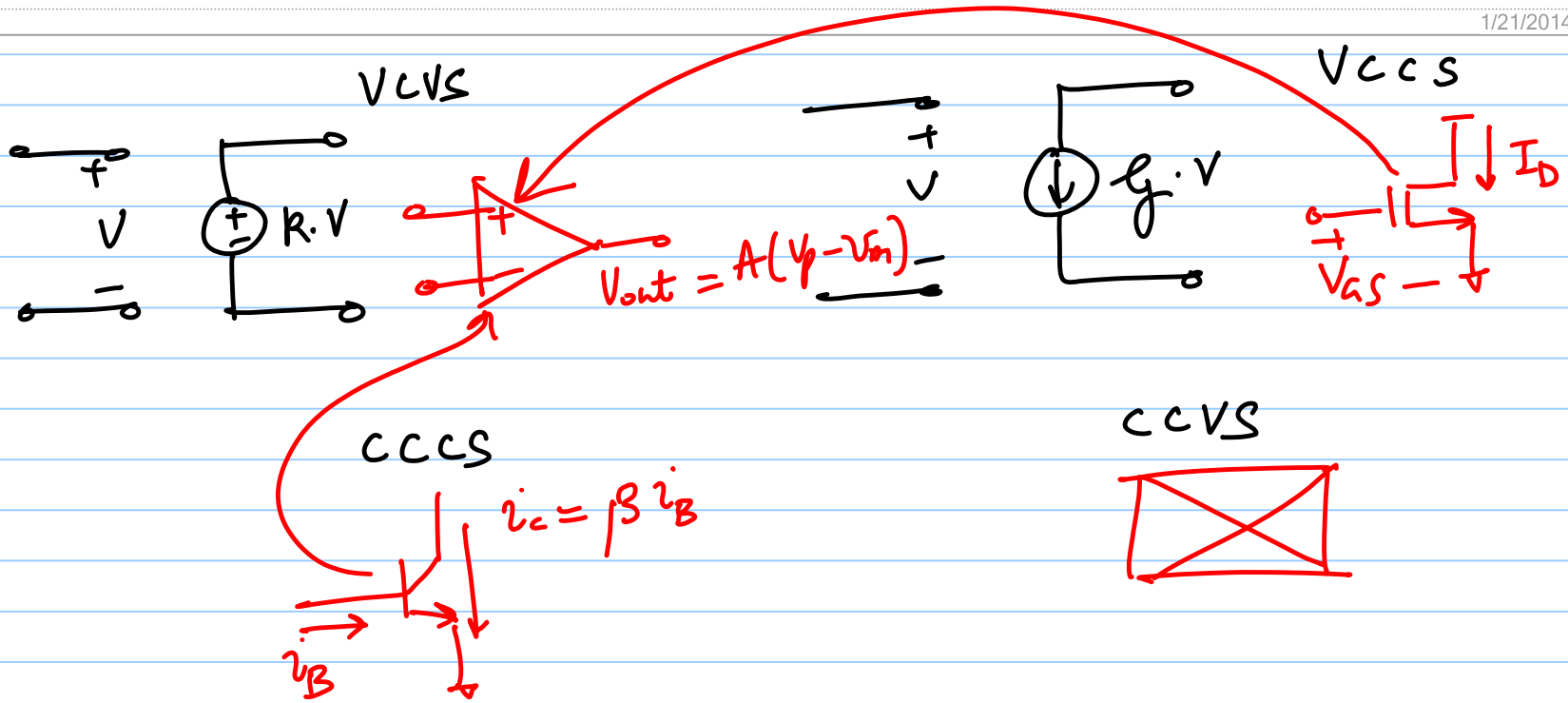
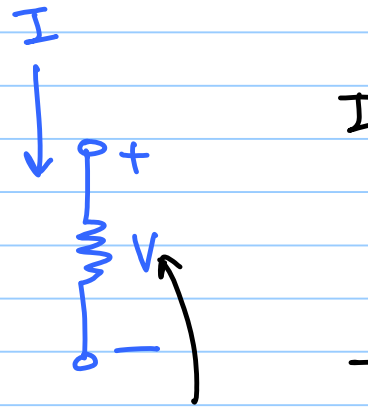
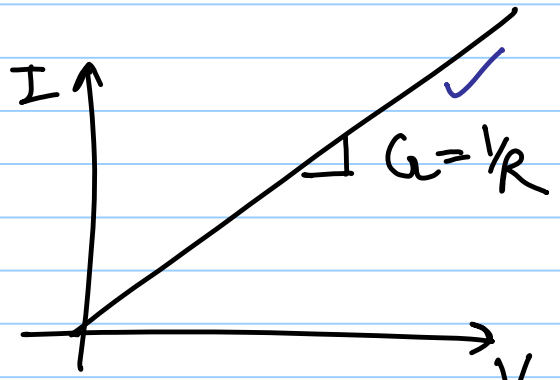
ECE 511 – Lecture 1

