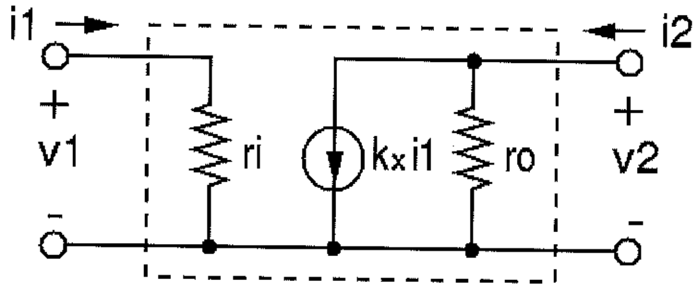
Name ....

1) BJT Model Parameters

The linear equivalent circuit of a BJT looks as follows



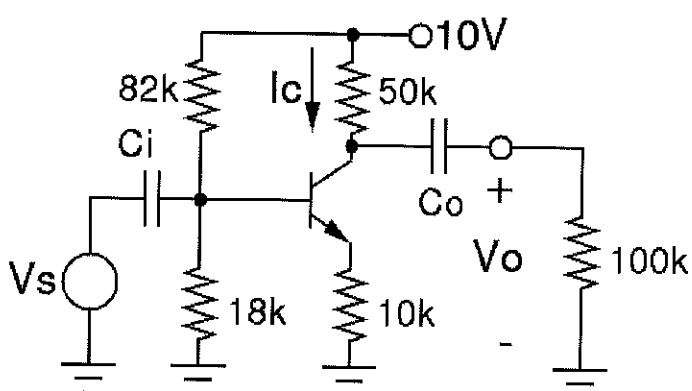
BJT Parameters:
$V_T = 30$ mV
$V_A = 60$ V
$\beta = 100$
$I_{CQ} = 0.6$ mA

a) Find **values** for $\mathbf{r_i}$ and $\mathbf{r_o}$ if the BJT is used in a **common emitter** configuration.

b) Find **values** for $\mathbf{r_i}$ and $\mathbf{r_o}$ if the BJT is used in a **common base** configuration.

c) Derive a **value** for the **voltage ratio** $\mathbf{A_V=v_2/v_1}$ for the circuit shown if the BJT is used in a **common base** configuration.

2) Common Emitter Amplifier



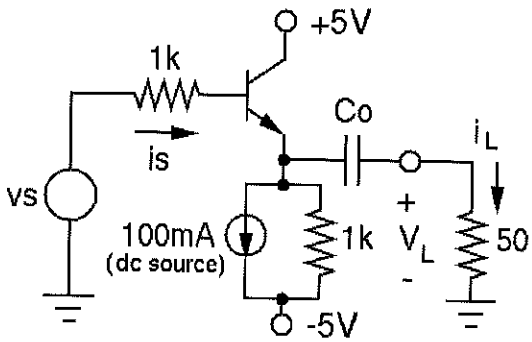
BJT Parameters:
$V_T = 30$ mV
$V_A = 60$ V
$\beta = 100$
$V_{BEQ} = 0.7$ V

a) Find values for $\mathbf{I_{CQ}}$ and $\mathbf{V_{CEQ}}$.

b) Determine $\mathbf{C_i}$ such that it forms a **low-frequency** corner at **100 Hz**.

c) Derive an **expression** and a **value** for the voltage gain $\mathbf{A_V=v_o/v_s}$ (assume that $\mathbf{C_i}$ and $\mathbf{C_o}$ act as **shorts** for the frequencies of interest).

3) Common Collector Amplifier



BJT Parameters:
$V_T = 30$ mV
$V_A = \infty$
$V_{BEQ} = 0.7$ V
$\beta = 100$

a) Find **values** for $\mathbf{I_{CQ}}$ and $\mathbf{V_{CEQ}}$ (**Note**: v_s is an ideal **ac voltage source**).

b) Determine values for the **input resistance R_{in}** (seen at the **base** of the transistor) and the **output resistance R_{out}** (seen at the **emitter**). Assume that $\mathbf{C_o}$ acts as a **short** when calculating of R_{in}.

c) What is the **current gain $A_I = i_L/i_s$** of this transistor gain stage?

