AEC lec 10 7/8/23

BJT amplifier (AC analysis)

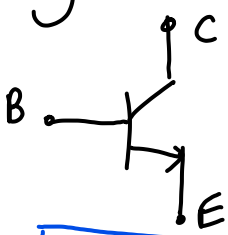
- CE amplr
- CB amplr
- CC amplr

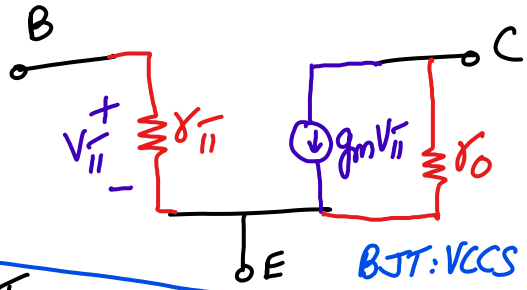
Cond^n^s for an amplifier:

1. I/P s/g should be small (~ mV)
2. BJT should be biased in "Forward-Active Mode"
3. Consider small s/g hybrid-π model
4. Consider small time-varying quantities ($v_{in}(t)$, $v_{out}(t)$)

Hybrid-π model:

npn BJT





BJT: VCCS

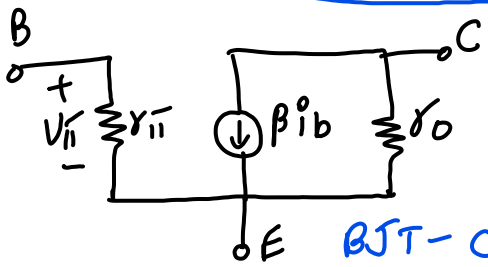
$V_T = 26mV$ at R.T (27°C)

V_A: Early voltage

$r_\pi = \frac{\beta}{g_m}$ ('Ω') ; $g_m = \frac{I_{CQ}}{V_T}$; $r_o = \frac{V_A}{I_{CQ}}$ ('kΩ')