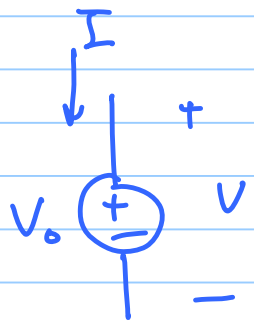
Note Title 1/21/2014

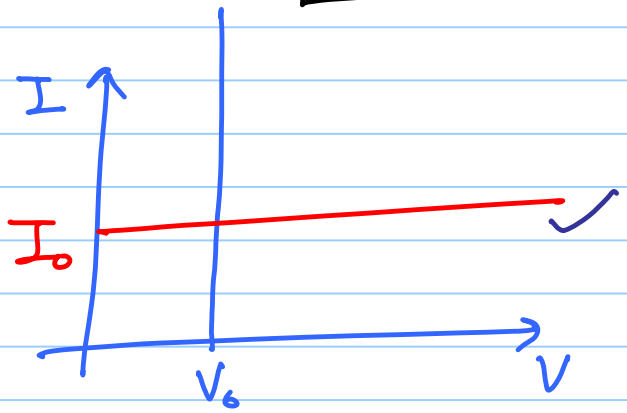




Controlling Variable







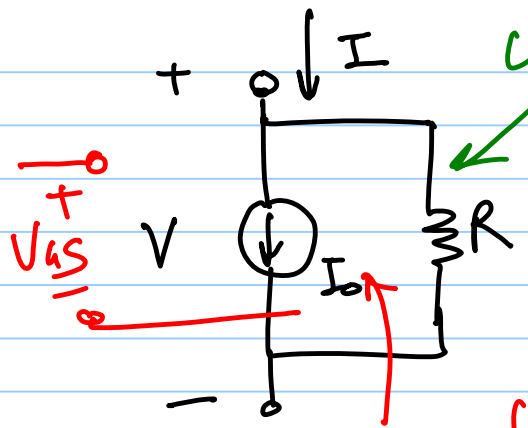
Triode

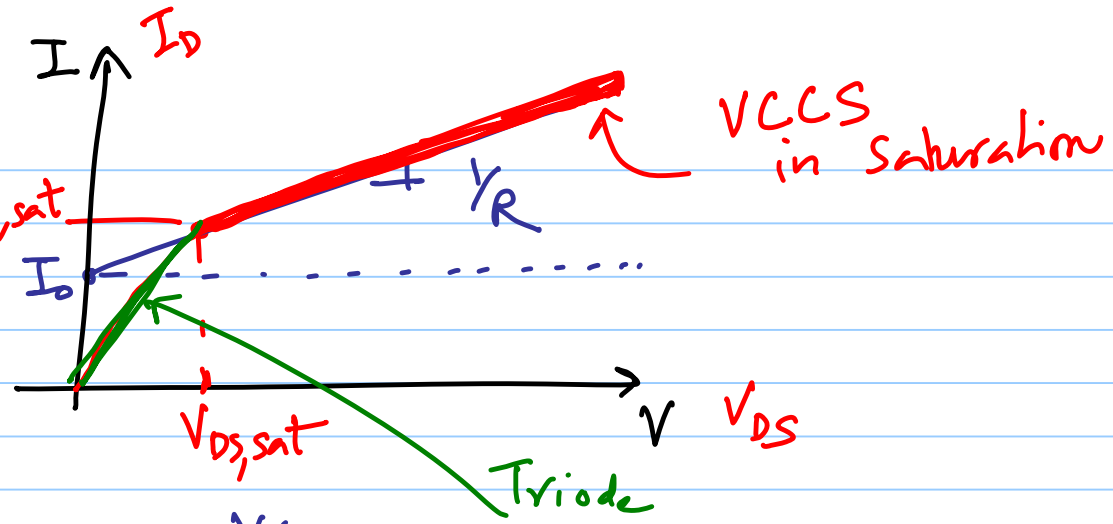
Saturation (pinch-off)

