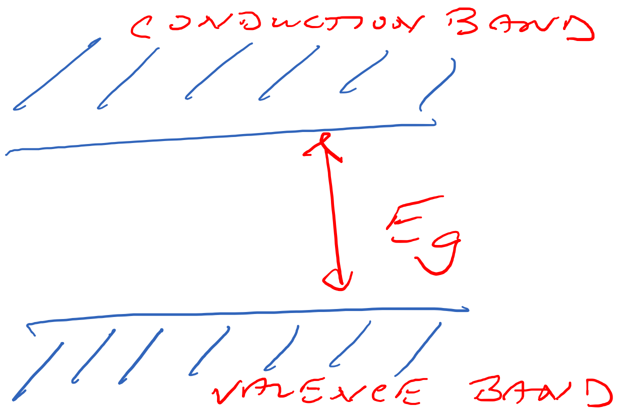
SEMICONDUCTORS

GROUP IV : Si, Ge

BAND STRUCTURE



Si : $E_g = 1.12$ eV

Ge : $E_g = 0.66$ eV

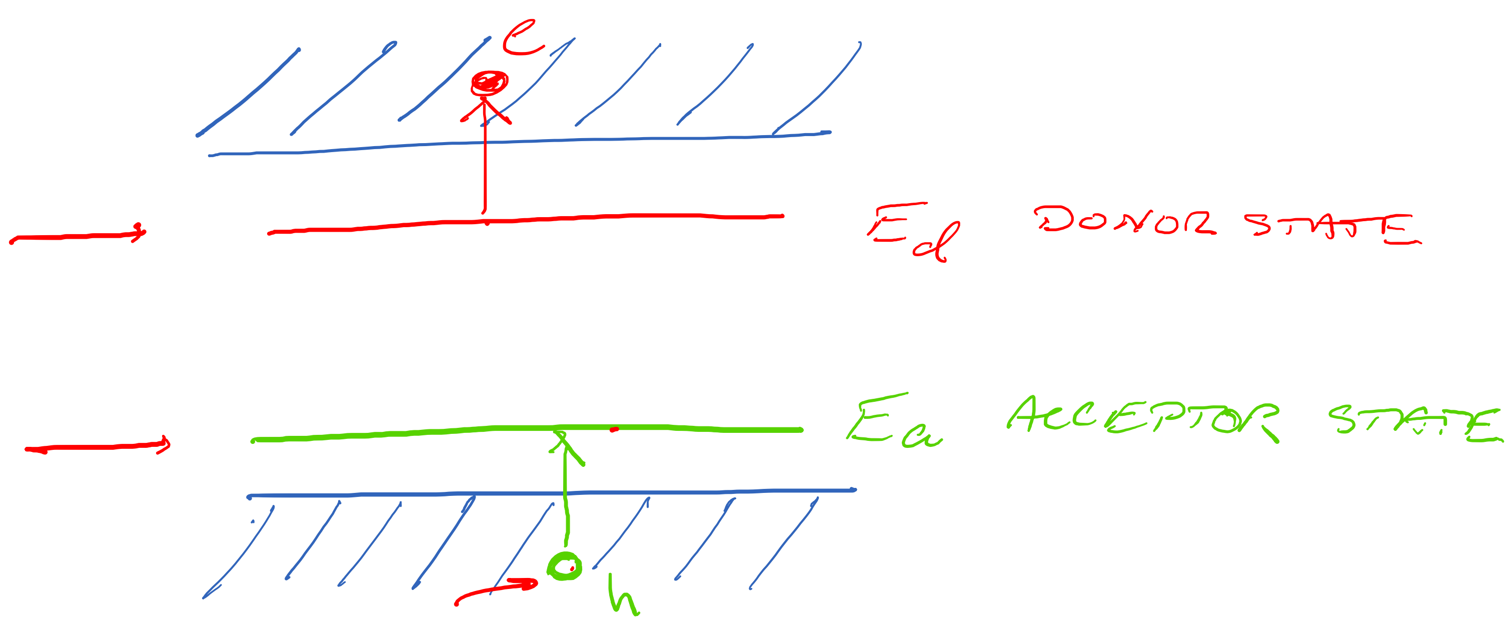
INTRINSIC SEMICONDUCTOR :

