BJT Amplifier
Common Emitter Amp (H.11)

20170630

References

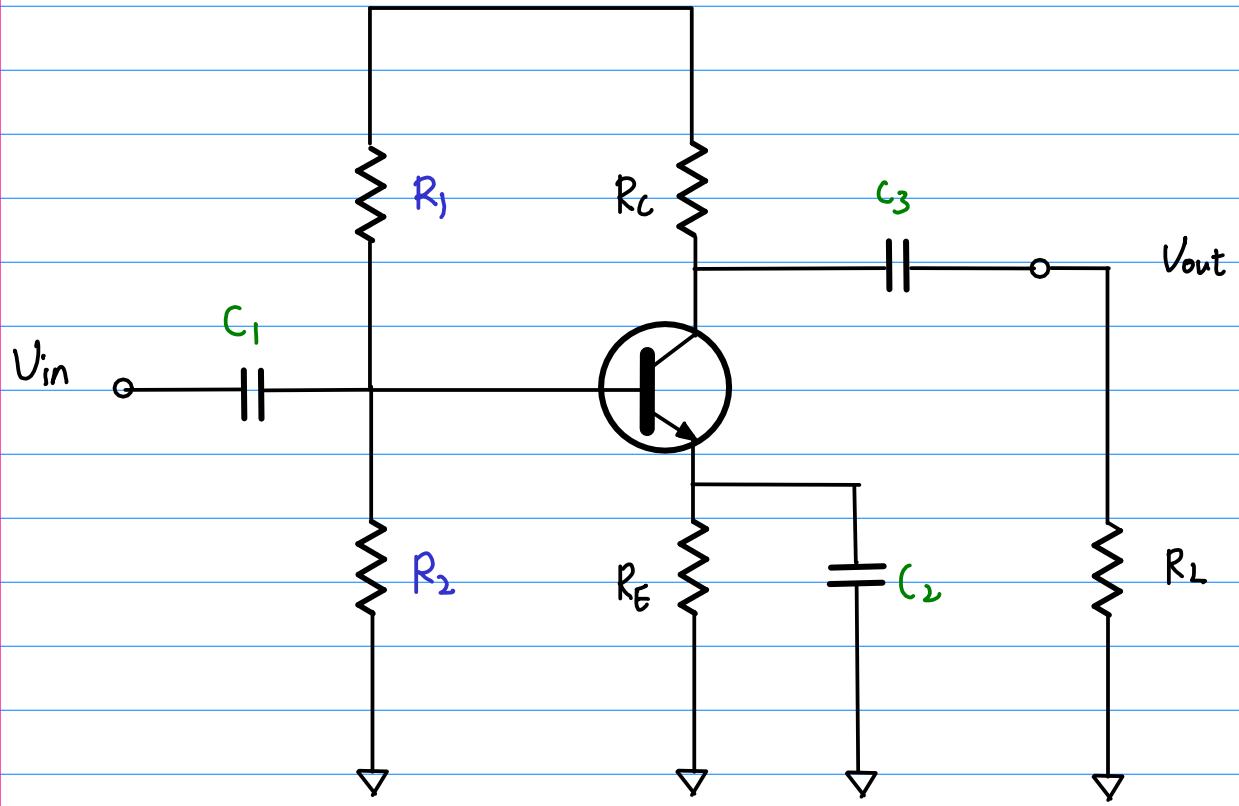
Based

[1] Floyd, Electronic Devices 7th ed
[2] Cook,

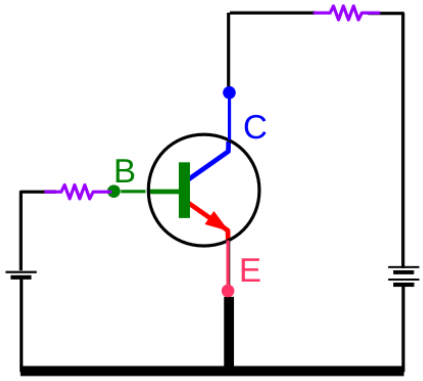
[2] en.wikipedia.org

	Common Base	Common Emitter	Common Collector
Z_{in}	CB : low $r_e \| \| R_E \approx r_e$	CE : med $R_1 \| \| R_2 \| \| \beta r_e$	CC : high $R_1 \| \| R_2 \| \| \beta(r_e + R_E)$
Z_{out}	CB : high R_C	CE : med R_C	CC : low $(r_e + \frac{R_s}{\beta}) \| \| R_E = \frac{R_s}{\beta} \| \| R_E$
A_v	CB : high $\frac{R_C}{r_e}, \frac{R_C \| \| R_L}{r_e}$	CE : med $\frac{R_C}{r_e}, \frac{R_C \| \| R_L}{r_e}$	CC : unity $\frac{R_E}{(r_e + R_E)} \approx 1$
A_i	CB : unity	CE : med	CC : high