CLM (λ)

Short-channel effects

Body effect



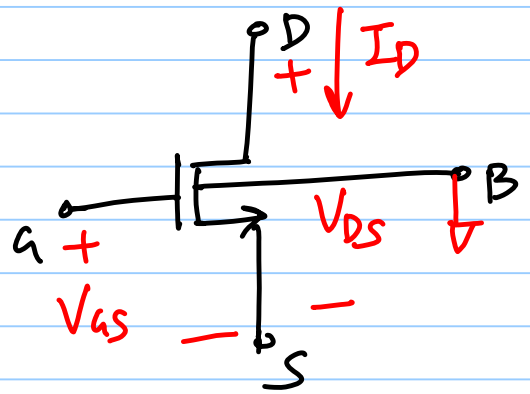


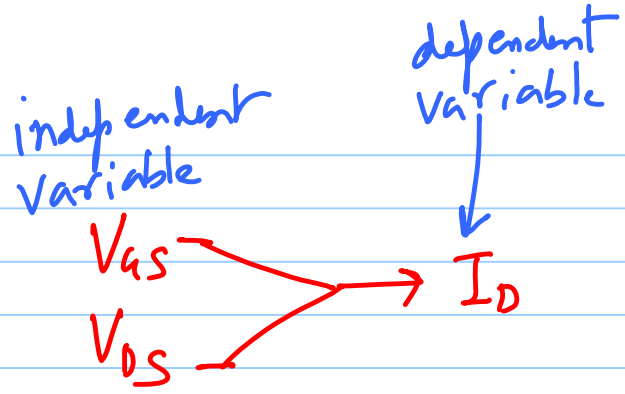
$I_{D,sat} = f(V_{GS})$

$= \frac{\beta}{2}(V_{GS} - V_{THN})^2$

$I = I_o + \frac{V}{R}$

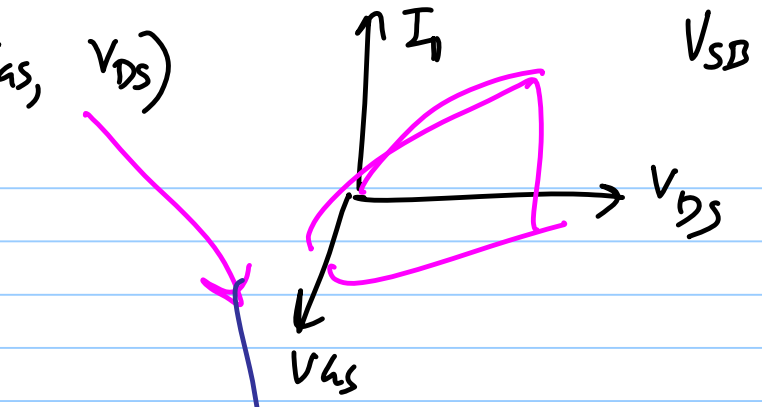
I-V curves of a MOSFET



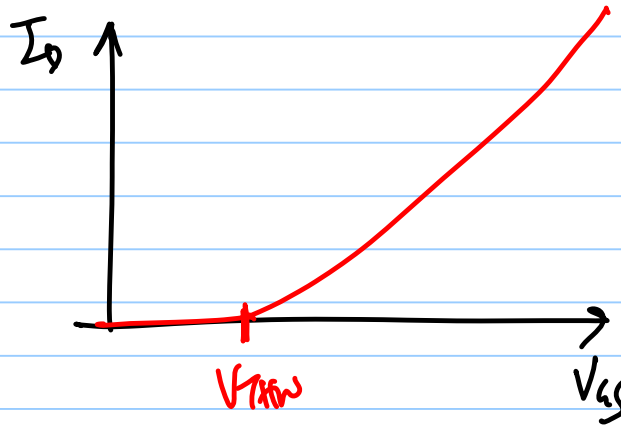


$$I_D = f(V_{GS}, V_{DS}, V_{SB})$$