CARRIER DENSITY $\sim e^{-E_g/k_BT}$

DOPE w/ COL. III OR COL. V TO GET CONDUCTION

h — p-TYPE

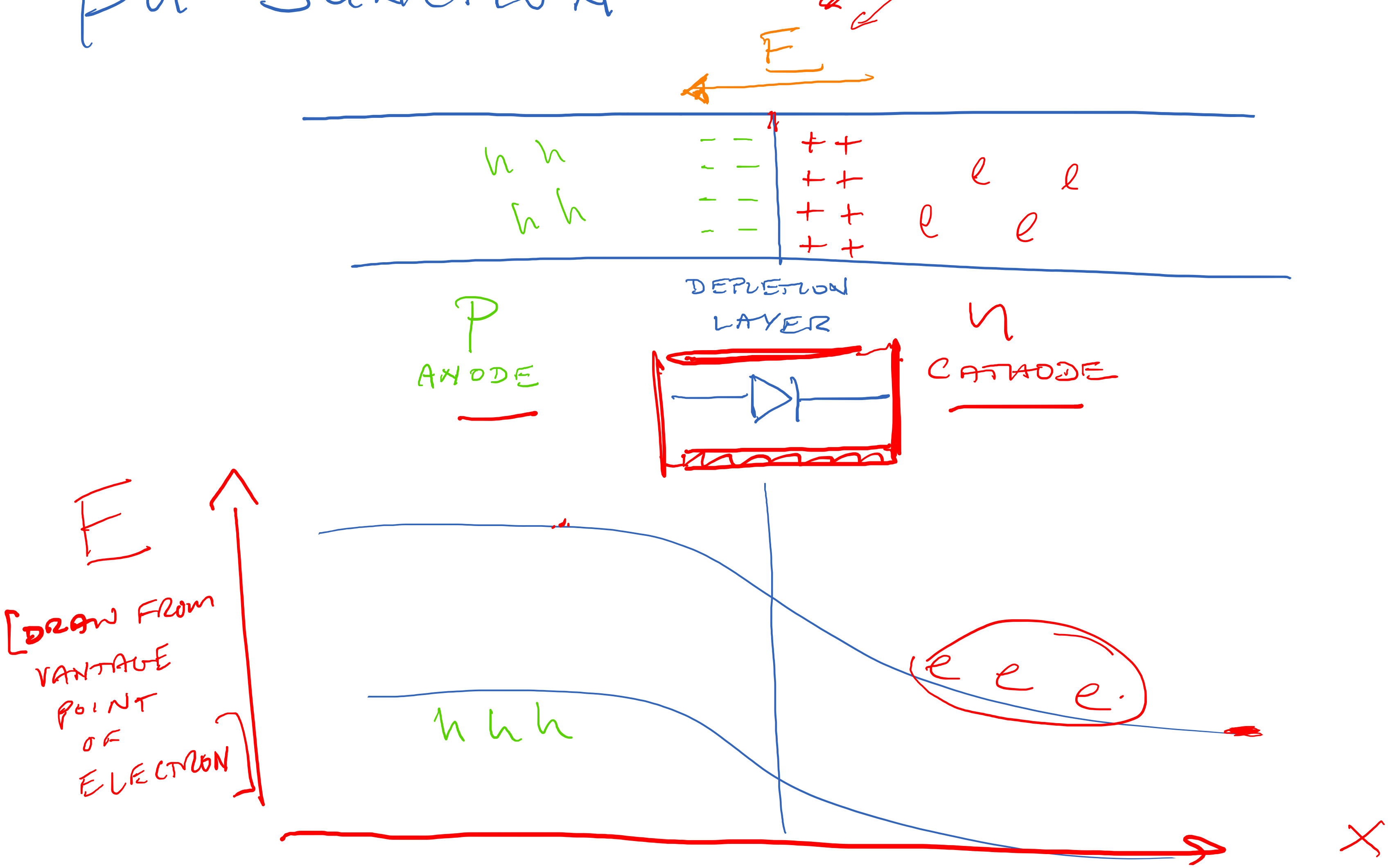
e — n-TYPE



INTRINSIC Si : $\sim 10^{10}\ cm^{-3}$

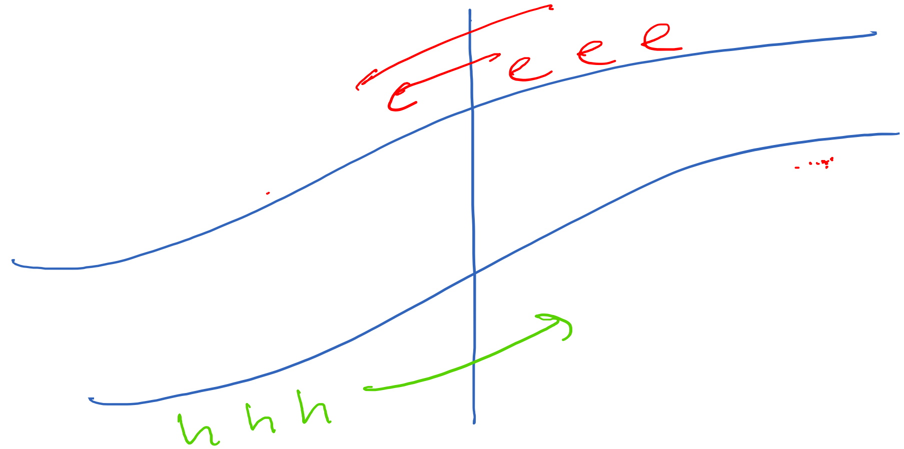
DOPED Si : TO $\sim 10^{18}\ cm^{-3}$

