E151 Lecture 10 – Emitter Follower and Multistage

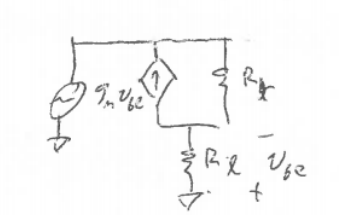
Matthew Spencer
Harvey Mudd College
ENGR151

Disclaimer

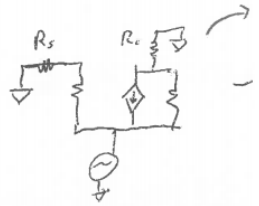
These are notes for Prof. Spencer to give the lecture, they were not intended as a reference for students. Students asked for them anyway, so I'm putting them up as a courtesy. Remember that they are not intended as a substitute for attending lecture.

Small Signal Patterns – repeat just in case

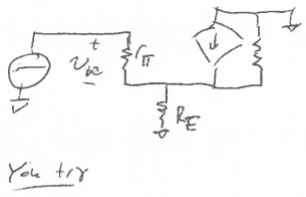
- We've just seen two common small signal models that are used a lot
- Here are more, can analyze fast if you understand / memorize
  - Thevenize aggressively, can remove from circuit
- Watch for variations: dividers to vbe, parallel stuff, ro, care w/ signs.



$R_{in} = R_B \| R_\pi + g_m R_E R_\pi$



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



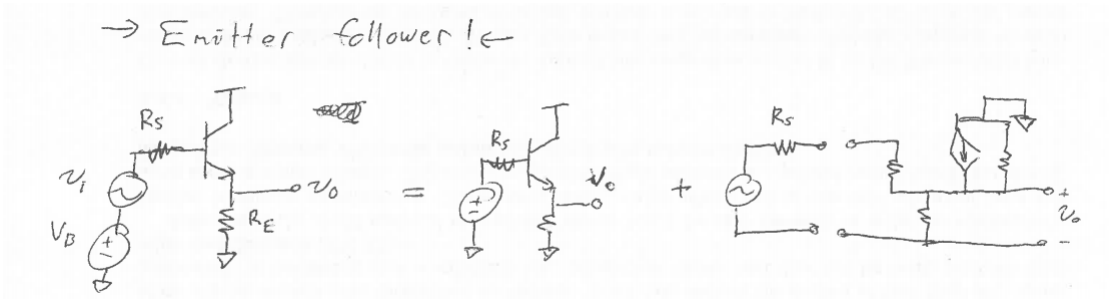
You try

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

These are Rth and not rin

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

$v_{be} = i_t r_\pi$

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

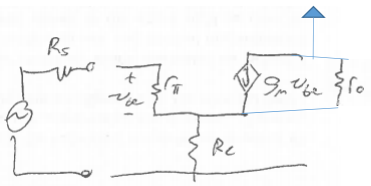
$= v_o\left(\frac{1}{R_E} + \frac{1}{r_o}\right) - g_m r_\pi i_t$

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

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

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

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



Exercise: you find av

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

Calc A_V

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

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

$\rightarrow A_V \approx 1$

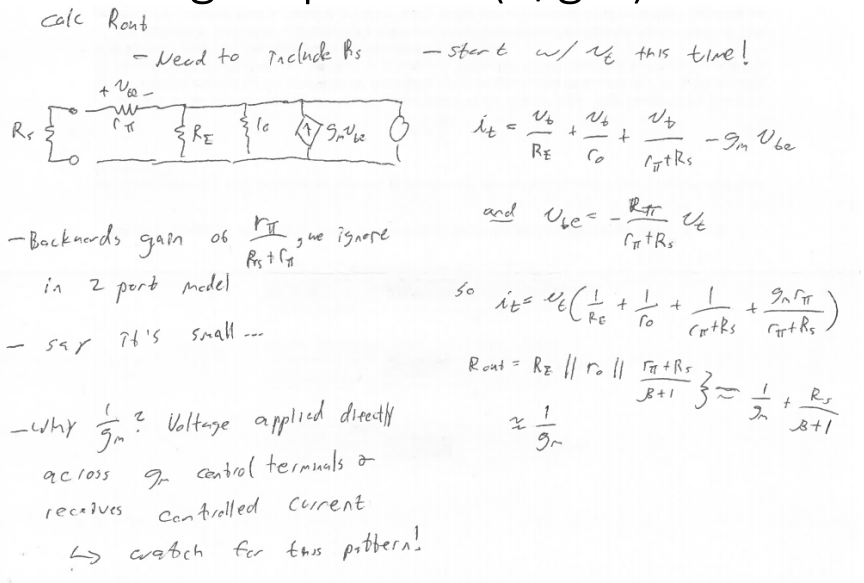
Let's look @ large signal to check this

$v_E = v_B - 0.7$

- 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



Multistage Picture and 2 Ports

- Large signal notes: separate bias points with AC coupling
- rin_tot = rin_1, rout_tot = rout_3,
- V_SW,tot = min VSW ← Need to use FFT to tell if you violate VSW