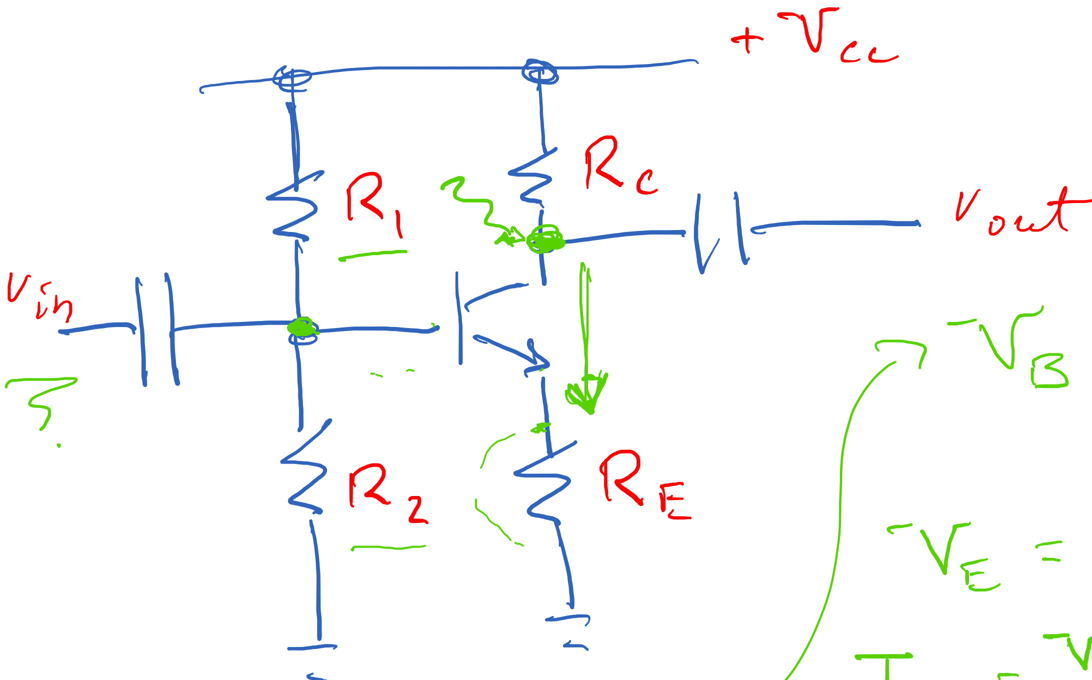
Common Emitter Amp.



