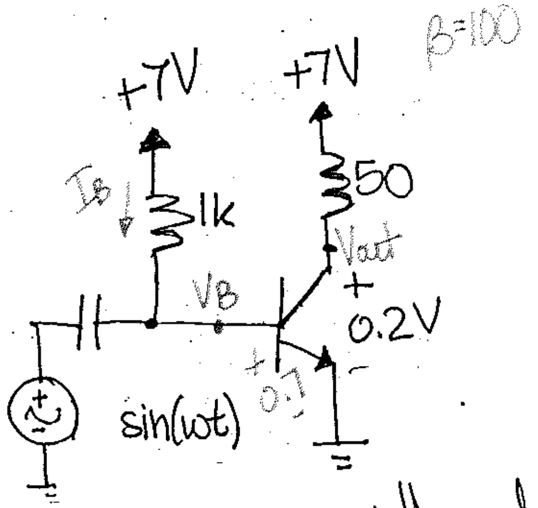
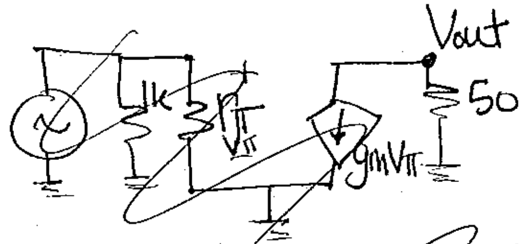


ω freq. in midband region.

$I_B = \frac{6.3}{1k} = 6.3m$, $I_C = .63A$

$V_B = 0.7$ $\quad 6.97 = V_C = 7 - 50(.63)$



$V_C < V_B$

$-g_m(50)V_{sig} = V_{out}$

$g_m = \frac{I_C}{V_T} = \frac{.63m}{25m} = 25.2m$

$\frac{V_{out}}{V_{sig}} = -25.2m(50) = -1.26 \, V/V$

$V_c = 6.97 - 1.26 \sin(\omega t)$

at peak, V_c will become $6.97 + 1.26 > 7V$!

Not possible.

SAT:

$V_{CESAT} = 0.2V$

$I_B = 6.3m$

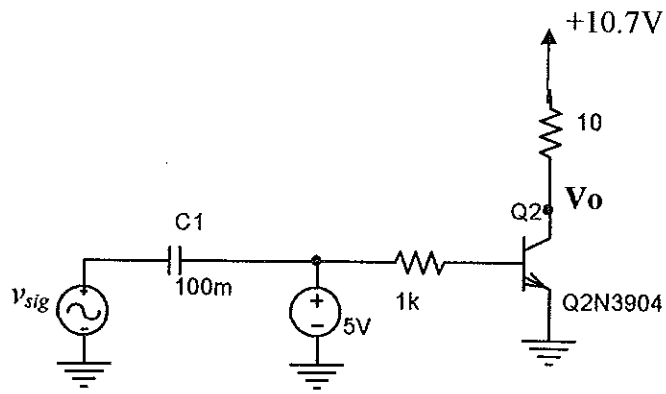
$$I_c = \frac{7-0.2}{50} = \frac{6.8}{50} = 136mA$$

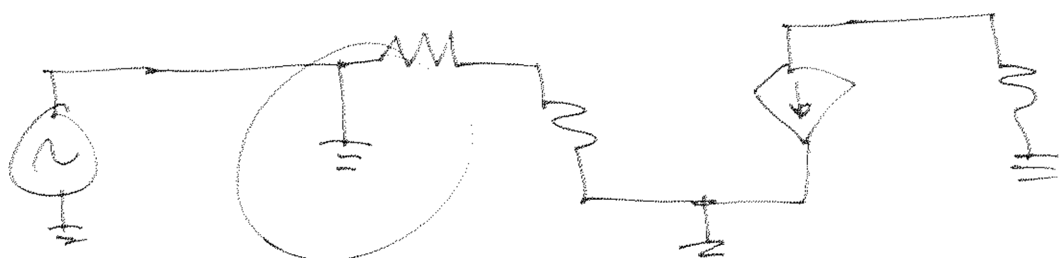
$$\beta_{forced} = \frac{I_C}{I_B} = \frac{136m}{6.3m} \approx \boxed{21.59} << 100$$

cond. for sat: $\beta_{forced} \lesssim\!< \beta_{normal}$

Problem 5 – (5 points)

$|V_{BE}|=0.7$, $\beta=100$, ignore r_o,, $v_{sig}=\{2+0.01\sin(\omega t)\}$Volts. Assume that the capacitor acts as an open for DC operation and short for AC operation. Does this circuit operate as a **linear** AC amplifier? If so, what is the gain, $\frac{Vo}{Vsig}$, of the following circuit? If not, explain why.