VDB

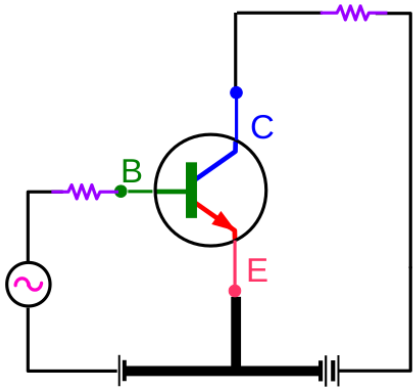

R_1
R_C
C_3
V_{out}
C_1
V_{in}
R_2
R_E
C_2
R_L

Common Emitter Configuration



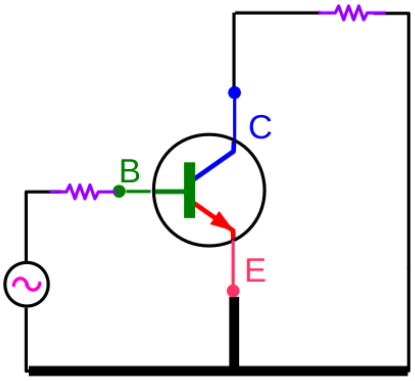
Common Emitter

DC Bias



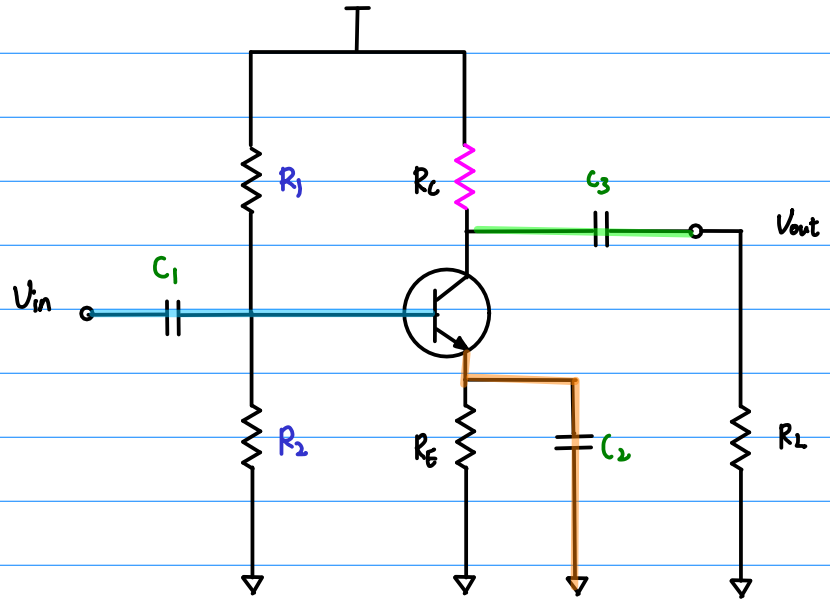
Common Emitter

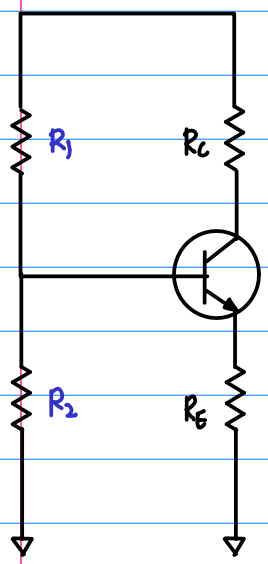
DC Bias + AC Signal

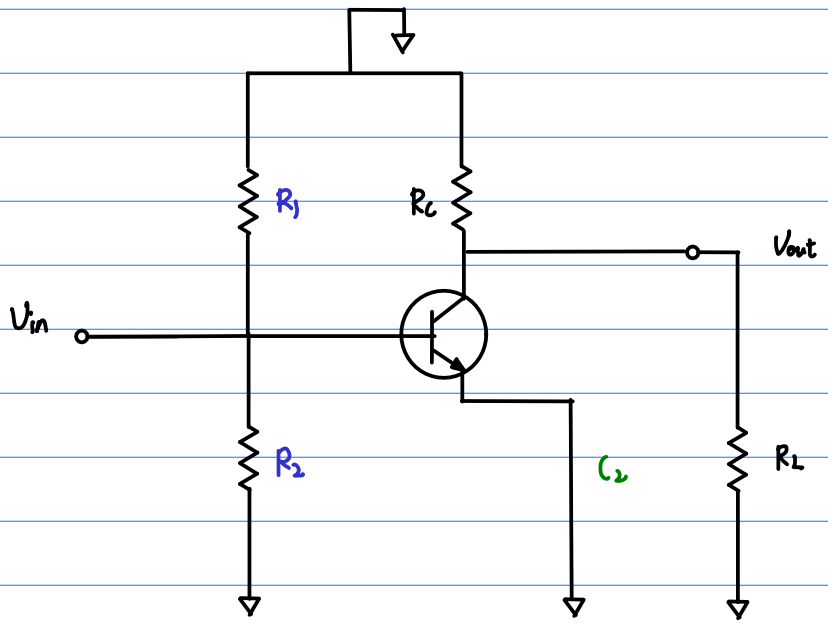


Common Emitter

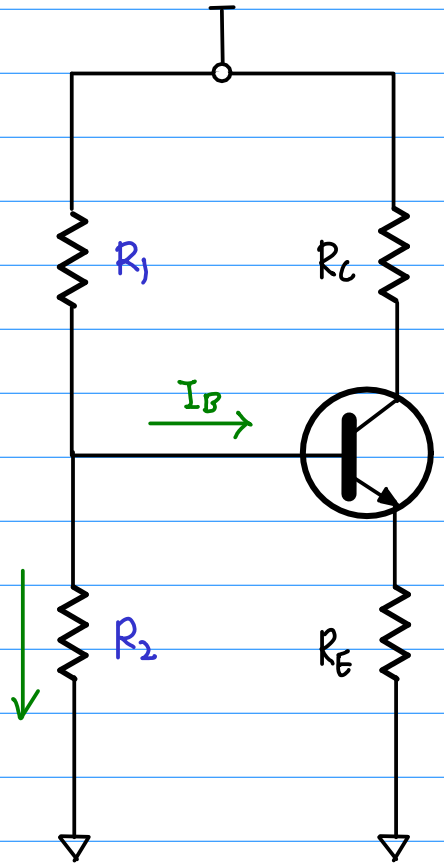
AC Signal



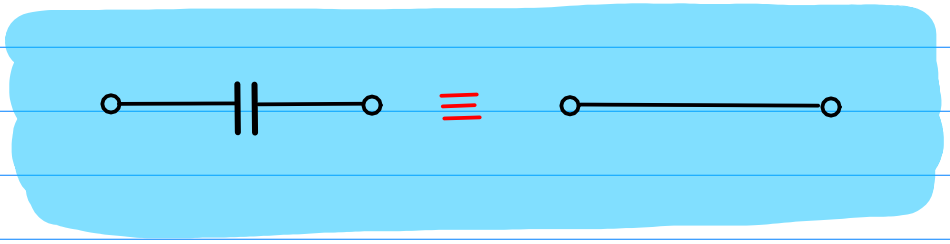




DC Analysis



AC Ground

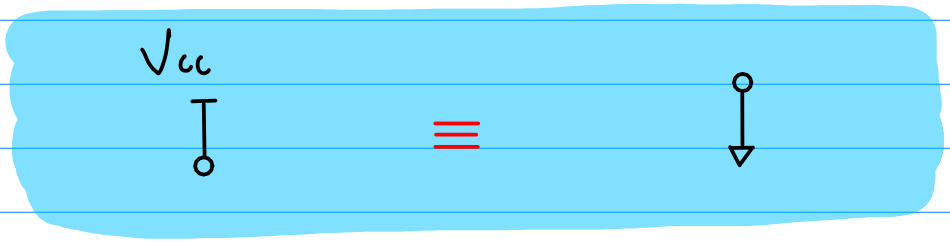


C_1, C_2, C_3 – effectively short

their values are selected

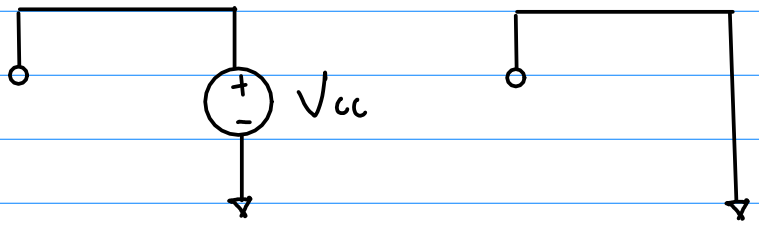
s.t $X_C = \frac{1}{j\omega C} \cong 0\,\Omega$

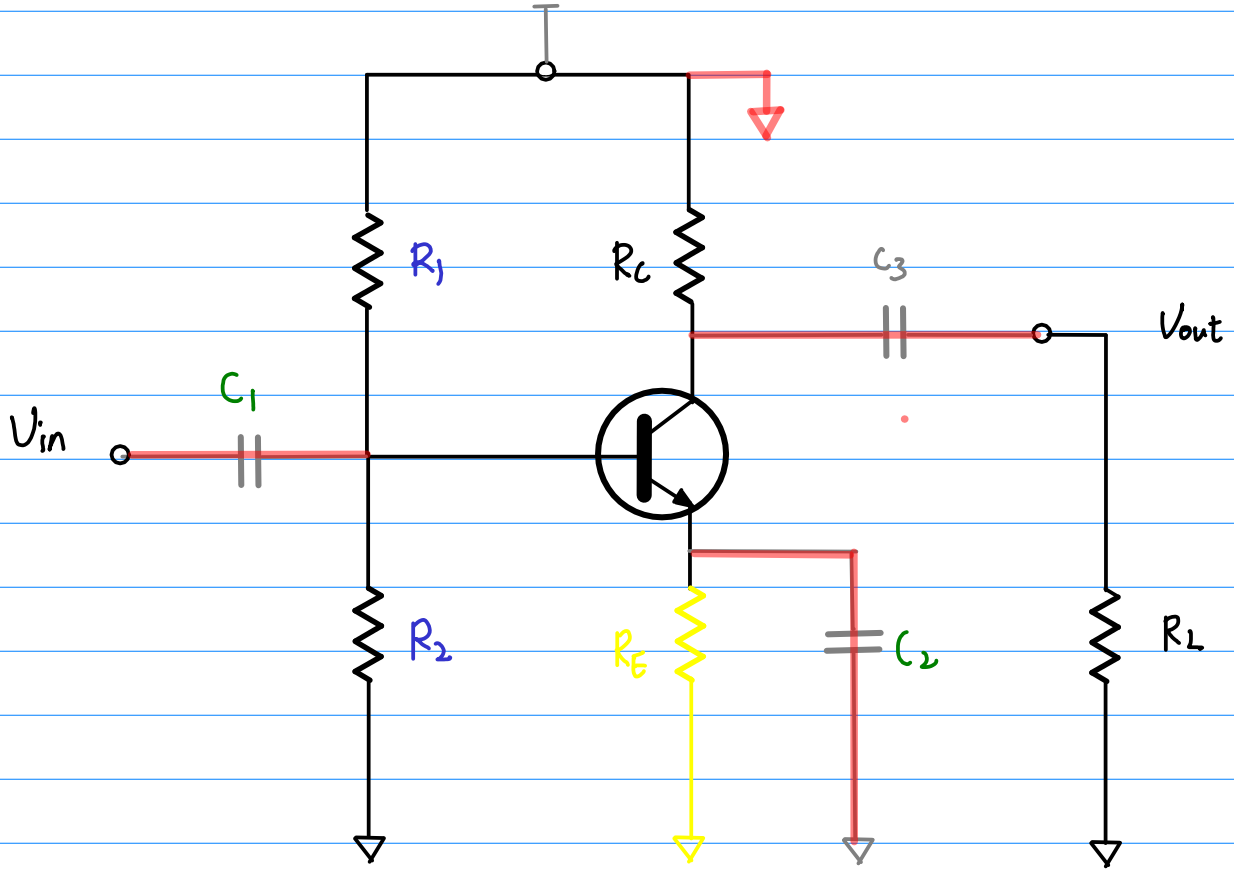
at the signal frequency (ω)

