Wed 7 Dec 2016

Final Friday 16 Dec, 221 HA
3:30 - 5:30

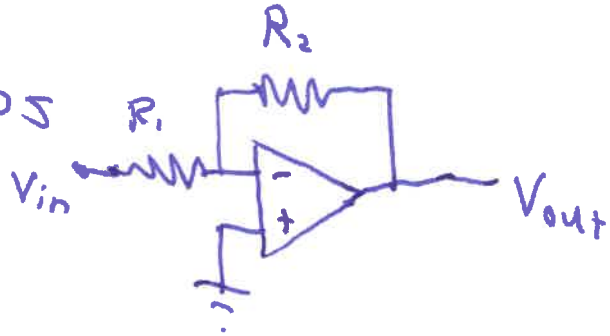
Check Blackboard (Update tonight?)

Watch Website for Office Hours + more

Email Re: Final Conflicts

Review

OP Amps



No current into op-Amp inputs

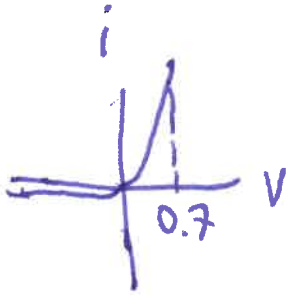
$V_+ - V_- = 0$ if possible

"Virtual Ground"

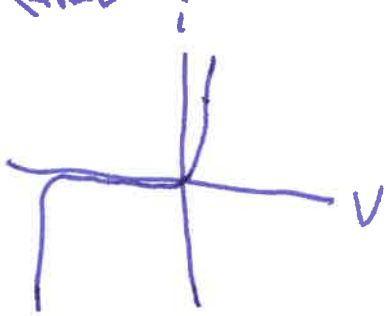
Gain $A_v = \frac{V_{out}}{V_{in}}$

Input + Output impedances.