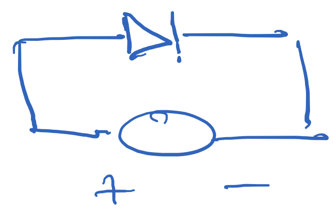
PN JUNCTION



E
DEPLETION
LAYER
P
ANODE
n
CATHODE
E
[DRAW FROM
VANTAGE
POINT
OF
ELECTRON]
X

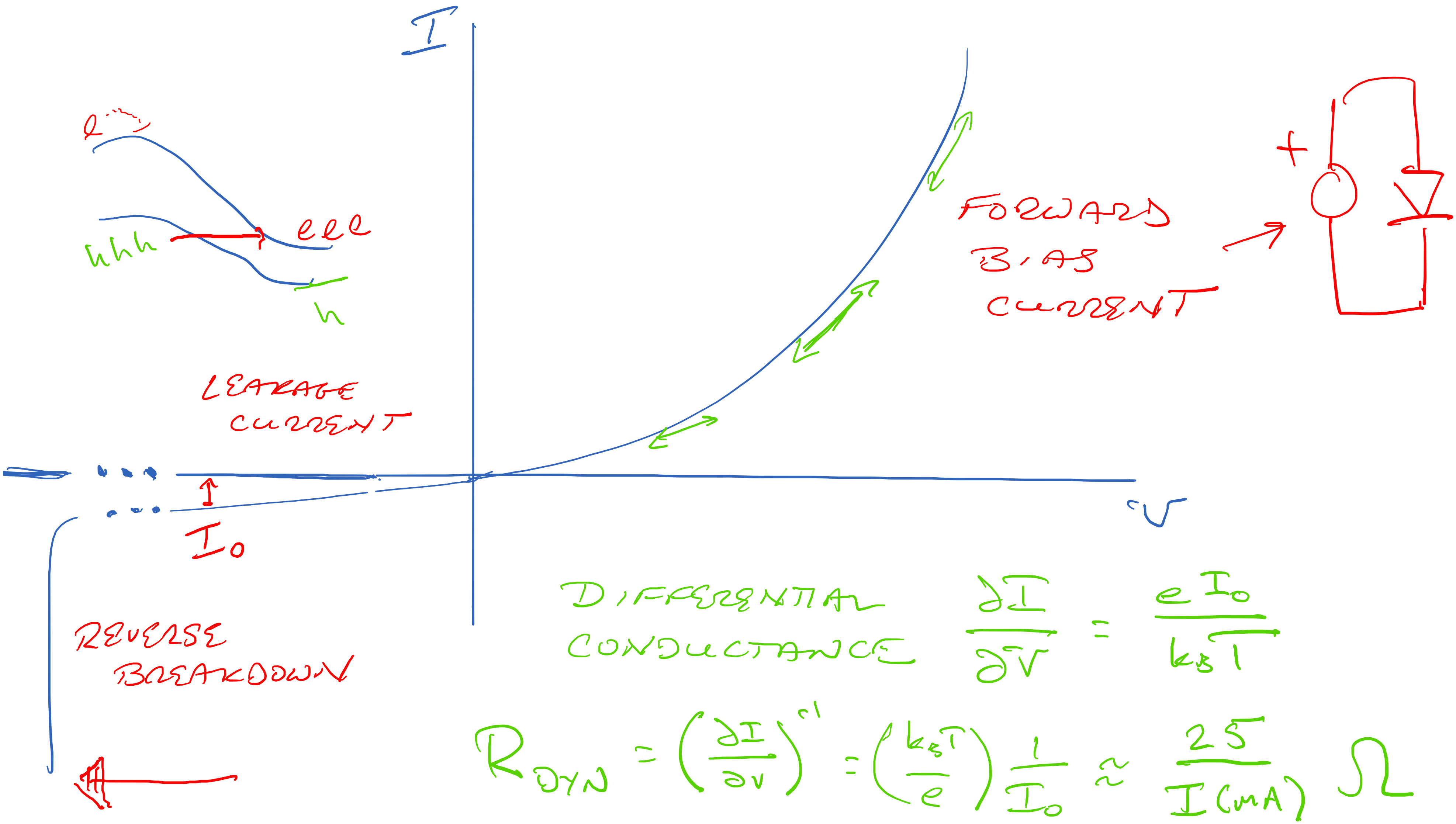
FORWARD BIAS





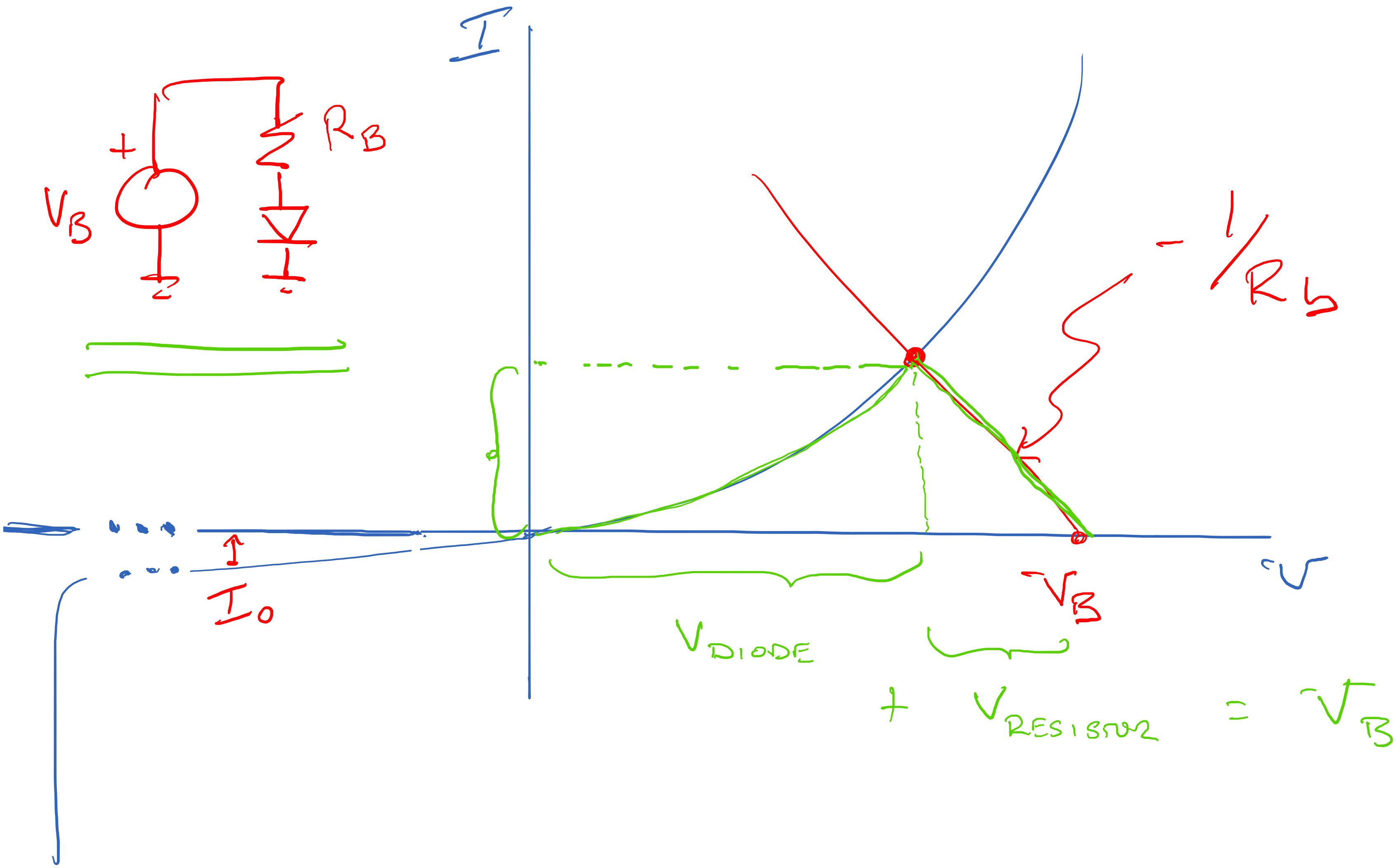
$$I = I_0 \left[e^{eV/k_B T} - 1 \right]$$

