E151 Lecture 10 – Emitter Follower and Multistage

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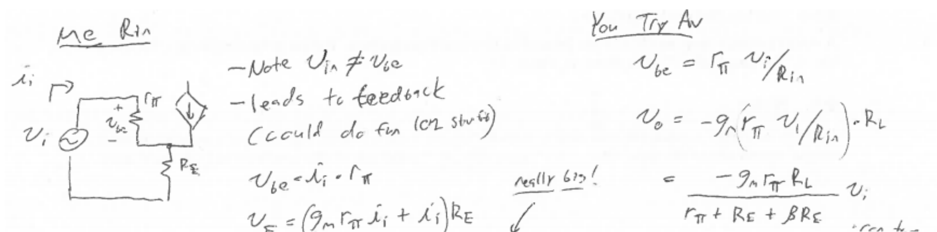
Disclaimer

These are notes for Prof. Spencer to give the lecture, they were not intended as a reference for students. Students asked for them anyway, so I'm putting them up as a courtesy. Remember that they are not intended as a substitute for attending lecture.

CE with Degen

- Find rin, rout, av

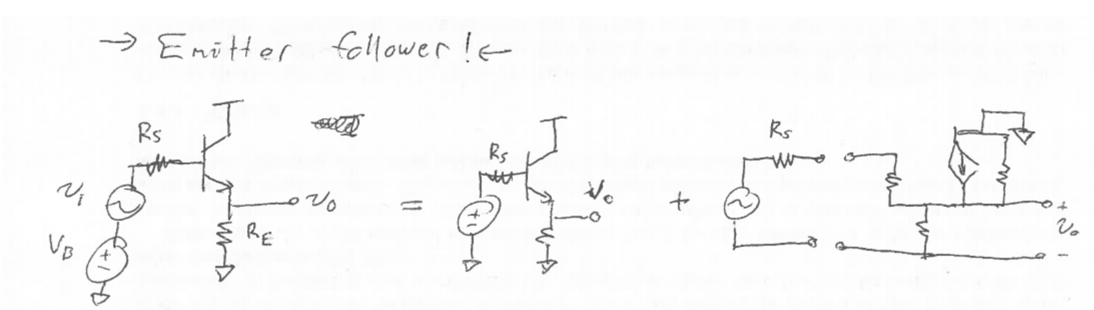


$$A_V = \frac{-\beta R_L}{r_\pi + (\beta + 1)R_E} \approx -\frac{R_L}{R_E}$$

- rout = R_L if ro presumed infinite, you will do more on your HW

Emitter Follower (Common Collector)

- We don’t yet have the ability to generate a small rout
- Need a new amplifier topology. I do rin, they do av, I do rout
- rin follows same patters as CE w/ degen, rout is a new pattern (1/gm)



rin

- Same pattern as CE with degen

$v_{be} = r_\pi i_i$

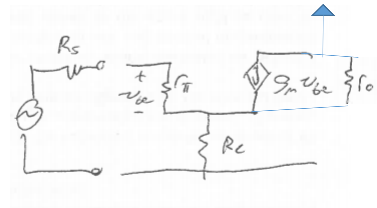
$i_i = \frac{v_o}{R_E \| r_o} - g_m v_{be}$

$= \frac{v_o}{R_E \| r_o} - g_m r_\pi i_i$

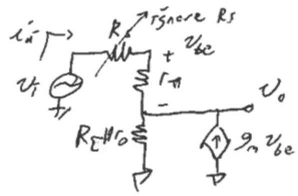
$v_o = (R_E \| r_o)(1 + \beta)$

$v_i = v_o + v_{be}$

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



OR



Exercise: you find av

- Gain of 1 isn't very high, level shift is nice interpretation

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

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

$\rightarrow A_v \approx 1$

Let's look @ large signal to check this

$v_E = v_B - 0.7$

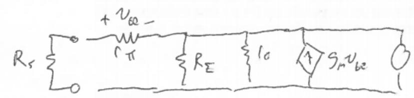
- Gain is 1, Level shifted down
- Used to get DC voltages right
- v_{BE} stays ~ 0.7, small sig captures changes

rout – a new small signal pattern (1/gm)

- Need to include Rs b/c not pure 1 directional
- Breaks our 2 port model a bit
- The reason why we measure rout w/ "input sourced:

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

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

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

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

– Backwards gain of $\frac{r_\pi}{R_s + r_\pi}$, we ignore in 2 port model

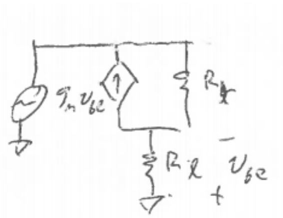
– say it's small ...

– why $\frac{1}{g_m}$? Voltage applied directly across g_m control terminals & receives controlled current

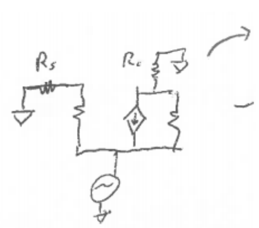
↳ watch for this pattern!

Small Signal Patterns

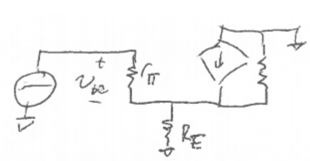
- We've just seen two common small signal models that are used a lot
- Here are more, can analyze fast if you understand / memorize
  - Thevenize aggressively, can remove from circuit
- Watch for variations: dividers to vbe, parallel stuff, ro, care w/ signs.



$R_{in} = R_\ell + R_r + g_m R_\ell R_r$



$R_{in} = r_\pi \parallel \frac{1}{g_m} + \frac{R_c}{\beta} + \frac{R_s}{\beta}$



You try

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

These are Rth and not rin