Given: β, V_A

g_m: mA/V

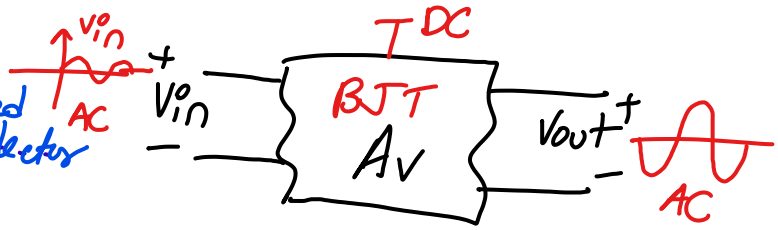


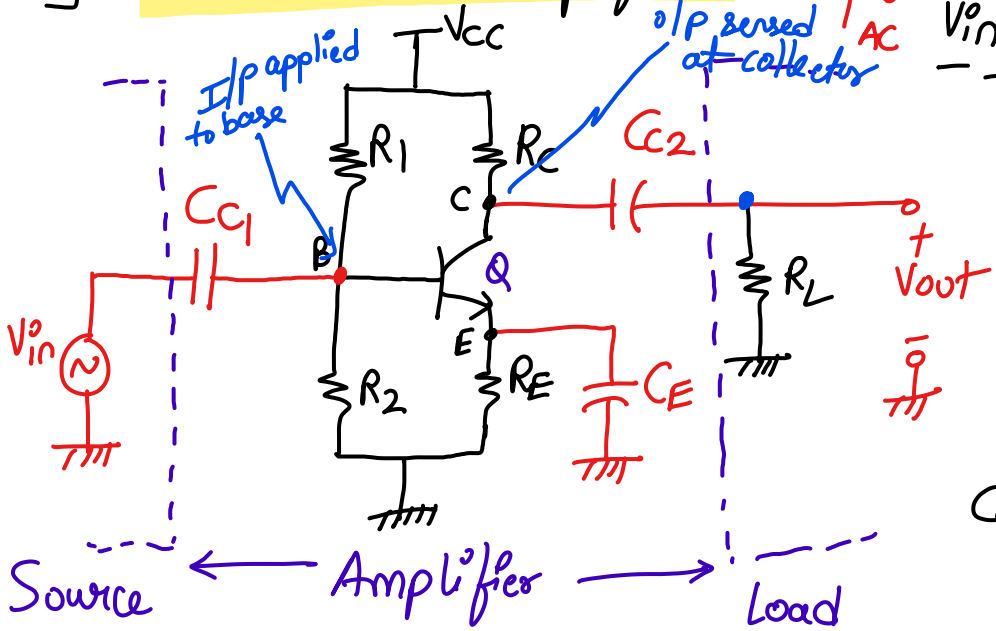
BJT - CCCS

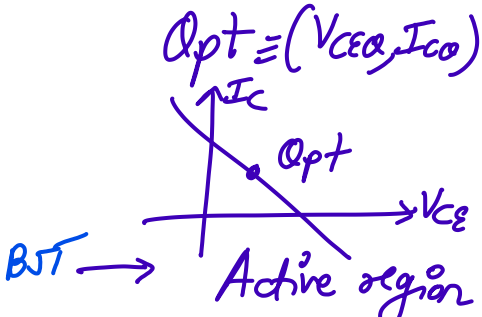
$i_c = g_m v_{be}$ ($v_{be} = v_\pi$) ; $i_c = \beta i_b$

→ Small-s/g parameters

I] Common emitter amplifier:







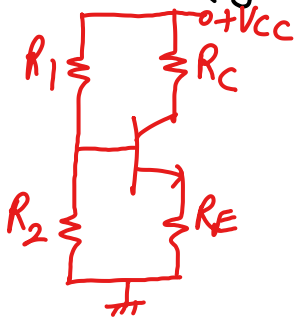
C_{C_1}, C_{C_2}: Coupling capacitor

C_E: Bypass capacitor

R_L: Load resistor

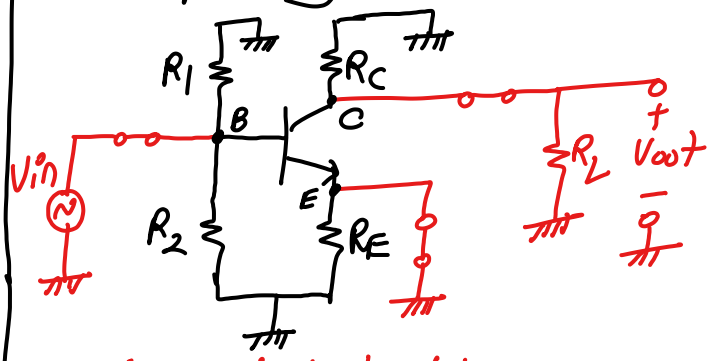
DC analysis:

→ consider all connected capacitors as open ckt ($f=0 \rightarrow X_C = \frac{1}{2\pi fC} \rightarrow \infty$)



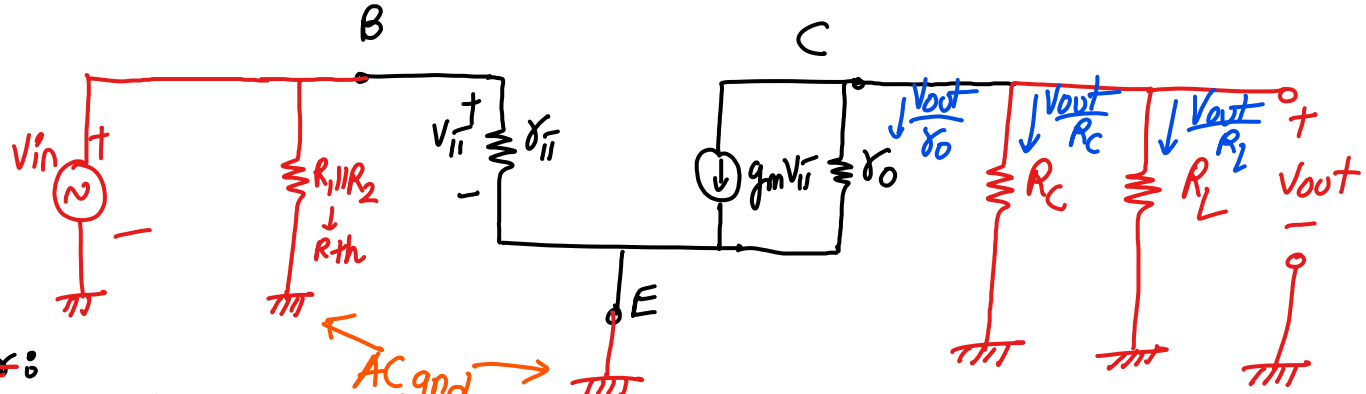
AC analysis: (DC supply → s.c)

→ All connected capacitors are replaced by short ckt ($f \neq 0$)



AC equivalent ckt

→ Replace bjt by its small-sig hybrid-π model



Small-sig equivalent circuit

$V_{\pi} = V_{in}$

Amplifier:

