

BJT Golden Rules

1) $I_E = I_C$ (ok: $I_E = I_C + I_B$ but generally $I_C \gg I_B$
 in fact (see below) $I_C = \beta I_B \Rightarrow I_E = (\beta + 1) I_B$)

$V_B = V_E + 0.6$ (ok: the 'turn-on' voltage of a forward biased PN junction varies with temperature; larger I_B does mean larger V_{BE} but during normal operation V_{BE} typically varies only $\pm \frac{1}{40} V$ - small change)

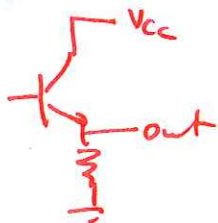
Common Emitter Amp



$$\Delta I_E = \frac{\Delta V_B}{R_E}$$

$$\Delta V_{out} = -R_C \Delta I_C = -\frac{R_C}{R_E} \Delta V_B$$

Emitter Follower

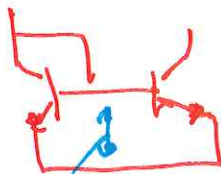


$$\Delta V_{out} = \Delta V_B$$

2) $I_C = \beta I_B$ (but: range of β allowed by specs large.
 β not constant - varies with I_B)

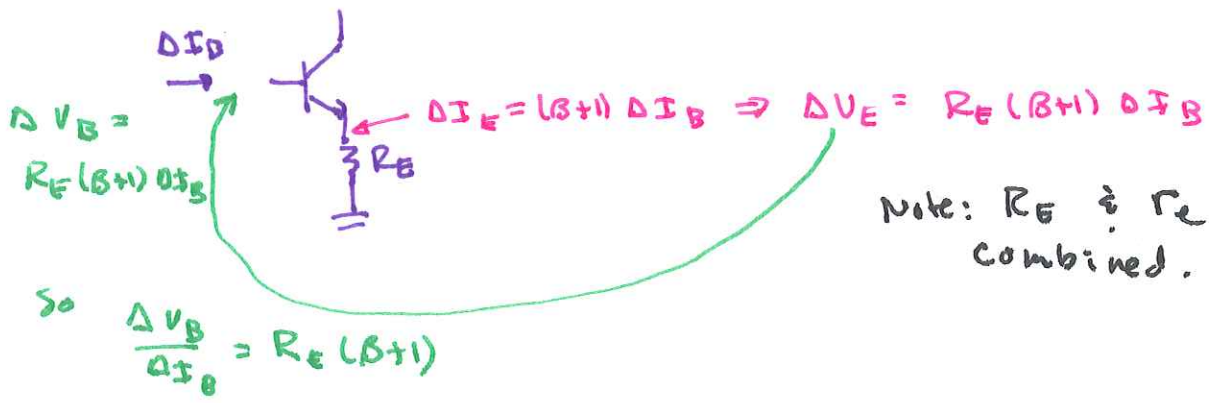
Avoid circuits that depend on a particular value of β - they may not work with replacement transistor.

3) I_B, I_C in fact functions of V_{BE} - match V_{BE} match results. (For a "matched pair")

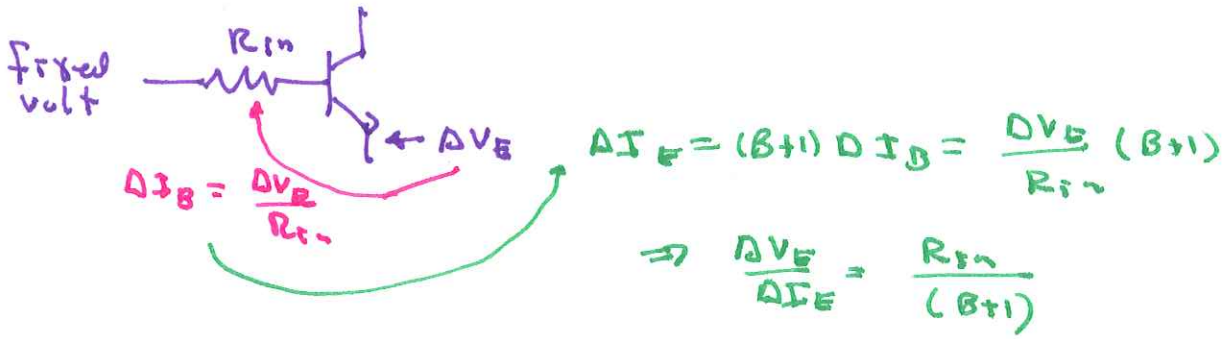


same V_{BE} - same currents thru device.

