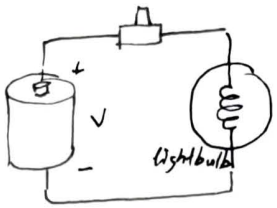
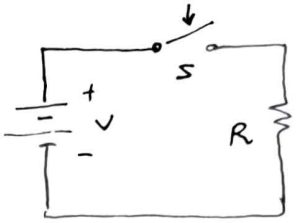
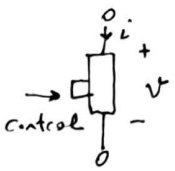
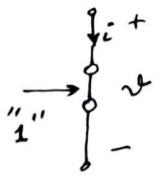
MOSFET SWITCH / AMPLIFIER

(Metal Oxide Semiconductor Field Effect Transistor)

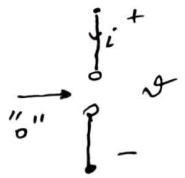




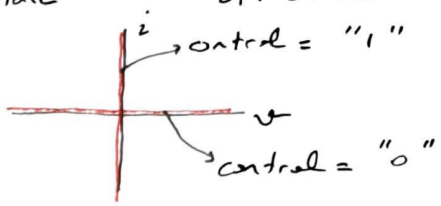




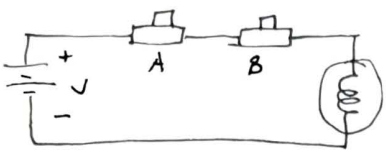
ON state



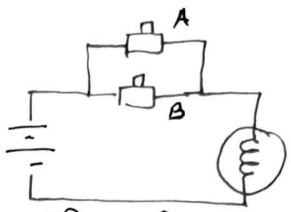
OFF state



Logic functions using Switches:

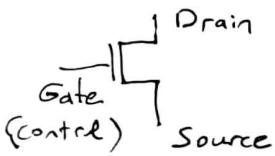


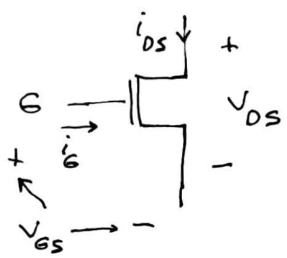
AND configuration

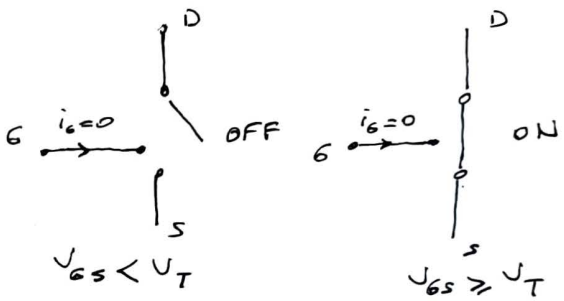


OR configuration

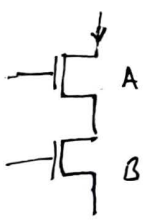
MOSFET is a type of trasistor that is three-terminal device:



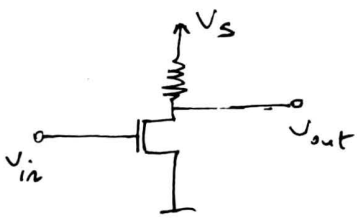




S-Model (Simple switch model)

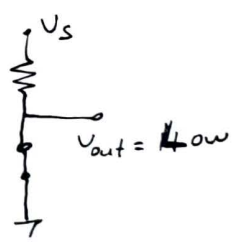


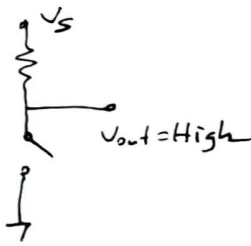
AND

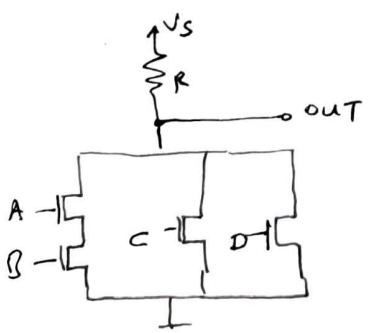


Inverter (Not)