$$\frac{\partial I}{\partial V} = \frac{e I_0}{k_B T}$$



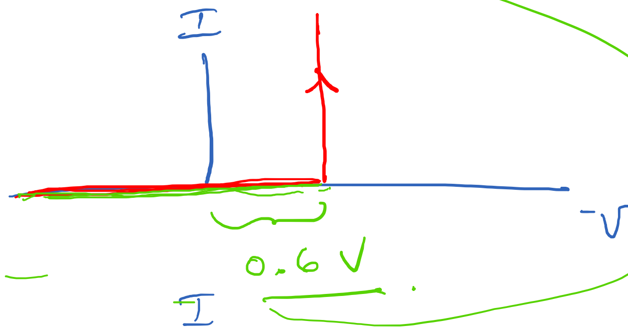
$$\frac{\partial I}{\partial V} = \frac{e I_o}{k_B T}$$

$$R_{DYN} = \left(\frac{\partial I}{\partial V}\right)^{-1} = \left(\frac{k_B T}{e}\right)\frac{1}{I_o} \approx \frac{25}{I(mA)}\ \Omega$$

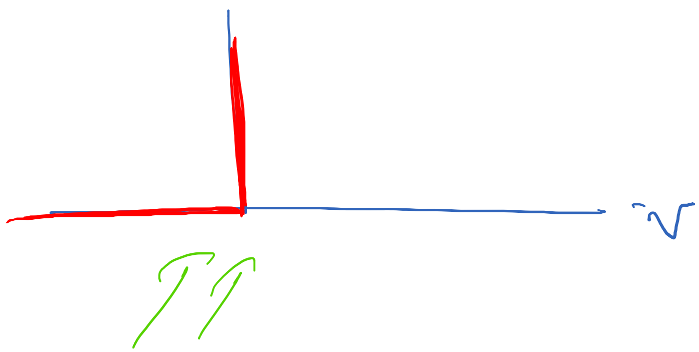


I
+
V_B
R_B
$-1/R_b$
I_0
V
V_B
V_{DIODE}
$+ \; V_{RESISTOR} = V_B$

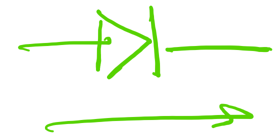
SIMPLIFIED MODEL



LARGE SIGNALS



Si:

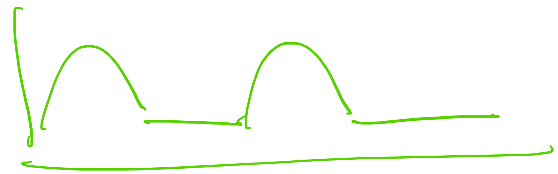


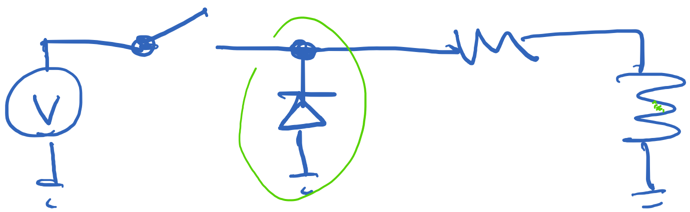
0.6 V

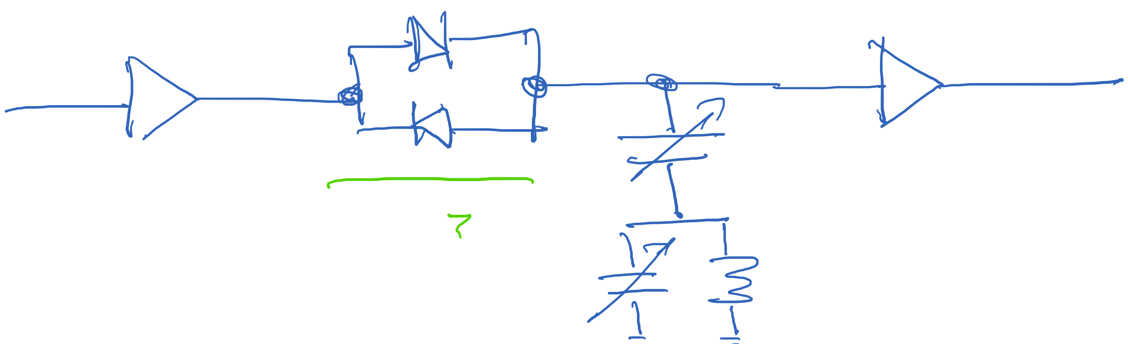
Ge ~ 0.2 - 0.3 V

SOME APPLICATIONS

RECTIFIER

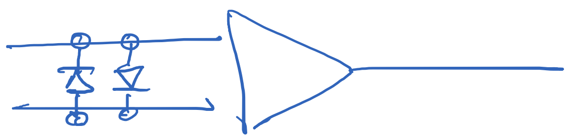




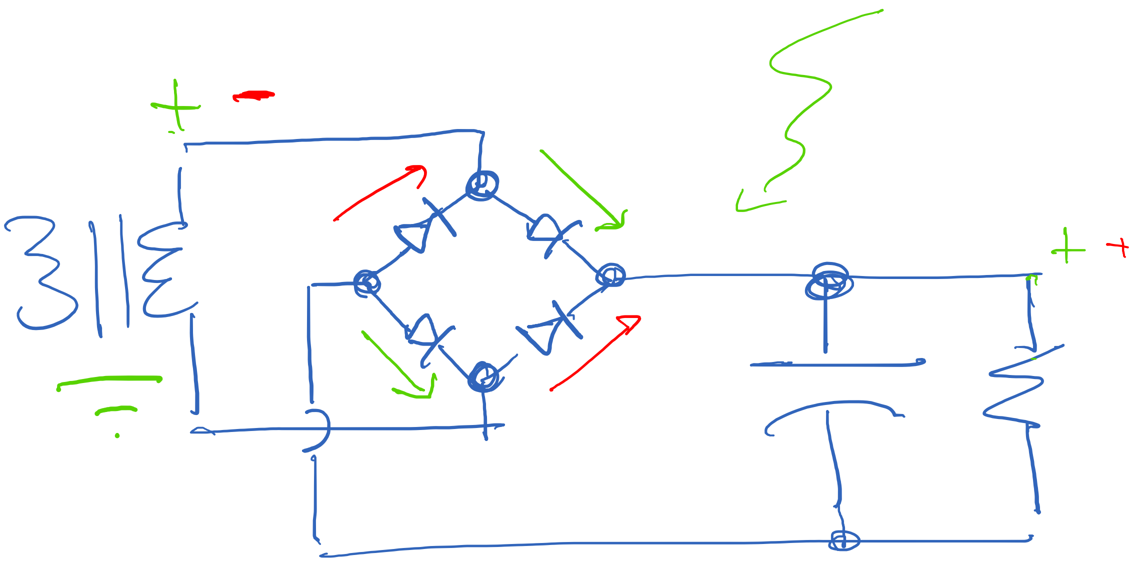


DIODE APPLICATIONS, CONT'D

DIODE CLAMP

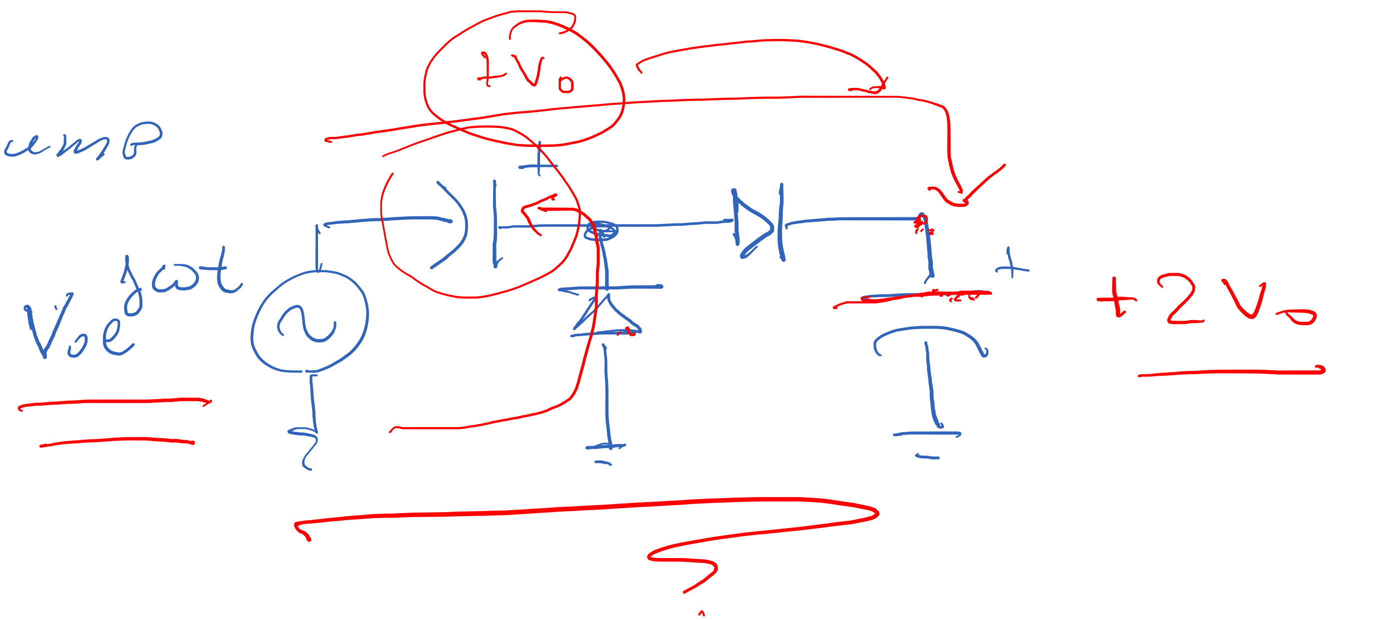


BRIDGE RECTIFIER

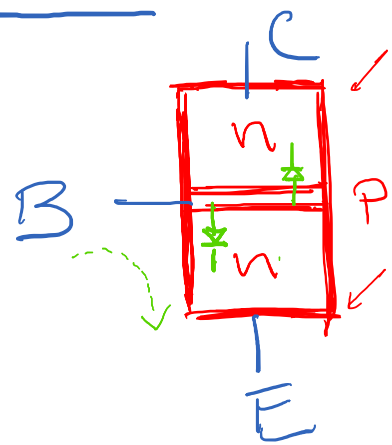


DIODE APPLICATIONS, CONT'D

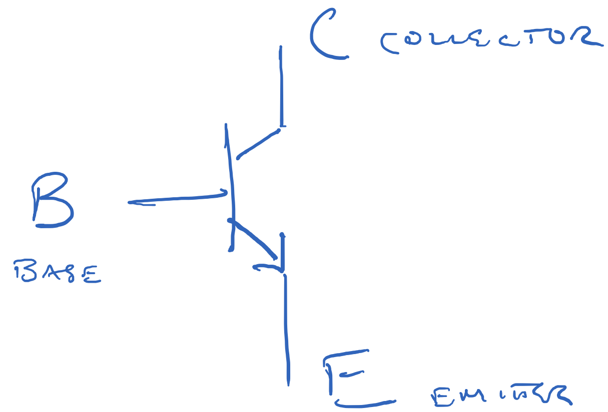