4) Quick Answer Questions

a) Assume that $\mathbf{R_E}$ of the BJT amplifier in problem 2) is bypassed with a large capacitor. Does the **ac voltage gain A_V** change if $\mathbf{R_E}$ is **reduced by 10%? If yes, how many % up or down?**

yes, ≈ 10% up

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b) A **common collector BJT amplifier** features the following properties: (mark all that apply)

A) high **voltage gain** ☐

B) high **current gain** ☒ 1

C) low **input resistance** ☐

D) low **output resistance** ☒ 1

c) A BJT features an Early voltage of **60V** and an $\mathbf{I_{CQ}}$ of **1mA**. How much does $\mathbf{I_C}$ change if $\mathbf{V_{CE}}$ **increases** by **3V** while V_{BE} remains constant?

ΔI_C = + 50 μA

2

d) Find the transconductance $\mathbf{g_m}$ of a BJT biased at $\mathbf{I_{CQ}=5mA}$ (V_T=30mV).

g_m = 0.167 S

1

e) How much does the bias current of the BJT circuit in problem 2) change if $\mathbf{V_{BE}}$ **increases** by **50mV** while V_{CC} and all resistors remain the same?

ΔI_C = − 5 μA

2

10

1) a) CE config.

$$r_i = \frac{\beta}{g_m} = \beta \frac{V_T}{I_{CQ}} = 5\,k\Omega$$ 2

$$r_o = \frac{V_A}{I_{CQ}} = 100\,k\Omega$$ 1

b) CB config.

$$r_i = \frac{\alpha}{g_m} = 49.5\,\Omega$$ 2

$$r_o = (1+\beta)\frac{V_A}{I_{CQ}} = 10.1\,\text{Meg}\,\Omega$$ 2

c) $V_2 = -k \cdot i_i \cdot r_o$, $V_1 = i_i \cdot r_i$ $\therefore$ $\frac{V_2}{V_1} = -k\frac{r_o}{r_i}$

common base config. $k = -\alpha$

$$\frac{V_2}{V_1} = \alpha\frac{r_o}{r_i} = \alpha\frac{(1+\beta)V_A}{\alpha V_T} = (1+\beta)\frac{V_A}{V_T} = 202{,}000$$ 3

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2) a) $I_{CQ} = \dfrac{V_{CC}\frac{R_2}{R_1+R_2} - V_{BEQ}}{\frac{R_1 \| R_2}{\beta} + R_E(1+\frac{1}{\beta})} = \dfrac{1.1V}{10.25k\Omega} = 107\mu A$ 2

$V_{CEQ} = V_{CC} - I_{CQ}(R_C + [1+\frac{1}{\beta}]R_E) = 3.55V$ 1

b) $C_i = \dfrac{1}{2\pi f_c \cdot R_{in}}$

$R_{in} = R_B \| (r_\pi + [1+\beta]R_E) = 14.5k\Omega$

$C_i = 109nF$ 3

c) $r_o = \dfrac{V_A}{I_{CQ}} = 560.7k\Omega \gg R_C$

neglect r_o (assume $V_A = \infty$)

$\therefore \quad A_V \cong -\dfrac{g_m \tilde{R}_L}{1+g_m R_E(1+\frac{1}{\beta})}$ where $\tilde{R}_L = R_C \| R_L$ 2

$\tilde{R}_L = 33.3k\Omega$

$g_m = 3.57mS$

$A_V \cong -3.2$ 2

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3) a) $I_{CQ} \cong I_0 + \frac{V_E - V_{EE}}{1k}$ $\quad V_{EE} = -5V$ 1

$V_E = -\frac{1k}{\beta} I_{CQ} - V_{BEQ}$

$\therefore \quad I_{CQ} = \left(I_0 - \frac{V_{BEE}}{1k} - \frac{V_{BEQ}}{1k} \right) \frac{1}{1.01}$

$I_{CQ} \cong 103.3\,mA$ $\quad V_{CEQ} = V_{CC} - V_E \cong 6.7V$ 2

b) $R_{in} = \frac{\beta}{g_m} + (1+\beta)\, r_e \| R_L$ $\quad r_e = 1k\Omega$

$R_{in} \cong 4.8k\Omega$ 2

$R_{out} = r_e \| \left(\frac{1}{g_m} + \frac{1k}{1+\beta} \right)$

$R_{out} \cong 10.4\Omega$ 2

c) $A_I = (1+\beta) \frac{r_e}{r_e + R_L}$

$A_I \cong 96$ 3

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