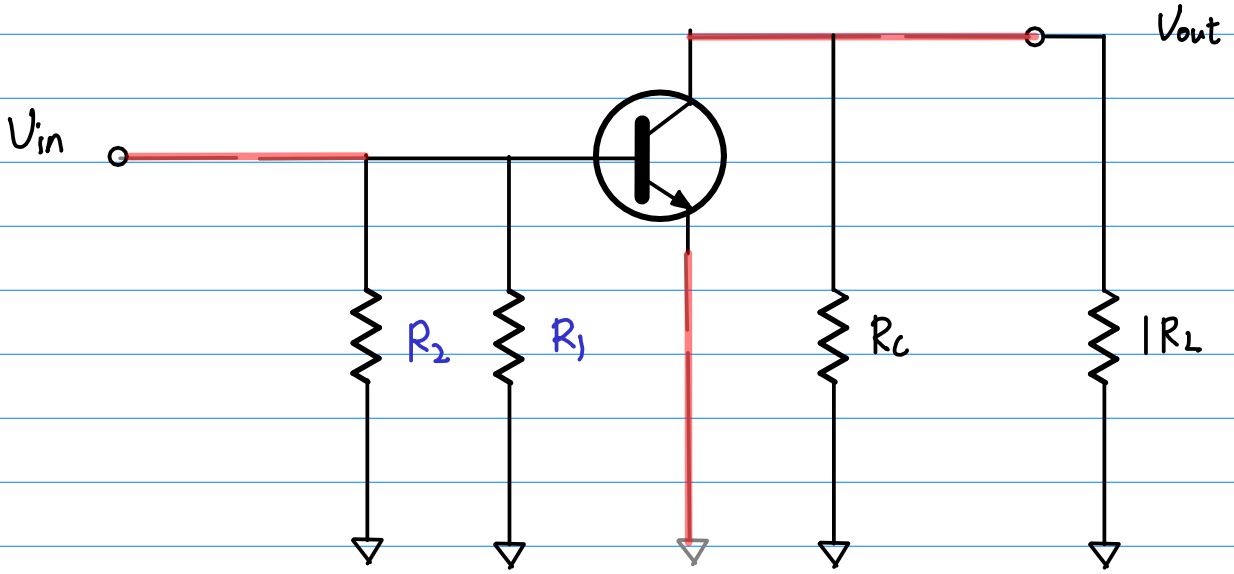


dc source

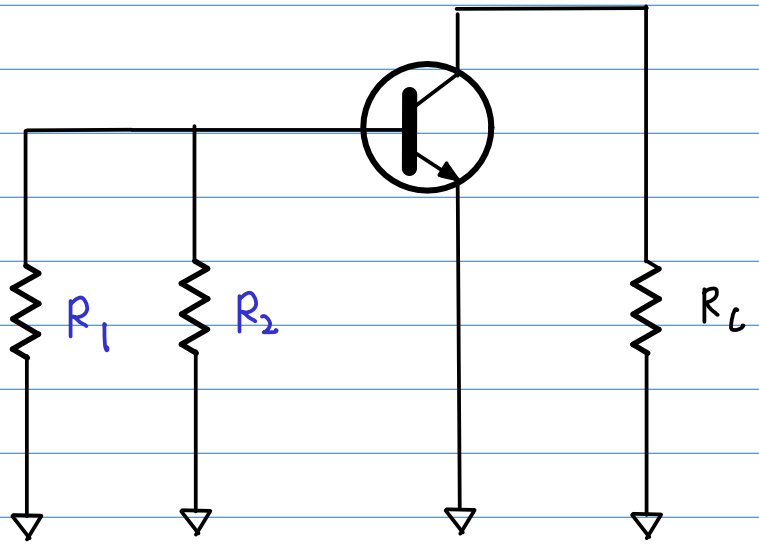
ac ground

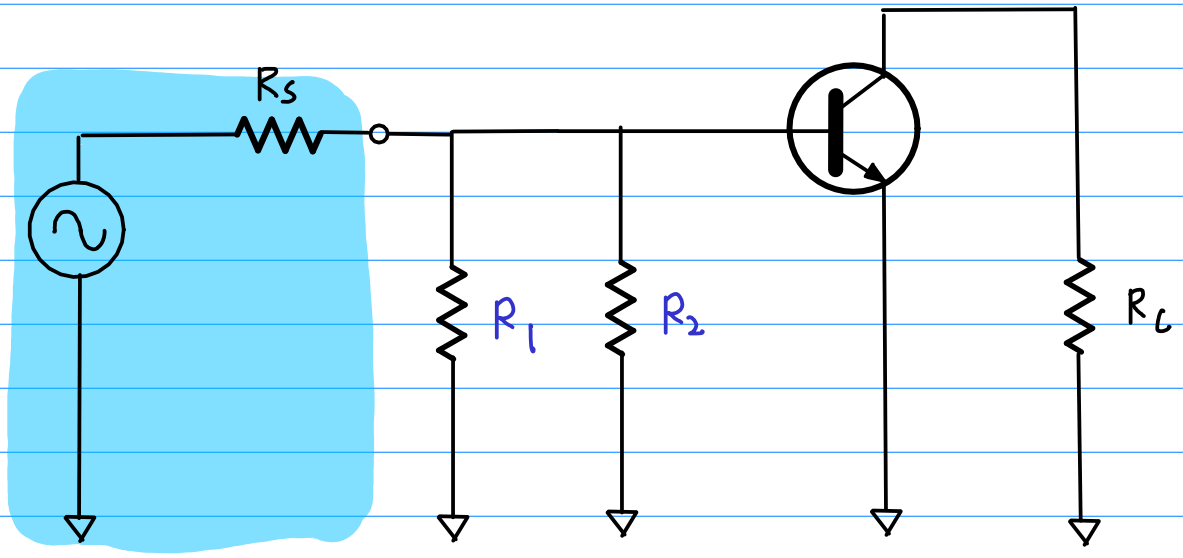



R1
RC
C3
Vout
C1
Vin
R2
RE
C2
RL

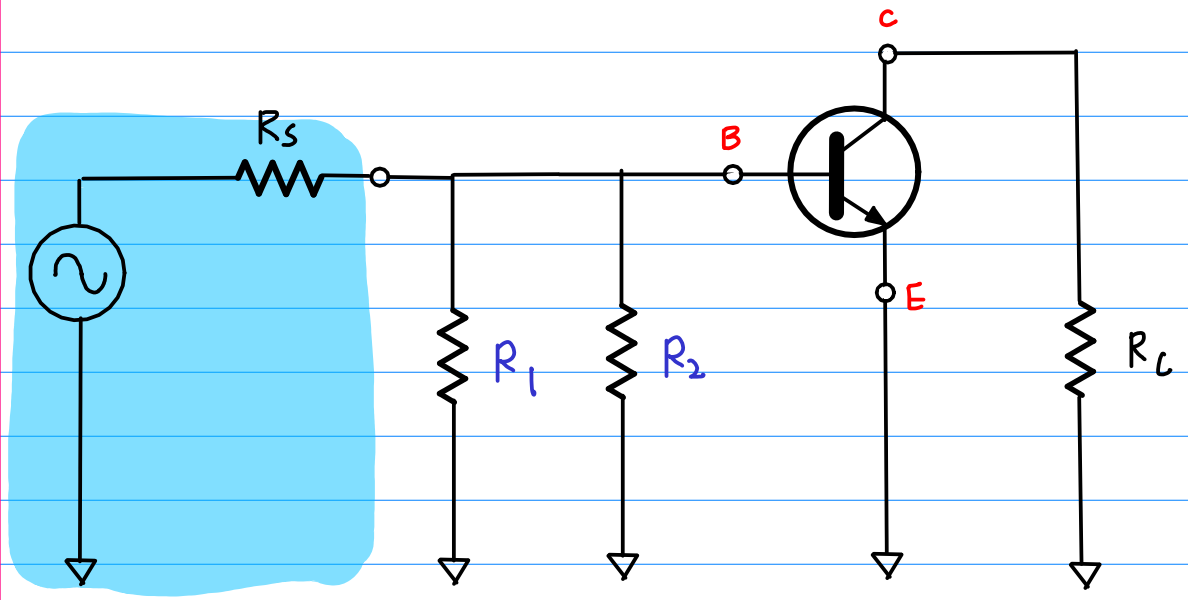

Vout
Vin
R2
R1
RC
RL

AC Equivalent Circuit

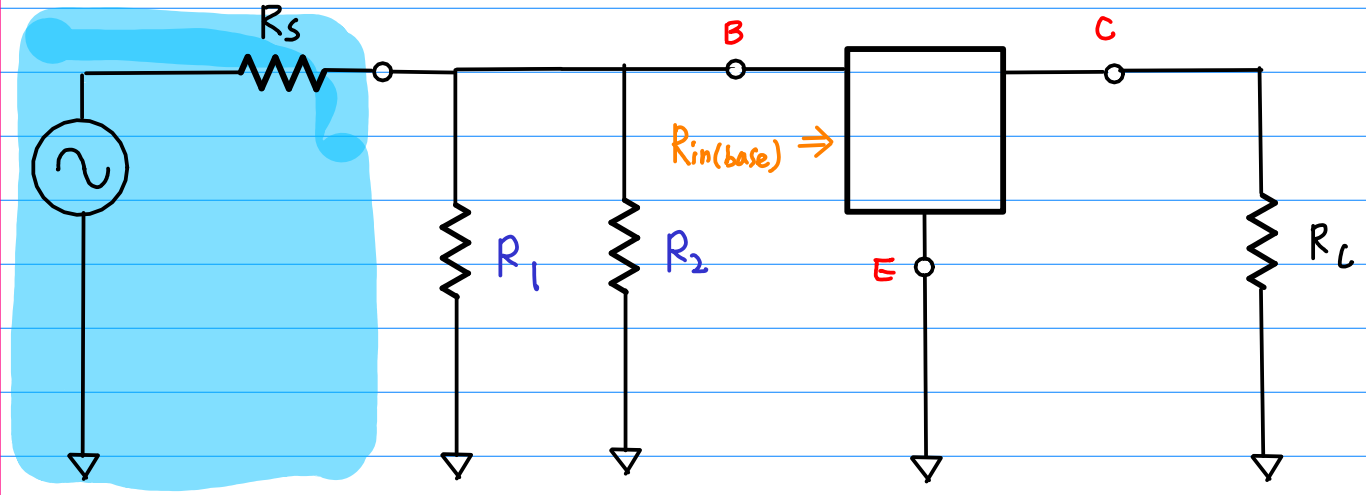


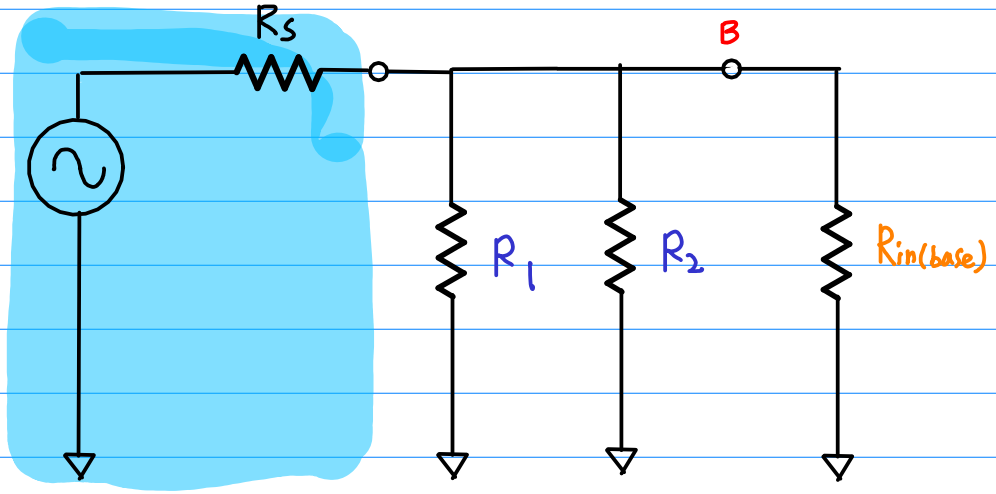


