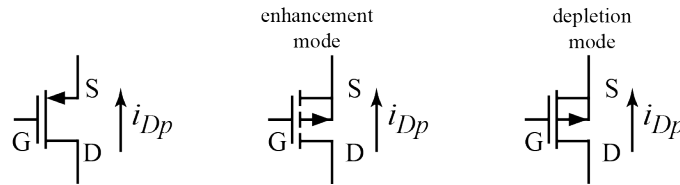


SYMBOLS:



PARAMS:

$$k_p = k'_p \frac{W}{L} = \mu_p C_{ox} \frac{W}{L} \quad V_{TH} < 0$$

TRIODE REGION:

$$0 < (-V_{DS}) < (-V_{GS}) - (-V_{TH})$$

V_{GS} is negative when PFET on

$$I_{Dp,tri} = -k_p [2(V_{GS} - V_{TH})V_{DS} - V_{DS}^2]$$

triode region

SATURATION:

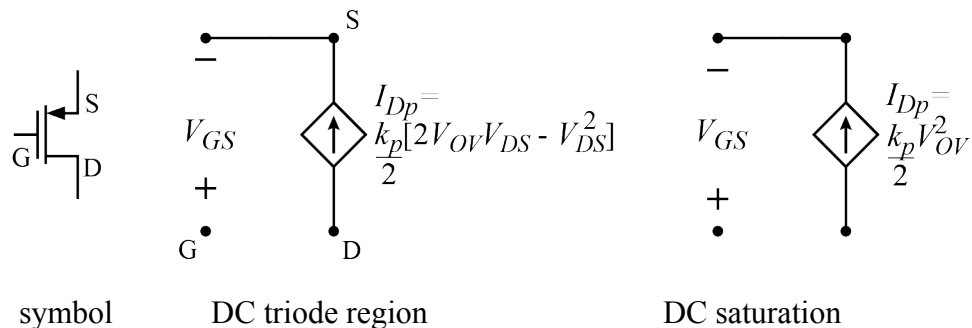
$$(-V_{DS}) > (-V_{GS}) - (-V_{TH}) > 0$$

V_{DS} is negative when PFET on

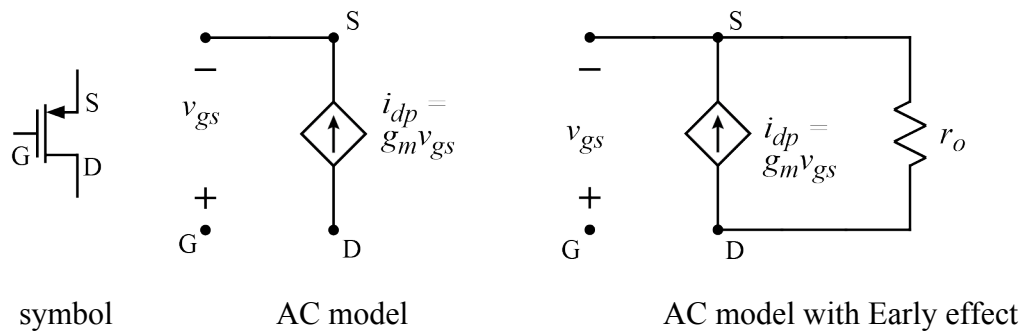
$$I_{Dp,sat} = -\frac{k_p}{2} (V_{GS} - V_{TH})^2 (1 - \lambda(V_{DS}))$$

saturation

MODEL: DC PMOS FET



MODEL: small signal (or AC) PMOS FET



AC MODEL:

$$\begin{aligned} g_m &= -k_p V_{OV,p} & V_{OV,p} \text{ is negative when PFET on} \\ g_m &= \frac{2I_{D,p}}{V_{GS} - V_{TH}} & \text{numerator and denominator are negative} \\ g_m &= \sqrt{2k_p(-I_{D,p})} & I_{D,p} < 0 \end{aligned}$$

CHANNEL MODULATION:

$$\begin{aligned} r_{o,p} &\approx -\frac{1}{\lambda I_{D,p}} & I_{D,p} < 0 \\ r_{o,p} &\approx -\frac{V_A}{I_{D,p}} & I_{D,p} < 0 \end{aligned}$$

REF: Behzad Razavi, *Fundamentals of Microelectronics with Robotics and Bioengineering Applications, 3rd Ed., Enhanced eText*, New York, NY: Wiley, 2021. ISBN: 9781119694397

Adel S. Sedra and Kenneth C. Smith, *Microelectronic Circuits, 5th Ed.*, New York, NY: Oxford University Press, 2004.