Diodes



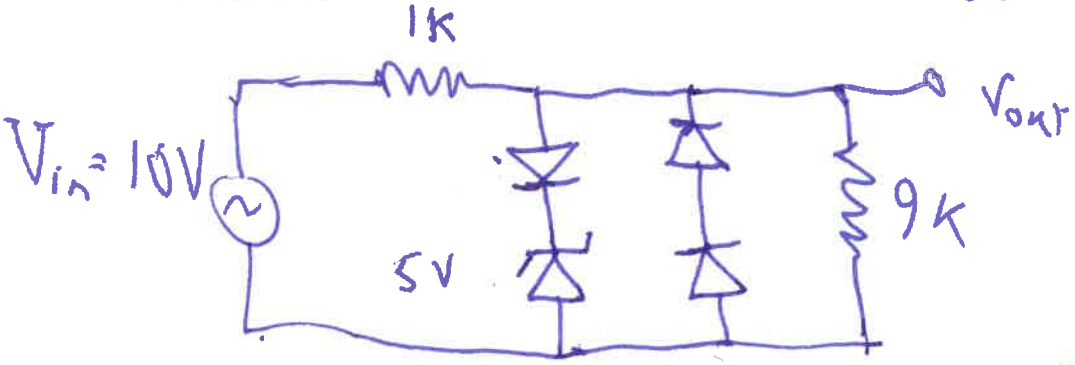
Zener

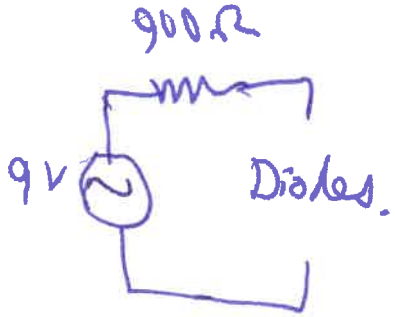


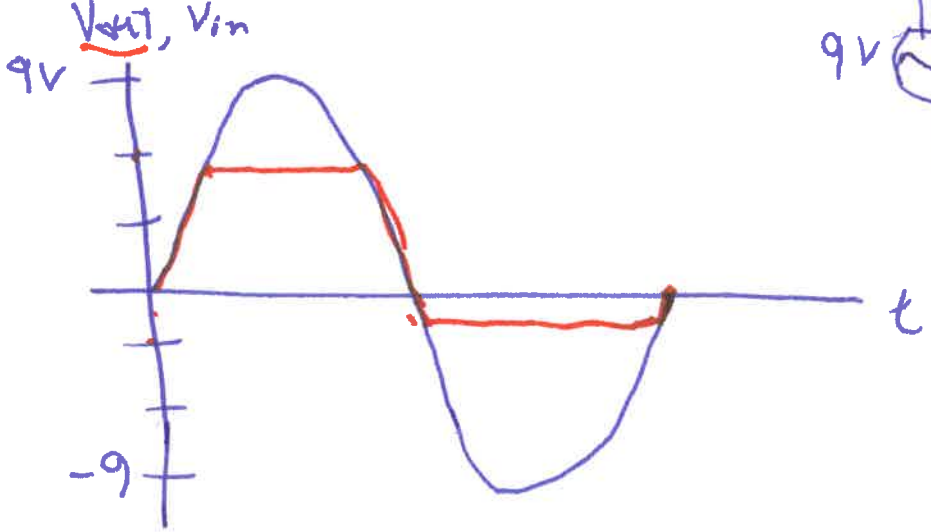
Shockley Eq.

