الجامعة الإسلامية العالمية ماليزيا

INTERNATIONAL ISLAMIC UNIVERSITY MALAYSIA

KULLIYYAH OF ENGINEERING

END OF SEMESTER EXAMINATION
SEMESTER 1, 2019/2020 SESSION

Programme	: **Electrical and Computer Engineering**	Level of Study	: **UG 2**
Time	: **2:30 pm - 5:30 pm**	Date	: **09/01/2020**
Duration	: **3.0 hours**		
Course Code	: **EECE 2313**	Section(s)	: **1-2**
Course Title	: **Electronic Circuits**		

This Question Paper Consists of **6 (Six)** Printed Pages (Including Cover Page) with **5 (Five)** Questions.

<u>INSTRUCTION(S) TO CANDIDATES</u>

DO NOT OPEN UNTIL YOU ARE ASKED TO DO SO

- Total mark of this examination is **100.**
- This examination is worth **50 %** of the total course assessment.
- Answer **ALL QUESTIONS**
- Only approved calculator with **'KoE approved'** sticker is allowed (non-programmable and non-graphical).
- Marks assigned to each question are listed in the margin.
- **Note that one of the conditions to pass the course is to obtain at least 50% of this examination.**

Any form of cheating or attempt to cheat is a serious offence which may lead to dismissal.

All electronics gadgets are prohibited in the exam hall / venue.
(e.g. mobile / smart phones, smart watches, and smart glasses)

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Question 1 (20 marks)

a) Consider the circuit shown in **Fig. 1**, derive the expression (step by step) for the voltage transfer function, $T(s) = v_o(s)/v_i(s)$. Determine the -3 dB corner frequencies of the circuit, considering, $R_1 = 1\ \text{k}\Omega$, $C = 0.1\ \mu\text{F}$, $R_2 = 2\ \text{k}\Omega$ and $R_3 = 4\ \text{k}\Omega$. (8+2)

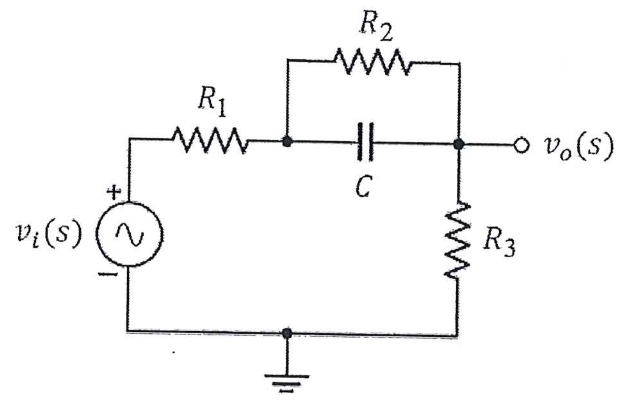

Fig. 1

b) Draw the Bode plots (magnitude and phase) of the following transfer function. (6)

$$T(s) = 10^{-3}\frac{(s + 50)(s + 300)}{s(s + 500)}$$

c) Determine the magnitude and phase of the transfer function from the plots drawn for **Question 1(b)** at frequency $\omega = 450$ radian/sec. (4)

Question 2 (20 marks)

a) Derive the expression for a short circuit high frequency current gain of a BJT (step by step) and prove that the beta frequency expression can be represented by the following expression. (7)

$$f_\beta = \frac{1}{2\pi r_\pi (C_\pi + C_\mu)}$$

b) If the small-signal and high frequency parameters of the BJT are, $r_\pi = 1.5\ \text{k}\Omega$, $\beta = 80$, $C_\pi = 15\ \text{pF}$ and $C_\mu = 10\ \text{pF}$, determine the value of the cutoff frequency, f_T of the transistor. (2)

c) A common source amplifier is shown in **Fig. 2** that operates at very high frequencies. The coupling and bypass capacitors have very large values. The transistor parameters are as follows: $g_m = 20$ mA/V, $r_0 = 50$ kΩ, $C_{gs} = 50$ fF and $C_{gd} = 8$ fF.