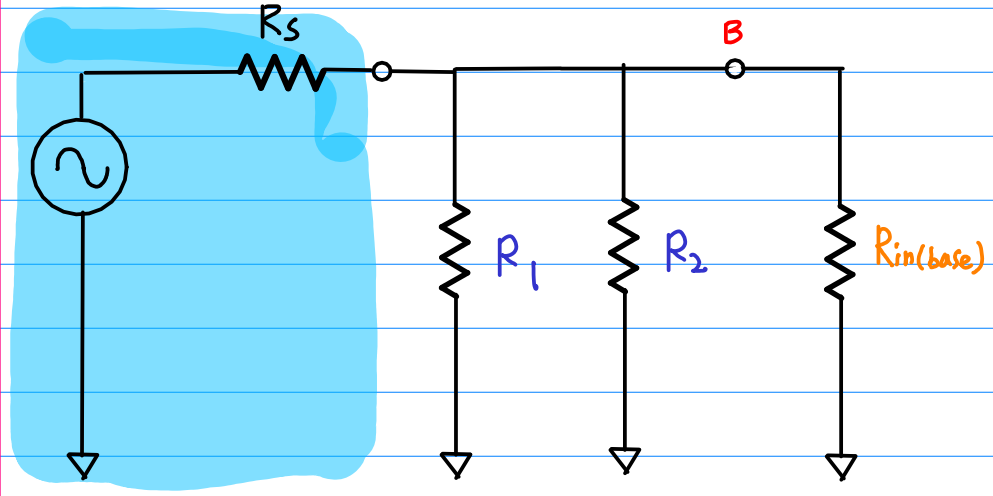
ac source

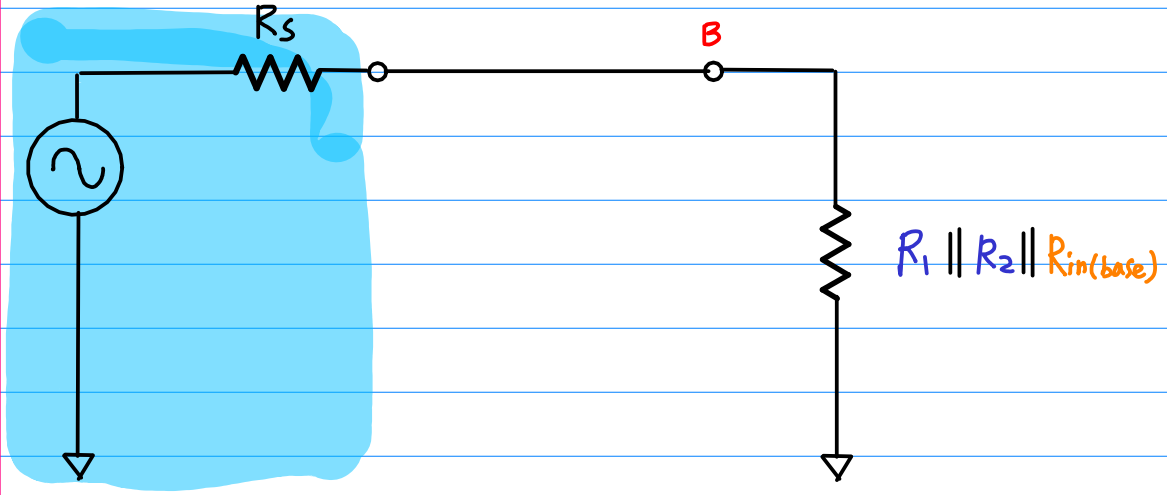


ac source

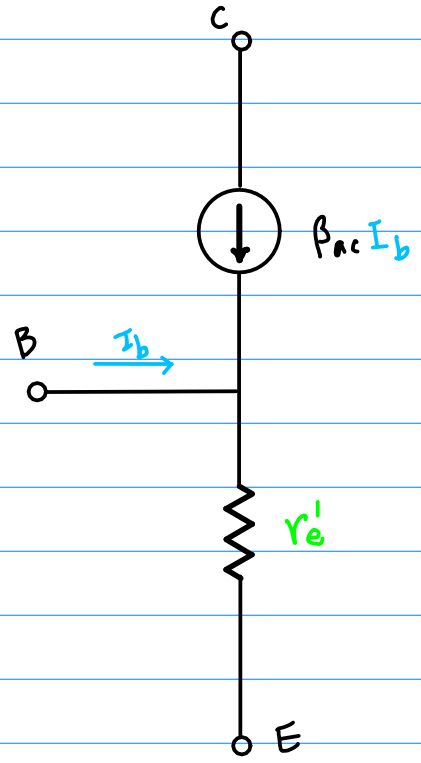


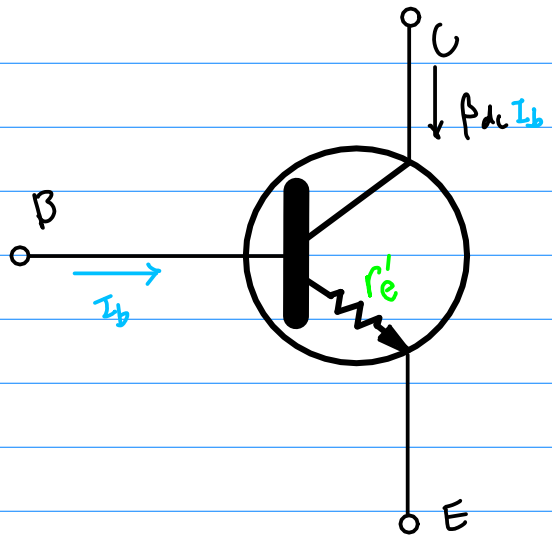


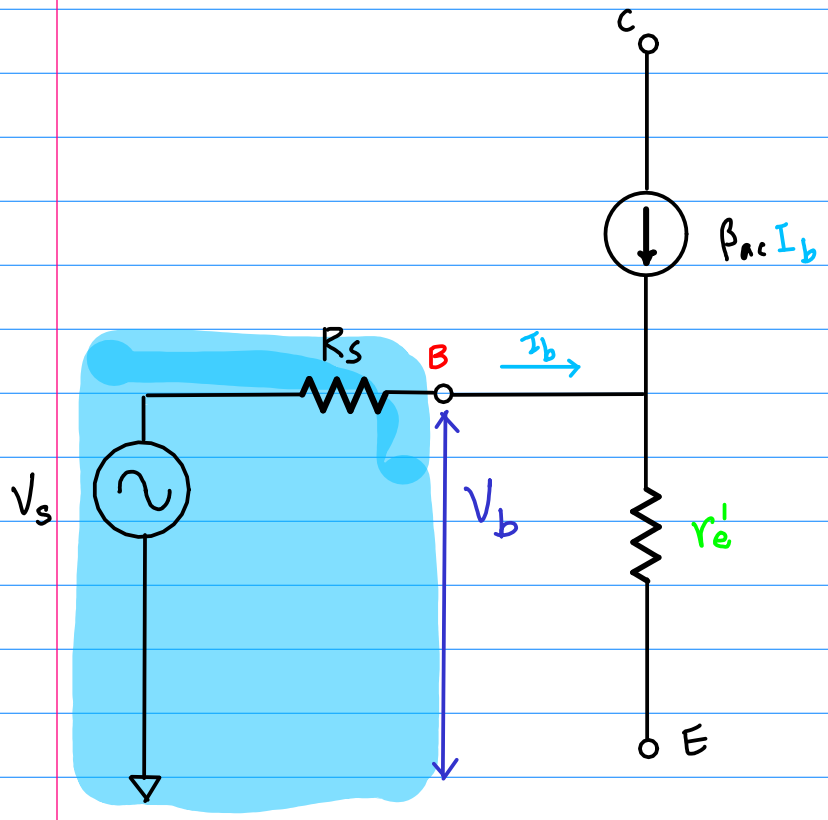

Rs
B
R1
R2
Rin(base)

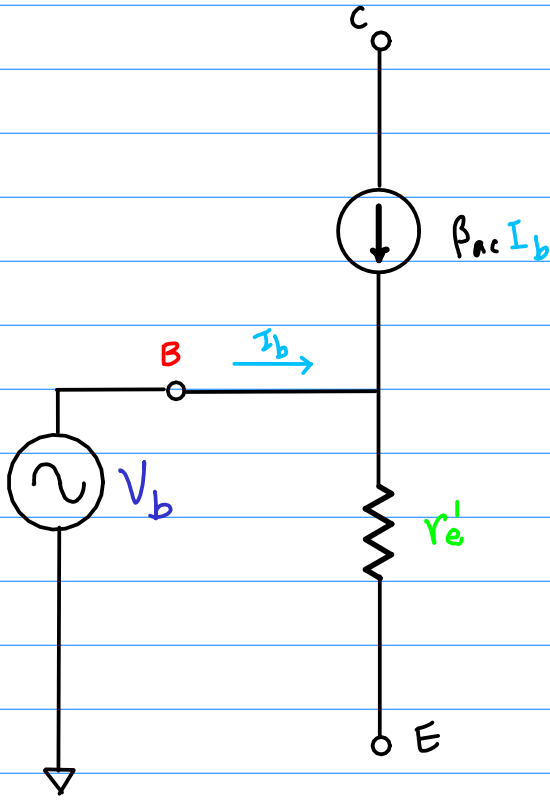

Rs
B
R1 || R2 || Rin(base)

