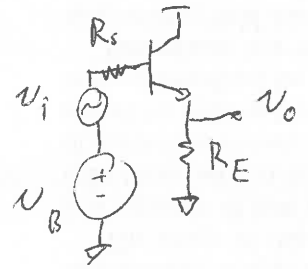
Common Emitter Derivations	Common Base Derivations	Project Q&A
– R_{in}, R_{out}, A_v	– R_{in}, R_{out}, A_v w/ & r_o	
~~Empta~~	– Current follower	
– Large signal level shift	– Finite r_o again, see GOM	
– $1/g_m$ b/c v_{be} controlled @ R_{out}	– Low input impedance?	
	– T model	

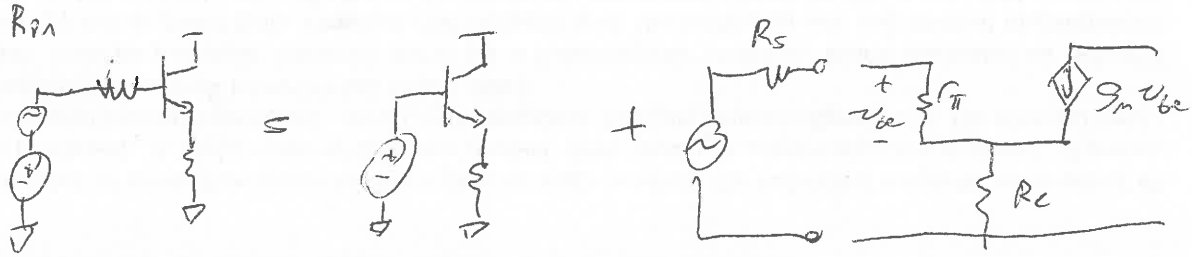
Left off hoping for an understanding of the EF



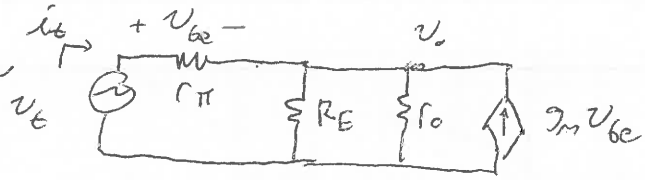
– $A_v = 1$, R_{in} high, R_{out} low → called a voltage buffer

– Need to include R_s in R_{out} analysis b/c life's not fair.

Find R_{in}



redraw



– Similar to CE w/ degen

– hard to start w/ v_t

$$v_{be} = i_t r_\pi$$

KCL: $$i_t = \frac{v_o}{R_E} + \frac{v_o}{r_o} - g_m v_{be}$$

$$= v_o\left(\frac{1}{R_E} + \frac{1}{r_o}\right) - g_m r_\pi i_t$$

$$i_t(\beta+1) = v_o / R_E \| r_o$$

$$v_o = i_t(\beta+1) R_E \| r_o$$

$$v_t = v_{be} + v_o = i_t\left(r_\pi + (\beta+1)(R_E \| r_o)\right)$$

$$R_{in} = r_\pi + (\beta+1)(R_E \| r_o) \approx \beta R_E$$

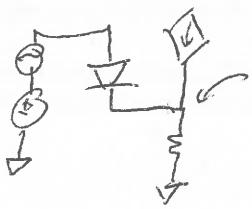
Calc A_v

$v_o = i_t(\beta+1)(R_E \| r_o)$ from above

$$A_v = \frac{(\beta+1)(R_E \| r_o)}{r_\pi + (\beta+1)(R_E \| r_o)} v_i \quad \text{b/c} \quad i_t = v_t / R_{in}$$

$\rightarrow A_v \approx 1$

Let's look @ large signal to check this

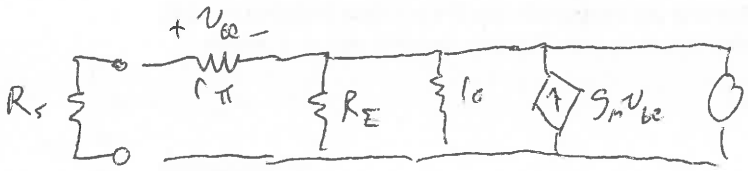


$v_E = v_B - 0.7$

- Gain is 1, Level shifted down
- Used to get DC voltages right
- v_{BE} stays ~0.7, small sig captures changes

Calc R_{out}

- Need to include R_s
- start w/ v_t this time!



$$i_t = \frac{v_t}{R_E} + \frac{v_t}{r_o} + \frac{v_t}{r_\pi + R_s} - g_m v_{be}$$

and $v_{be} = -\frac{r_\pi}{r_\pi + R_s} v_t$

- Backwards gain of $\frac{r_\pi}{R_s + r_\pi}$, we ignore in 2 port model
- say it's small ...