i. Draw the simplified high-frequency small signal equivalent circuit diagram and Miller equivalent circuit diagram. (2)

ii. Compute the maximum voltage gain in dB (4)

iii. Determine the Millar capacitance. (2)

iv. Evaluate the upper $-3dB$ higher corner frequency f_H with and without considering the Miller capacitance. (3)

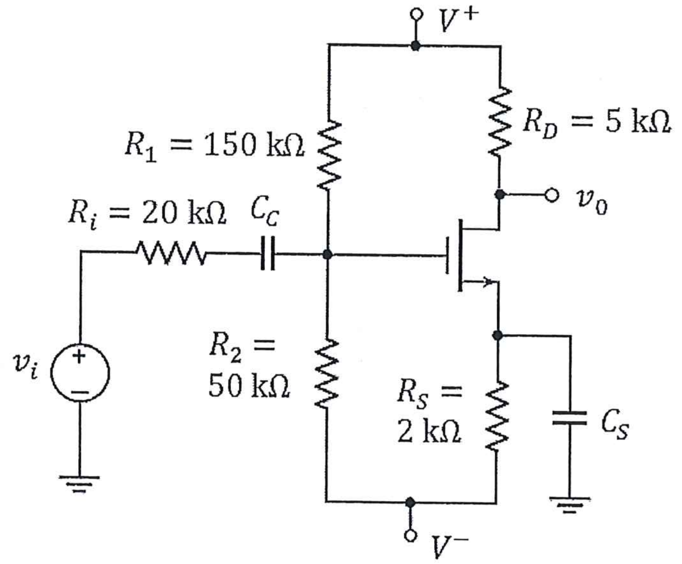

Fig. 2

Question 3 (20 marks)

a) Draw the small-signal equivalent circuit of the Wilson current source as shown in **Fig. 3.** (3)

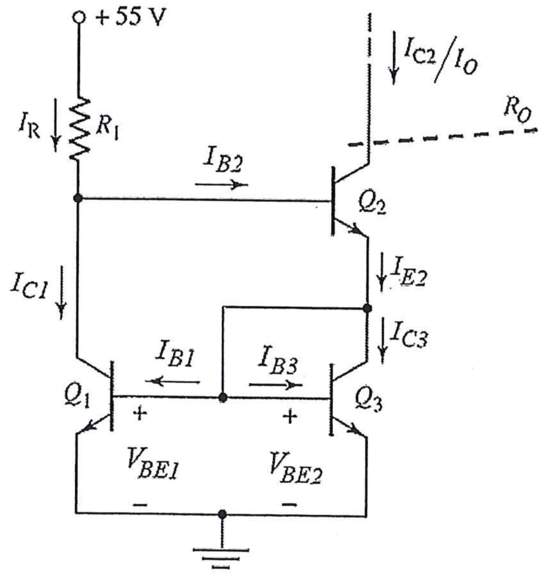

Fig. 3

b) Derive the expression (step by step) for Wilson current source as shown in **Fig. 3** for output current, I_O in terms of I_R and β, assume that all transistors are identical. (6)

c) Design the Wilson current source circuit as shown in **Fig. 3** such that, $I_O = 2.0$ mA. Assume that the transistor parameters are: $V_{BE}(on) = 0.7$ V, $\beta = 50$ and $V_A = \infty$. (3)

d) Design a MOSFET current source shown in **Fig. 4** such that, $I_{REF} = 1.0$ mA, $I_{01} = 4.5$ mA, $I_{02} = 15.0$ mA and $V_{DS4}(\text{sat}) = 3.0$ V. The transistors are available with parameters, $k'_n = 40\ \mu\text{A/V}^2$, $V_{TN} = 1.5$ V and $\lambda = 0$. (8)