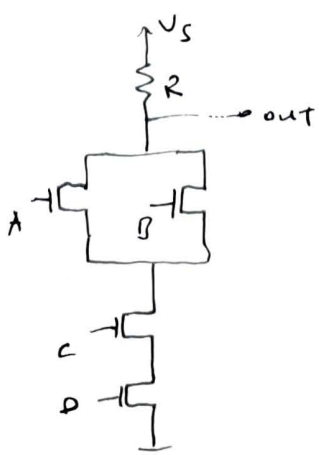
⇒



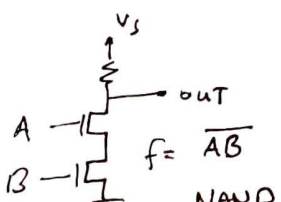




$f = \overline{AB + C + D}$

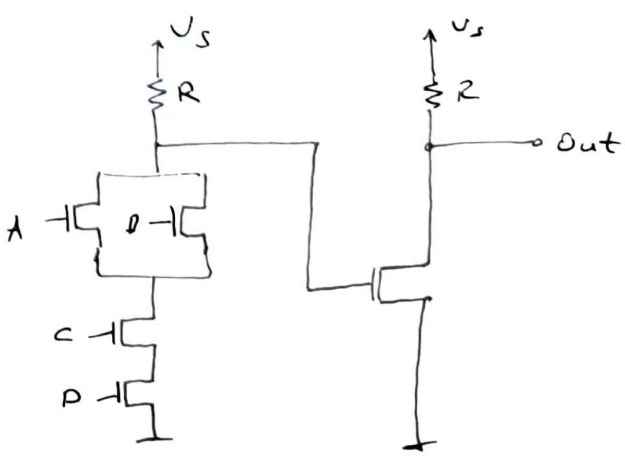


$f = \overline{(A+B)CD}$



$f = \overline{AB}$

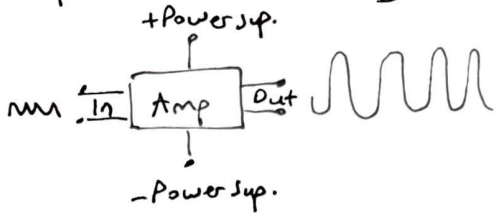
NAND

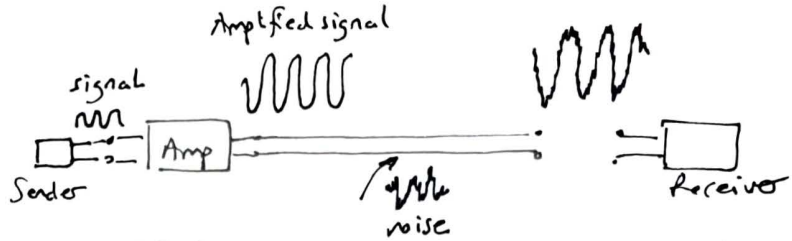


$f = (A+B)CD$

MOSFET – Signal Amplification

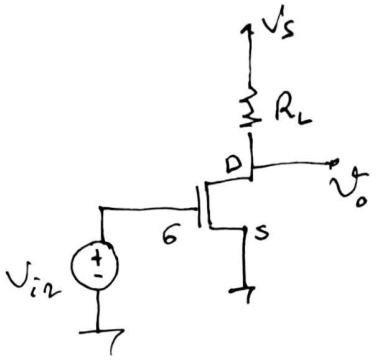
Amplification is a ~~big~~ kind of signal processing.

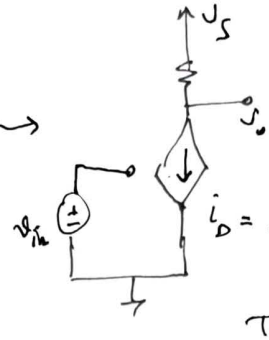




a) Amplification provides noise-tolerance!

b) " is needed for low-output sensors before Analog-to-Digital conversion.