CHARGE PUMP



BIPOLAR TRANSISTOR

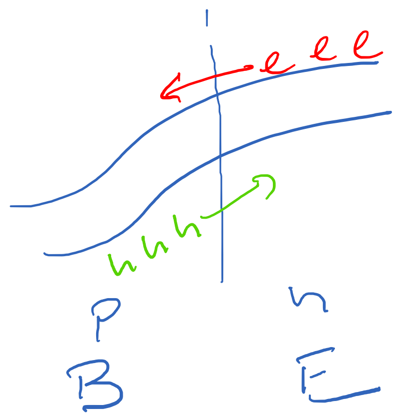


npn

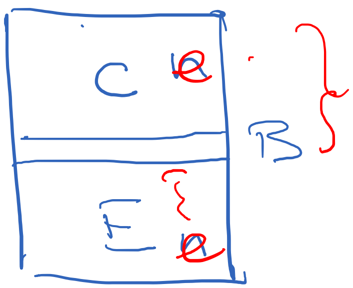


SMALL CURRENT FROM BASE TO EMITTER PROGRAMS MUCH LARGER CURRENT FROM COLLECTOR → EMITTER

FORWARD BIAS



→ CURRENT - CONTROLLED DEVICE

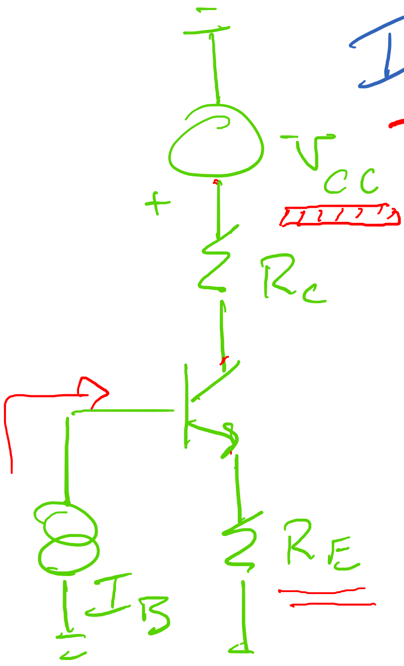


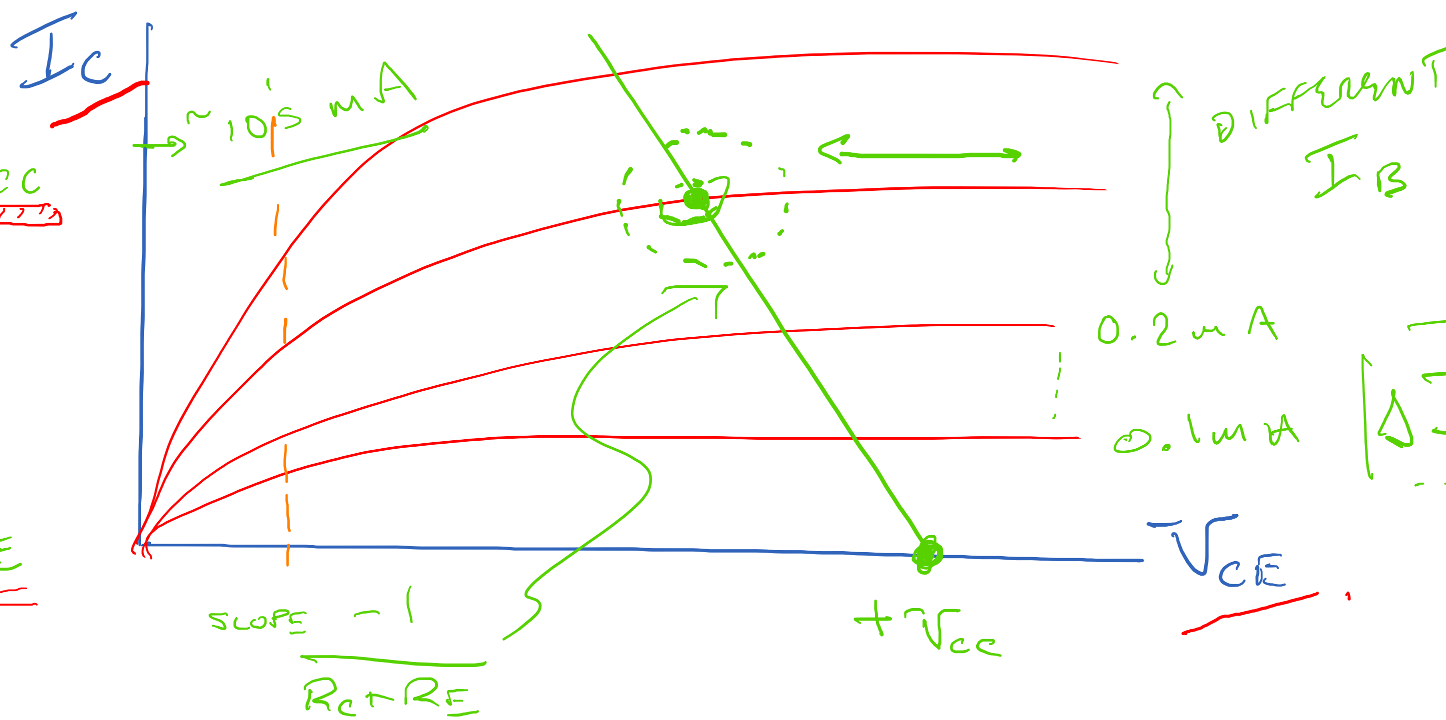
CB JUNCTION : MAX POWER DISSIPATION

EMITTER : HEAVILY DOPED

BASE : LIGHTLY DOPED

(MINIMIZE RECOMBINATION)