$$I_C \approx \frac{V_{CC}}{2(R_E + R_C)}$$

$$V_B \approx \frac{R_2}{R_1 + R_2} V_{CC}$$

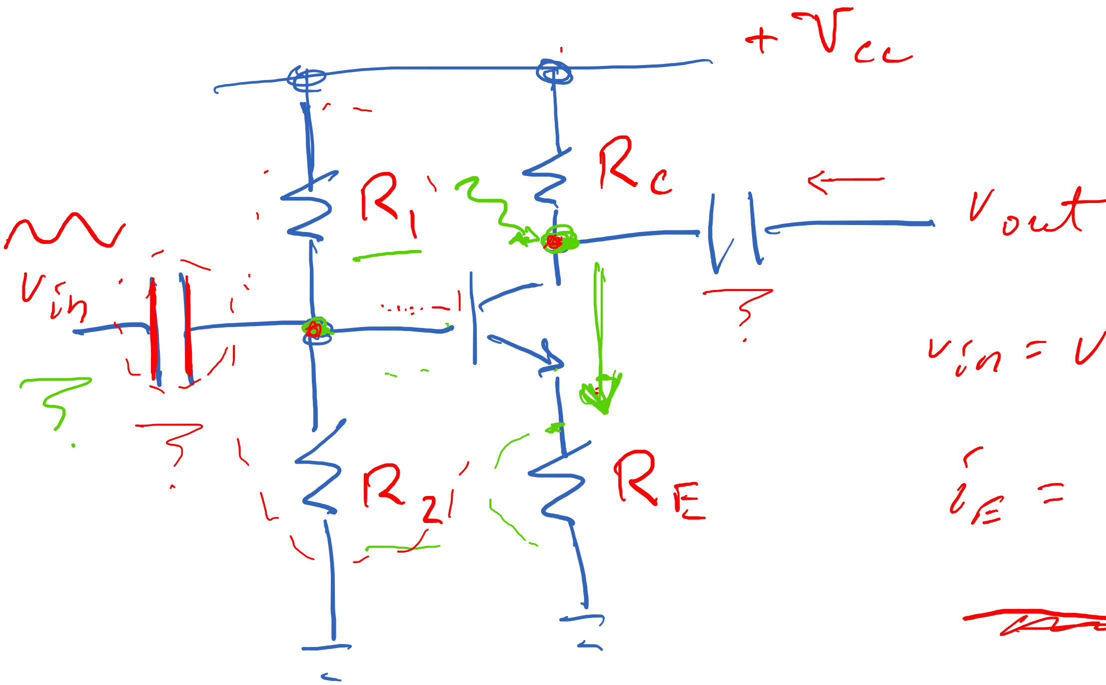
$$V_E = V_B - 0.6\,V$$

$$I_E = V_E / R_E \approx I_C$$

$$V_C = V_{CC} - I_C R_C$$

$$R_1 \| R_2 \lesssim 0.1\,\beta R_E$$

Common Emitter Amp.



$$R_1 \| R_2 \leq 0.1 \beta R_E$$

VOLTAGE GAIN

$$A_V = \frac{v_{out}}{v_{in}} = \frac{-R_c}{R_E}$$

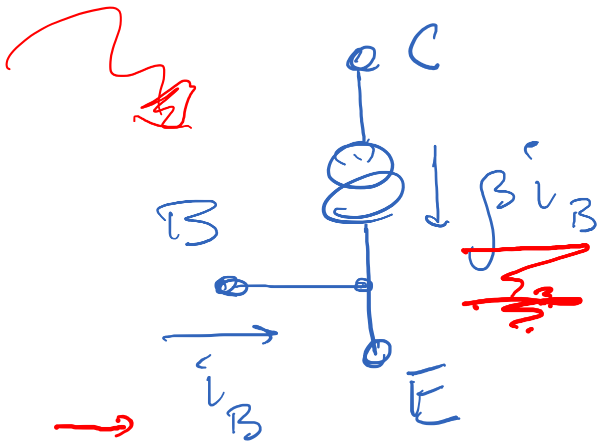
$$v_{in} = v_B = v_E$$

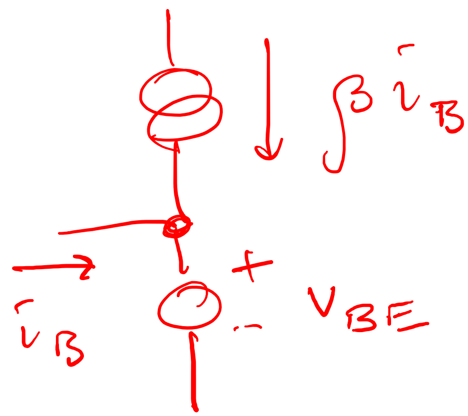
$$i_E = \frac{v_E}{R_E} \approx i_c \quad [\beta >> 1]$$

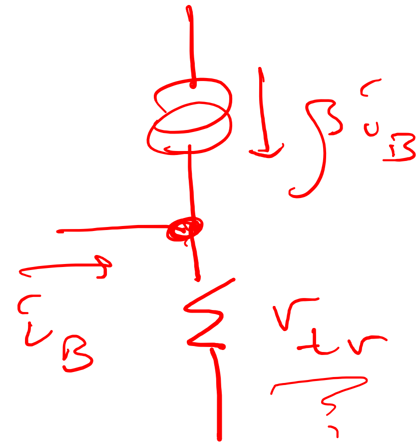
$$v_c = -i_c R_c$$

$$v_c = v_{out} = -\frac{R_C}{R_E} \cdot v_{in}$$

BIPOLAR TRANSISTOR: SMALL-SIGNAL EQUIVALENT





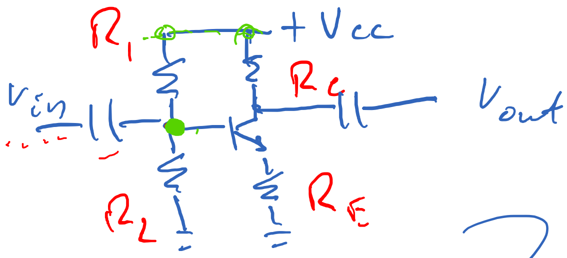


$$\frac{\partial I}{\partial V} \approx \left(\frac{k_B T}{e}\right)\frac{1}{I} \approx \left[\frac{25}{I(mA)}\,\Omega\right]^{-1}$$

