Resistive-Load Inverter Design

Deriving V_{IL}:

We equate current in resistor & current through MOS:

$$\frac{V_{DD}-V_{out}}{R_L} = I_{DS}(sat)$$
$$= \frac{W v_{sat} C_{ox} (V_{in}-V_T)^2}{\underbrace{(V_{in}-V_T)}_{\text{small (ignored)}}+E_c L}, \quad v_{sat}=\frac{\mu E_c}{2}, \quad \text{set } k=\left(\frac{W}{L}\right)\mu_n C_{ox}$$

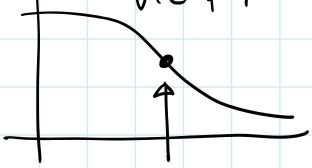
$\frac{d}{dV_{in}}$ both sides

$$\frac{1}{R_L} = \frac{W v_{sat} C_{ox}\cdot 2\cdot(V_{in}-V_T)}{E_c\cdot L}$$
$$= \frac{W\left(\frac{\mu \cancel{E_c}}{\cancel{2}}\right) C_{ox}\cdot \cancel{2}\cdot(V_{in}-V_T)}{\cancel{E_c}\cdot L}$$
$$= \underbrace{\frac{W}{L}\cdot C_{ox}\cdot \mu_n}_{k}\cdot(\underbrace{V_{in}}_{V_{IL}}-V_T)$$

$$\frac{1}{R_L} = kV_{IL} - kV_T$$
$$V_{IL} = V_T + \frac{1}{kR_L} \quad (?)$$

V_S (switching point):

VTC plot



switching point : input & output is the same.

$\Downarrow$

$V_G = V_D$

$\Downarrow$

$\underbrace{V_G = V_{DS} = V_D - V_{DS}}$

$\Downarrow$

Device is in saturation

Recall condition for saturation:

$V_{DS} > (V_{GS}-V_T) \,||\, E_c\cdot L$

$V_{DS} > (V_{GS}-V_T) > (V_{GS}-V_T) \,||\, E_c\cdot L$

$\rightarrow V_G = V_{DS} > V_{GS} - V_T$

$V_{DS} > (V_{GS}-V_T) > (V_{GS}-V_T) \| E_C L$

$\Downarrow$

Device is in saturation

$\rightarrow V_G = V_{DS} > V_{GS} - V_T$

$I_R = I_{DS}$ and $V_{in} = V_{out} = V_S$

$$\frac{W v_{sat} C_{ox} (V_S - V_T)^2}{(V_S - V_T) + E_C L} = \frac{V_{DD} - V_S}{R_L}$$

To solve this, we can rearrange & solve the

① quadratic equation

② Iteration technique

③ SPICE