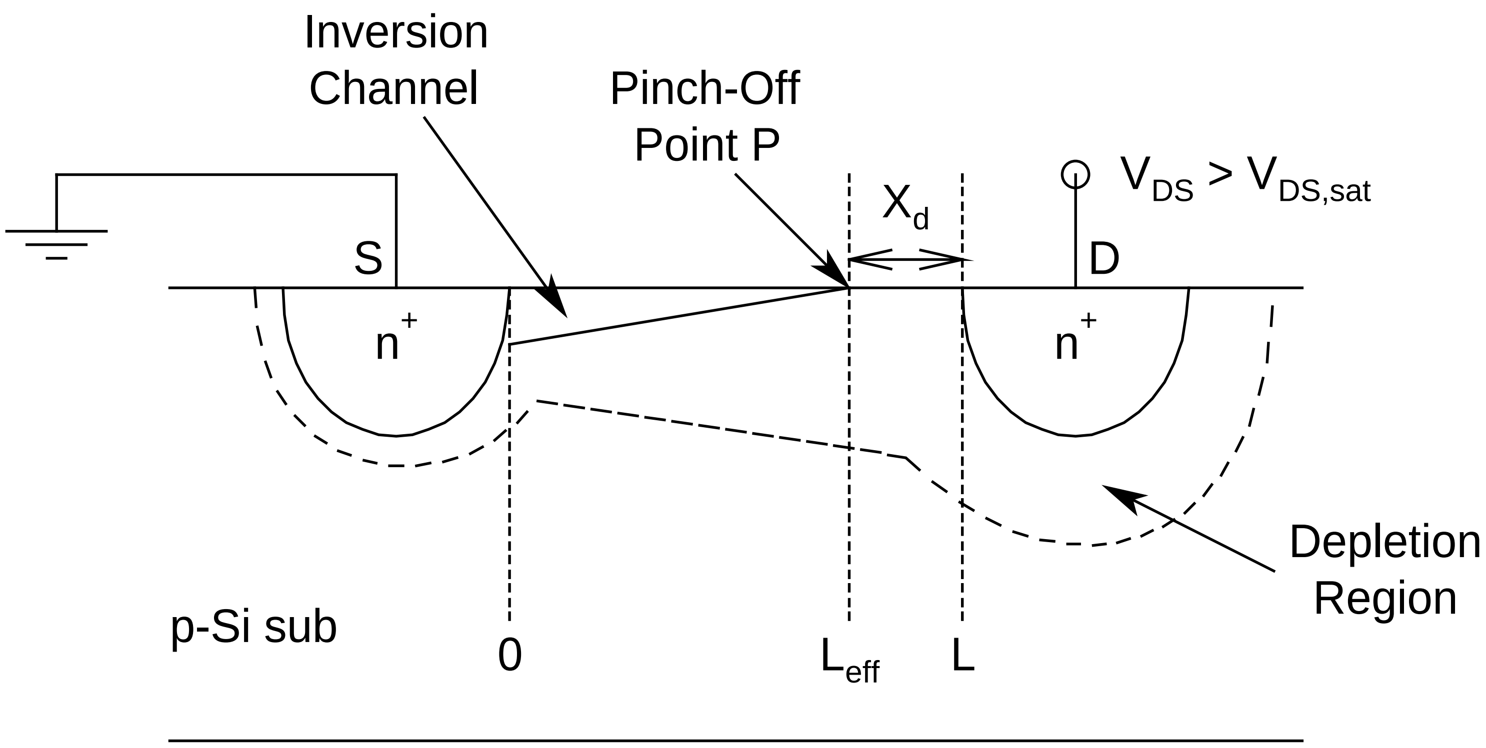
Channel Length Modulation (CLM)



$X_d \rightarrow$ length of the pinched-off region

- For $V_{DS} = V_{DS,sat}$, ***pinch-off point P at D end***
- For $V_{DS} > V_{DS,sat}$, ***P moves towards source***
- ***Effective channel length reduces*** from L to $L_{eff} = L - X_d$
  - X_d = ***pinch-off region/drain region/saturation region length***
- ***Excess voltage*** $(V_{DS} - V_{DS,sat})$ ***drops across*** X_d

- ***Reduction of effective channel length causes an increase in current***
  - ***Channel length modulation***
- With $V_{DS}\uparrow$, $X_d\uparrow$, $L_{eff}\downarrow$, and $I_D\uparrow$
  - ***No real current saturation***
- Thus, ***saturated drain current***:

$$
\begin{aligned}
I_{D,sat} &= \left(k'_N/2\right)\left(W/L_{eff}\right)V_{GT}^2 \\
&= \left(k_N/2\right)V_{GT}^2\left(1+\lambda V_{DS}\right)
\end{aligned}
$$

- λ = ***Channel length modulation parameter***

$$= \frac{1}{L}\frac{dX_d}{dV_{DS}}$$

  - ***Function of L and N_A***
  - ***Higher L and N_A*** => ***Lower λ***
  - ***Typical values of λ*** may range from ***close to 0*** to ***as high as 0.1-0.3*** V^{-1}
  - ***Very similar to V_A for BJTs***