$$r_{tr} = r_{dyn} + r_{ohmic}$$

$$r_{dyn} = \frac{25}{I(mA)}\,\Omega \qquad r_{ohmic} \sim \text{few } \Omega$$

Common Emitter Amp: Small Signal



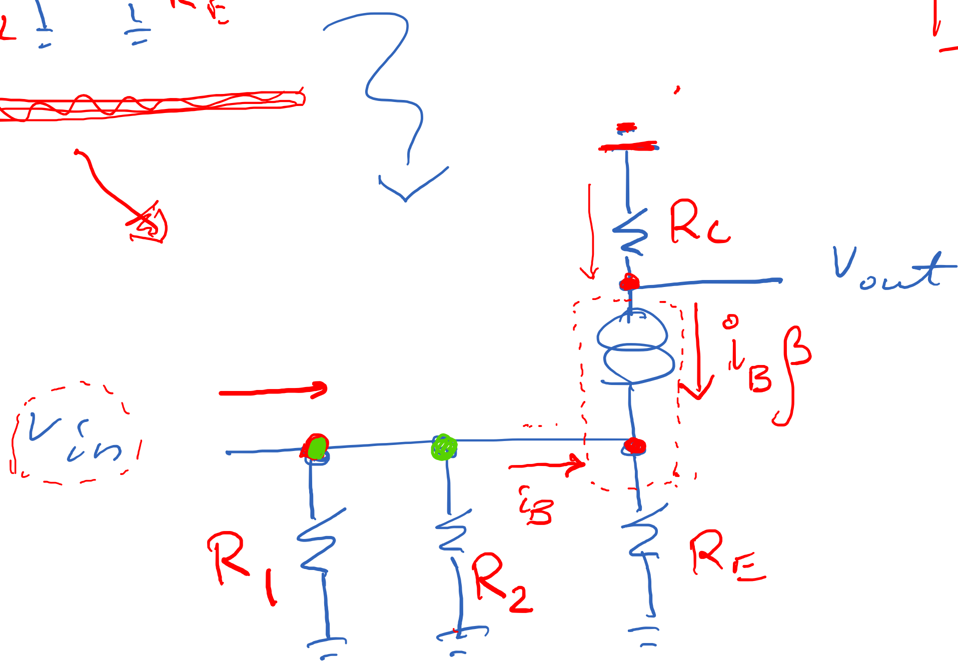
2 $R_{out} = R_C$

3

$$v_{in} = v_E = (\beta+1)\, i_B R_E$$

$$v_{out} = -\beta\, i_B R_C$$

$$A_v = \frac{v_{out}}{v_{in}} = \frac{-\beta}{\beta+1}\,\frac{R_C}{R_E}$$



1

$$R_{in} = R_1 \,||\, R_2 \,||\, R(\text{into BASE}) = R_1 \,||\, R_2 \,||\, \beta R_E$$

Common Emitter Amp: Design

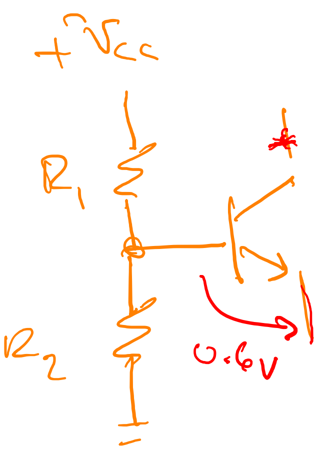
1. Choose R_C for desired R_{out} $\quad \boxed{R_{out} = R_C}$