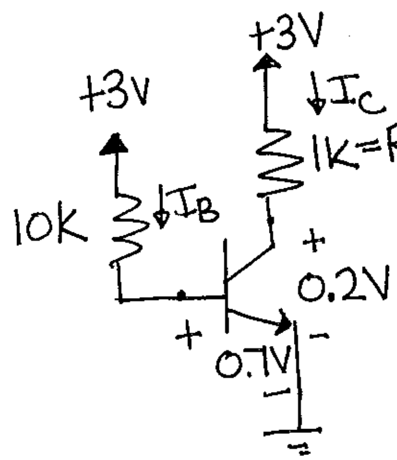




Not going to work!

Saturation: Use $V_{CESAT} = 0.2V$, Find β_{forced}.
[$\beta = 100$]

①



$3 - I_B(10k) - 0.7 = 0$

$I_B = \frac{2.3}{10K} = 230\mu A$

$I_c = \frac{3-0.2}{1k} = 2.8mA$ $\qquad I_B + I_C = I_E$

$\beta_{forced} = \frac{I_c}{I_B} = \frac{2.8m}{230\mu} \cong \boxed{12} < 100 \quad \therefore$ SAT

What value of R_c will put transistor at threshold between active and sat? $V_C = V_B$

$3 - V_B = I_c \cdot R_c$

$I_c = \beta I_B = 100(230\mu) = 23mA$

$V_B = 0.7V$

$3 - 0.7 = 23m(R_c) \quad \therefore \quad R_c = \frac{2.3}{23m} = \boxed{100\Omega}$

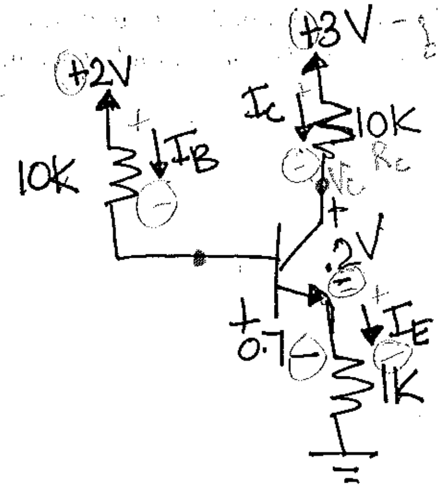
What condition for R_c is needed to keep transistor in Active Region?

$\boxed{R_c < 100}$

SATURATION :

$V_{CESAT} = 0.2V$, $\beta = 100$, find β_{forced}

(2)



① $+2 - 10K\,I_B - 0.7 - I_E\,1K = 0$

② $+3 - I_c(10K) - 0.2 - I_E(1K) = 0$

③ $I_B + I_c = I_E$

solve using matrix solution

OR

plug ③ into ②

$+3 - I_c(10K) - 0.2 - I_B(1K) - I_c(1K) = 0$

$\therefore$ ④ $I_B = \dfrac{2.8 - I_c(11K)}{1K}$

plug ③ into ① and ④ into ①

$1.3 - 10K\,I_B - I_B(1K) - I_c(1K) = 0$

$1.3 - \dfrac{11K(2.8)}{1K} + \dfrac{I_c(11K)(11K)}{1K} - I_c(1K) = 0$

$1.3 - 30.8 + I_c(121K) - I_c(1K) = 0$

$I_c(\cancel{121K}) = \dfrac{+29.5}{121K} = 243.8\mu A$

$\therefore I_B = \dfrac{2.8 - (243.8\mu)(11K)}{1K} = 118.2\mu A$

$I_E = I_c + I_B = 362\mu A$

$\beta_{forced} = \dfrac{I_c}{I_B} = \dfrac{243.8\mu}{118.2\mu} = \boxed{2.06}$

matrix solution:

① $-10K\,I_B - 1K\,I_E + 0\,I_c = -1.3$

② $0\,I_B - 1K\,I_E - 10K\,I_c = -2.8$

③ $I_B - I_E + I_c = 0$

$$\underbrace{\begin{bmatrix} -10K & -1K & 0 \\ 0 & -1K & -10K \\ 1 & -1 & 1 \end{bmatrix}}_{A} \underbrace{\begin{bmatrix} I_B \\ I_E \\ I_c \end{bmatrix}}_{X} = \underbrace{\begin{bmatrix} -1.3 \\ -2.8 \\ 0 \end{bmatrix}}_{B}$$

$I_B = 95.83\mu A$

$I_E = 341.7\mu A$

$I_c = 245.8\mu A$

$\beta_{forced} = \dfrac{245.8\mu}{95.83\mu} = \boxed{2.56}$

what condition for R_c needs to be met for transistor to stay in active mode?