1) A_V → Voltage gain
2) R_{in} / Z_{in}
3) R_{out} / Z_{out}

BJT → gain: β; Rin: r_{π}; Rout = r_o

① A_v : Voltage gain ; $A_v = \frac{V_{out}}{V_{in}}$

Apply KCL at 'c' terminal,

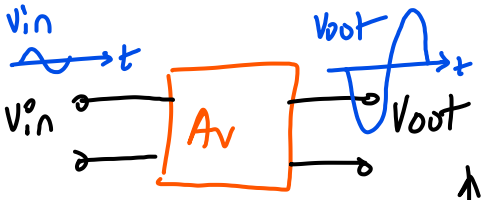
$$g_m V_{\pi} + \frac{V_{out}}{r_o} + \frac{V_{out}}{R_C} + \frac{V_{out}}{R_L} = 0$$

$$\rightarrow g_m V_{in} = -V_{out}\left(\frac{1}{r_o} + \frac{1}{R_C} + \frac{1}{R_L}\right)$$

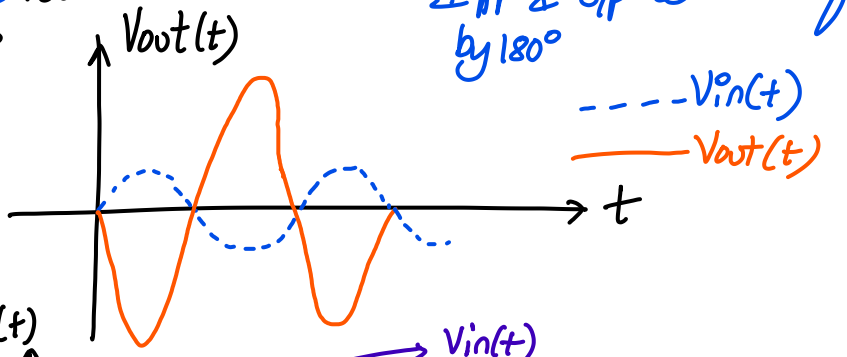
$$\rightarrow \boxed{A_v = \frac{V_{out}}{V_{in}} = -g_m(r_o \| R_C \| R_L)}$$ → Voltage gain

inversion

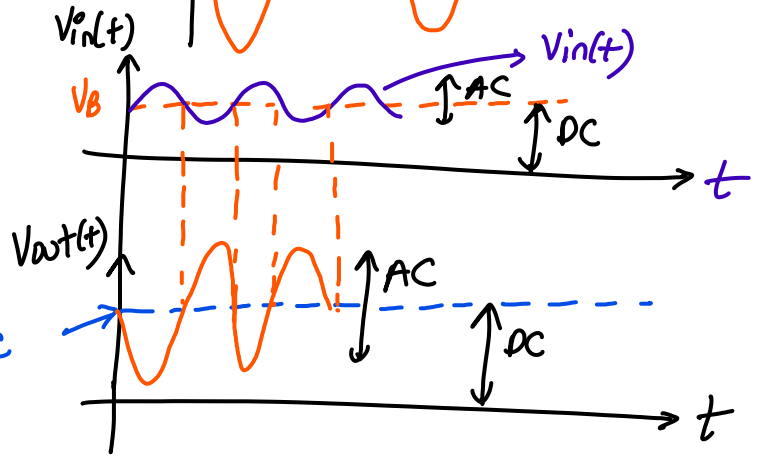
-ve sign indicates that I/P & o/p are out of phase by 180°