→ 2. Choose R_E for desired Gain $\quad \boxed{A_v = -R_C/R_E}$

3. Choose R_1, R_2 so that $R_1 \| R_2 \lesssim 0.1\,\beta R_E$;

Also, want

$$\boxed{I_C \approx \frac{V_{CC}}{2(R_E + R_C)}}$$



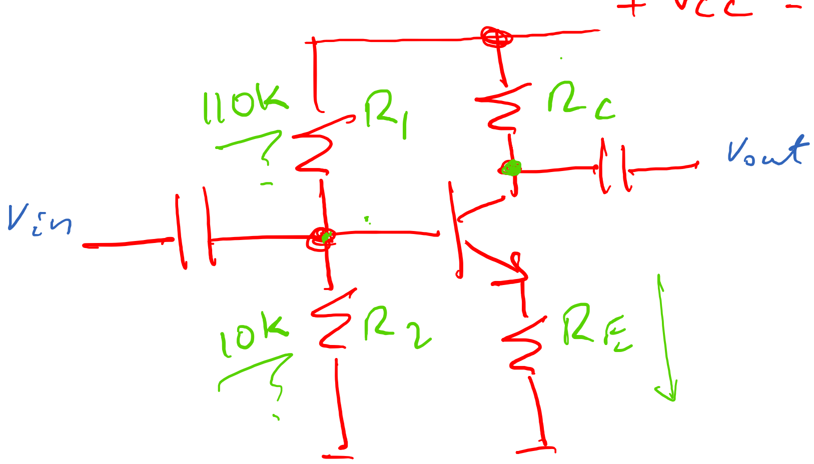
$$V_B = \frac{R_2}{R_1 + R_2} V_{CC}$$

DESIGN EXAMPLE

WANT: $R_{out} = 10\,k\Omega$

$A_v = -10$

HAVE: $V_{cc} = +20\,V$



1. $R_c = 10\,k\Omega$

2. $R_E = 1\,k\Omega$

3. $R_1 \| R_2 \ll 100 \cdot 1\,k\Omega$ (β)

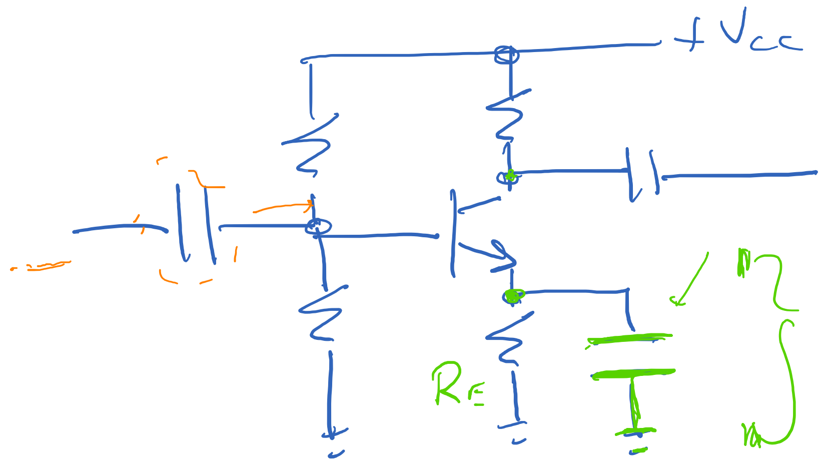
$R_1 \| R_2 \sim 10\,k\Omega$

$V_C \sim 10\,V$

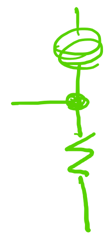
$I_C \sim 1\,mA$

$V_E \sim 1\,V$; $V_B \sim 1.6\,V$

BYPASS R_E TO INCREASE GAIN ?

