Indian Institute of Technology, Kharagpur -721302

Mid-Semester

Date: FN/AN; Time: 2 hours; Full Marks: 30; Number of Students 204

Spring Semester, 2010-2011; Department: E & ECE; Subject no. EC 21008/EC21010

II year B. Tech.; Subject name: **Analog Electronic Circuits**

Instruction: Answer ***ALL*** questions and in the **same order** of the questions.

Wherever it is necessary, you may use assumption(s) with reasonable justification

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Given: (i) Saturation region drain current of an enhancement mode MOS transistor is,

$$|I_{DS}| = K\left(|V_{GS}| - |V_{th}|\right)^2\left(1 + \lambda|V_{DS}|\right)$$

Where, $K =$ 500 uA/V^2, $|V_{th}| =$ 1.0V and $\lambda \approx 0$ V^{-1}

Given: (ii) Collector current of a bipolar transistor in active region is,

$$|I_{CE}| \approx |I_S| \exp\left(|V_{BE}| / V_T\right)\left[1 + \frac{|V_{CE}|}{V_A}\right]$$

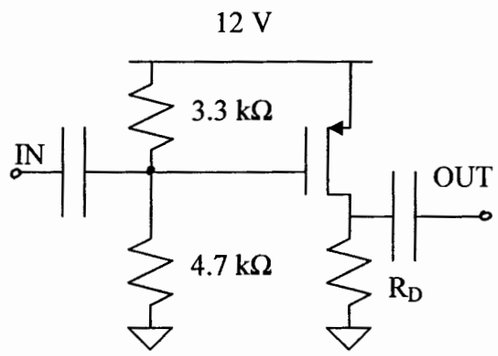
Where, $V_T = 25$mV; $V_A = 50$V; $|V_{BE(on)}| \approx 0.7$V and $|V_{CE(sat)}| \approx 0.3$V

Q.1.

(i) Find the maximum value of R_D so that the transistor is just in saturation region of operation.

(ii) Draw the small signal equivalent circuit and calculate the small signal voltage gain of the amplifier with R_D equal to half of the maximum value obtained in part (i). Assume that the d.c. decoupling capacitors are very high.

(3 + 3)

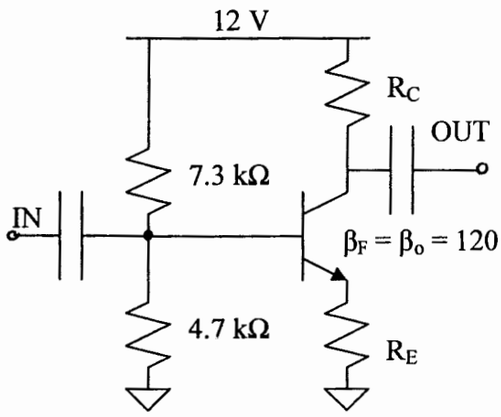


Q.2.

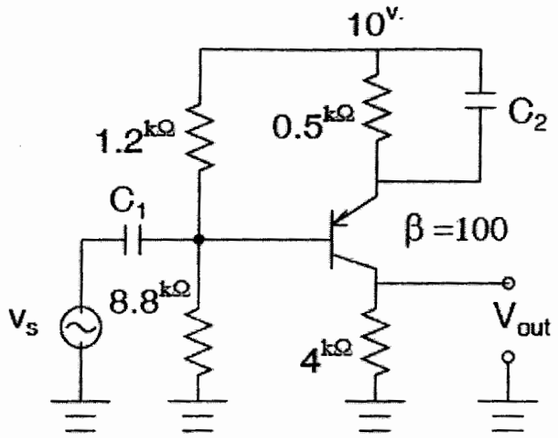
(i) Find the value of R_E and R_C such that the operating point of the transistor is $I_{CQ} = 1$ mA and $V_{CEQ} = 5$ V.

(ii) Calculate the value of small signal gain (v_{out} / v_s) of the circuit in "mid-frequency range" while it is driving a load resistance of 1kΩ.. Assume that the d.c. decoupling capacitors are very high.

(3 + 3)



Q.3.

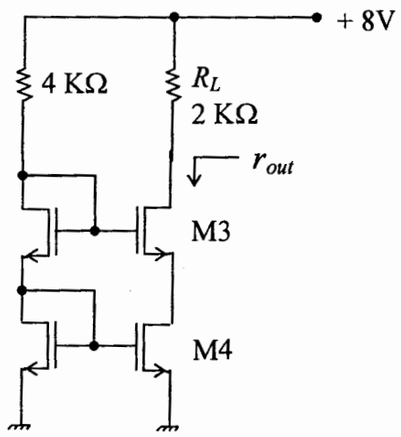


(i) Derive the d.c. operating point of the transistor. Assuming C_1 and C_2 are very high, calculate the upper cut off frequency of the amplifier while it drives a load capacitor of C_L = 120 pF. It is given that $C\pi = C\mu = 5pF$.

(ii) Calculate and neatly sketch V_{out} for $v_s = 10 \sin(2000 \pi t)$ mV.

(3 + 3)

Q.4. In the cascode current mirror circuit, as shown in Fig. Q4, all the transistors are identical and are having the parameters as given at the beginning of the question paper. However, for MOS transistors M3 and M4, assume $\lambda = 0.05\ V^{-1}$.



(i) Find out the current flowing through the load resistor R_L.

(ii) Find out the small signal output resistance (r_{out}) of the current source as seen by the load resistor R_L.

(3+3)

Q.5. (i) Draw the circuit diagram of a common collector amplifier (including its biasing arrangements) and also draw its ac equivalent circuit replacing the transistor with its appropriate model. (ii) Derive the expression for its current gain in terms of the transistor's small signal parameters. (iii) Derive the expression for its small signal output resistance in terms of the transistor's small signal parameters considering finite resistance of its input signal source.

(6)