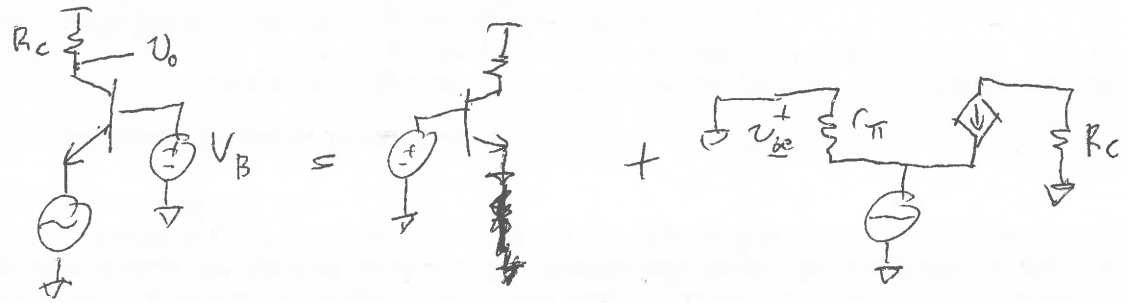
so $i_t = v_t\left(\frac{1}{R_E} + \frac{1}{r_o} + \frac{1}{r_\pi + R_s} + \frac{g_m r_\pi}{r_\pi + R_s}\right)$

$$R_{out} = R_E \| r_o \| \frac{r_\pi + R_s}{\beta+1} \Big\} \approx \frac{1}{g_m} + \frac{R_s}{\beta+1}$$

$$\approx \frac{1}{g_m}$$

- why $\frac{1}{g_m}$? Voltage applied directly across g_m control terminals & receives controlled current
  ↳ watch for this pattern!

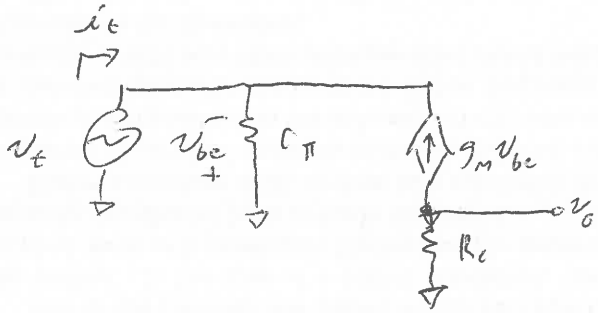
Last type of single stage amplifier is called common base



- Hard to bias more later

- Ignore r_o for now
- See GoM for full derivation w/ finite r_o — a pain
  - not unilateral

R_{in}



- $v_{be} = -v_t$
- $i_t = \frac{v_t}{r_\pi} - g_m(-v_t)$

common to draw w/ reversed g_m source

$$\frac{v_t}{i_t} = R_{in} = \frac{1}{\frac{1}{r_\pi} + g_m} = \frac{1}{g_m} \| r_\pi$$

- Same $\frac{1}{g_m}$ pattern from controlling the emitter!
- Low input impedance good for antennas & matching to 50Ω RF stuff

R_{out}

$R_{out} = R_C$ ... g_m src turned off b/c v_t started like CE w/ degen

A_v

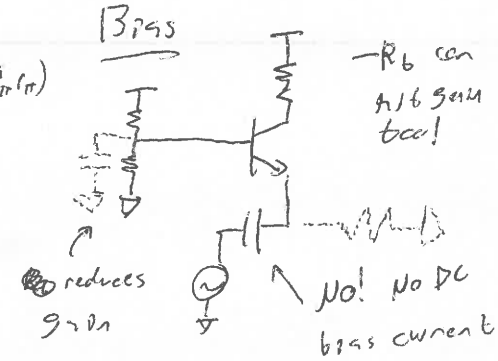
$$v_o = -g_m v_{be} R_C$$
$$= -g_m(-v_t) R_C$$
$$= g_m R_C$$

A_i → current buffer

$i_o = g_m v_{be}$ ($-i_\pi r_\pi$)
$= -\beta i_\pi$
$= \frac{-\beta}{\beta+1} i_i$
$A_i = \frac{-\beta}{\beta+1} \approx -1$

$i_\pi = i_i + g_m(-i_\pi r_\pi)$
$i_\pi(\beta+1) = i_i$

Bias



- R_b can alt gain too!

- can do this analysis w/ a T-model of BJT