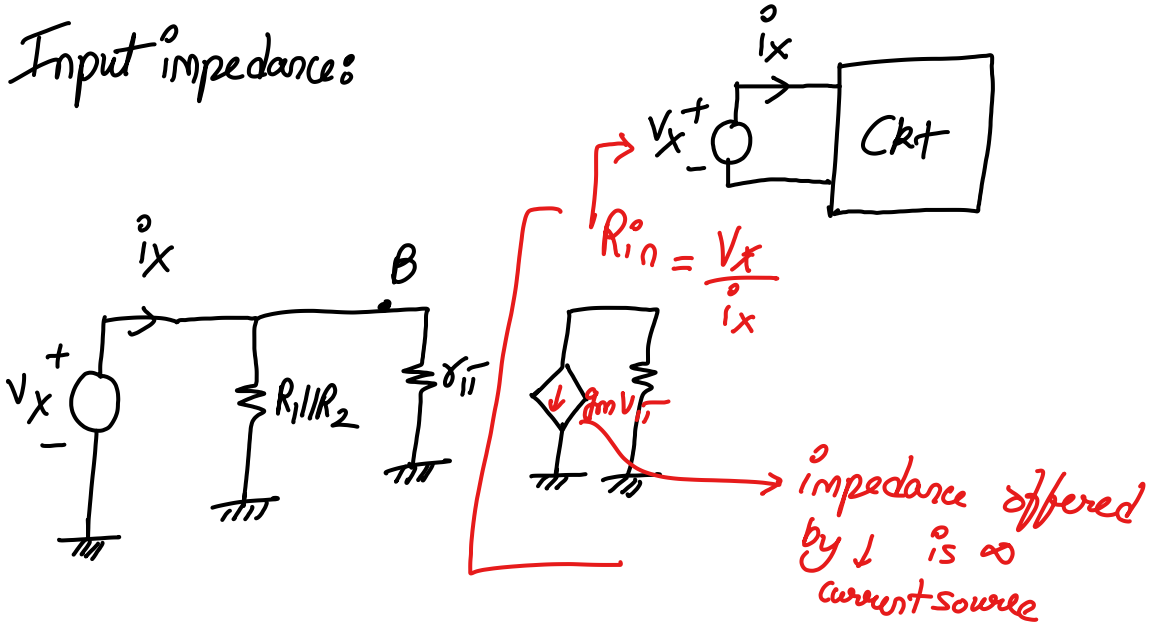
With capacitor's ✓



w/o capacitor's ✗



b) Input impedance:



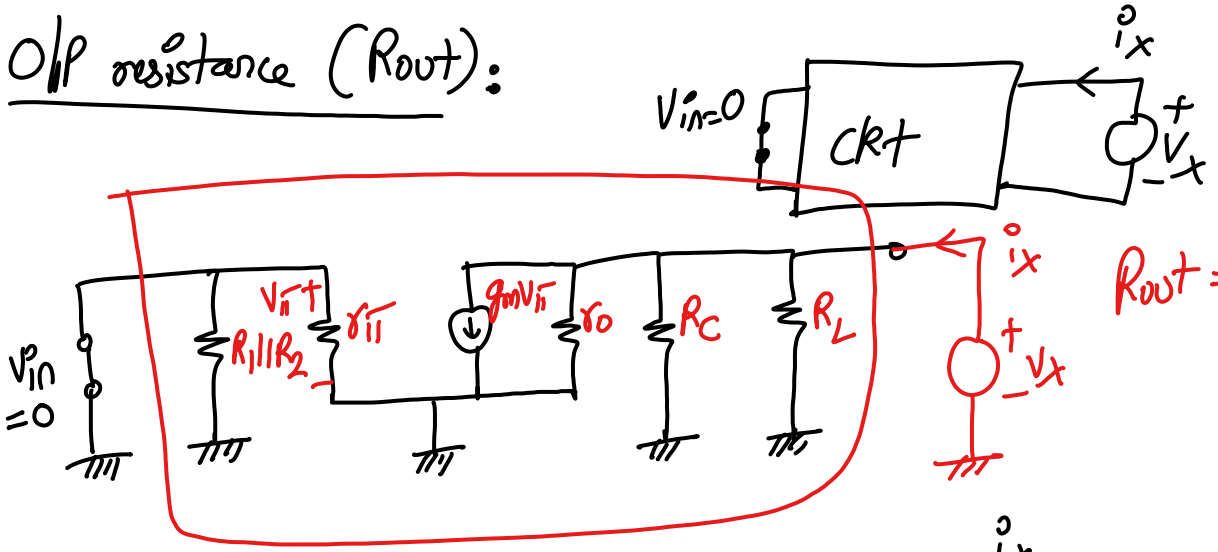
$\frac{V_x}{i_x} = R_1 \| R_2 \| r_\pi$

$R_{in} = r_\pi$

BJT

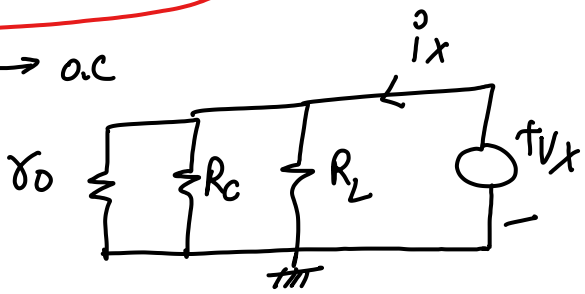
$R_{in} = R_1 \| R_2 \| r_\pi$ → I/p impedance of amplifier

c) O/p resistance (Rout):



$R_{out} = \frac{V_x}{i_x}$

$V_{in}=0 \rightarrow V_\pi = 0 \rightarrow g_m V_\pi = 0 \rightarrow$ o.c



$\frac{V_x}{i_x} = r_o \| R_C \| R_L$

$R_{out} = r_o \| R_C \| R_L$ → o/p resistance of amplr

BJT
$R_{out} = r_o$

97, 80, 78, 85, 67,
44, 101, 8, 64, 2

Attendance, AEC lec 10 (7/8/23)