Input Resistance

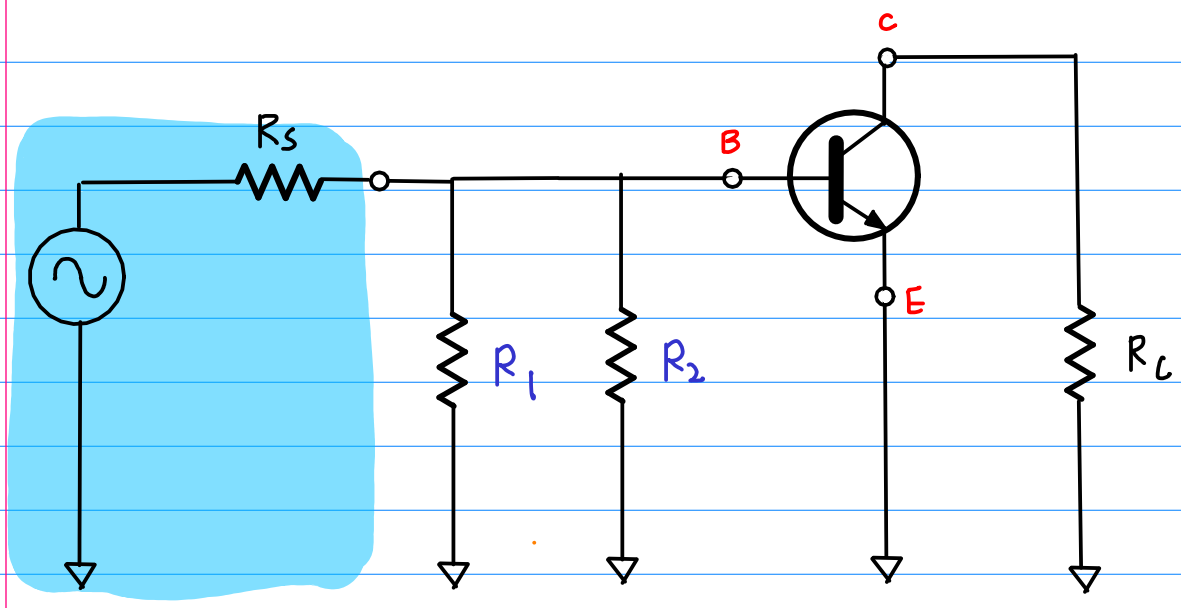




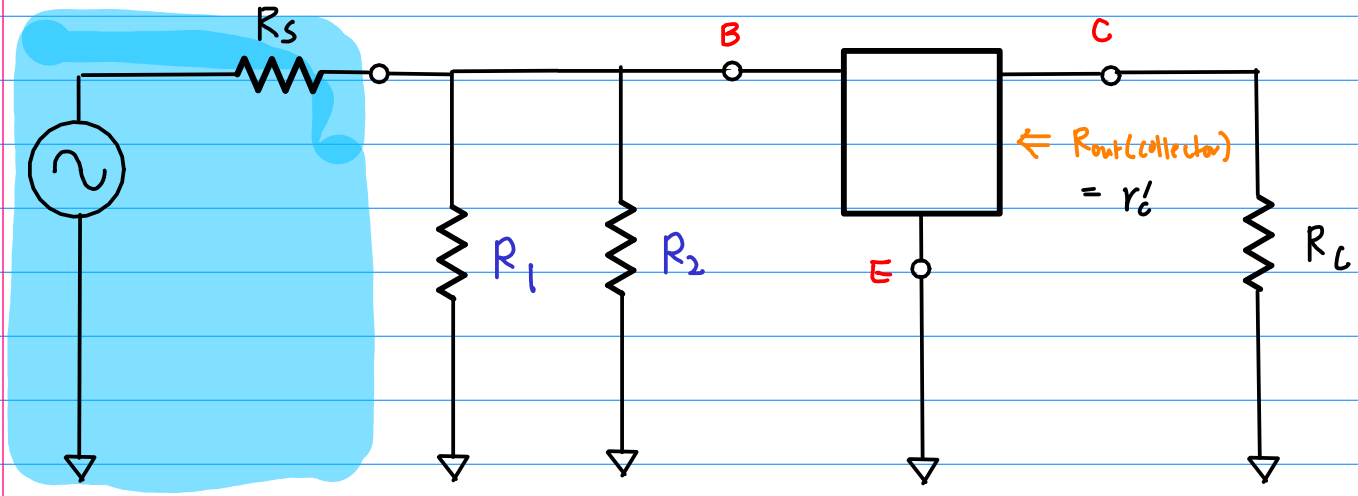




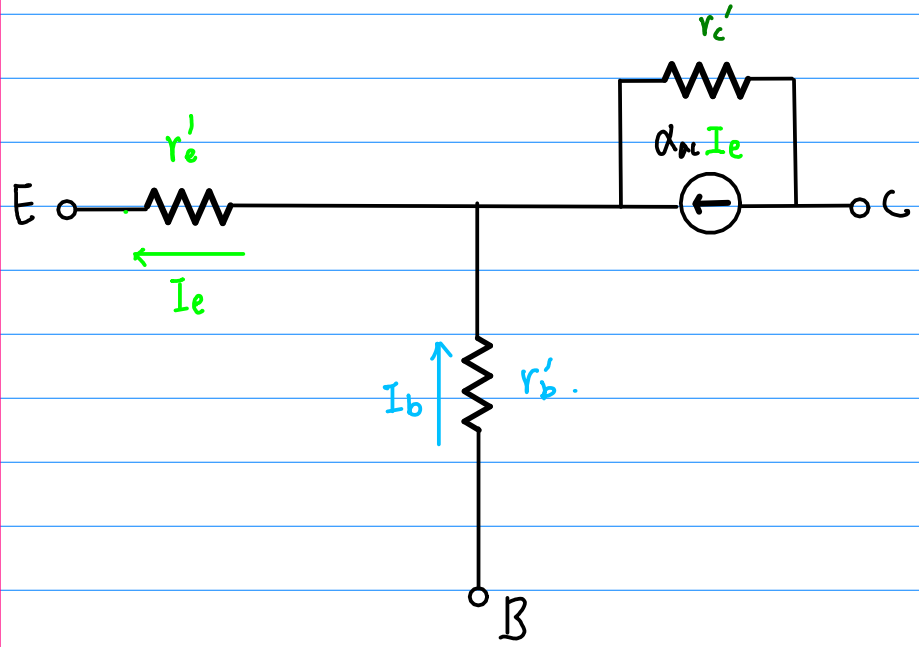
Output Resistance

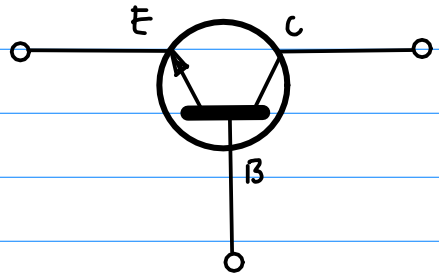


ac source

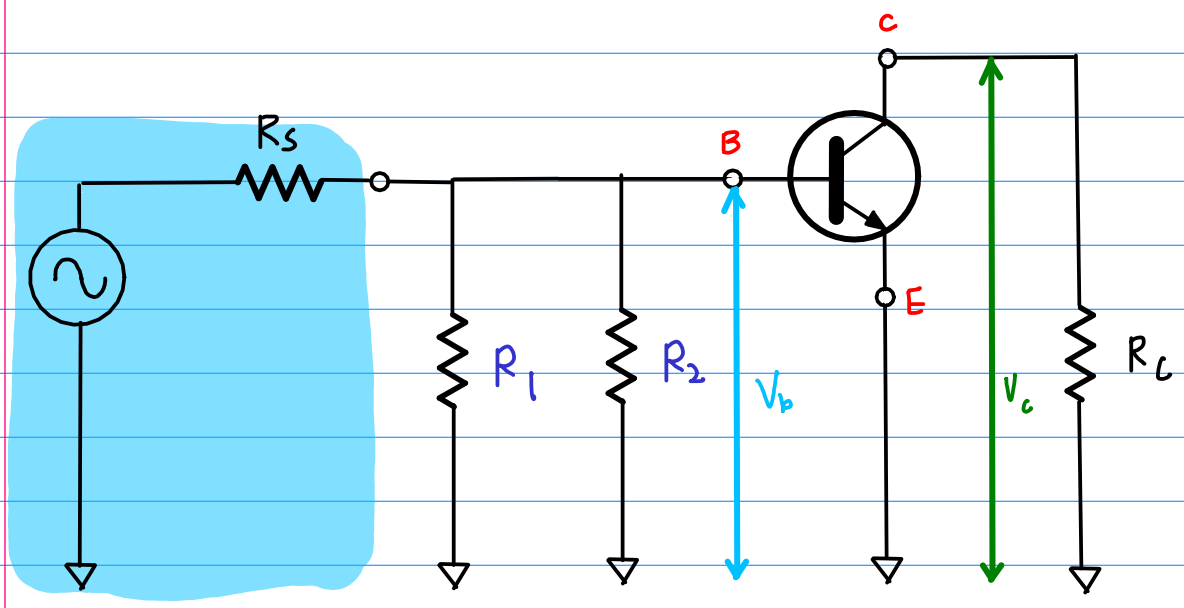


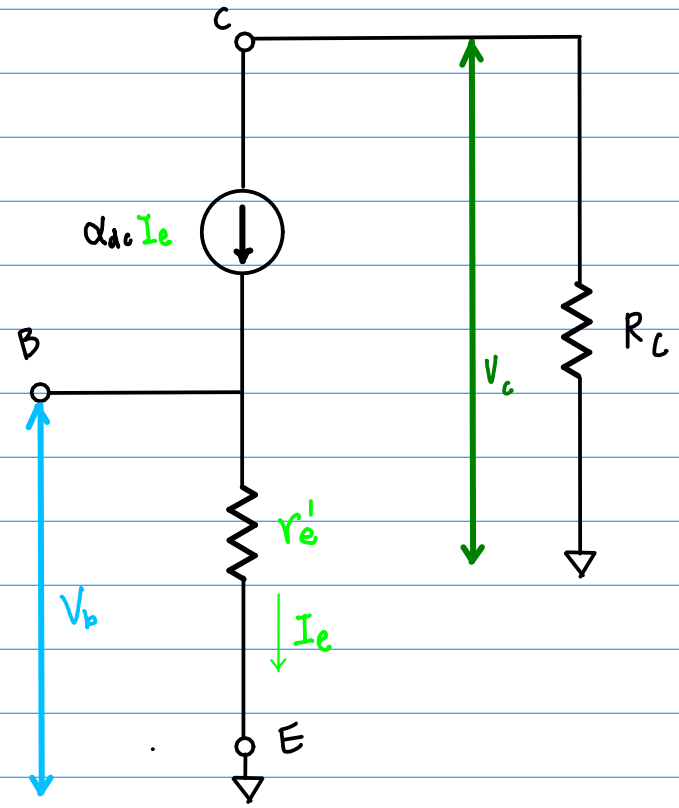
$$R_{out(collector)} = r_c' \parallel R_C$$
$$\cong R_C \quad (r_c' \gg R_C)$$


r_c'
r_e'
$\alpha_{dc} I_e$
E
C
I_e
I_b
r_b'
B


E
C
B

Voltage Gain



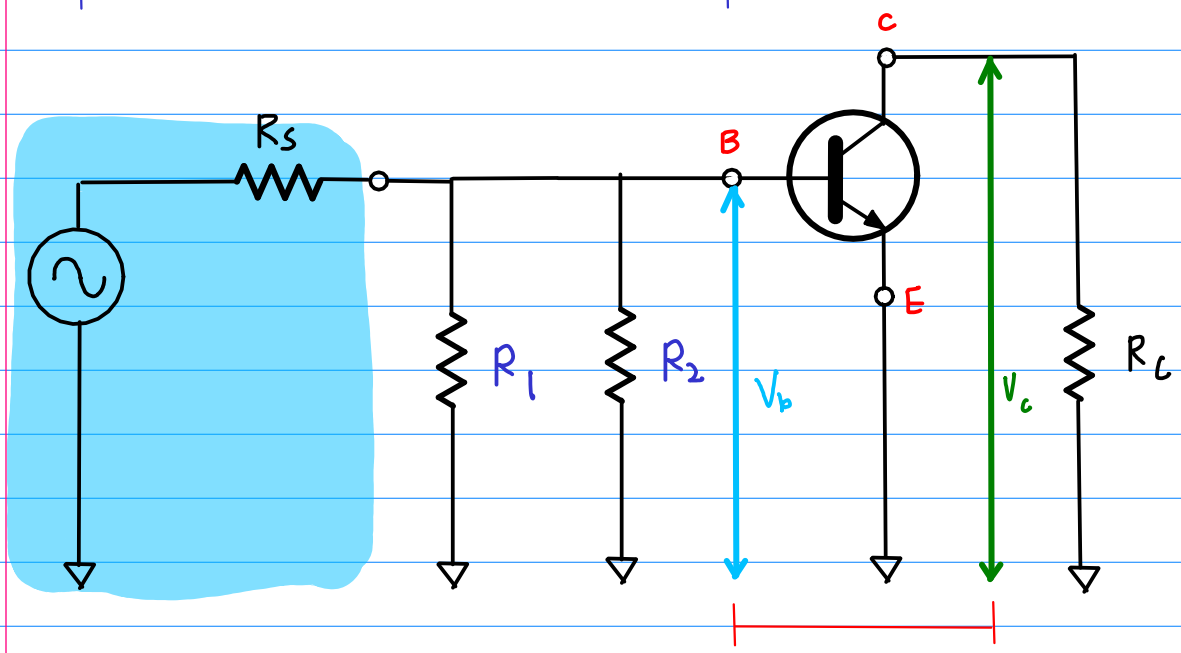


$$A_v = \frac{V_{out}}{V_{in}} = \frac{V_c}{V_b}$$

$$A_v = \frac{I_c R_c}{I_e r'_e} = \frac{R_c}{r'_e}$$

Overall Gain $V_c / V_s = V_b / V_s \times V_c / V_b$

attenuation V_b / V_s

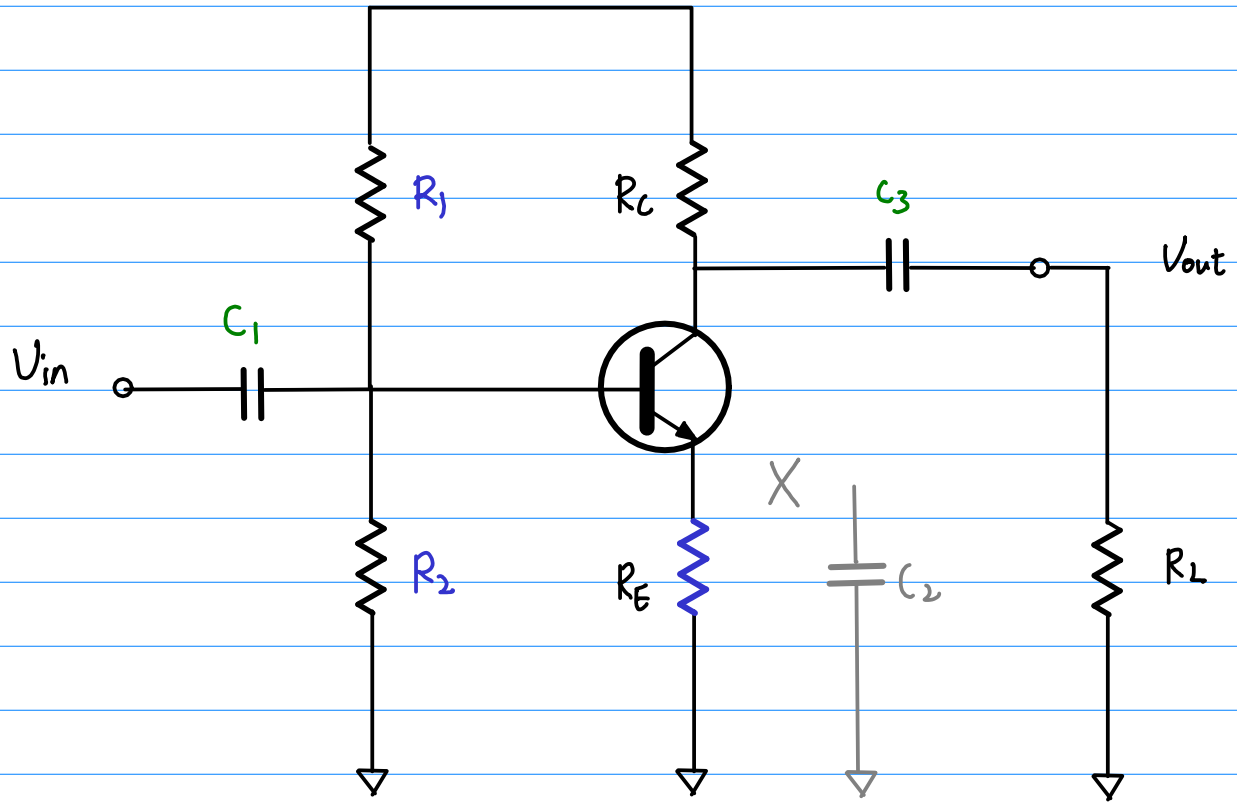


amplifier gain base-to-collector V_c / V_b

$$\text{Attenuation} = \frac{V_b}{V_s} = \frac{R_{in(tot)}}{R_s + R_{in(tot)}}$$

$$A_v' = \left(\frac{V_b}{V_s}\right) \cdot A_v \simeq \frac{R_{in(tot)}}{R_s + R_{in(tot)}} \frac{R_C}{r_e'}$$