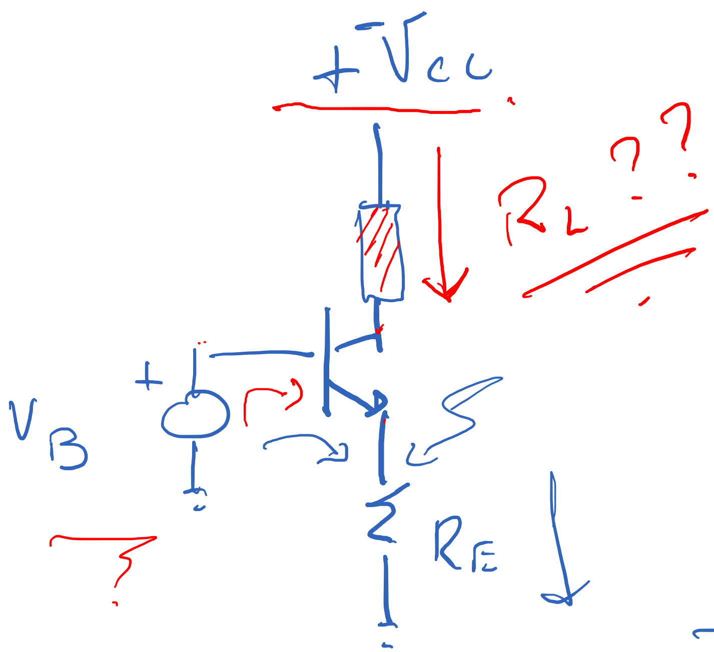




$$\Delta I_C = \beta \Delta I_B$$

$\beta \sim 100$

TRANSISTOR CURRENT SOURCE



Current Source

For $V_C \gtrsim 0.2V + V_E$

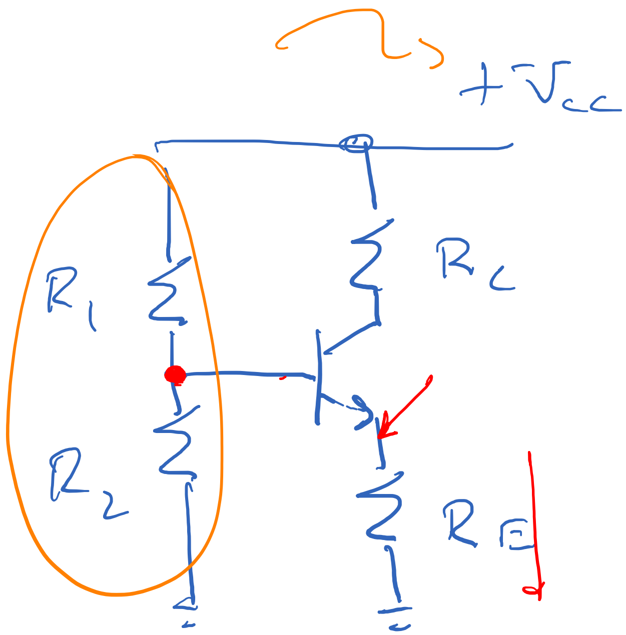
$$V_E \approx V_B - 0.6V$$

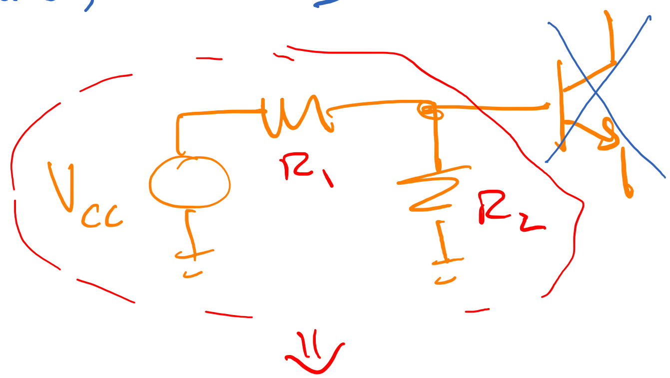
$$I_E = \frac{V_B - 0.6V}{R_E}$$

$$I_E = I_B + I_C \approx I_C$$

$\beta \gg 1$

TRANSISTOR BIASING, CONT'D





$$V_T = \frac{R_2}{R_1 + R_2} V_{CC}$$

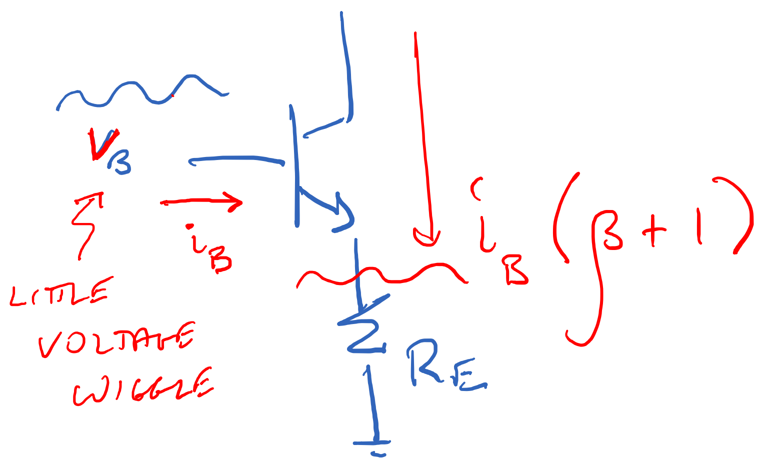
$$R_T = R_1 \parallel R_2 = \frac{R_1 R_2}{R_1 + R_2}$$

NEED

$$R_1 \parallel R_2 \ll (\beta + 1) R_E$$

← STIFF VOLTAGE BIAS.