$v_{GS} = v_{in}$, $v_{DS} = v_o$

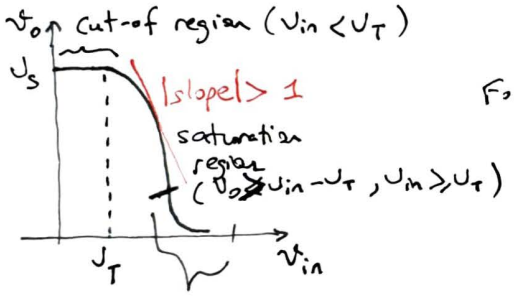
$$i_{DS} = \frac{K(V_{GS} - V_T)^2}{2}$$

$$i_D = \frac{K(v_{in} - v_T)^2}{2} \quad \text{and} \quad i_D = \frac{V_S - v_o}{R_L}$$

Therefore $$v_o = V_S - K\frac{(v_{in} - v_T)^2}{2} \cdot R_L$$

The transfer function (or gain) is : $$\frac{v_o}{v_{in}} = \frac{V_S - K(v_{in} - V_T)^2 \cdot R_L/2}{v_{in}} \quad \text{(non linear)}$$

v_o Cut-off region ($v_{in} < V_T$)



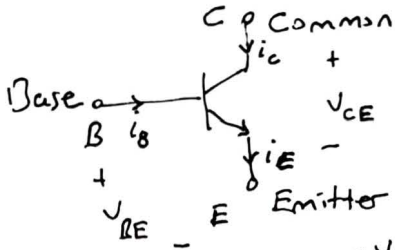
Triode region
($v_o < v_{in} - V_T$ and $v_{in} \geq V_T$)

For ex : $V_S = 10\ V$
$K = 1\ mA/V^2$
$R_L = 10\ k\Omega$
$V_T = 1\ V$

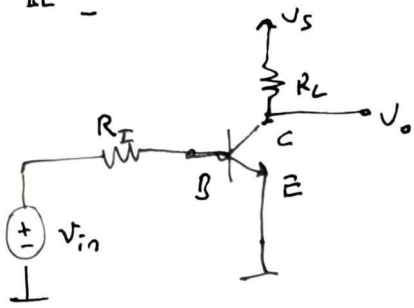
$$\Rightarrow v_o = 10 - 5(v_{in} - 1)^2$$

v_{in}	v_o	
1	10	→ Cut-off
1.4	9.2	Saturation region (Good for amplifying)
1.5	8.8	
1.8	6.8	
1.9	6	
2	5	
2.1	4.0	
2.2	2.8	
2.3	1.6	
2.32	1.3	Triode region $v_{in} > 2.3$
2.35	0.9	
2.4	≈0	

Bipolar Junction Transistor (BJT)



β (Gain)



Determine V_o for $V_{in} = 1\,V,\ 1.1\,V,\ 1.2\,V$

($R_I = 100\,k\Omega$, $R_L = 10\,k\Omega$, $\beta = 100$, $V_S = 10\,V$)

$$i_B = \frac{v_{in} - 0.6}{R_I} \quad \text{and} \quad \frac{V_S - V_o}{R_L} = \beta\, i_B$$

$$v_o = V_S - \frac{v_{in} - 0.6}{R_I} \cdot \beta \cdot R_L = 16 - 10\, v_{in}$$

$v_{in} = 1\,V \Rightarrow V_o = 6\,V$

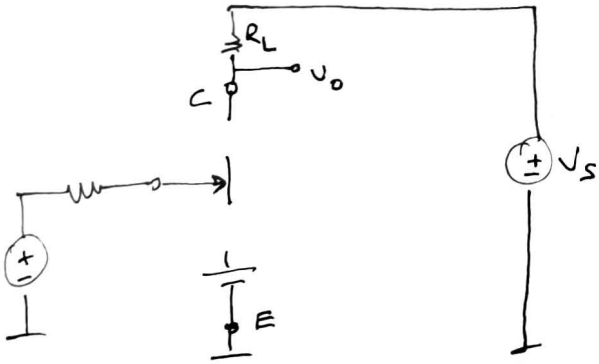
$v_{in} = 1.1\,V \Rightarrow V_o = 5\,V$