Voltage Gain without Bypass Capacitor



$$A_v \simeq \frac{I_c R_c}{I_e r_e'} = \frac{R_c}{r_e'}$$

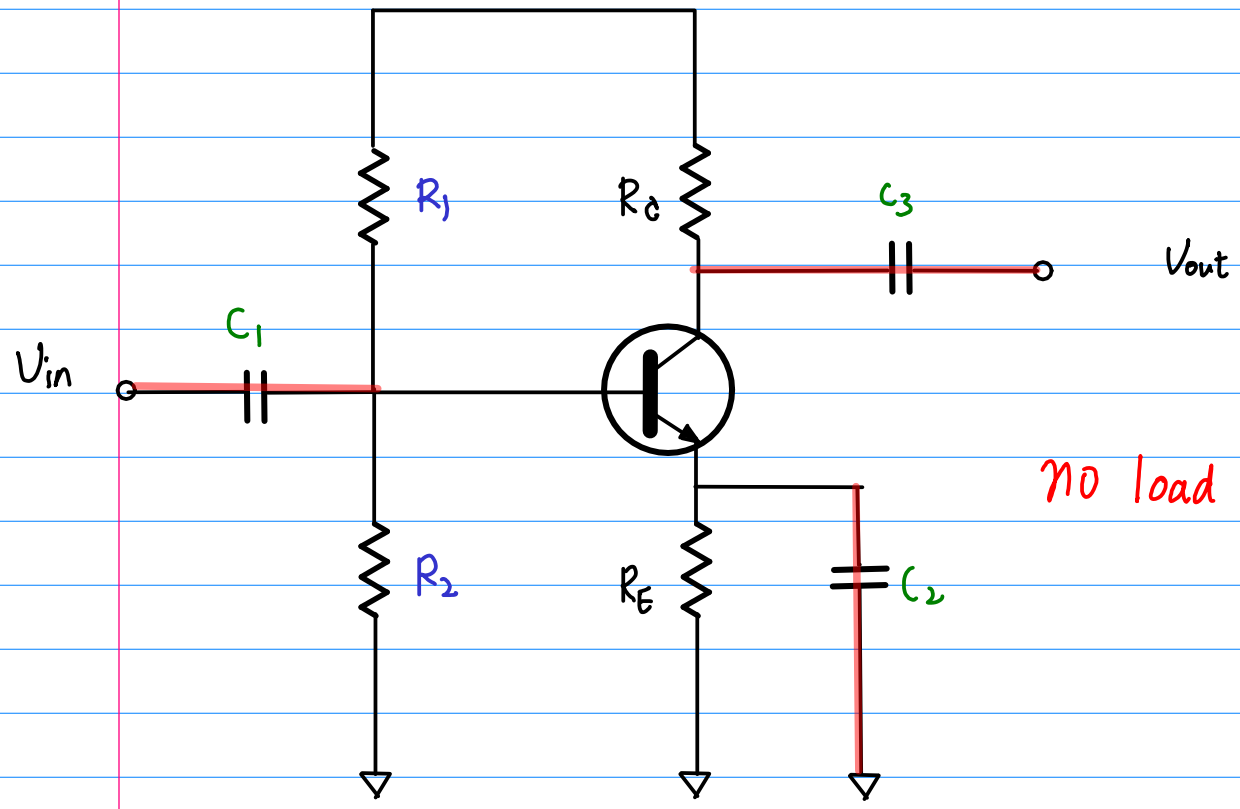
$$A_v = \frac{I_c R_c}{I_e (r_e' + R_E)} = \frac{R_c}{(r_e' + R_E)}$$

R_E decrease A_v

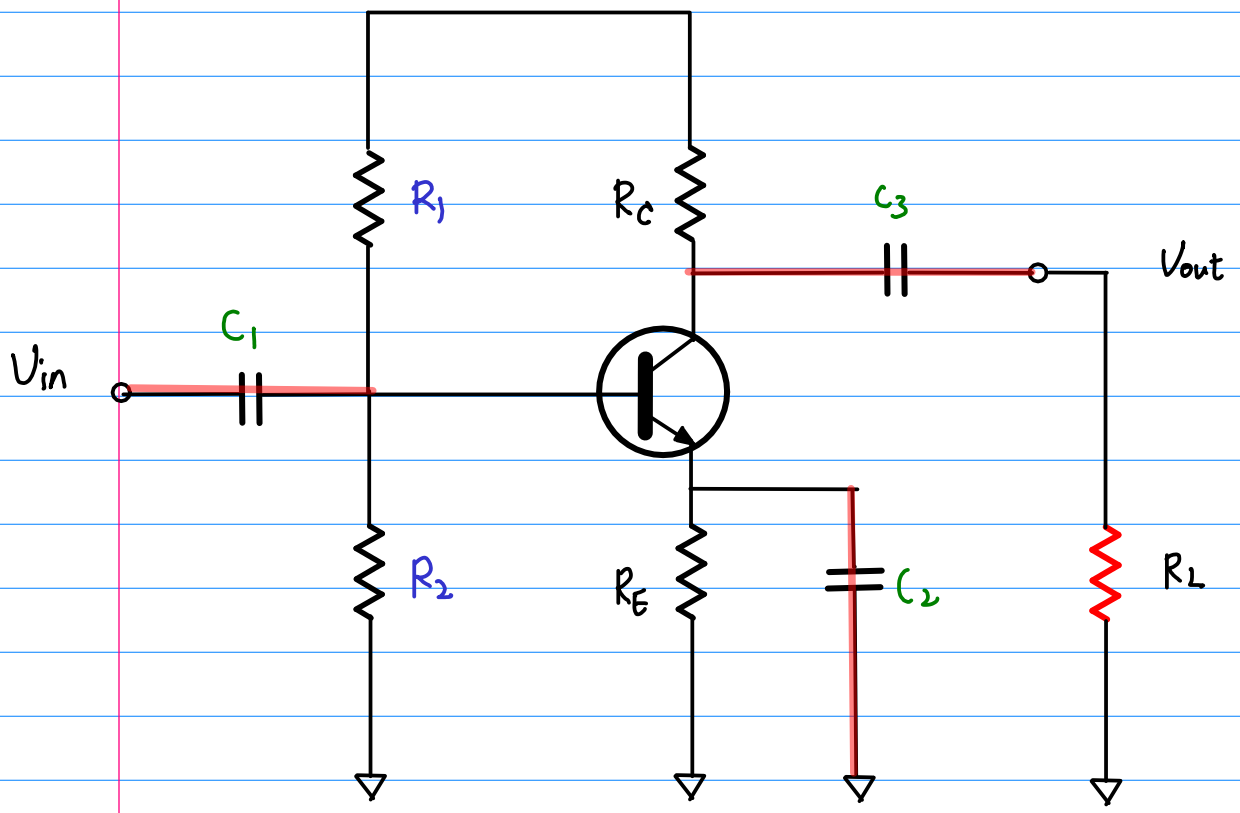
$$A_v = \frac{I_c R_c}{I_e (r_e' + R_{E1})} = \frac{R_c}{(r_e' + R_{E1})} \simeq \frac{R_c}{R_{E1}}$$

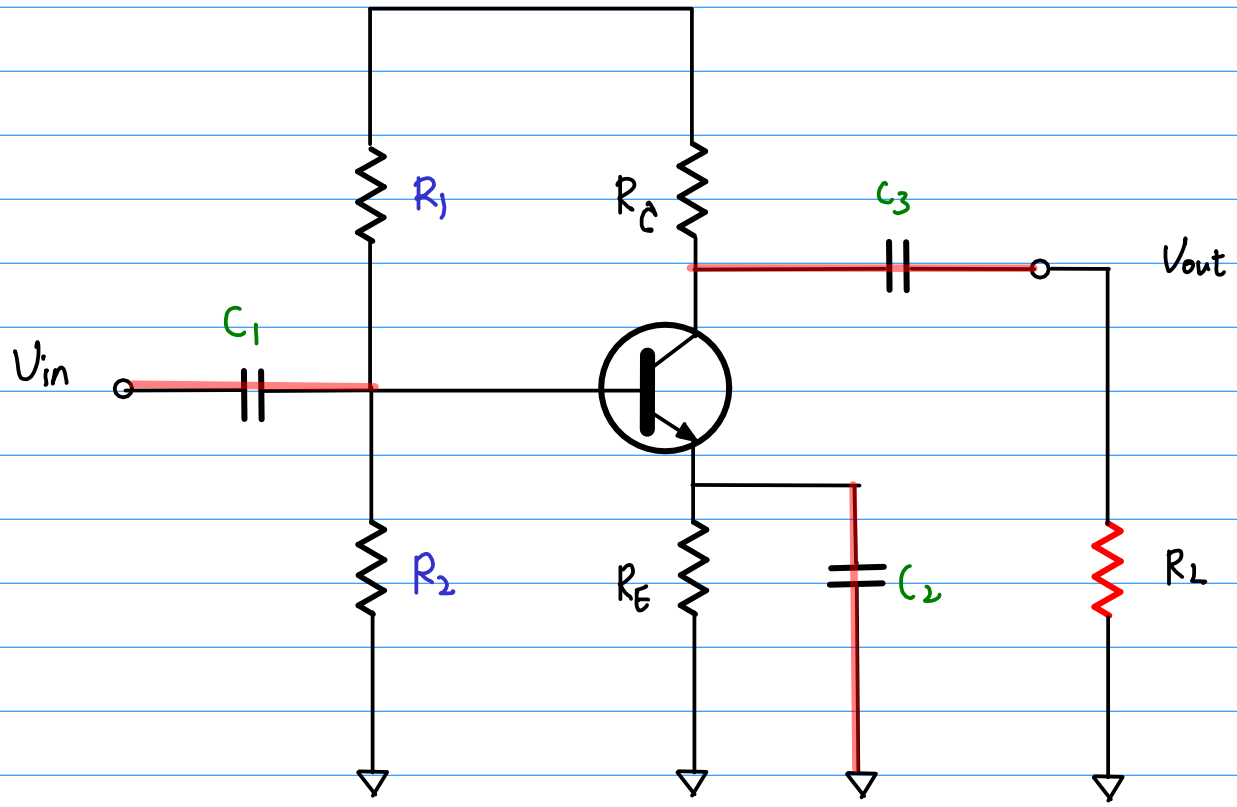
swamping

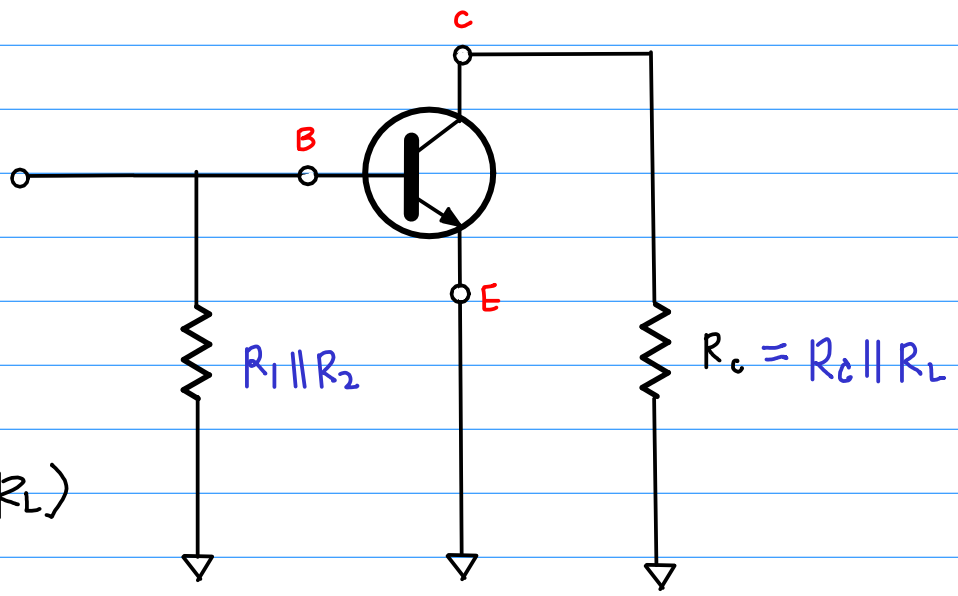
Load Effect on the voltage Gain



no load ($R_L = \infty$)







$R_c = R_C$ (no load)

$R_c = \dfrac{R_C R_L}{R_C + R_L}$ (with R_L)

$R_c = R_C$ (no load) $\qquad A_v = \frac{R_C}{r_e'} = \frac{R_C}{r_e'}$

$R_c = \frac{R_C R_L}{R_C + R_L}$ (with R_L) $\qquad A_v = \frac{R_C}{r_e'} = \frac{R_C}{r_e'} \frac{R_L}{R_C + R_L}$

$R_C \ll R_L \qquad \frac{R_L}{R_C + R_L} = 1$

$R_C > R_L \qquad \frac{R_L}{R_C + R_L} < 1 \qquad A_v \downarrow$

$R_C = R_L \qquad \frac{R_L}{R_C + R_L} = \frac{1}{2} \qquad \frac{1}{2} A_v.$

https://en.wikipedia.org/wiki/Swamp#/media/File:Briesetal_bei_Briese.JPG

swamp (plural swamps)

A piece of wet, spongy land; low ground saturated with water; soft, wet ground which may have a growth of certain kinds of trees, but is unfit for agricultural or pastoral purposes.

