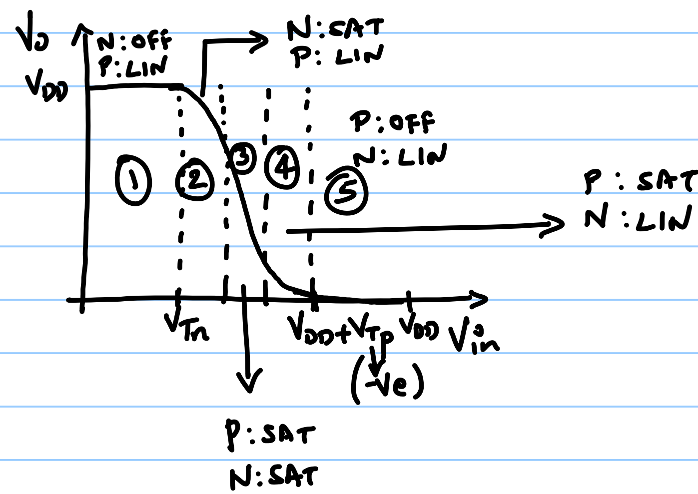
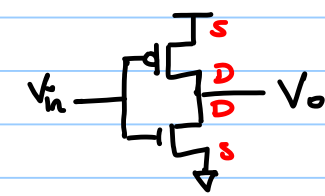
28/08/2019

EE5311

MODULE-3 : THE INVERTER

VOLTAGE TRANSFER CHAR (VTC)



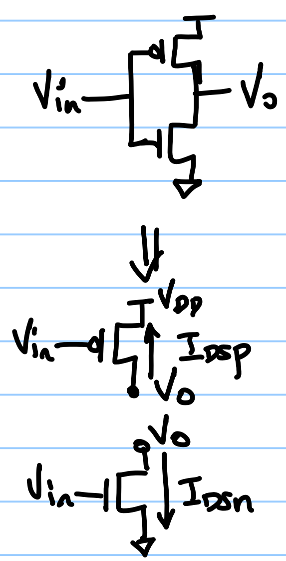


$I_{DSn} = -I_{DSp}$

$V_{GSn} = V_{in}$ $\qquad$ $V_{GSp} = V_{in} - V_{DD}$

$V_{DSn} = V_o$ $\qquad$ $V_{DSp} = V_o - V_{DD}$

<u>LOAD LINE ANALYSIS</u>



$0 \le V_o \le V_{DD}$

$I_{DSn} = -I_{DSp}$

$V_{GSn} = V_{in}$ $\qquad$ $V_{GSp} = V_{in} - V_{DD}$

$V_{DSn} = V_o$ $\qquad$ $V_{DSp} = V_o - V_{DD}$

SWEEP 'V_o' WITH V_{in} as a param.

