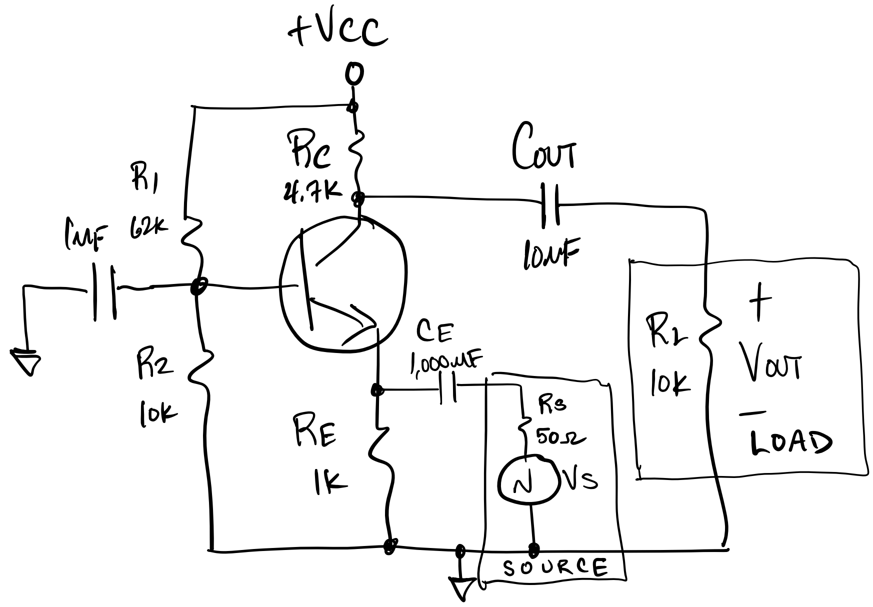
Common-Base Amplifier

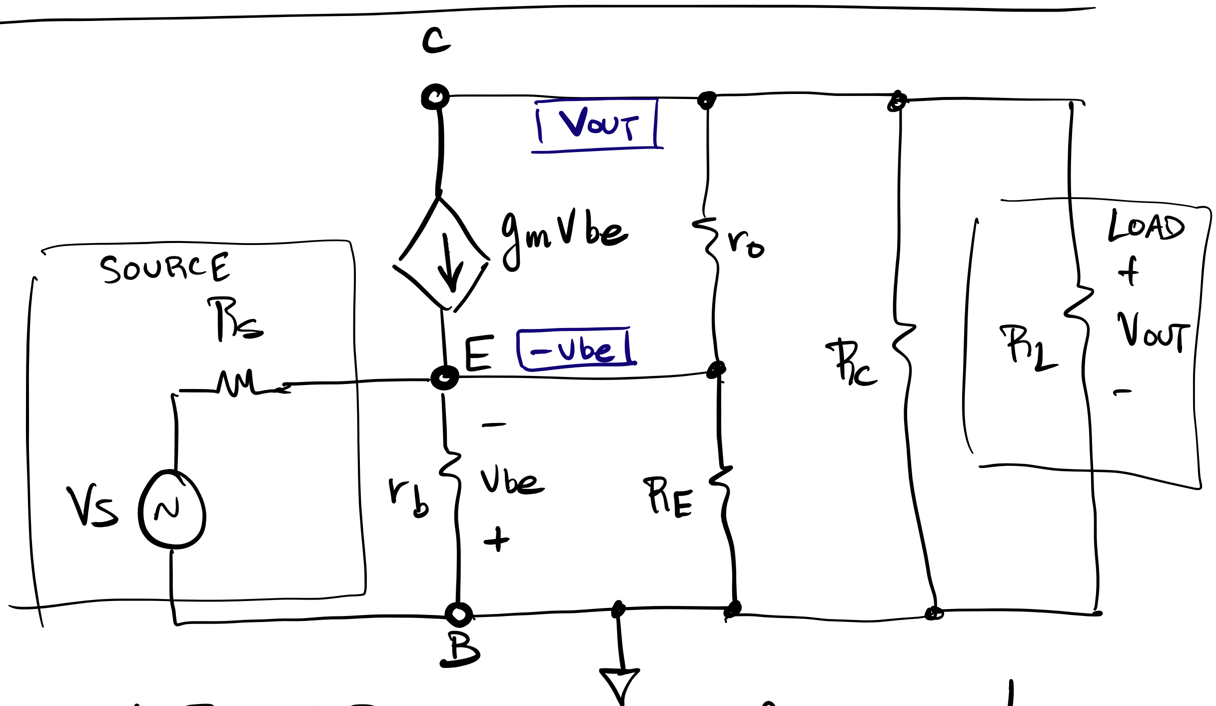


-- alternate method of modulating V_{BE}!