INPUT IMPEDANCE OF BJT?

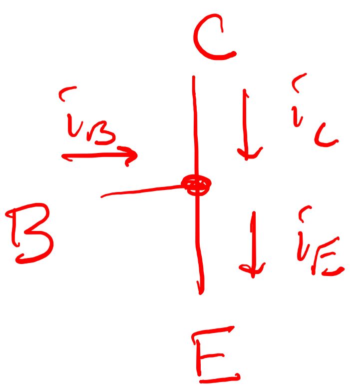


$$R_{in} = \frac{v_{in}}{i_{in}} = \frac{v_B}{i_B}$$

LITTLE WIGGLE @ BASE

→ IDENTICAL LITTLE WIGGLE @ EMITTER

$$v_{in} = v_B = v_E = i_E R_E = i_B(\beta+1)R_E$$



$$R_{in} = \frac{v_{in}}{i_{in}} = \frac{v_B}{i_B} = (\beta+1)R_E$$

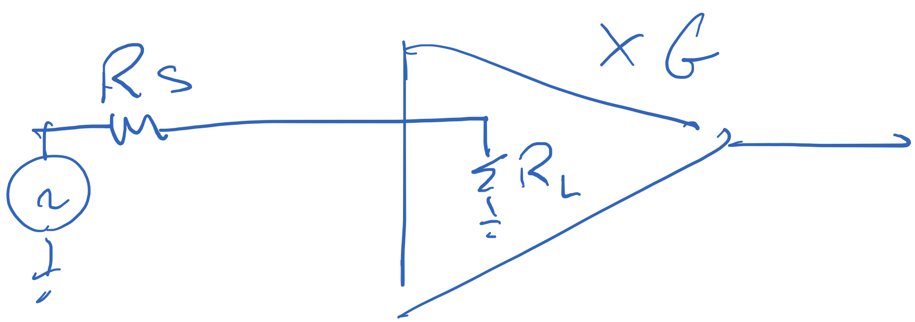
$$i_E = i_C + i_B$$
$$= \beta i_B + i_B = (\beta+1)i_B$$

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

$$V_L = \frac{R_L}{R_S + R_L} \cdot V_S$$

For $R_L \gg R_S$

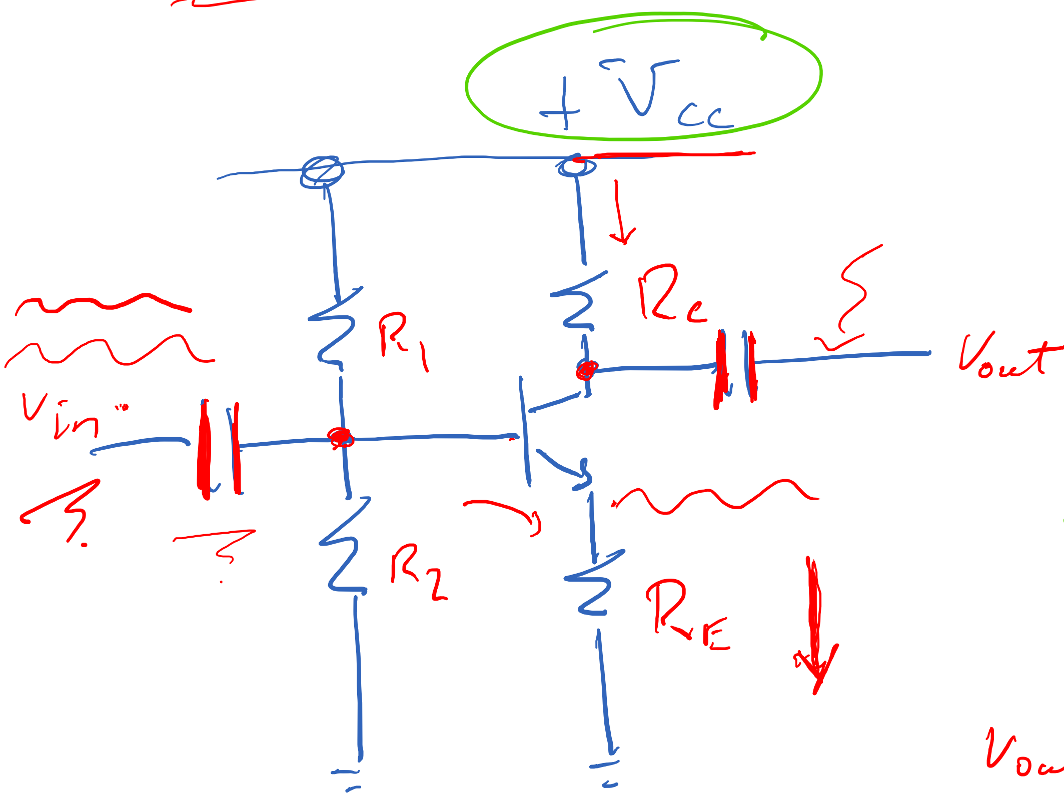
$$V_L \approx V_S$$



* DESIRED, IF AMPLIFYING VOLTAGES.

"STIFF SOURCE"

COMMON EMITTER AMPLIFIER



$v_E = v_{in}$

$i_E = \frac{v_E}{R_E} = \frac{v_{in}}{R_E}$

$i_E \approx i_c$ [$\beta >> 1$]

$i_c \approx \frac{v_{in}}{R_E}$

$V_{out} = V_c = -i_c R_c = -\frac{R_c}{R_E} v_{in}$

$V_c = V_{cc} - I_c R_c$

$\Rightarrow$ $v_o / v_i = -R_c / R_E$