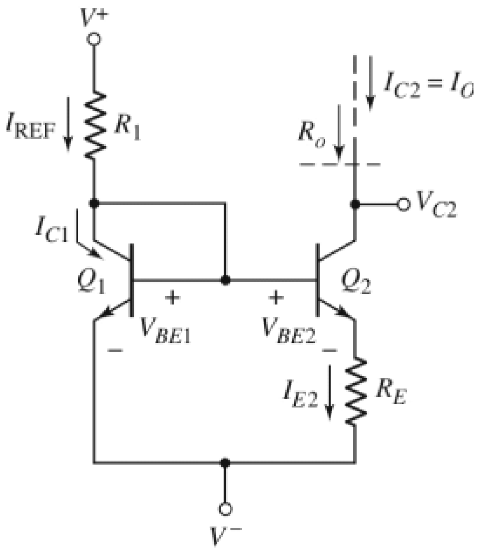

Figure 1

(b) Design a **pnp version of the Wilson current source** using a resistor, R_1, to establish the current, I_{REF}. The circuit parameters are $\boldsymbol{V^+}$ **= 10 V**, $\boldsymbol{V^-}$ **= −10 V**, and the transistor parameters are: $\boldsymbol{V_{EB}(on)}$ **= 0.6 V**, $\boldsymbol{\beta}$ **= 80**, and $V_A = \infty$**.**

i) **Sketch** the circuit of the design. [8 marks]

ii) What is I_{REF}, if the load current, $\boldsymbol{I_O}$ **is 0.8 mA**? [8 marks]

iii) **Compare and contrast** the **stability** of the **Wilson current source** to a **three-transistor current source**. [4 marks]

Answers for Question 1(b)

<u>Question 2</u> **[30 marks]**

(a) Consider the basic two-transistor NMOS current source in **Figure 2**. The circuit parameters are V^+ **= 2.5V**, V^- **= -2.5V**, and I_{REF} **= 120μA**. The transistor parameters are V_{TN} **= 0.8 V**, k'_n **= 80 μA/V²**, $(W/L)_1$ **= 3**, $(W/L)_2$ **= 4.5**, and λ **= 0.01 V⁻¹**. Calculate I_{D2} at V_{DS2} = **3 V**.

[15 marks]

(b) **<u>Redesign</u>** the NMOS current source circuit in **Figure 2** such that the **minimum voltage at** V_{D2} **= -2.0 V**, I_{REF} **= 60 μA**, and the load current I_O **= 100 μA**. [15 marks]

<u>Answers for Question 2</u>

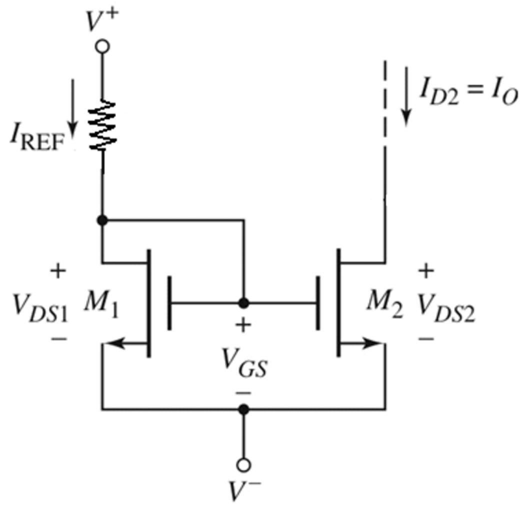

Figure 2

Answers for Question 2 (continued)

Question 3 **[30 marks]**

The basic BJT differential pair is shown in **Figure 3**. The circuit parameter values are: V^+ **= +12 V**, V^- **= -12 V,** I_Q **= 1.2 mA,** and R_C **= 12 kΩ**. The transistor parameters in the differential pair are β = ∞ (neglect base currents), V_A = ∞, and V_{BE} (on) = **0.7 V**. The constant current source in **Figure 3** that is providing the current I_Q is implemented using the **cascode current source**.

(a) **Sketch the full differential pair circuit** that includes the circuit for the **cascode current source**. [10 marks]

(b) **Determine** i_{C1} and v_{CE2} for common-mode voltages $v_{B1} = v_{B2} = v_{CM}$ = **-3.5 V**. [10 marks]

(c) It is given that the input voltages for the differential amplifier are v_{B1} **= 210 x** 10^{-6} **sin ωt** V and v_{B2} **= 180 x** 10^{-6} **sin ωt** V. **Calculate** the differential-mode input voltage **(**v_d**)** and common-mode input voltage **(**v_{cm}**)** of the differential amplifier. Then, find the **maximum and minimum values of** v_d and v_{cm}. [10 marks]

Answers for Question 3

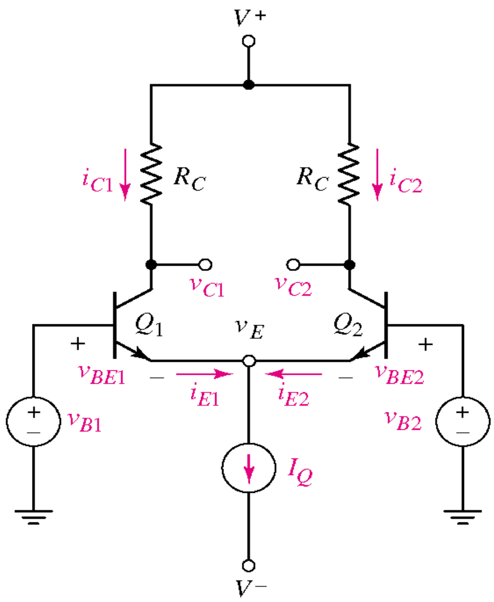

Figure 3