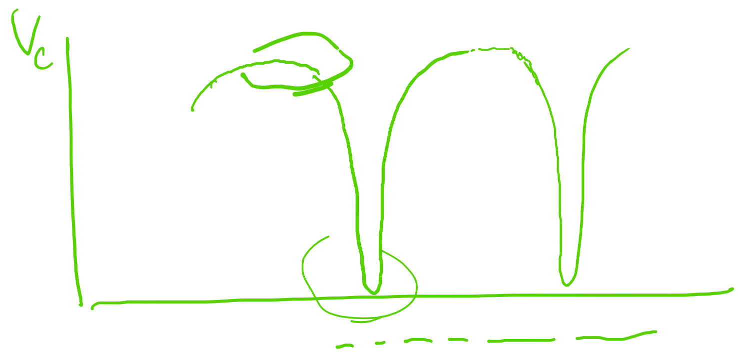


$$A_V = \frac{-R_C}{R_E}$$

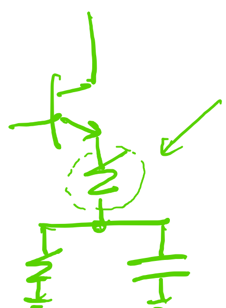


$$r_{tr} = \frac{25\,\Omega}{I_C(mA)} + 2\,\Omega$$

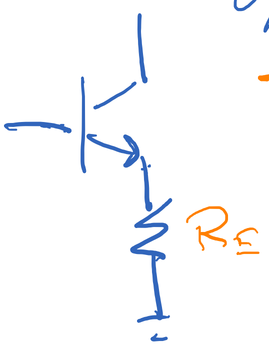
$$A_V = \frac{-R_C}{r_{tr}}$$



BETTER IS...



EMITTER RESISTOR AS NEGATIVE FEEDBACK



$$v_{BE} = v_{in} - i_E R_E$$

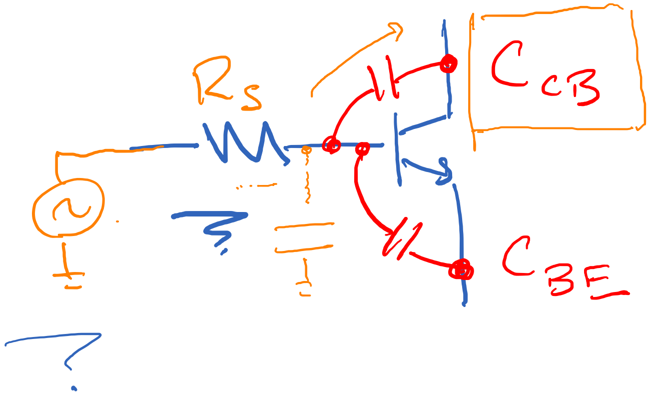
SAMPLE OUTPUT, SUBTRACT FROM INPUT SIGNAL