Threshold is when $V_c = V_B$ (min value for V_c)

$$+2 - 10K\, I_B - 0.7 - I_E(1k) = 0$$

$$I_B = \frac{I_E}{101}$$

$$\therefore \quad 1.3 - \frac{10k}{101} I_E - I_E(1k) = 0$$

$$I_E = \frac{1.3}{\frac{10k}{101} + 1k} = 1.18mA \rightarrow I_B = \frac{1.18m}{101} = 11.7\mu A$$

$$\therefore \quad V_B = 2 - 10K(11.7\mu) = 1.883 = V_c = 3 - I_c R_c$$

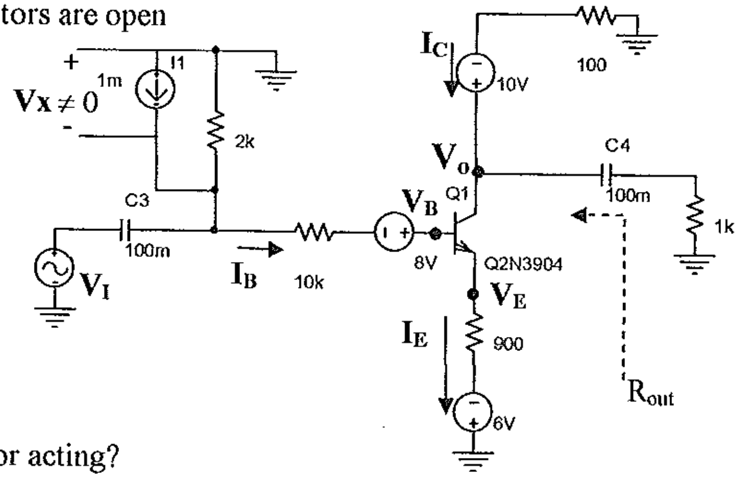
$$I_c = \beta I_B = 100(11.7\mu) = 1.17mA$$

$$R_{cMAX} = \frac{3 - 1.883}{1.17m} = 954.7\Omega$$

$$\therefore \quad \boxed{R_c \leq 955\Omega}$$

Problem 1 – (37 points)

Use: **ignore r_o, $|V_{BE}|=0.7$, $\beta=100$**
$V_I = 20+0.001\sin(20t)$
For DC analysis, assume that the capacitors are open



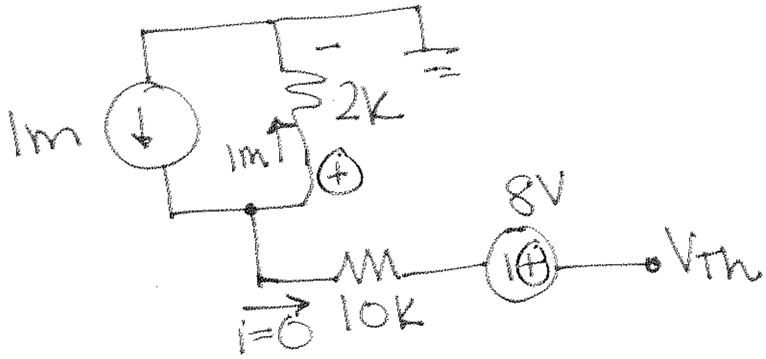
(a) Solve for the DC currents:
  a. I_B
  b. I_E
  c. I_C

(b) Solve for the DC voltages:
  a. V_B
  b. V_E
  c. V_o

(c) What region of operation is this transistor acting?

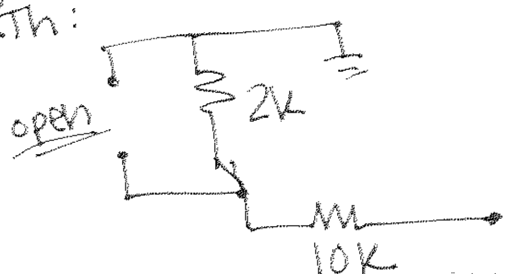
(d) Sketch the total instantaneous waveform observed for Ic if V_o/V_I=5V/V.