-- rather than couple Vs to the base and "ground" the emitter we couple Vs to the emitter and ground the base!

- this configuration suffers from <u>very</u> low R_{IN}; $\sim r_e = \frac{1}{g_m}$, thus it is not often used by itself, but as part of compound amplifier called the <u>cascode</u>.

Mid-Frequency SSM of CB Amplifier



- note R_1 and R_2 are now gone from model!
- not quite so simple to determine input and output gains A_{v1} and A_{v2}
- node voltage to the rescue!
- assume r_o is "large" and may be neglected

from the emitter terminal ($-v_{be}$):

$$\frac{-V_{be}-V_S}{R_S} + \frac{-V_{be}-0}{R_E} + \frac{-V_{be}-0}{r_b} + -g_m V_{be} = 0$$

$$-V_{be}\left(\frac{1}{R_S} + \frac{1}{R_E} + \frac{1}{r_b} + g_m\right) = \frac{V_S}{R_S}$$

$$A_{v1} = \frac{v_{be}}{V_S} = \frac{-1}{R_S\left(\frac{1}{R_S} + \frac{1}{R_E} + \frac{1}{r_b} + g_m\right)}$$

$$A_{v1} = -\frac{\left(R_S \parallel R_E \parallel r_b \parallel \frac{1}{g_m}\right)}{R_S}$$

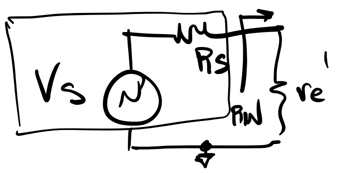
define $r_e' = R_E \| r_b \| \frac{1}{g_m}$

then $A_{v_1} = \dfrac{-R_S \| r_e'}{R_S} = \dfrac{-\cancel{R_S}\, r_e'}{(R_S + r_e')\cancel{R_S}}$

$$A_{v_1} = \frac{-r_e'}{R_S + r_e'}$$

← voltage division between r_e' and R_S!

∴ clearly shows that $R_{IN} = r_e'$!



∴ we already know

$g_m = 92.05$ mA/V

$R_E = 1\ k\Omega$

$r_b = 2.173\ k\Omega$

$R_S = 50\Omega$

$$\frac{1}{g_m} = \frac{1}{92.05} = 0.01086\ k\Omega$$

or 10.86Ω

∴ $r_e' = \frac{1}{g_m} \| R_E \| r_b \simeq \frac{1}{g_m} = 10.86\ \Omega$!!!!

$$A_{v_1} = \frac{-r_e'}{R_s + r_e'}$$

$$= \frac{-10.86}{50 + 10.86} = \underbrace{-0.1784}$$

or $-15\,dB$ (inverting)

not much of an amplifier yet!

.. node voltage from the collector terminal, again neglecting r_o:

$$g_m v_{be} + \frac{V_{OUT} - 0}{R_C} + \frac{V_{OUT} - 0}{R_L} = 0$$

$$V_{OUT}\left(\frac{1}{R_C} + \frac{1}{R_L}\right) = -g_m v_{be}$$

$$A_{v_2} = \frac{V_{OUT}}{V_{be}} = -g_m\left(\frac{1}{\frac{1}{R_C} + \frac{1}{R_L}}\right)$$

$$\underbrace{A_{v_2} = -g_m (R_C \| R_L)}$$

(just like common emitter!)

if $g_m = 92.05$
$R_C = 4.7k$
$R_L = 10k$ $\Big\}$ $R_C \| R_L = 3.197k$

about 0.7 dB higher than CE due to r_o (big deal)

then $A_{v_2} = -92.05 \cdot 3.197 = \underbrace{-294}$ or $\underline{49\,dB}$ (inverting)

$$A_v = A_{v_1} \times A_{v_2} = -0.1784 \cdot -294$$

$$= +\underline{52.45} \text{ or } \underline{34\text{ dB}}$$

<u>non-inverting!</u>

.. so CB configuration has <u>less gain</u> and <u>much lower R_{IN}</u> than CE.

