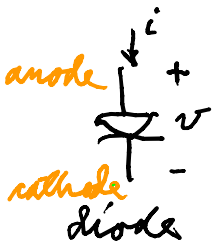
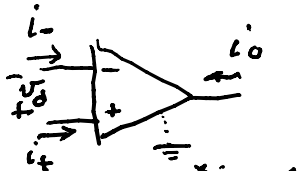
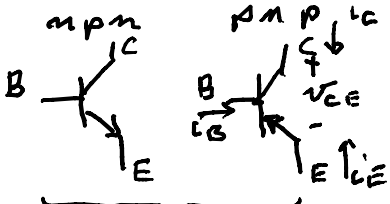
EE 303 corrected
01/26/07



diode



operational amplifier

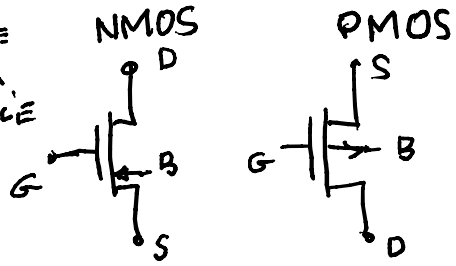


BJT
= bipolar junction transistor

B = base
E = emitter
C = collector

exponential law

CCCS
"current controlled current source



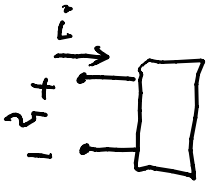
MOS
= metal oxide silicon

G = gate
S = source
D = drain
B = bulk

square law

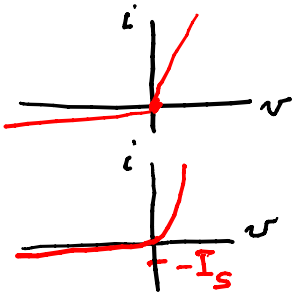
VCCS
"voltage controlled current source

polarity convention



diode: primitive level model

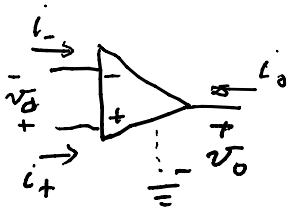
secondary model



$$i = I_S\left(e^{+v/\eta V_T} - 1\right)$$

$$V_T = \frac{kT}{|q_{electron}|} = 0.026\ V \text{ @ room temp}$$

op-amp



primary level
$v_d = 0$, $i_- = 0$, $i_+ = 0$

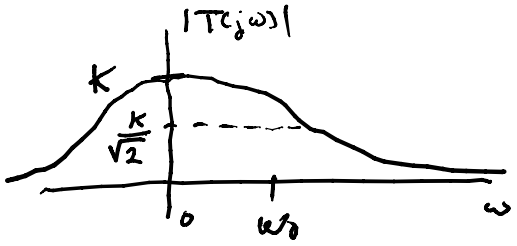
next level: $v_o = K v_d$, $K > 0$
$i_- = i_+ = 0$

next level: $i_- = i_+ = 0$; $v_o = \frac{K}{1+(s/\omega_0)} \cdot v_d$; s = Laplace transform variable = complex number or the derivative operator

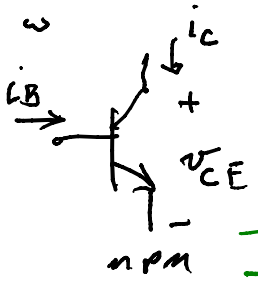
if $s = j\omega$ then means sinusoidal steady state

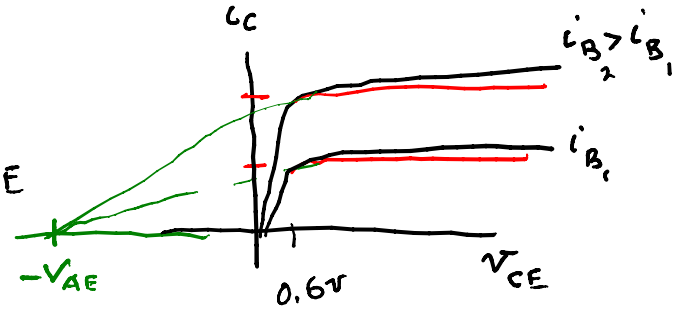
$$T(j\omega) = \frac{v_o}{v_d} = \frac{K}{1+j(\omega/\omega_0)} = \text{transfer function of op-amp}$$