$V_n = V_1, V_2, V_3, V_4, V_5.$

$V_1 \rightarrow < V_{Tn}$

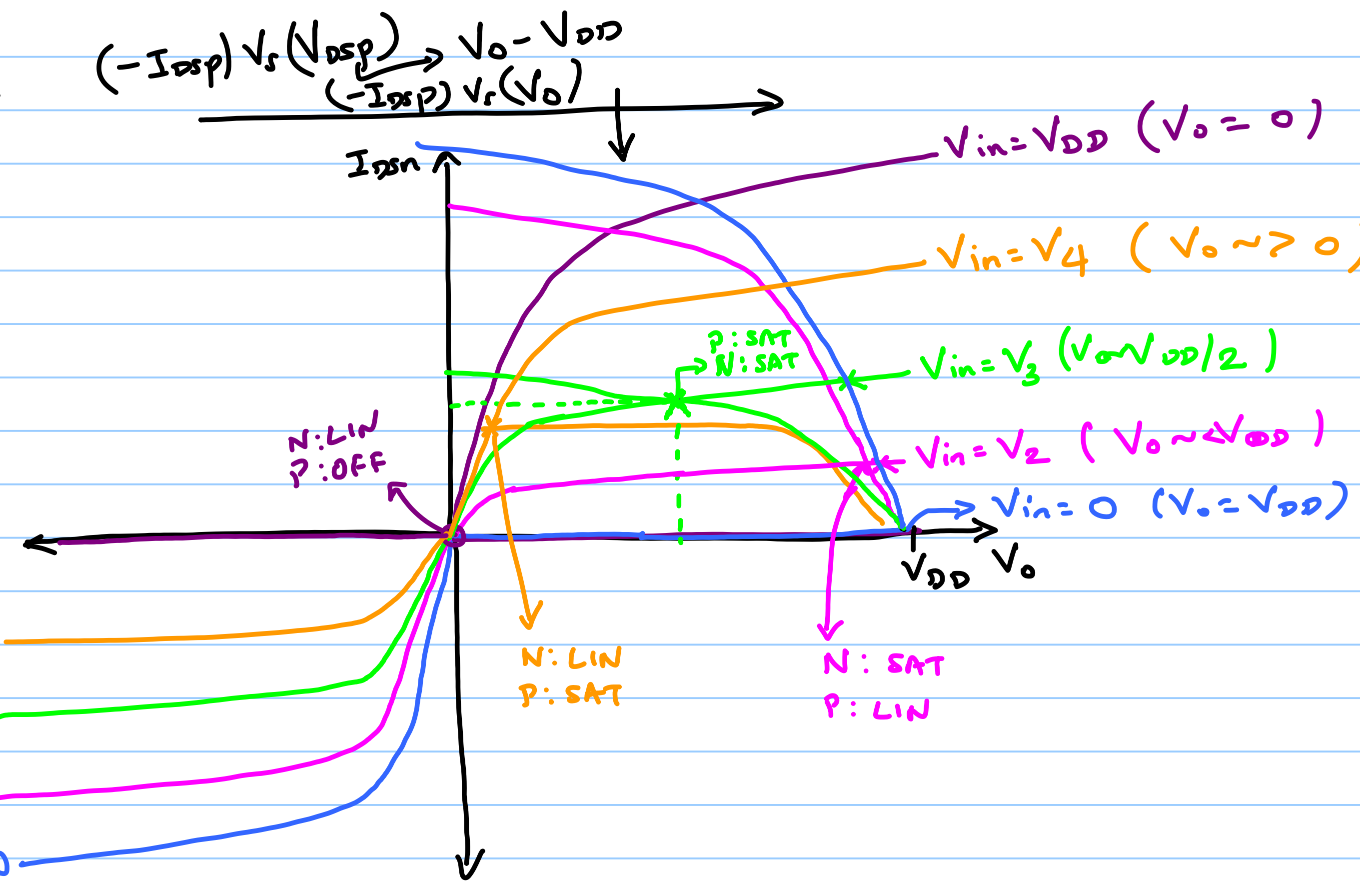
$V_3 \rightarrow$ Both in SAT

$V_5 \rightarrow > V_{DD} + V_{Tp}.$

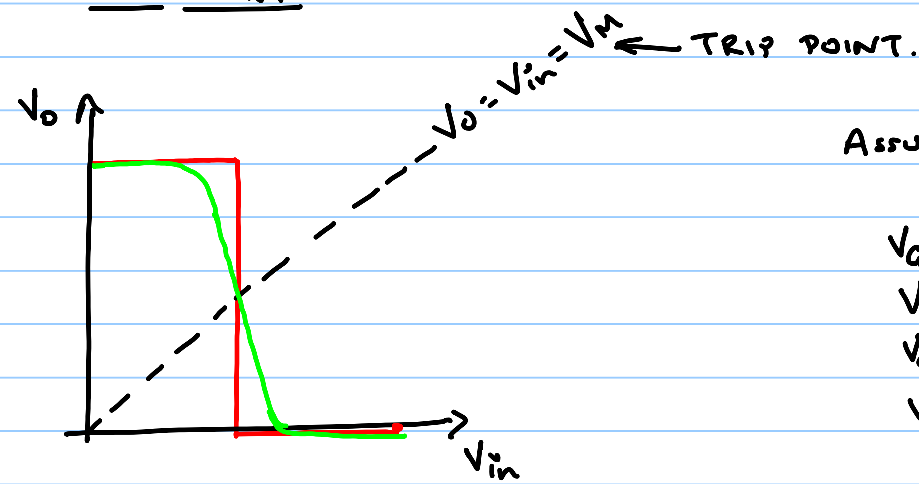
NMOS I_{DS} vs V_{DS}

$I_{DSn} = -I_{DSp}$

$V_{GSp} = V_{in} - V_{DD}$

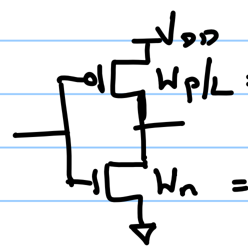


TRIP POINT



ASSUME : * N & P are in Vel sat regim
* $\lambda_n = \lambda_p = 0$

$V_{GSn} = V_{in} = V_M$
$V_{DSn} = V_o = V_M$
$V_{GSp} = V_{in} - V_{DD} = V_M - V_{DD}$
$V_{DSp} = V_o - V_{DD} = V_M - V_{DD}$



