MR-123-(25)

INDIAN INSTITUTE OF TECHNOLOGY KHARAGPUR

End-Autumn Semester Examination 2022-23

Date of Examination: _____ Session: (FN/AN) ____ Duration: 3 hrs. Full Marks: 120

Subject No.: EC 21201 Subject: Basic Electronics

Department/Center/School: E & ECE

Specific charts, graph paper, log book etc., required None

Special Instructions (if any): _____

Answer all questions. Marks for the questions are indicated on the right.

1.

i. In Figure 1, what is the minimum allowable value of V_{DD} if M_1 must not enter the triode region? (assume λ=0, threshold voltage = 0.4V, μCox=200 $\mu A/V^2$) [5]

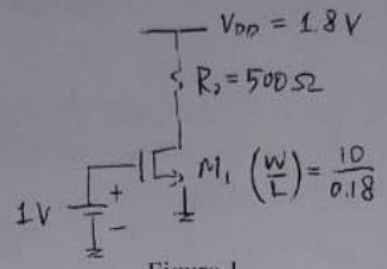

Figure 1

ii. In the circuit in Figure 2, assume the transistor acts as a linear resistor. Determine (W/L) of the transistor such that the circuit attenuates the signal by only 5%. Assume V_G=1.8 V, R_L=100 Ω, threshold voltage = 0.4V, μCox=200 $\mu A/V^2$. [5]

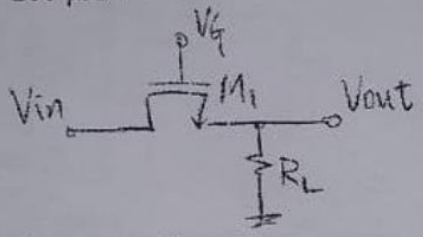

Figure 2

. Sketch Ix as a function of Vx for the two circuits in Figure 3. Assume Vx goes from 0 to V_{DD}=1.8 V. Also show in the plot at what value of Vx the device changes its region of operation (assume V_{TH}=0.4V) [5]

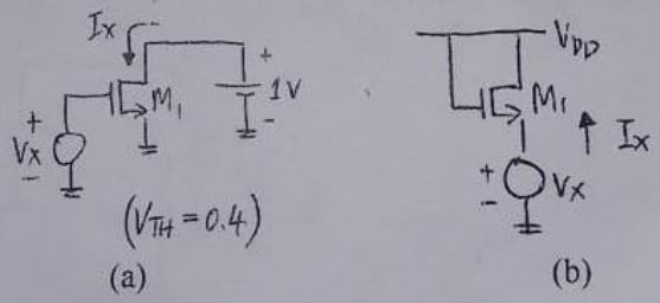

Figure 3

iv. Find out MOSFET current (I_{DS}) and gate source voltage (V_{GS}) for the circuit in Figure 4. Assume λ=0, threshold voltage = 1 V, $\mu Cox(W/L) = 1$ mA V^{-2}. [5]

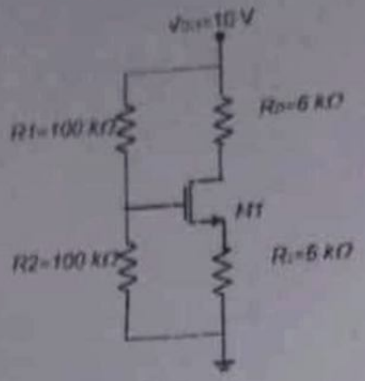

Figure 4

2.

i. For the transistor in the circuit in Figure 5, β=200. Find I_E (emitter current) and V_C (voltage at collector) for (a) V_B=0V, (b) V_B=1V and (c) V_B=2V. (Assume that if transistor is on V_{BE}=0.7V and if transistor is in saturation V_{CE}=0.2V) [10]

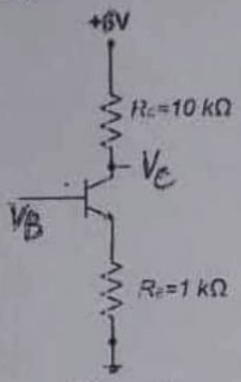

Figure 5

ii. Consider a common emitter circuit using a npn BJT having Is=10^{-15}A at room temperature (assume thermal voltage 26 mV), a collector resistance R_C=6.8 kΩ, and a power supply Vcc=10V. Determine the value of the bias voltage V_{BE} required to operate the transistor at V_{CE}=3.2V. [5]

iii. In the circuit in Figure 6, base collector is at 200 mV reverse bias, Vcc=2.5V and R_E=1 kΩ. Find emitter current I_E (assume V_{BE} = 0.7V). [5]

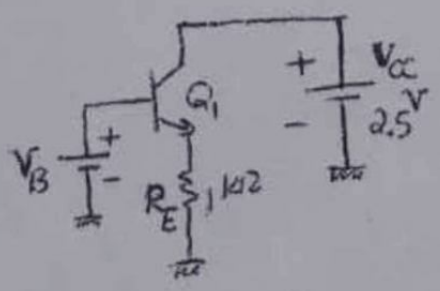

Figure 6

3. For the circuit in Figure 7, beta (β) = 100, Vbe =0.7 V, kT/q = 25 mV. Assume BJT output resistance (ro) is very high.

i. Find out the operating point of the BJT. [10]

ii. Draw the $g_m - \pi$ model of the BJT and find out the voltage gain. [10]