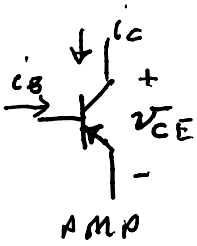
$$|T(j\omega)| = \left|\frac{v_o}{v_d}(j\omega)\right| = \frac{|K|}{\left|1+j\frac{\omega}{\omega_0}\right|} = \frac{|K|}{\sqrt{1+(\omega/\omega_0)^2}} \qquad \text{if } \omega = \omega_0, \left|\frac{v_o}{v_d}\right| = \frac{K}{\sqrt{2}}$$

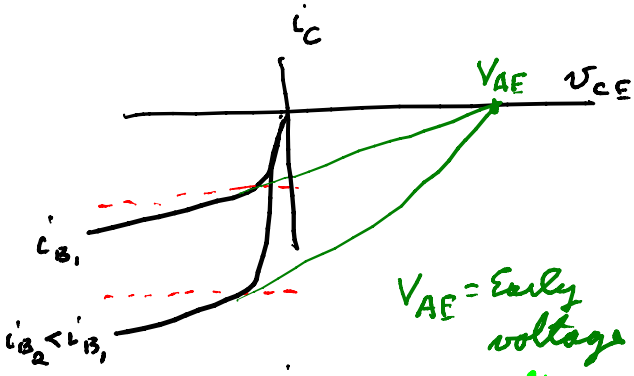


curves for BJT's



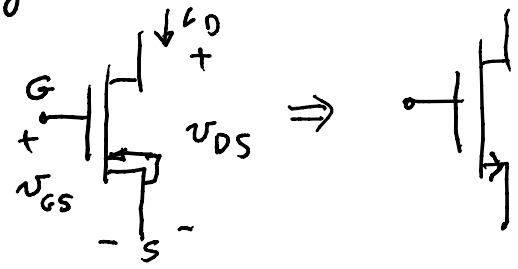


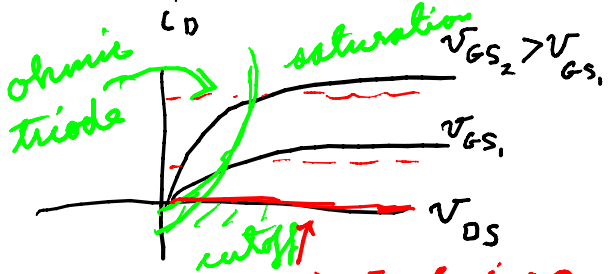




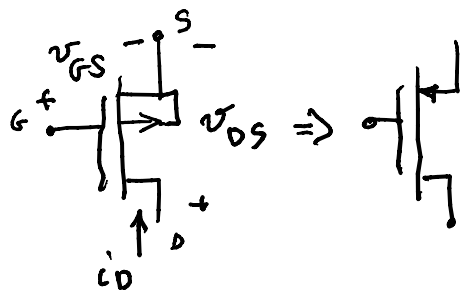
V_{AE} = Early voltage

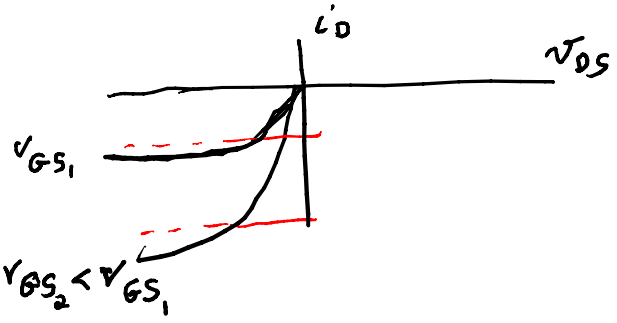
curves for MOS





min v_{GS} for $i_D > 0$ is VTO = V_{th}





NMOS: (DC characteristics)

$$i_D = \frac{KP}{2}\cdot\frac{W}{L}\begin{cases} 0 & V_{DS}\geq 0,\ \text{but } V_{GS} < VTO \quad \text{cutoff} \\ (V_{GS}-VTO)^2(1+\lambda V_{DS}) & V_{DS}\geq 0,\ 0 \leq V_{GS}-VTO \leq V_{DS} \quad \text{ohmic} \\ \{(V_{GS}-VTO)V_{DS}-2V_{DS}^2\}(1+\lambda V_{DS}) & 0 \leq V_{DS} \leq V_{GS}-VTO \quad \text{saturation} \end{cases}$$

correct the 2 to here

often ignore unless effect design