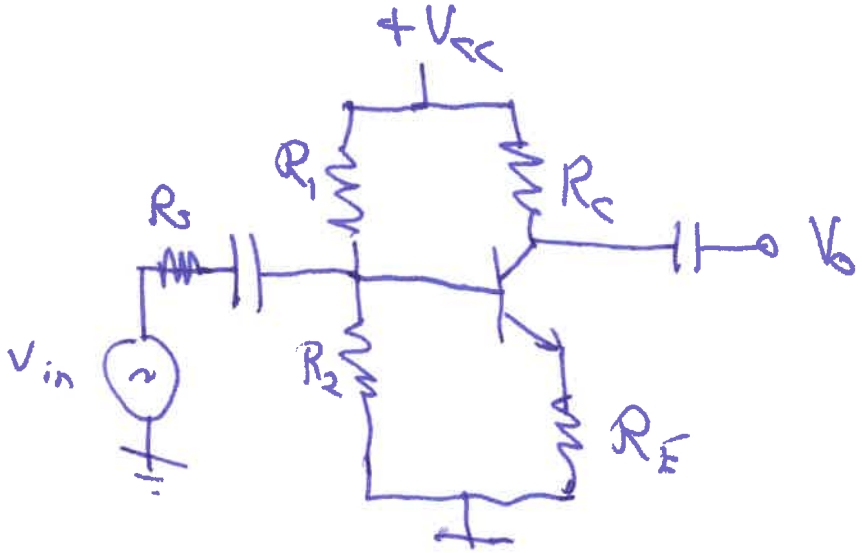
$$i = I_S\left(-1 + e^{V/nV_T}\right)$$

Example

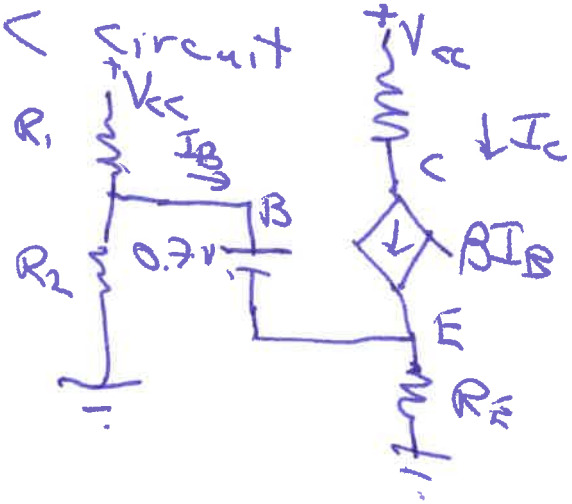




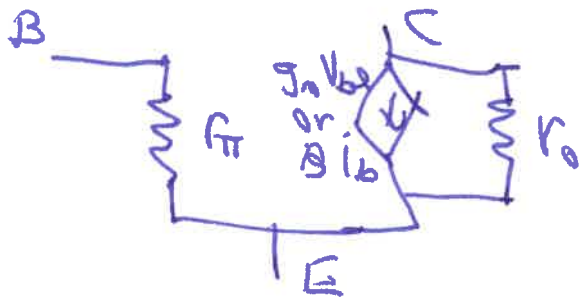




1 DC circuit



2 Small signal model of the transistor



$$r_\pi = \frac{\beta V_T}{I_C} \qquad g_m = \frac{I_C}{V_T}$$

3 AC circuit (whole circuit)

Gain: $A_V = \frac{V_{out}}{V_{in}}$ Impedances.

BJT amplifiers.

CE high gain

CC $A_v = 1$

CB $A_i = 1$

FET

Act

Triode ~~Saturation~~.