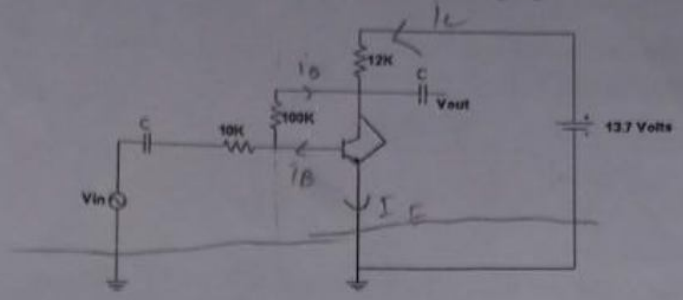

Figure 7

4.

i. In the circuit in Figure 8, the transistor possesses a beta (β) = 65, Early Voltage V_A= 75 V with V_T =26mV. Find the transistor parameters r_π, r_o & g_m. [10]

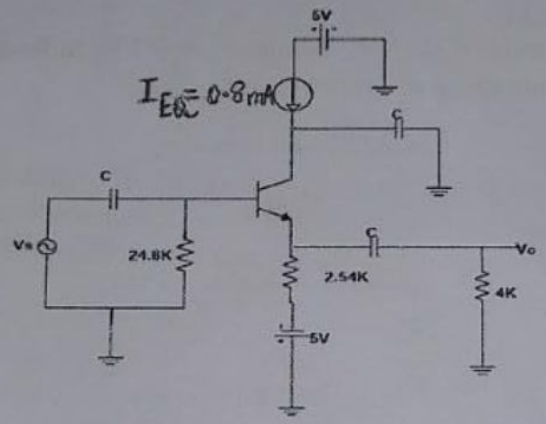

Figure 8

ii. In the circuit in Figure 9, given that beta (β) = 120, r_o=∞, V_{BE}=0.7V and V_T = 26mV. Draw the $g_m - \pi$ model of the BJT and find out the voltage gain. [10]

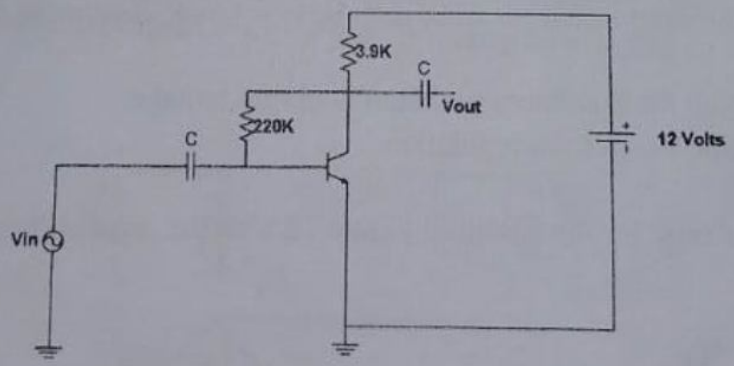

Figure 9

3/4

5.

i. The parameters in the circuit in Figure 10 are $V_\gamma = 0.7$ V, $V_{Z1} = 2.3$ V, and $V_{Z2} = 5.6$ V. Determine v_O versus v_I over the range of $-10 \le v_I \le +10$ V. **[10]**

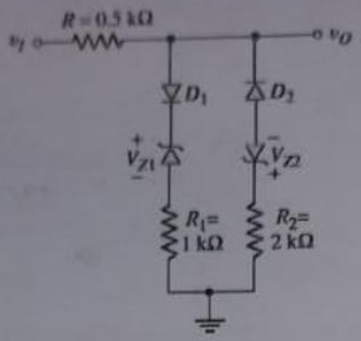

Figure 10

ii. For the circuit in Figure 11,
(a) plot v_O versus v_I for $0 \le v_I \le 15$ V. Assume $V_\gamma = 0.7$ V. Indicate all breakpoints.
(b) Plot i_D over the same range of input voltage. **[10]**

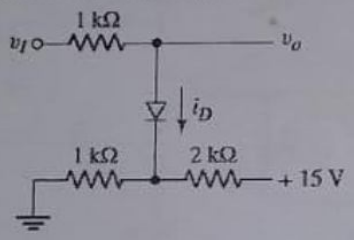

Figure 11

6.

i. A voltage regulator is to have a nominal output voltage of 10 V. The specified Zener diode has a rating of 1 W, has a 10 V drop at $I_Z = 25$ mA, and has a Zener resistance of $r_z = 5\ \Omega$. The input power supply has a nominal value of $V_{PS} = 20$ V and can vary by ±25 percent. The output load current is to vary between $I_L = 0$ and 20 mA. **[10]**

(a) If the minimum Zener current is to be $I_Z = 5$ mA, determine the required input resistance Ri.
(b) Determine the maximum variation in output voltage.
(c) Determine the percent regulation.

ii. Sketch v_o versus time for the circuit in Figure 12 with the input shown. Assume $V\gamma = 0$. **[10]**

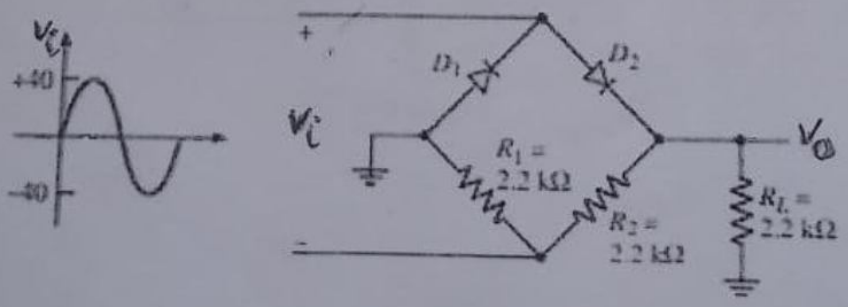

Figure 12