- This gives ***LEVEL 1 model*** (also known as ***Shichman-Hodges model***) for MOSFETs:

$$I_D = k_N\left[V_{GT}V_{DS} - V_{DS}^2/2\right]\left(1+\lambda V_{DS}\right)$$

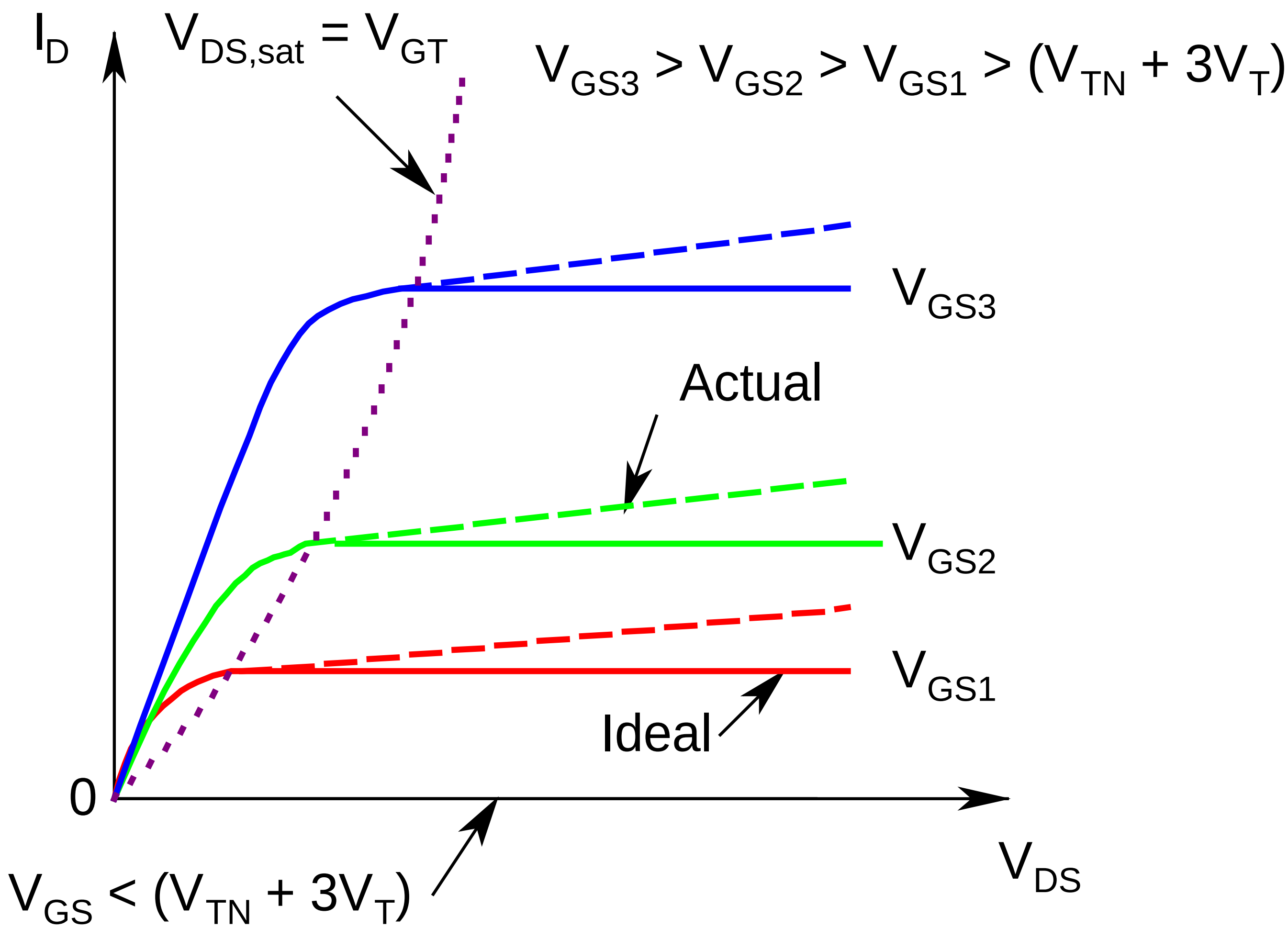
$$(\textbf{\textit{linear region}}\ \text{-}\ \ V_{GT} > 3V_T,\ V_{DS} < V_{GT})$$

$$= \left(k_N/2\right)V_{GT}^2\left(1+\lambda V_{DS}\right)$$

$$(\textbf{\textit{saturation region}}\ \text{-}\ V_{GT} > 3V_T,\ V_{DS} \geq V_{GT})$$

$$= 0$$

$$(\textbf{\textit{cutoff region}}\ \text{-}\ V_{GT} \leq 3V_T,\ \text{any } V_{DS})$$



I_D-V_{DS} Characteristics in presence of CLM