$W_p/L = W_p/2\lambda$ (8λ)

$W_n = W_n/2\lambda$ (4λ)

$$I_{DSn} = k_n' \frac{W_n}{L} V_{DSATn} \left(V_M - V_{Tn} - \frac{V_{DSATn}}{2} \right)$$

$$I_{DSp} = k_p' \frac{W_p}{L} V_{DSATp} \left(V_M - V_{DD} - V_{Tp} - \frac{V_{DSATp}}{2} \right)$$

$$\left(I_{DSn} = - I_{DSp} \right)$$

IN 180 nm : $2\lambda = 180$ nm.
$\lambda \rightarrow$ NOT SAME AS CLM (λ_n, λ_p)

$$\Rightarrow \quad k_n' \frac{W_n}{\cancel{L}} V_{DSATn} \left(V_M - V_{Tn} - \frac{V_{DSATn}}{2} \right) = - k_p' \frac{W_p}{\cancel{L}} V_{DSATp} \left(V_M - V_{DD} - V_{Tp} - \frac{V_{DSATp}}{2} \right)$$

$$r = \frac{k_p' W_p V_{DSATp}}{k_n' W_n V_{DSATn}} \quad (\text{+ve no.})$$

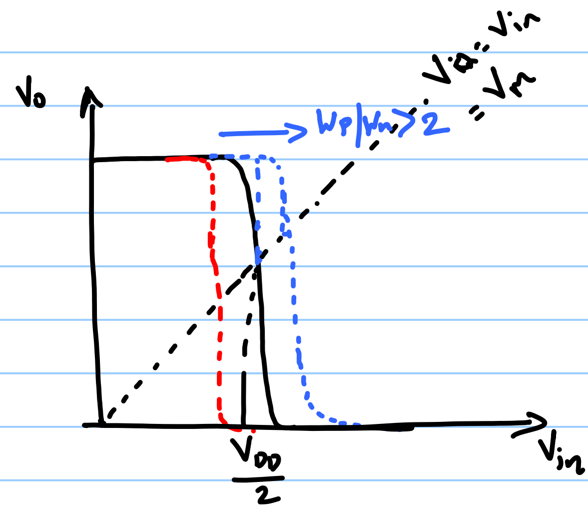
$$\therefore \quad V_M = \frac{\left(V_{Tn} + \frac{V_{DSATn}}{2} \right) + r \left(V_{DD} + V_{Tp} + \frac{V_{DSATp}}{2} \right)}{1 + r}$$

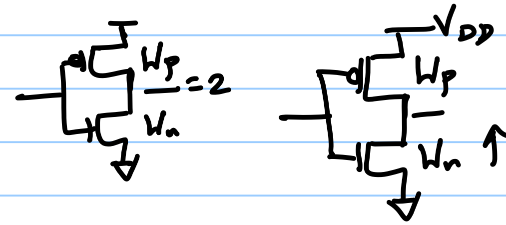
$V_{DSATn} = - V_{DSATp}$, $V_{Tn} = - V_{Tp}$

$(W_p / W_n) = k_n' / |k_p'| \sim 2$

$$\Rightarrow \quad r = 1$$

$$\Rightarrow \quad V_M = \frac{V_{DD}}{2}$$





$I_{DSn} > I_{DSn}(ref)$

LONG CHANNEL DEVICES

$V_{in} = V_o = V_M$

$I_{DSn} = \frac{1}{2} k_n' \frac{W_n}{L} (V_M - V_{Tn})^2$

$I_{DSn} = - I_{DSp}$.

$I_{DSp} = \frac{1}{2} k_p' \frac{W_p}{L} (V_M - V_{DD} - V_{Tp})^2$

$$I_{Dsn} = -I_{Dsp}$$

$$\Rightarrow \quad k_n' W_n (V_M - V_{Tn})^2 = -k_p' W_p (V_M - V_{DD} - V_{Tp})^2$$

$$\Rightarrow \quad r = \sqrt{\frac{-k_p' W_p}{k_n' W_n}}$$

$$\Rightarrow \quad (V_M - V_{Tn}) = \pm r \, (V_M - V_{DD} - V_{Tp})$$

$$\Rightarrow \quad V_M (1 + r) = V_{Tn} + r (V_{DD} + V_{Tp})$$

$$\therefore \; V_M = \frac{V_{Tn} + r (V_{DD} + V_{Tp})}{1 + r}$$