Thevenin:

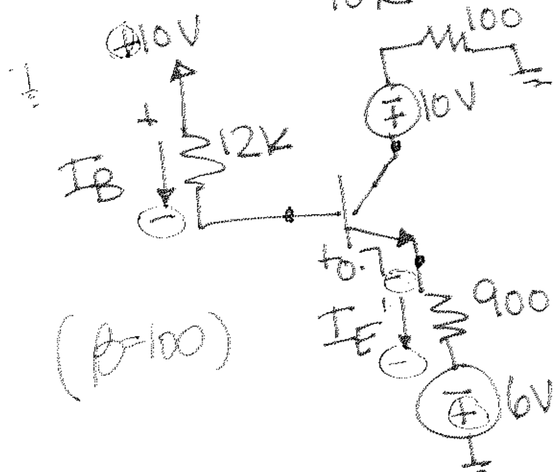


$$+2k(1m) + 8 - V_{Th} = 0 \Rightarrow V_{Th} = 8 + 2 = +10V$$

R_{Th}:



$$R_{Th} = 12k$$



$$0 = +10 - I_B(12k) - 0.7 - I_E(900) + 6$$

$$I_B = \frac{I_E}{\beta+1} \quad \text{OR} \quad I_E = (\beta+1) I_B$$

$(\beta = 100)$

$$0 = +10 - \frac{I_E(12k)}{101} - 0.7 - I_E(900) + 6$$

$$I_E = \frac{10 - 0.7 + 6}{\frac{12k}{101} + 900} = \underline{15mA}$$

$$I_B = \frac{15m}{101} = \underline{149\mu A}$$

$$I_c = \beta I_B = \underline{14.9mA}$$

$V_B = +10 - I_B(12K) = 10 - 149\mu(12K) \cong 8.2V$

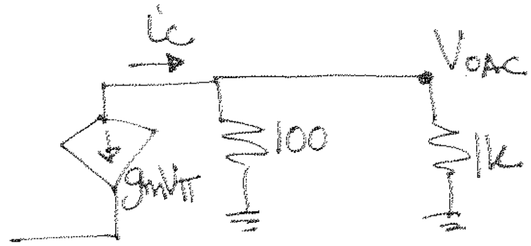
$V_C = -I_C(100)+10 = -14.9m(100)+10 = 8.5V$

$V_C > V_B$ ∴ Active

$V_E = V_B - 0.7 = 8.2 - 0.7 = 7.5V$

DC value for $I_C = 14.9m$

AC:

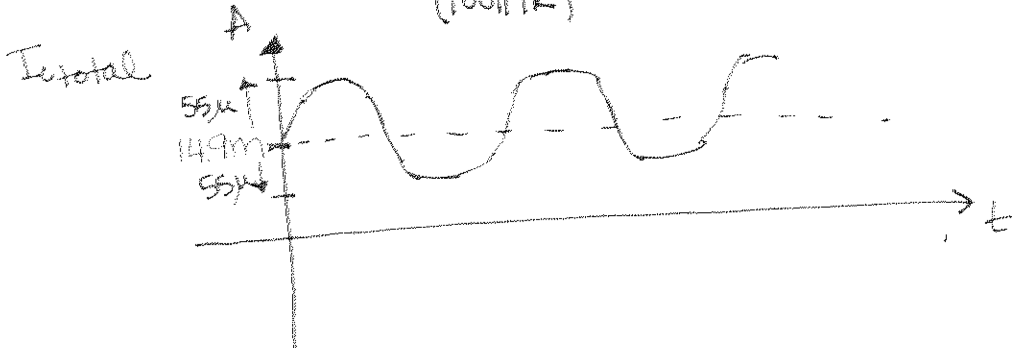


Knowing $\frac{V_o}{V_I} = 5V/V$ and $V_I = \cancel{20} + 1m\sin(20t)$

Blocked

$V_{OAC} = 5m\sin(20t)$

∴ $i_{C_{AC}} = \frac{V_{OAC}}{(100 \| 1K)} = \frac{5m\sin(20t)}{91} = 55\mu A$



Exam:

1. DC analysis
2. AC analysis
3. Saturation
4. Understanding
5. Draw hybrid π