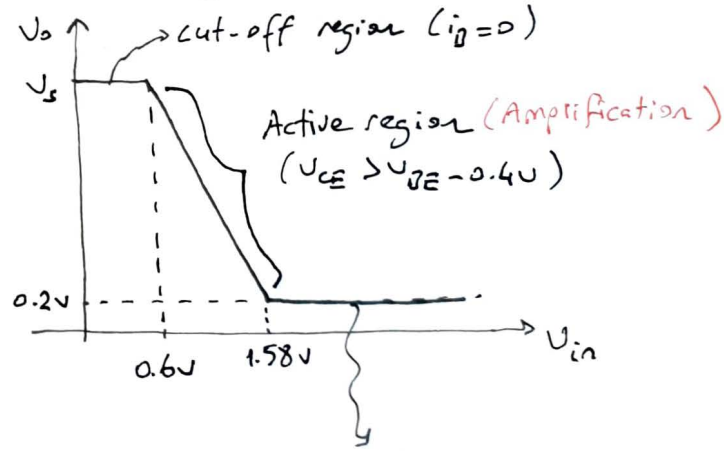
$v_{in} = 1.2\,V \Rightarrow V_o = 4\,V$

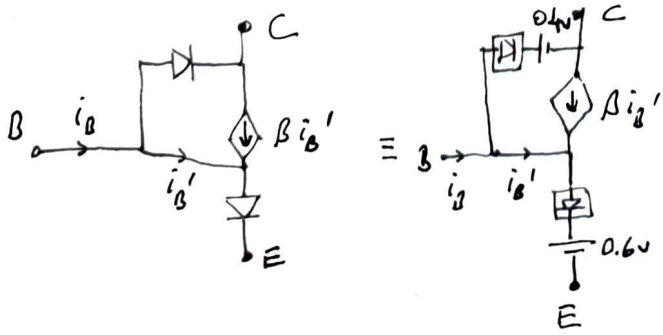
$v_{in} = 1.2\,V$, $V_o = 4\,V \Rightarrow V_{BC} = V_{BE} - V_{CE} = 0.6 - 4 = -3.4 < \underline{0.4}$ (threshold)

$V_{CE} > \underline{0.2}$ (threshold)

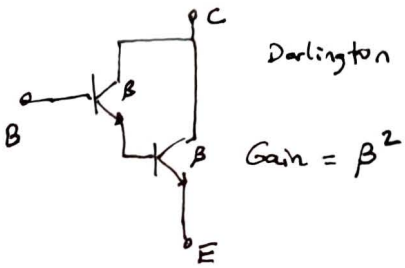
We can conclude that transistor is in active region.





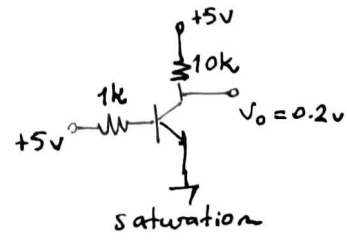


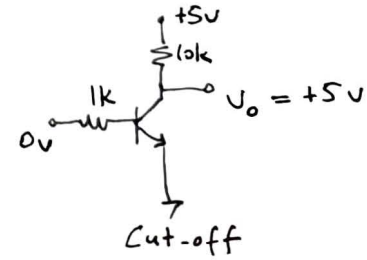
$$i_c = \begin{cases} \beta\, i_B & \text{for } i_B > 0 \text{ and } V_{CE} > V_{BE} - 0.4\,V \\ 0 & \text{otherwise} \end{cases}$$



Darlington network

Gain = β^2





This is a NOT gate !