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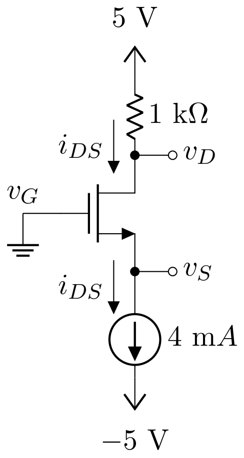
Brac University

Semester: Summer 2022
Course No: CSE251
Course Title: Electronic Devices and Circuits
Section: 1 to 13

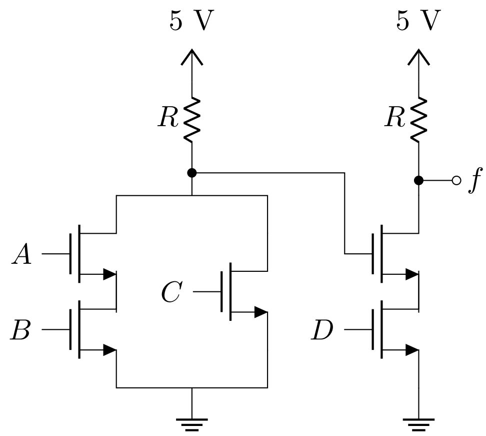
Final Exam
Full Marks: 30
Time: 1 hour 45 minutes
Date: September 21, 2024

Answer **any 3 questions**. All the questions carry equal marks.

Question 1 [CO1, CO2] **10**



Circuit 1



Circuit 2

Part a: Refer to the **Circuit 1** above. For the MOSFET, $V_T = 1$ V and $k = k_n' \frac{W}{L} = 4$ mA/V^2.

(a) **Identify** the value of the gate voltage v_G and the drain-source current i_{DS}. [0.5+0.5]

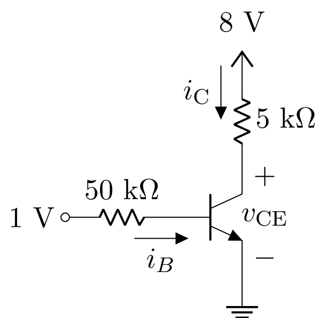
(b) **Calculate** the value of the drain voltage v_D using the 1 kΩ resistor. [1]

(c) **Analyze** the circuit to find v_S. Here, **use** the Method of Assumed State. You must **validate** your assumptions. [Hint: assume $v_S = x$] [3+2]

Part b: **Analyze** the **Circuit 2** above to find f in terms of *boolean* inputs A, B, C, and D. [3]

Question 2 [CO3, CO4] **10**

Part a: **Analyze** the circuit below to find i_C and v_{CE}. Here, **use** the Method of Assumed State. You must **validate** your assumptions. [6]



$\beta = 100$

$\alpha = 0.99$

$v_{BE(\text{Active})} = 0.7$ V

$v_{BE(\text{Saturation})} = 0.8$ V

$v_{CE(\text{Saturation})} = 0.2$ V

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Part b: A BJT common emitter amplifier with $V_S = 20$ V, $\beta = 120$, $R_L = 3$ kΩ and $R_I = 20$ kΩ has an input signal $v_{IN} = V_X + v_i(t)$ and an output signal $v_O = V_Y + kv_i(t)$ where $v_i(t) = 0.2\sin(50\pi t)$.

(i) **Determine** the operating point (V_X, V_Y) for maximum input voltage swing. [3]

(ii) **Calculate** the value of the small signal gain k for the amplifier. [1]

Question 3 [CO1, CO4] **10**

(a) **Show** the IV characteristics graph of both MOSFET (i_D vs v_{DS}) and BJT (i_C vs v_{CE}).
Identify the different operating regions in the graphs. [2+2]

(b) Consider a MOSFET inverter (**SR model**) with the following circuit parameters: $V_S = 5$ V, $R_L = 10$ kΩ. Also, for the MOSFET, $V_T = 1$ V and $1/(k_n' V_{ov}) = 5$. **Determine** a W/L sizing for the MOSFET so that the inverter gate output of logical 0 is able to switch OFF the MOSFET of another inverter. [4]

(c) Consider the static discipline $V_{\mathrm{OL}} = 1.5$ V, $V_{\mathrm{IL}} = 3.5$ V, $V_{\mathrm{IH}} = 4.7$ V, $V_{\mathrm{OH}} = 5.5$ V.
Calculate the noise margins NM_0 and NM_1. [2]

Question 4 [CO1, CO4] **10**

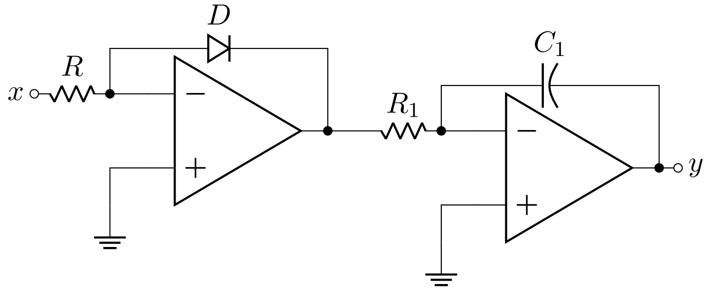
(a) **Design** a circuit using **Op-Amp comparator** to automatically turn ON (or OFF) the street lights. For this, you have a lux sensor installed on top of the street lights (facing above) that outputs a voltage proportional to amount of natural light, as listed below:

$v_{\text{night, 0 lux}} = 1$ V	$v_{\text{dusk, 20 lux}} = 2$ V	$v_{\text{dawn, 80 lux}} = 3$ V

The lights require 20 V and should be ON if the amount of light goes ***below*** 20 lux (at dusk). [3]

(b) **Design** a circuit using Op-Amp to implement the expression: $f = -3\frac{dx}{dt} + 2\exp y + 4z$ [4]

(c) **Analyze** the circuit below to find y as a function of x. For the diode, $I_S R = 1$ and $V_T = 1$. [3]



Equations for MOSFET

$I_D = 0$, if $V_{GS} < V_T$

$I_D = k\left[(V_{GS} - V_T)V_{DS} - \frac{1}{2}V_{DS}^2\right]$, if $V_{GS} \geq V_T$ and $V_{DS} < (V_{GS} - V_T)$

$I_D = \frac{1}{2}k(V_{GS} - V_T)^2$, if $V_{GS} \geq V_T$ and $V_{DS} \geq (V_{GS} - V_T)$