A type of wetland that stretches for vast distances, and is home to many creatures who have adapted specifically to that environment.

To drench or fill with water.

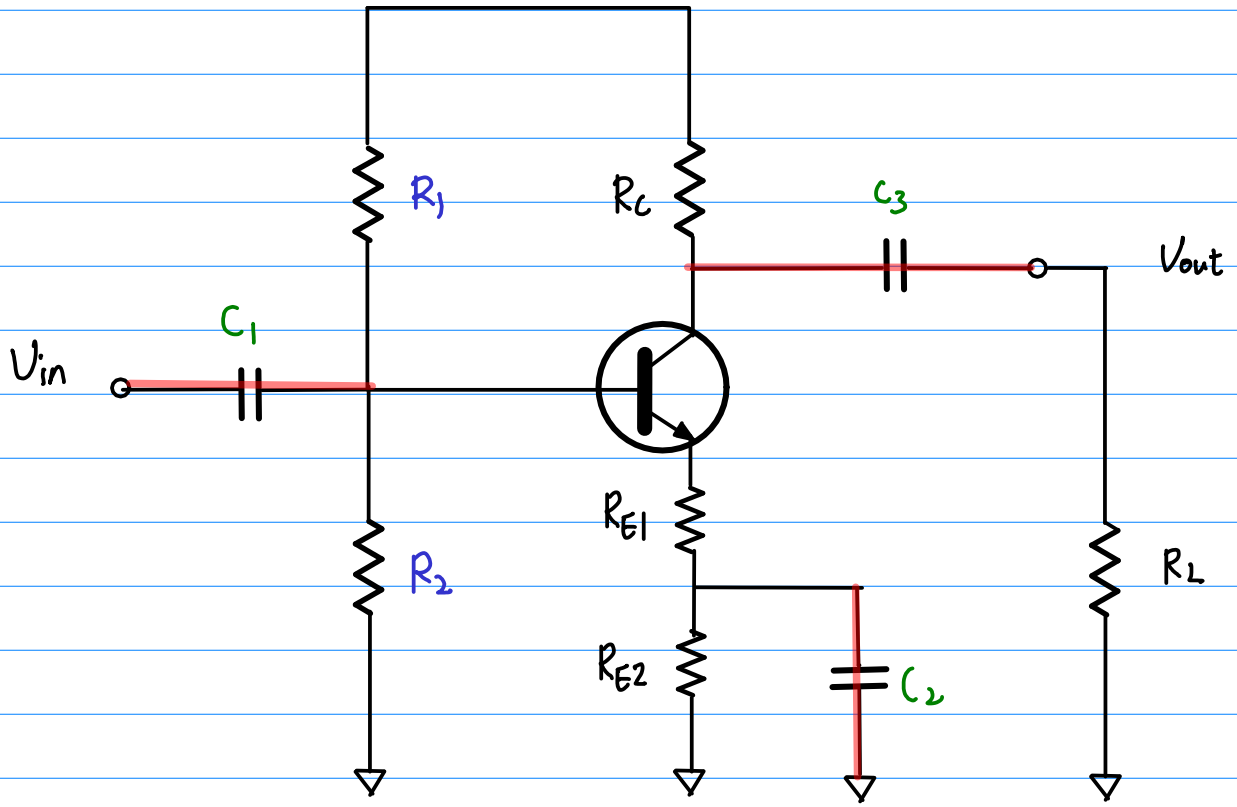
The boat was swamped in the storm.

To overwhelm; to make too busy, or overrun the capacity of.

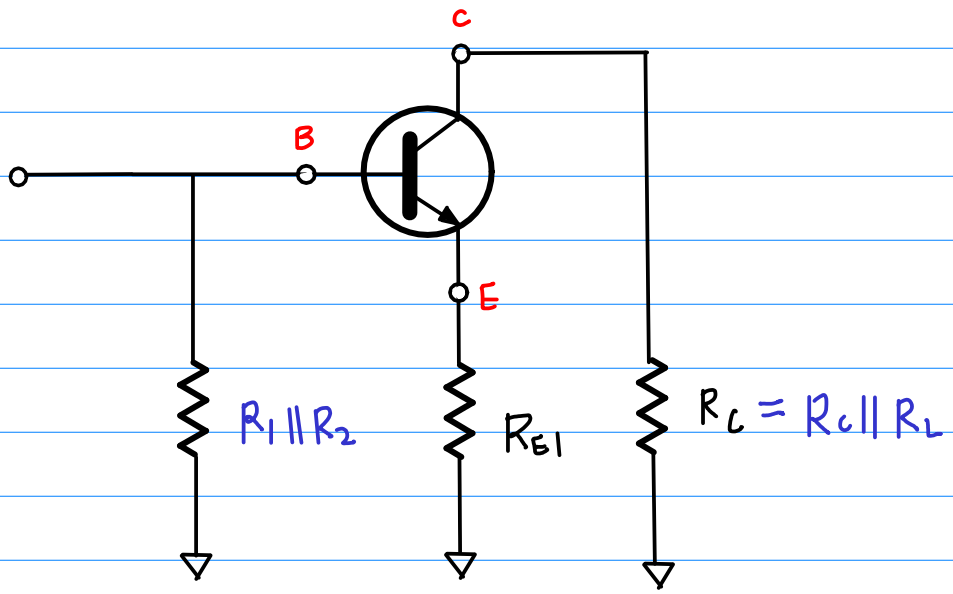
I have been swamped with paperwork ever since they started using the new system.

(figuratively) To plunge into difficulties and perils; to overwhelm; to ruin; to wreck.