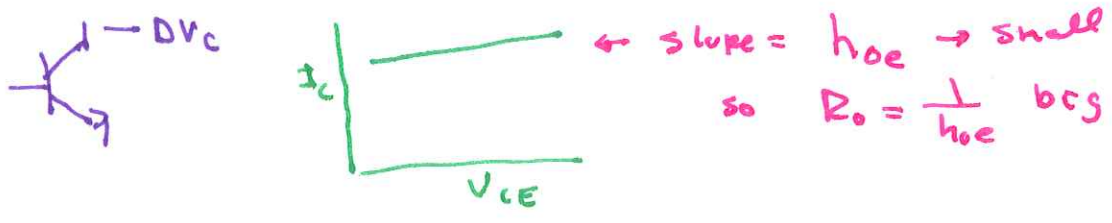
Impedance "looking in base"



Impedance "looking in emitter"



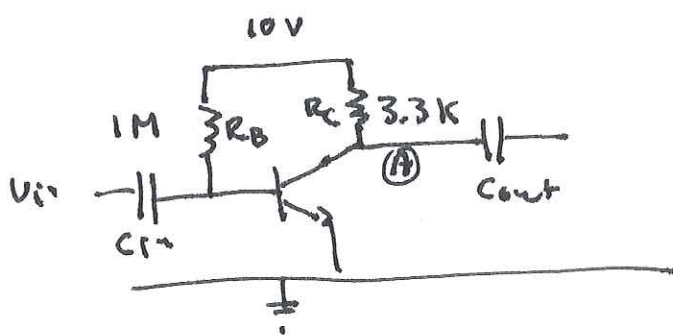
Impedance "looking in collector"



IMPORTANT: words "looking into base" quite different from words "looking from base"

↳ refers to what is upstream from base - re what is connected to base.

Example — (DO NOT BUILD THIS CIRCUIT!)



$V_{CC} = 10V$
 $R_C = 3.3k\Omega$
 $R_B = 1M\Omega$
 $\beta = 100$
 $F = 100 - 10k\text{ Hz}$
 important part
 Find V_{CE} , A_v (voltage gain $-A_v$)
 C_{out} , C_{in}

$$V_B = .6V \Rightarrow I_B = \frac{(V_{CC} - V_B)}{R_B} = \frac{(10 - .6)}{10^6} = 9.4 \mu A$$

$$I_C = \beta I_B = .94 \text{ mA}$$

$$V_C = V_{CC} - R_C I_C = 10 - 3.3(.94) = 6.9V$$

$$r_e = \frac{25}{(\beta + 1) I_B} = \frac{25}{(101) 9.4 \mu A} = 26.3 \Omega$$

$$A_v = -\frac{R_C}{r_e} = -125$$

Just as with FET impedance "looking in from A"

$$\text{is } R_C \parallel \frac{1}{h_{oe}} \approx R_C$$

It is expected that circuit output connects to device with much greater input impedance

so $X_{C_{out}} \ll R_C$ does little harm —

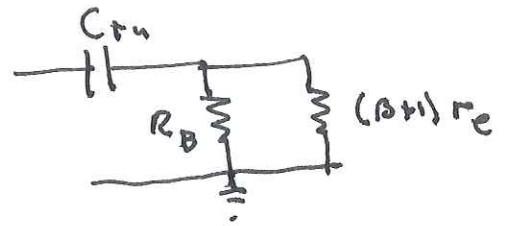
$$\frac{1}{\omega C_{out}} \ll R_C$$

↑ use smallest ω as largest ω satisfies even more

$$\frac{1}{2\pi f R_C} \leq C_{out}$$

$$\frac{1}{2\pi \cdot 100 \cdot 3.3 \times 10^3} = .48 \mu F$$

Looking in from V_{in} see:



seek small input impedance.
avoid having C_{in} double it.

$$\frac{1}{\omega C_{in}} \leq \frac{1}{10} (R_B \parallel (\beta+1)r_e) \approx .266 \text{ k}\Omega$$

$\underbrace{\hspace{1.5cm}}_{1 \text{ M}\Omega} \quad \underbrace{\hspace{1.5cm}}_{2.66 \text{ k}\Omega}$

$$\frac{1}{2\pi f \cdot (266 \Omega)} \leq C_{in}$$

"

$$\frac{1}{2\pi 100 (266)} = 6 \mu\text{F}$$