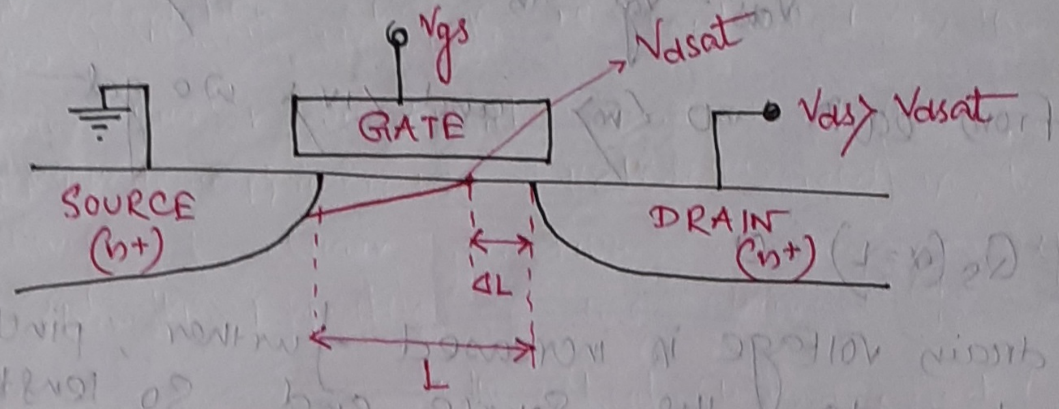
* Channel Length Modulation *



In a long channel device, drain current stays constant when the drain voltage exeeded V_{dsat}. In contraast, the drain current of a short channel MOSFET increase slightly beyond the pinch-off or the velocity saturation point. This arises because of two factors, —

i) The short channel effect ii) channel Length Modulation

N.B: → As the drain voltage increases beyond the saturation voltage V_{dsat}, ~~the saturation~~ point where the surface channel collapses begins to move slightly toward the source

Channel length modulation effect come into existance after pinch off take place and current saturation occurs.

Now, Surface charge density, —

$$\boxed{Q_s = -C_{ox}\left(V_{gs} - V_{th} - V_c(x)\right)} \quad \text{---} \langle i \rangle$$

At the source-end it becomes, —

$$\boxed{Q_s(x=0) = -C_{ox}\left(V_{gs} - V_{th}\right)} \quad \text{---} \langle ii \rangle$$

At the drain-end it becomes, —

$$Q_s(x=L) = -C_{ox}\left(V_{gs} - V_{th} - V_{ds}\right) \quad \text{----} \langle iii \rangle$$

We know that, when Saturation take place —

$$V_{ds} = V_{gs} - V_{th} \quad \text{------} \langle iv \rangle$$

So, from eqn. no $\langle iii \rangle$ and $\langle iv \rangle$ we get —

$$Q_s (x = L) = 0$$

As the drain voltage is increased further, pinch-off point shift towards the Source end, So length of the channel decreases.

Now, the effective length (L') is given by —

$$\boxed{L' = L - \Delta L}$$

When n-channel Enhancement type MOSFET operating in Saturation region, then —

$$I_{dsat} = \mu_n \left(\frac{W}{L'}\right) \cdot C_{ox} \cdot \frac{(V_{gs} - V_{th})^2}{2}$$

$$= \mu_n \left(\frac{W}{L - \Delta L}\right) \cdot C_{ox} \cdot (V_{gs} - V_{th})^2 / 2$$

$$= \frac{\mu_n \cdot (W/L) \cdot C_{ox} \cdot (V_{gs} - V_{th})^2 / 2}{\left(1 - \frac{\Delta L}{L}\right)} = \frac{I_{dsat}}{\left(1 - \frac{\Delta L}{L}\right)}$$

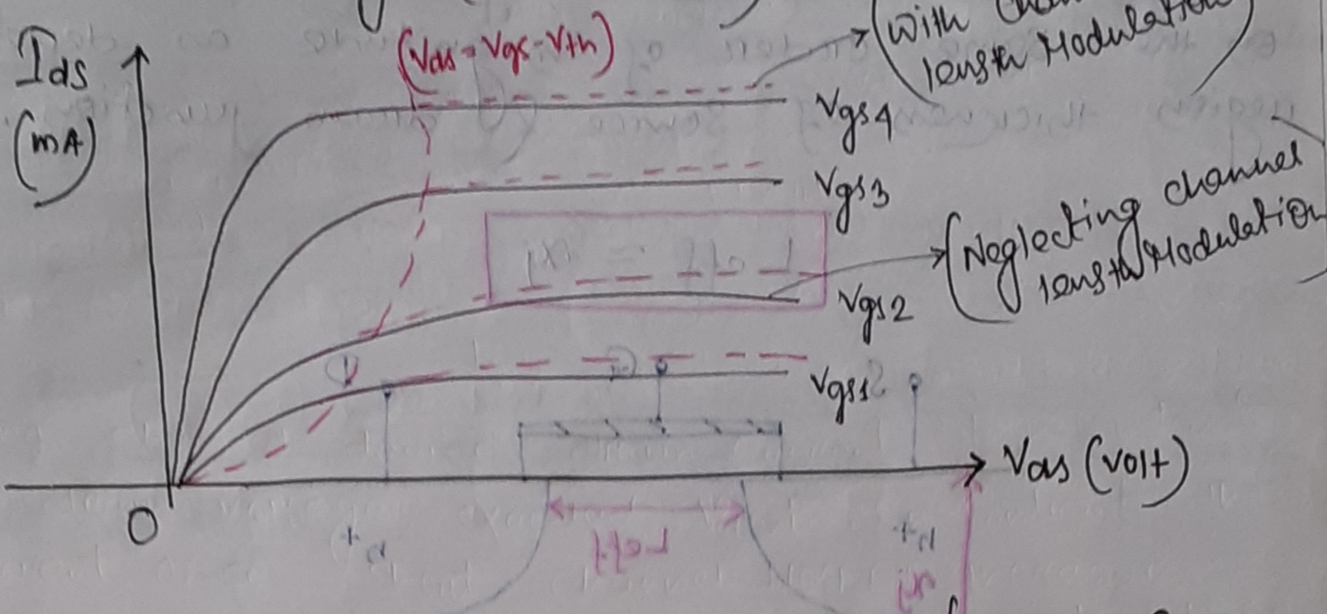
Here, $\boxed{\left(1 - \frac{\Delta L}{L}\right) = (1 - \lambda \cdot V_{ds})}$

So,

$$\boxed{I_{dsat} = \mu_n \cdot C_{ox} \cdot \frac{W}{2L} (V_{gs} - V_{th})^2 \cdot (1 + \lambda V_{ds})}$$

here, λ = Empirical model parameter.

assuming $(\lambda V_{ds} << 1)$.



N.B :- The electrons in the channel, that come from the Source travel through the shortened channel & are injected into the depletion region from, where they are streered to the drain by the high electric field.