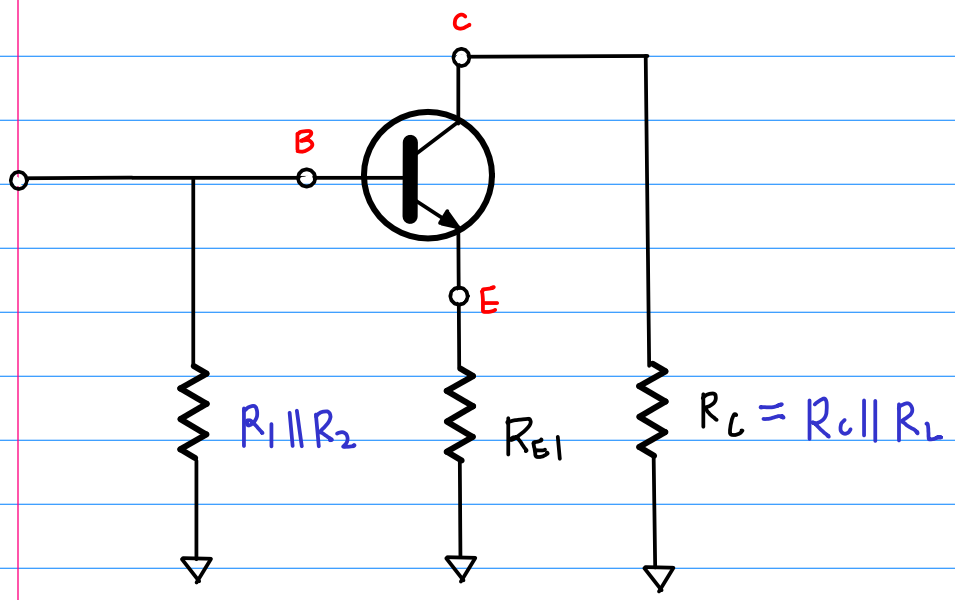
Swamped Amplifier



bypassed resistance to minimize the effect of $r_e' \Rightarrow$ gain stability



AC Emitter Feedback



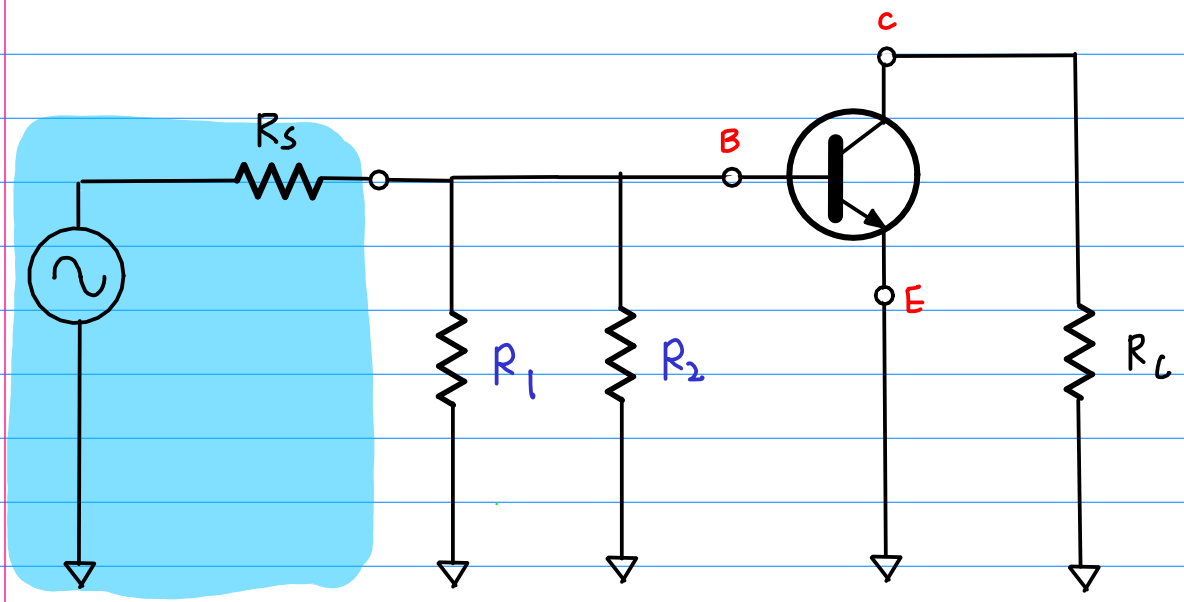
R_{E1} : feedback resistor

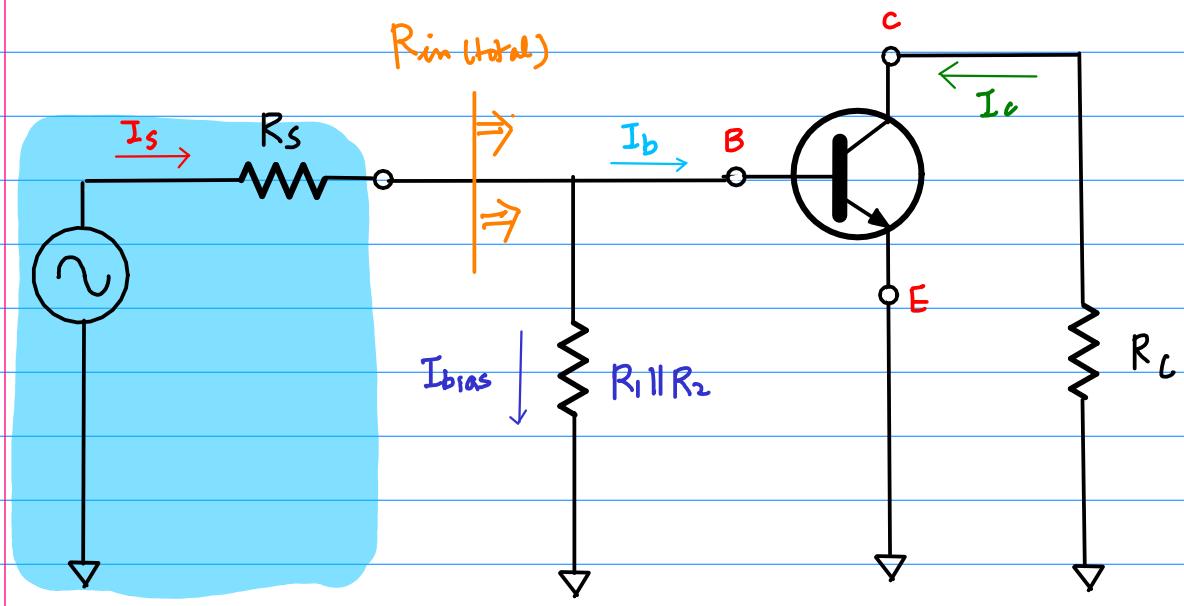
$\beta \uparrow \rightarrow I_c \uparrow \rightarrow V_{R_{E1}} \uparrow \rightarrow V_{be} \downarrow$

$V_{be} \downarrow \rightarrow I_b \downarrow \rightarrow I_c \downarrow$

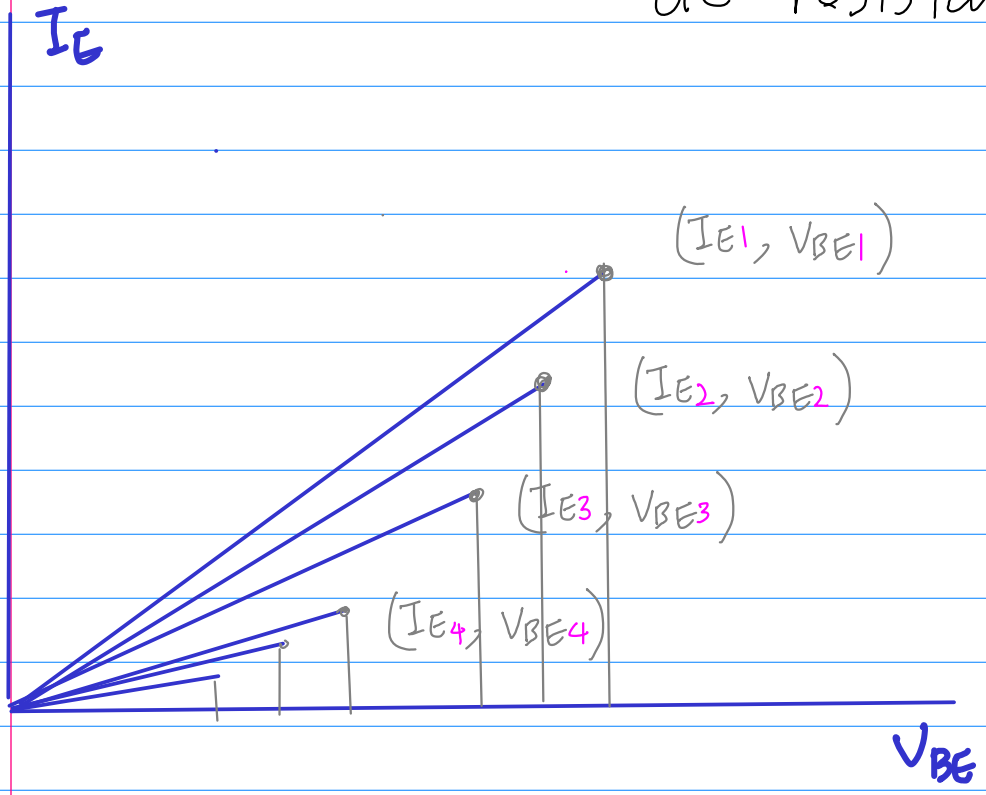
negative feedback

Current Gain





dc resistance



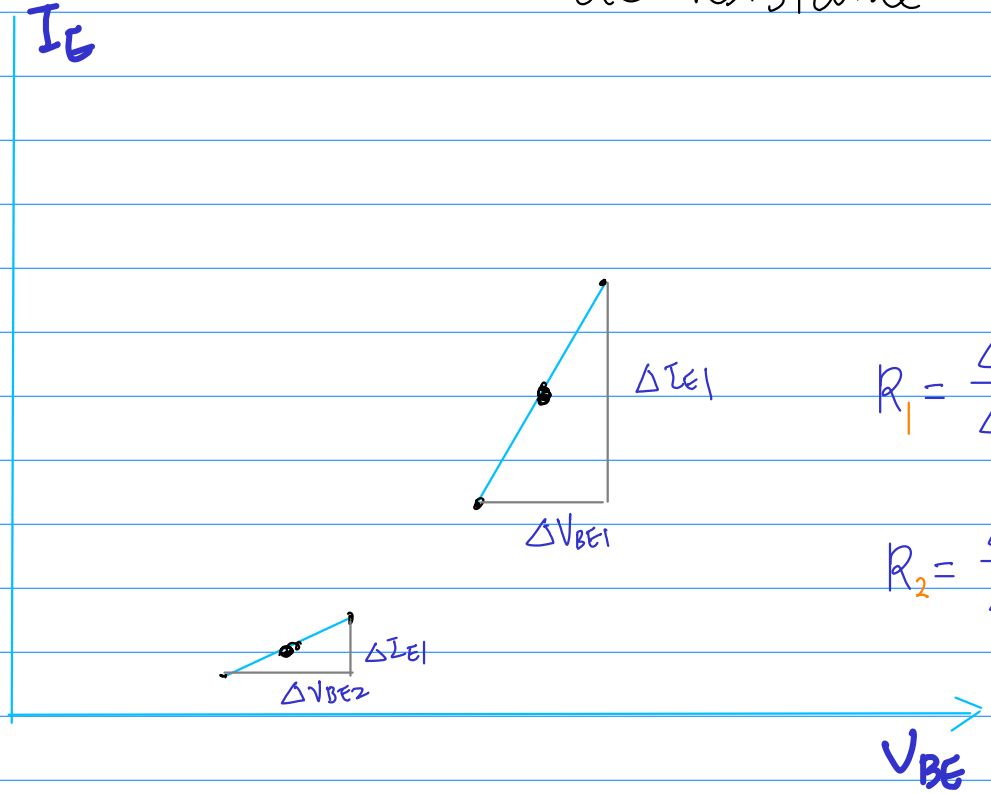
$$R = \frac{V_{BE1}}{I_{E1}}$$

$$R = \frac{V_{BE2}}{I_{E2}}$$

$$R = \frac{V_{BE3}}{I_{E3}}$$

$$R = \frac{V}{I}$$

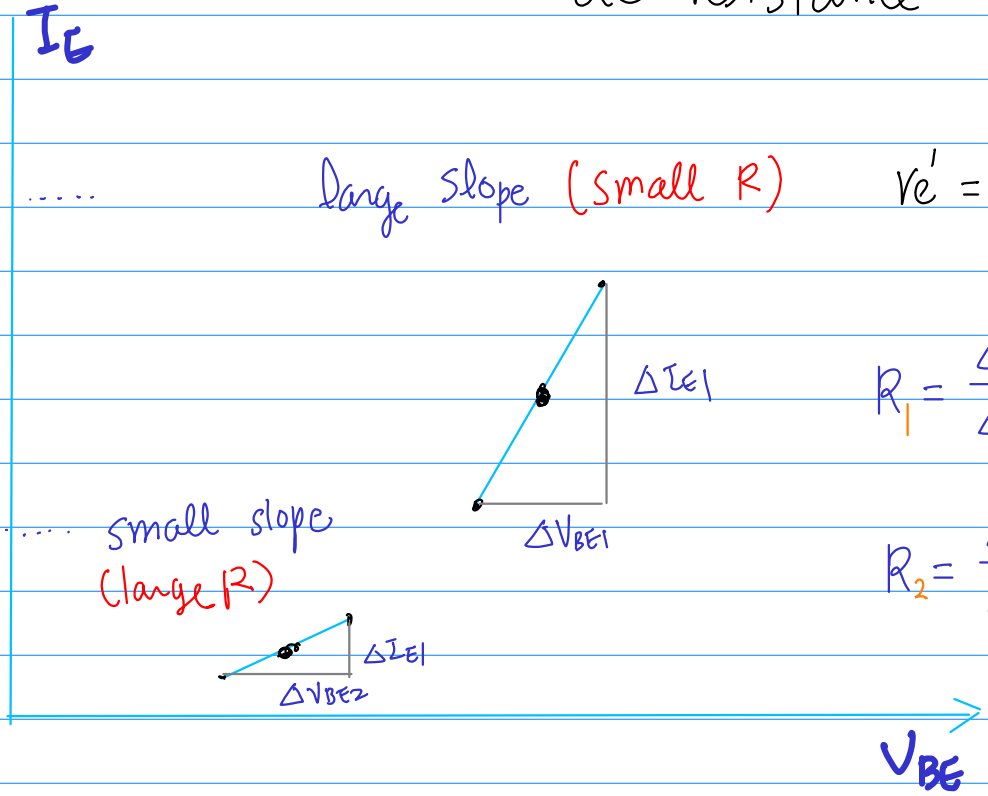
ac resistance



$$R_1 = \frac{\Delta V_{BE1}}{\Delta I_{E1}}$$

$$R_2 = \frac{\Delta V_{BE2}}{\Delta I_{E2}}$$

ac resistance



large I_E ..... large slope (small R)

$$r_e' = \frac{V_{be}}{i_e}$$

$$R_1 = \frac{\Delta V_{BE1}}{\Delta I_{E1}}$$

small I_E ..... small slope (large R)

$$R_2 = \frac{\Delta V_{BE2}}{\Delta I_{E2}}$$