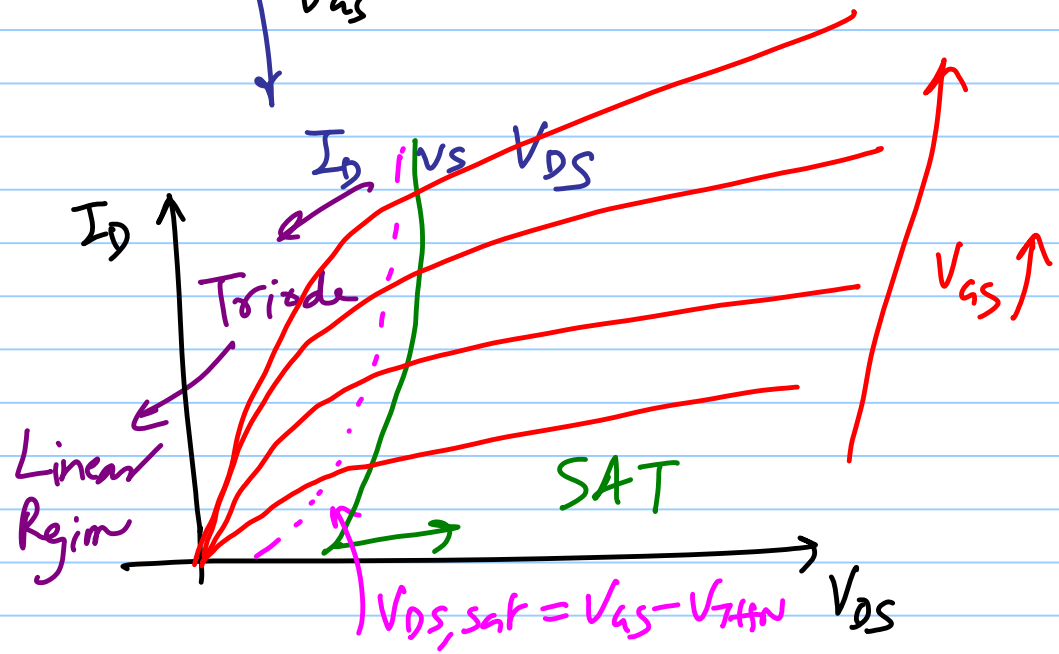
$I_D = f(V_{GS}, V_{DS})$



I_D vs V_{GS}



$$I_D = \frac{k_p}{2}\frac{W}{L}(V_{GS} - V_{THN})^2$$



Triode

$$I_D = K_n \frac{W}{L}\left[(V_{GS} - V_{THN})V_{DS} - \frac{V_{DS}^2}{2}\right]$$

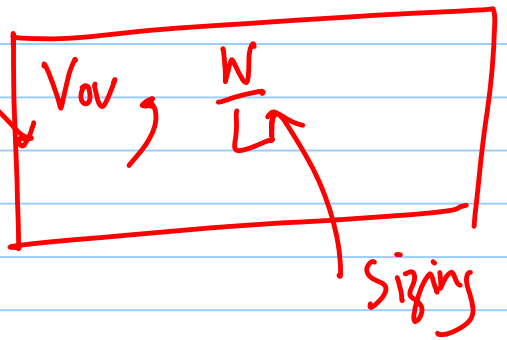
$$V_{DS,sat} = V_{GS} - V_{THN}$$

V_{OV} "Overdrive Voltage"