$$i_D = K\left[2(V_{GS} - V_{TO})V_{DS} - V_{DS}^2\right]$$

Saturation

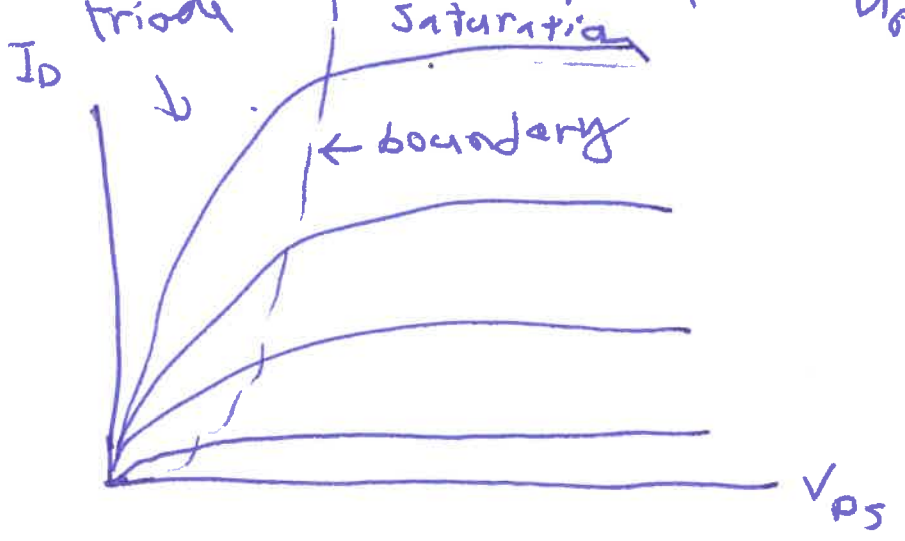
$$i_D = K(V_{GS} - V_{TO})^2$$

Boundary

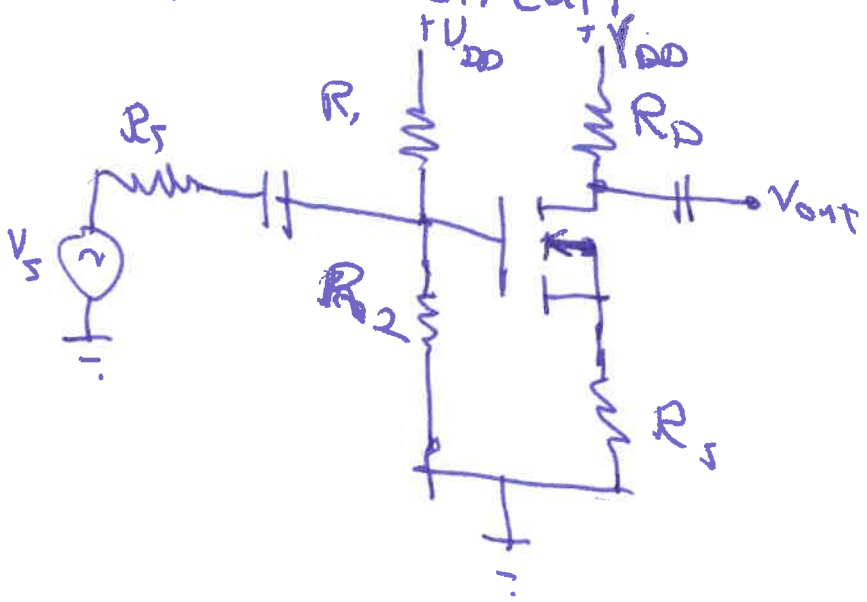
$$I_D = K V_{DS}^2 \quad \text{or} \quad V_{DS} = V_{GS} - V_{TO}$$

$$K = \frac{W}{L}\frac{K_P}{2} \qquad K_P = \mu_n C_{ox} \simeq 50\,\mu A/V^2$$

or $\mu_p C_{ox}$ $\qquad \mu_p \simeq \frac{1}{2}\mu_n$



1 DC Circuit

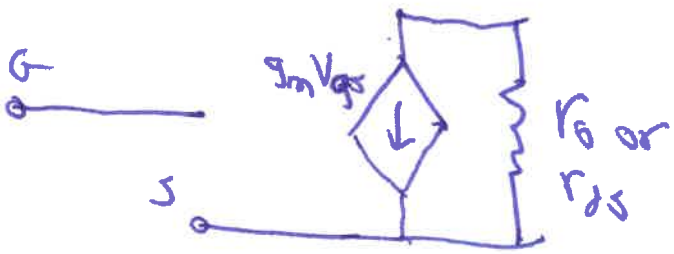


Quadratic Eqn.

$I_G = 0$

$I_S = I_D$

2 Small Signal Model



$$g_m = 2k(V_{GS} - V_{TO})$$

$$= 2I_D / (V_{GS} - V_{TO})$$

$$= 2\sqrt{kI_D}$$

$$r_o = \frac{V_A}{I_D}$$

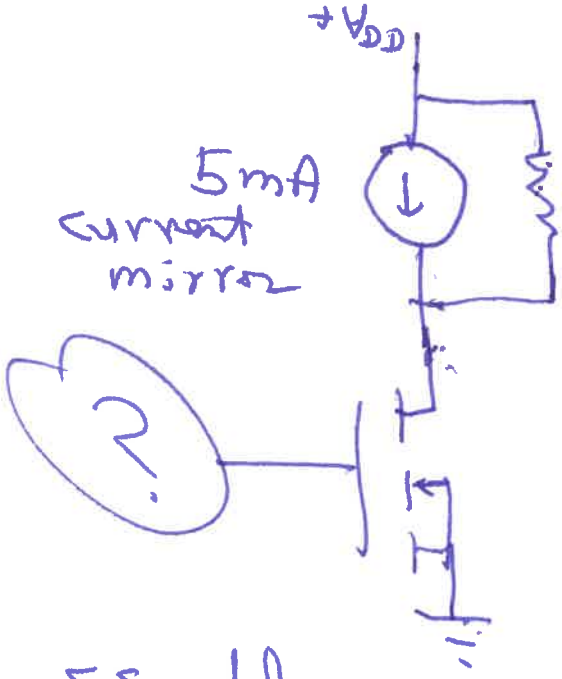
AC circuit

Gain $A_v = \frac{V_{out}}{V_{in}}$ Impedances.