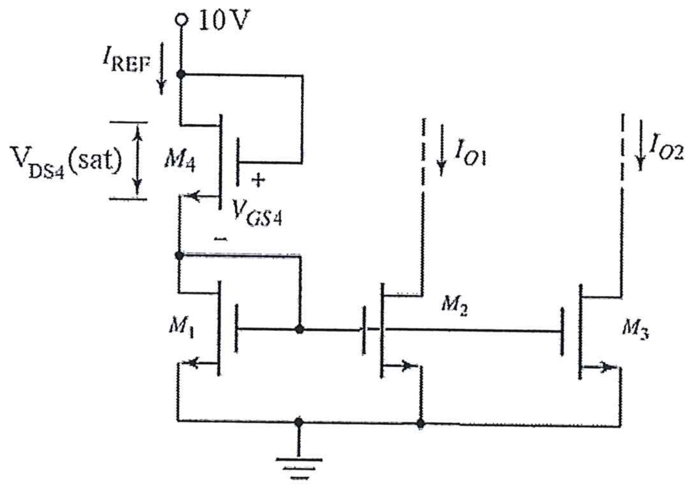

Fig. 4

Question 4 (20 marks)

a) Draw the block diagram and small signal equivalent circuit diagram of a shunt-series ideal feedback amplifier. Analyze the feedback amplifier step by step to find the expression of the closed loop gain, A_f, the input resistance, R_{if} and the output resistance, R_{of} in terms of the open-loop amplifier gain, A and feedback factor, β. (8)

b) The open-loop and closed loop gains of the shunt-series feedback amplifier are, $A = 5 \times 10^3$ and $A_f = 2 \times 10^2$ respectively.

i. Determine the feedback amplifier input resistance, R_{if} and output resistance, R_{of}. Assume that the input and output resistances of the amplifier without feedback are, $R_i = 15$ kΩ and $R_O = 50$ kΩ respectively. (3)

ii. Determine the bandwidth of the amplifier with feedback, given that bandwidth without feedback, $f_{BW} = 20$ kHz. (2)

c) Prove that, the gain sensitivity is improved by using negative feedback. (4)

d) The open loop gain changes of a voltage amplifier is 30%. Calculate the percentage of gain changed when there is a negative feedback. Assume that, the open loop gain and closed loop gain of the amplifier are 4.5×10^5 and 1.5×10^2 respectively. (3)

Question 5 (20 marks)

a) What are the conditions for a sustainable oscillation of an oscillator circuit? (2)

b) A Wien-Bridge oscillator is shown in **Fig. 5**. Derive the equation for the frequency of oscillation, f_O and the minimum gain of the amplifier for sustained oscillation. (14)

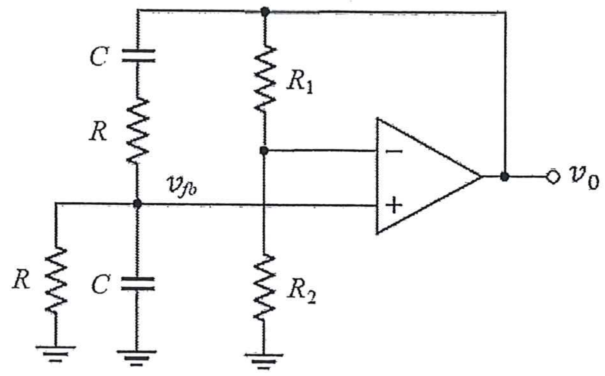

Fig. 5

c) Design a Wien-Bridge oscillator as shown in **Fig. 5,** with oscillation frequency of $f_O = 10$ kHz. (4)

END OF PAPER

APPENDIX

Some Useful Formulas

BJT	MOSFET
$i_C = I_S e^{v_{BE}/V_T}\left(1+\frac{v_{CE}}{V_A}\right)$ $g_m = \frac{I_{CQ}}{V_T}$ $r_\pi = \frac{\beta V_T}{I_{CQ}}$ $r_o = \frac{V_A}{I_{CQ}}$ $V_T = 26\,\text{mV}$ $V_{BE}(on) = 0.7\text{V}$	$I_D = \frac{1}{2}k_n'\left(W/L\right)(V_{GS}-V_{TN})^2(1+\lambda V_{DS})$ $g_m = 2\sqrt{K_n I_{DQ}}$ $r_o = \frac{1}{\lambda I_{DQ}}$ $K_n = \frac{k_n'}{2}\left(\frac{W}{L}\right)$