Analog Electronic Circuits (EC2.103) : Midsem exam

Instructor: Prof. Abhishek Srivastava, CVEST, IIIT Hyderabad

Date : 29^{th} Apr, 2023, Duration : 1 Hour 30 minutes, Max. Marks : 15

Instructions:

- Clearly write your assumptions (if any)
- Numerical answers must be correct upto **two places** of decimal to get any credit
- Refrain from copying
- You can use your lecture notebooks and own handwritten short notes in the exam hall
- Use of text books, mobile phone, tablets and computers are not allowed during this exam

1. True/False, fill in the blanks, short answer

   (a) In an npn BJT, which is biased in forward active mode, collector current (I_C) increases with an increase in V_{CE} because base width increases and more electrons recombine in base region. (T/F) [1 Mark]

   (b) For the large signal model of an npn transistor shown in Fig. 1, write KCL at node E and C. The notations have their usual meanings discussed in lecture. [1 Mark]

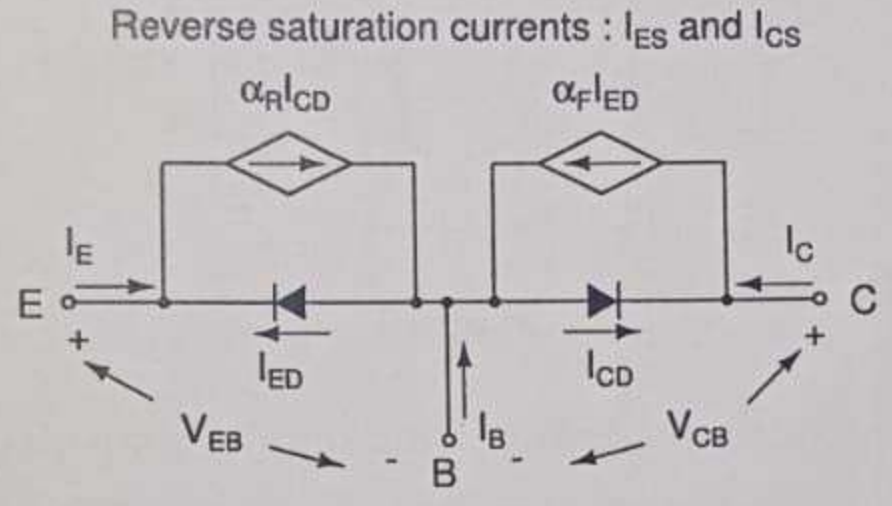


Figure 1

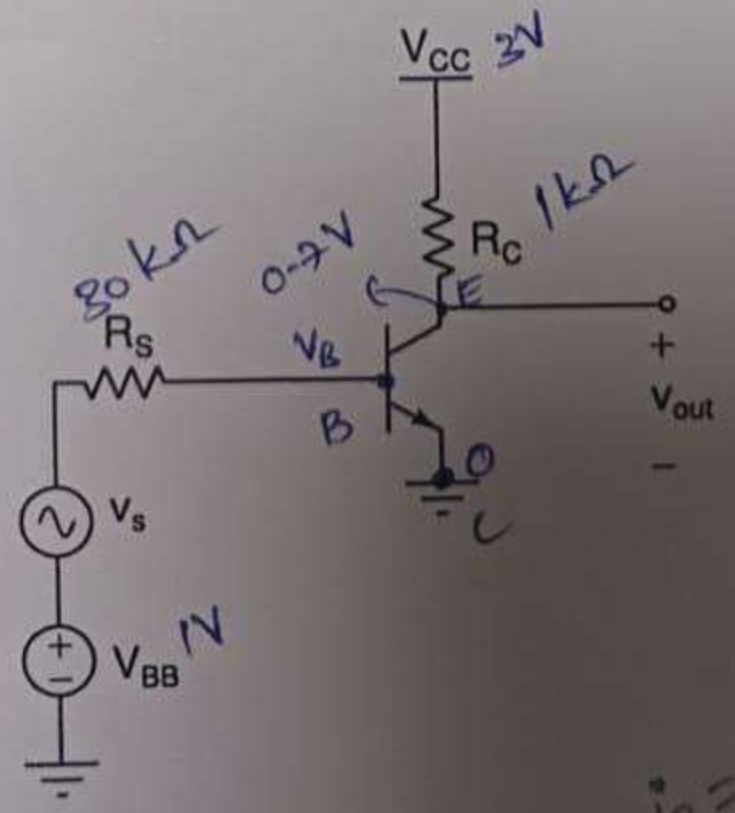
   (c) For the large signal model of an npn transistor shown in Fig. 1, in active mode, **fill in the blanks** using parameters shown in the figure; clearly show all steps and mention approximations taken (if any). Please note I_{CS} is the reverse saturation current of CB junction. [2 Mark]