→ IMPROVED LINEARITY ←

→ INCREASED Z_{in} ←

⇒ → REDUCED SENSITIVITY TO DETAILS OF DEVICE

INPUT CAPACITANCE OF BJT



$V_C = -|A_v| V_B$

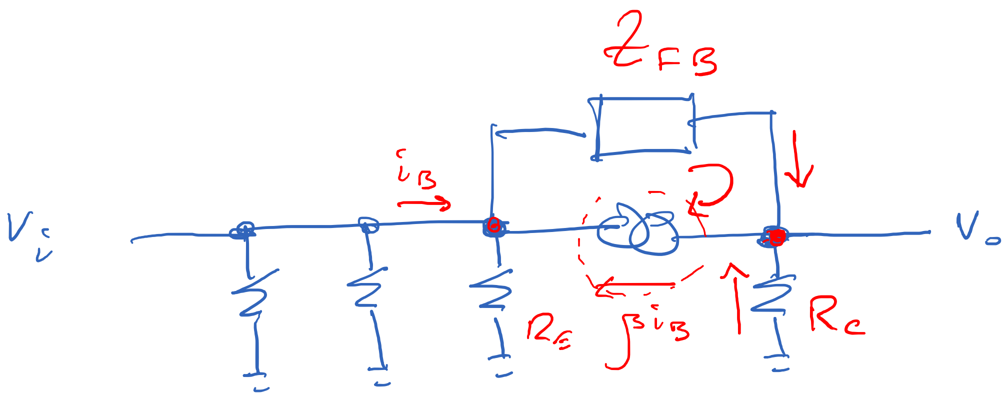
RECALL, $I = C \frac{dV}{dt}$

$\Rightarrow$ CURRENT THRU C_{CB} ENHANCED BY

$\rightarrow |A_v| + 1$

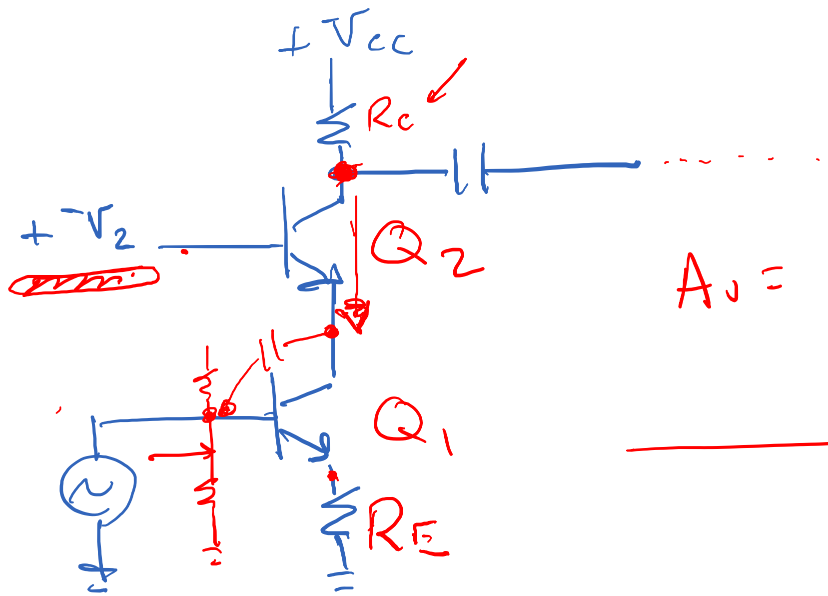
$|V_{CB}| = (|A| + 1) |V_B|$

$\rightarrow C_{eff} = [|A_v| + 1] C_{CB}$ $\rightsquigarrow$ MILLER EFFECT



Z_{FB}
i_B
V_i
V_o
R_E
βi_B
R_c

CIRCUMVENTING MILLER

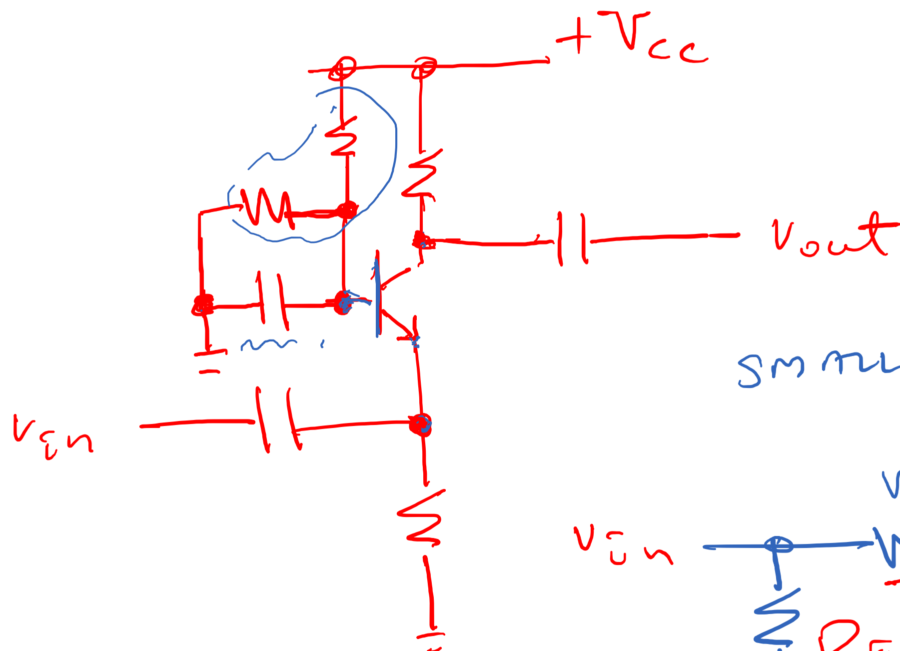


$$A_v = -\frac{R_C}{R_E}$$

CASCODE

CIRCUMVENTING MILLER:

COMMON BASE AMPLIFIER



$$V_o = -i_B \beta R_c$$

$$V_i = -i_B(\beta+1) r_{tr}$$

$$A_v = \frac{\beta}{\beta+1}\frac{R_c}{r_{tr}}$$

SMALL SIGNAL