LF Response of CB Amplifier

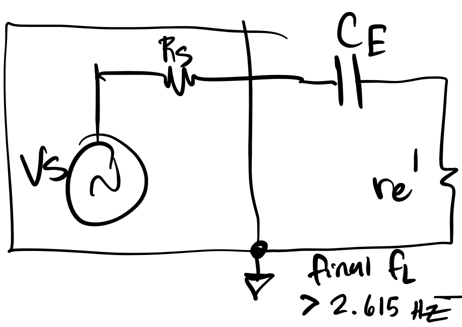
-- good news: capacitor to ground at base no longer creates high-pass filter

.. the capacitor at the collector (C_{OUT}) does the same thing in CB as it does in CE; thus,

$$f_{L\,OUT} = \frac{1}{2\pi\, C_{OUT}\,(r_o \| R_C + R_L)}$$

$$= \underline{1.12\text{ Hz}} \text{ in previous example (with } r_o)$$

.. now C_E creates high-pass filter with R_S and r_e'



final f_L > 2.615 Hz

$$\therefore f_{L\,IN} = \frac{1}{2\pi \cdot C_E \cdot (R_S + r_e')}$$

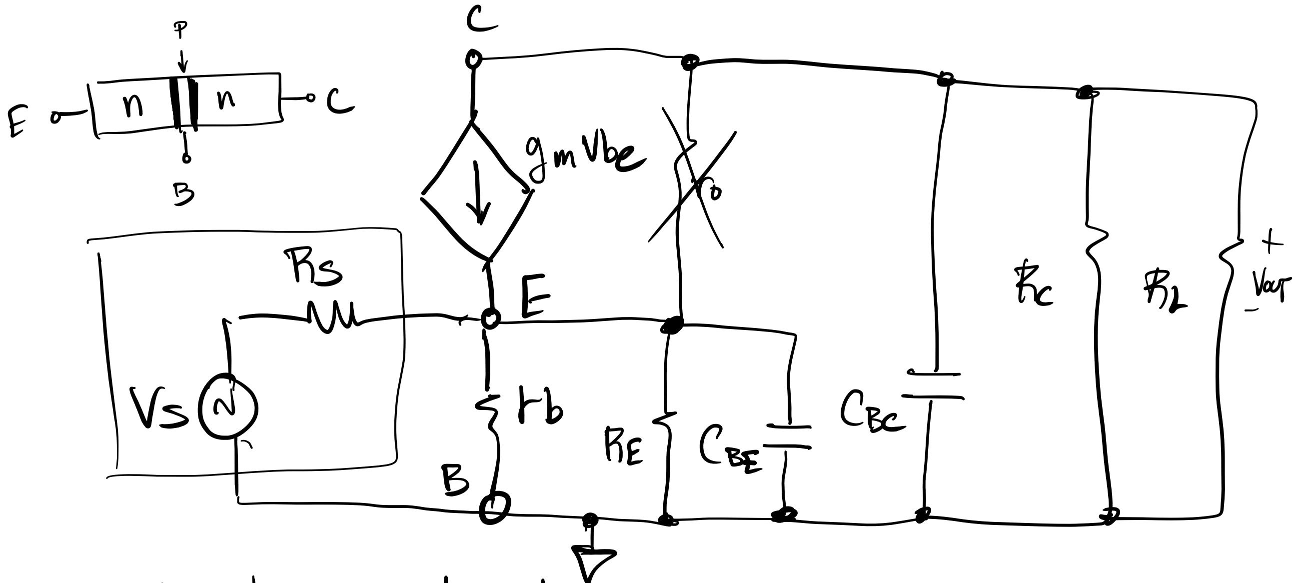
$$f_{L\,IN} = \frac{1}{2\pi \cdot 1000\times10^{-6}\,(50 + 10.86)}$$

$$= \underline{2.615\text{ Hz}}$$

HF Response of CB Amplifier

-- this is where things get interesting!

HF SSM:



-- note that we don't have any capacitance between input and output

⟶ No Miller Time !!! ...

-- just two simple low-pass filters!

$$f_{HIN} = \frac{1}{2\pi \cdot C_{BE}\,(R_s \parallel r_e')}$$

$r_e' \longrightarrow \approx \frac{1}{g_m}$

$$f_{HIN} = \frac{1}{2\pi \cdot 18\times10^{-12}\,(50 \parallel 10.86)}$$

18: from previous lecture!

$(50 \parallel 10.86) \longrightarrow = 8.922\,\Omega$

$f_{HIN} = 991\ \text{MHz}$!!! ...

-- Compare this to 2.97 MHz of CE, wow!

$$f_{H\,OUT} \cong \frac{1}{2\pi \cdot \underbrace{C_{BC}}_{4\,pF} \underbrace{(R_C \parallel R_L)}_{3.197k}}$$

(same as CE amplifier if you ignore r_o)

$f_{H\,OUT}$ = 12.4 MHz [was 13.5 including r_o]

→ this is the dominant pole

∴ $f_H \approx$ 12.4 MHz

-- so despite lower gain and much lower R_{IN}, CB has superior HF response to the CE configuration

-- we'll combine the two into the best of both worlds!