$$I_C = (----)I_E + (----)I_{CS}$$

$$I_C = (----)I_B + (----)I_{CS}$$

   (d) Draw Bode magnitude and phase plots for the transfer function $H(s) = \frac{(s-1)}{s(s+10)(s+20)}$. [1 Mark]

2. For the circuit shown in Fig. 2, it is given that $V_{CC} = 3$ V, $V_{BB} = 1$ V, $V_{BE} = 0.7$ V, $R_S = 30\ k\Omega$, $R_C = 1\ k\Omega$, $\beta = 100$, early voltage $|V_A| = 10$ V, $V_T = kT/q = 25$ mV (room temperature).



(a) Verify that the transistor is in forward active mode and find the value of transconductance (g_m). [1 Mark]

(b) Find the value of small signal resistance (r_π) between base and emitter junction. [1 Mark]

(c) Draw the small signal equivalent circuit for the amplifier. [1 Mark]

(d) Derive the gain expression ($A_{v1} = |\frac{v_{out}}{v_s}|$) and find its value. [1 Mark]

(e) Find the value of gain (A_{v2}), if the value of R_S is changed to 60 $k\Omega$. [1 Mark]

(f) Find the value of gain (A_{v3}), if the BJT with $|V_A| = 5$ V is used in Fig. 2 with $R_S = 60$ $k\Omega$. [1 Mark]

For the circuit shown in Fig. 3, assume that BJT is in forward active mode and ignore the Early effect.

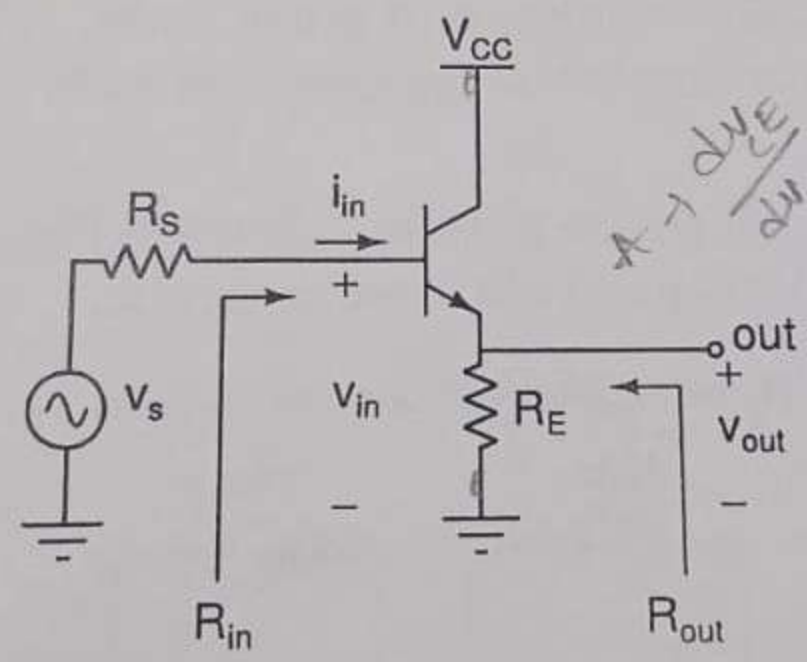


Figure 3

a) Draw the small signal model and derive expression for the voltage gain $A_v = \frac{v_{out}}{v_s}$. [2 Mark]

b) Derive the expression for the small signal input resistance defined as $R_{in} = \frac{v_{in}}{i_{in}}$. Is it high or low, briefly explain. [1 Mark]
(Hint: Ground V_{CC}, remove v_s, remove R_s, apply test source v_{in}, measure i_{in}.)

) In your small signal model make $v_s = 0$ and derive the expression for the small signal output resistance $R_{out} = \frac{v_x}{i_x}$, where v_x is an incremental voltage applied at the 'out' node and i_x is the corresponding incremental current drawn. Is R_{out} high or low, briefly explain. [1 Mark

Good luck !!