$$V_{OV} = V_{GS} - V_{THN}$$

↑ Voltage above threshold by which the MOSFET is driven

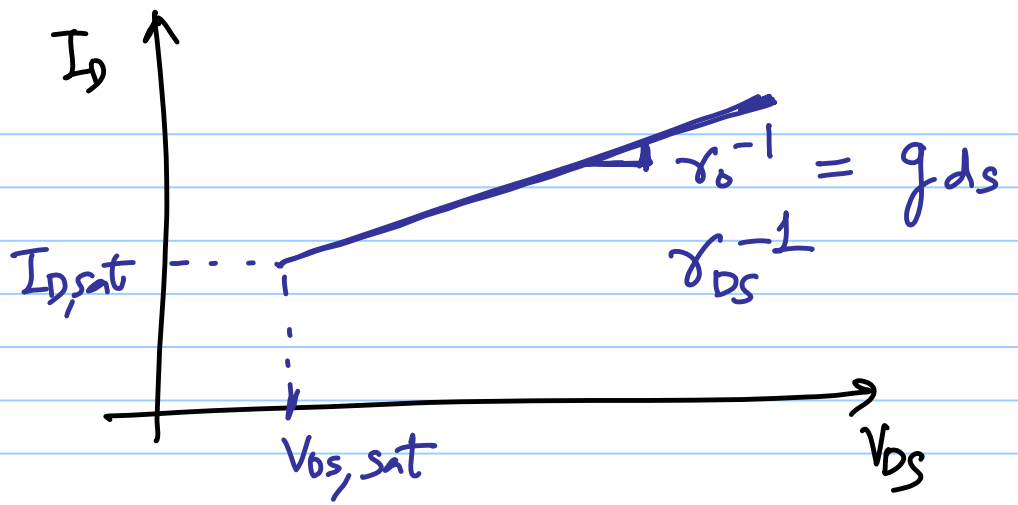
overdrive



for Long channel CMOS

$$V_{DS,sat} \triangleq V_{OV}$$

In Saturation



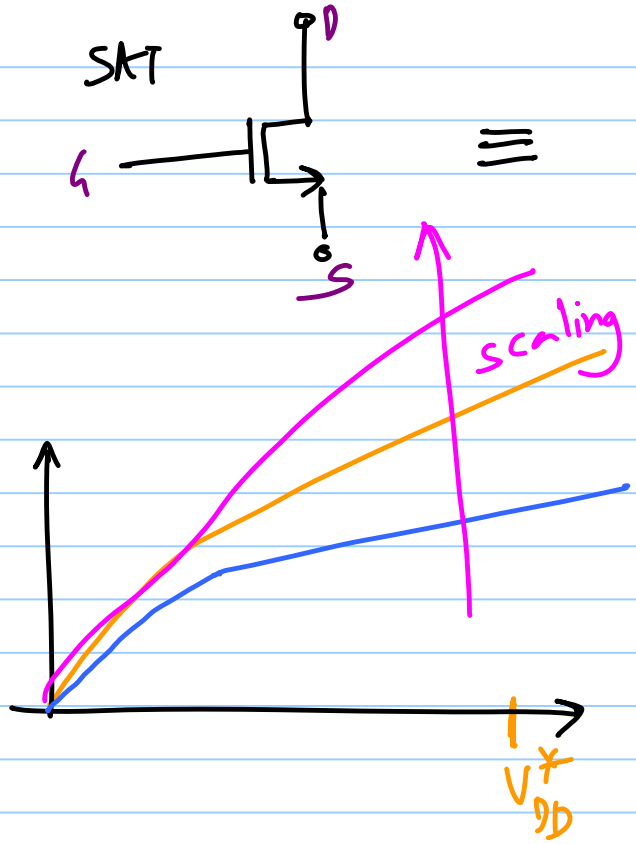
$$I_D = I_{D,sat} + I_{D,sat}\lambda\left(V_{DS} - V_{DS,sat}\right)$$

$$\gamma_o = \left(\frac{\partial I_D}{\partial V_{DS}}\right)^{-1} = \left(\lambda I_{D,sat}\right)^{-1}$$

$$\boxed{\gamma_o = \frac{1}{\lambda I_{D,sat}}}$$

$\lambda \Rightarrow$ CLM parameter

$$I_{D,sat} = \frac{K_n'}{2}\frac{W}{L}V_{ov}^2$$



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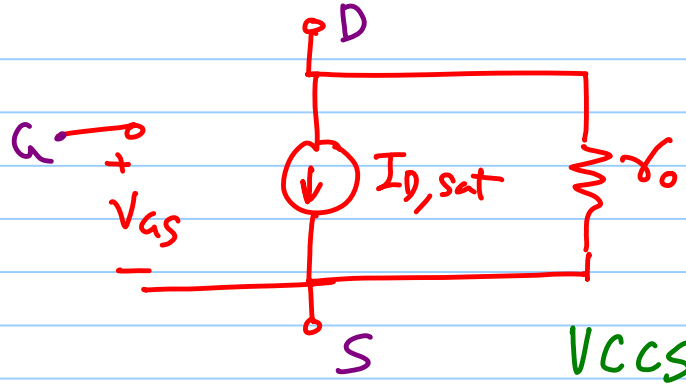