- CS - High Gain
- CD - $A_v \approx 1$
- CG $A_i = 1$

Current mirrors + Active load

FET with (r_o or r_{ds})

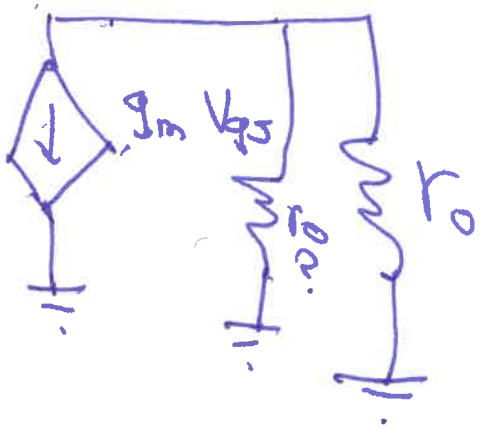


$V_A = 100V$

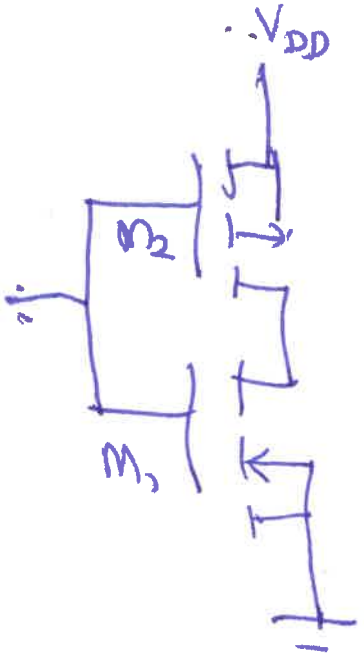
$r_o = \frac{100V}{5mA} = 20K$

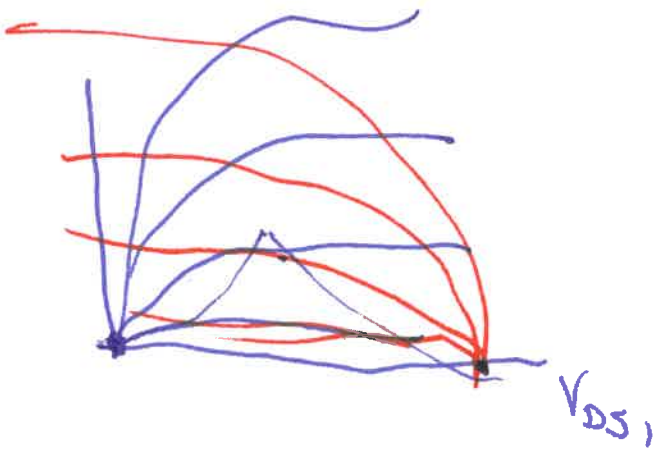
SS model

?



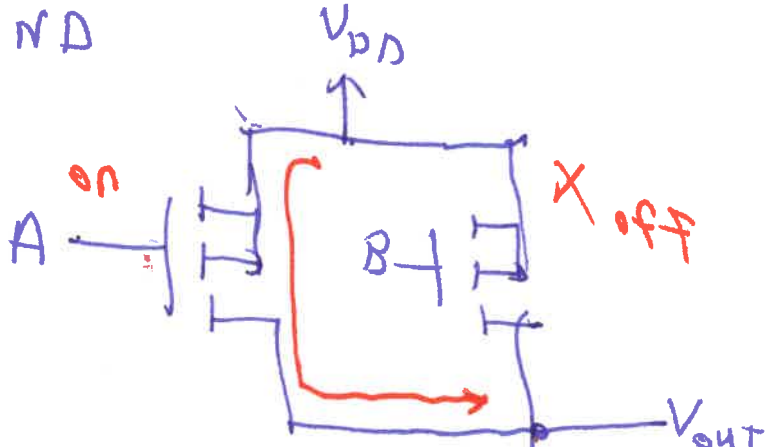
CMOS logic





Inverter

NAND



A	B	V_{OUT}
L	L	H
L	H	H
H	L	H
H	H	L