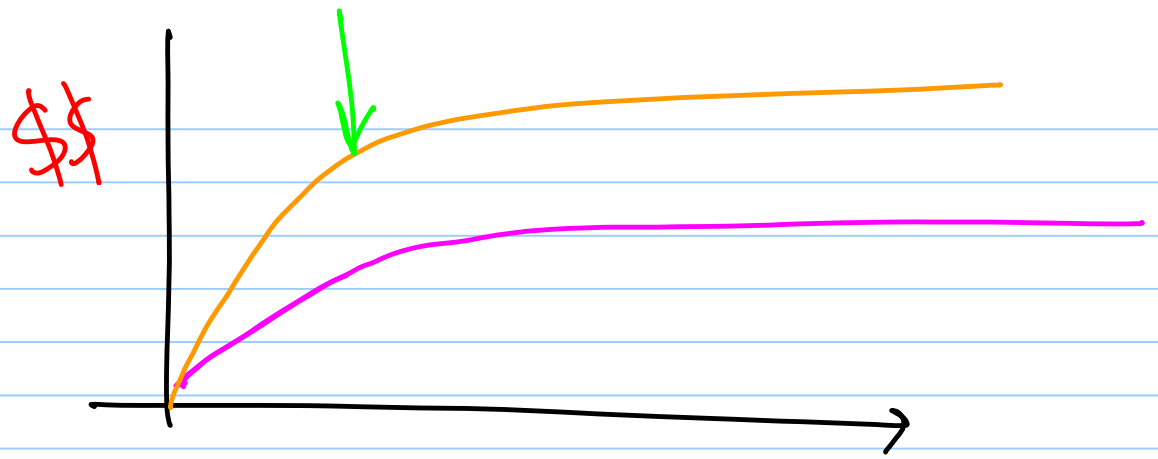
VCCS with r_o

with cmos scaling

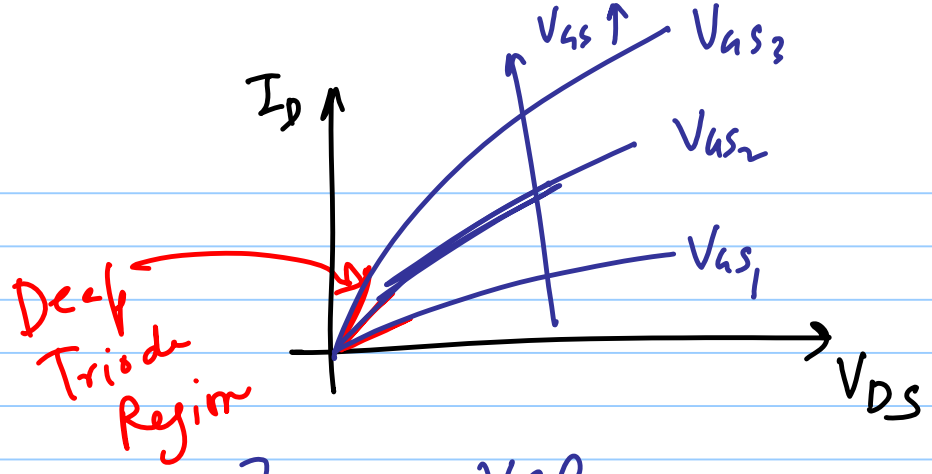
L ↓

r_o ↓

$A_v = g_m r_o$ ↓



In Triode:



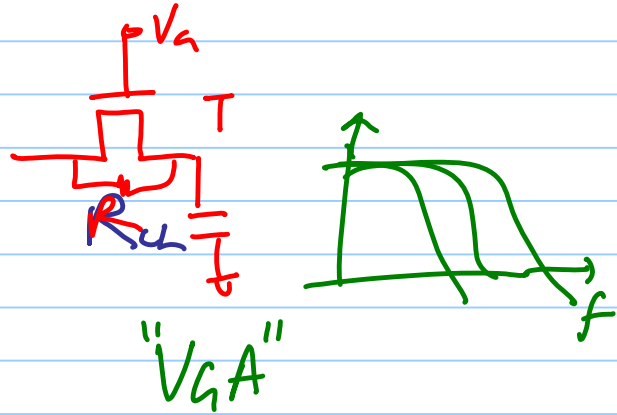
$$I_D = k_n \frac{W}{L}\left[(V_{GS} - V_{THN})V_{DS} - \frac{V_{DS}^2}{2}\right]$$

$$\frac{\partial I_D}{\partial V_{DS}} = \underbrace{k_n \frac{W}{L}}_{\beta}\left[V_{GS} - V_{THN} - V_{DS}\right]$$

$$R_{ch} = \left(\frac{\partial I_D}{\partial V_{DS}}\right)^{-1} = \frac{1}{\beta(V_{GS} - V_{THN} - V_{DS})}$$

VCR

Voltage Controlled resistor

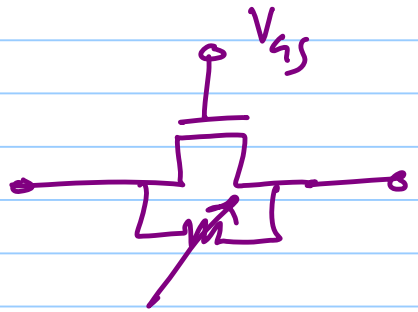


$$R_{ch} = \frac{1}{\beta(V_{GS} - V_{THN} - V_{DS})}$$

Let's say the M_1 is in deep Triode

$$V_{DS} << V_{GS} - V_{THN}$$

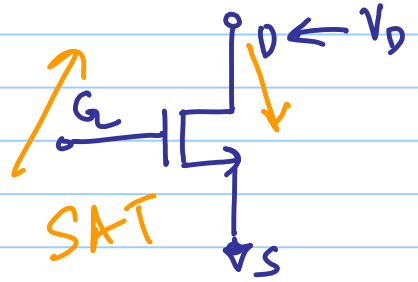
$$\boxed{R_{ch} \simeq \frac{1}{\beta(V_{GS} - V_{THN})}}$$



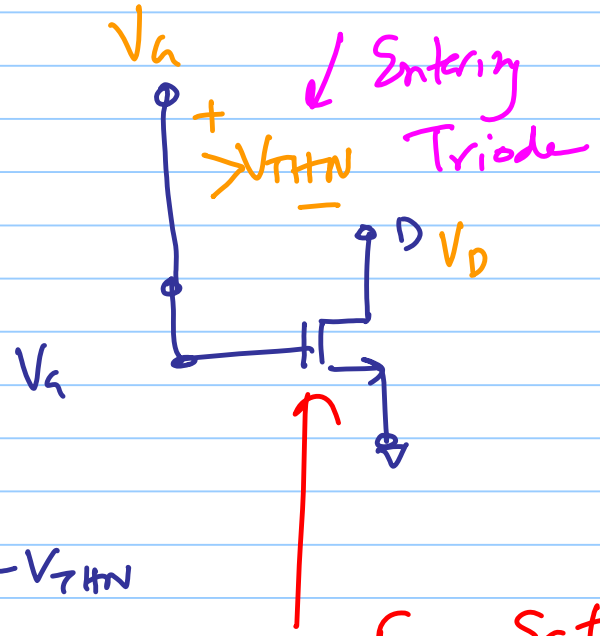
Trend: $R_{ch} \propto \frac{1}{V_{ov}}$

Saturation

(chap 9 → CMOS
chap 2 ← Razavi)



$V_{DS,sat} = V_{GS} - V_{THN}$



$V_{DS} \leq V_{GS} - V_{THN}$

$V_{DS} \leq V_{DS,sat}$

for saturation

$V_D > V_G - V_{THN}$

or $V_G < V_D + V_{THN}$