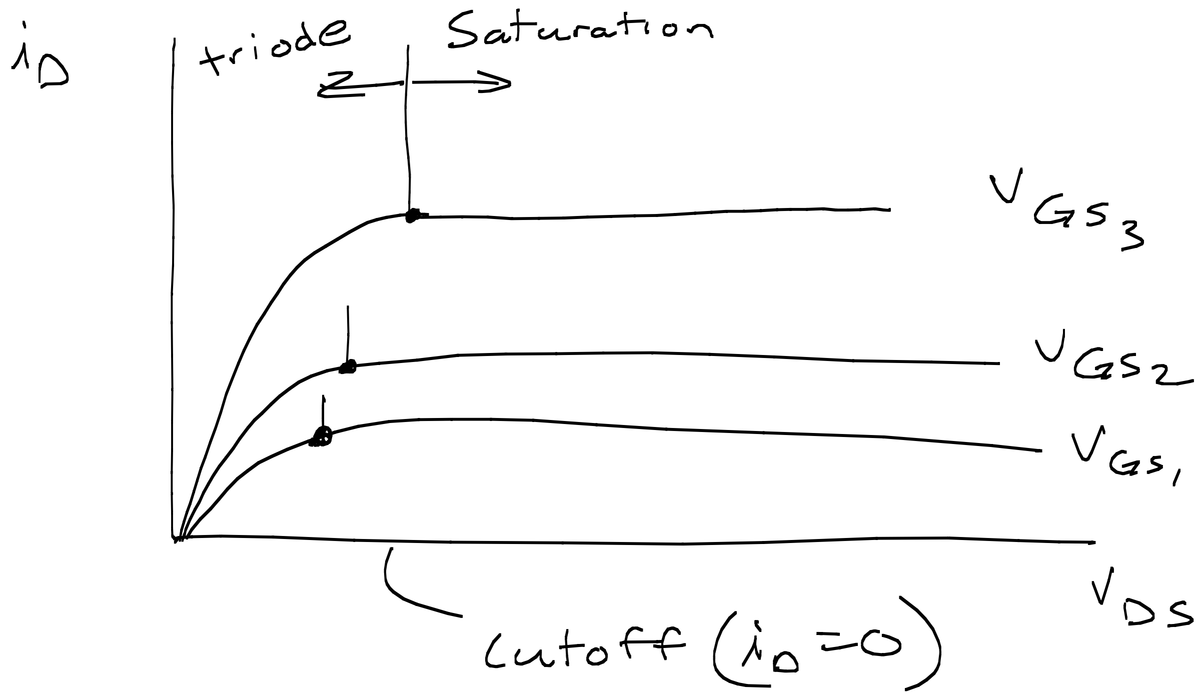
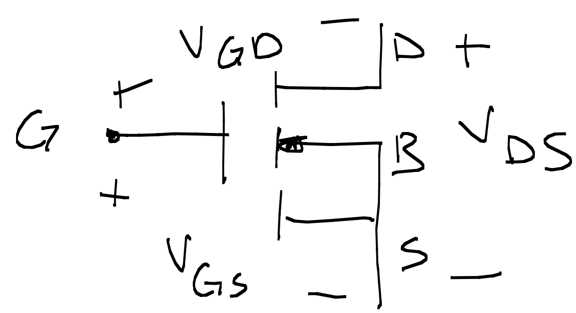


Boundary between Triode and Saturation

$V_{GD} = V_{to}$



KVL

$-V_{GS} + V_{GD} + V_{DS} = 0$

At the boundary $\Rightarrow v_{GD} = V_{to}$

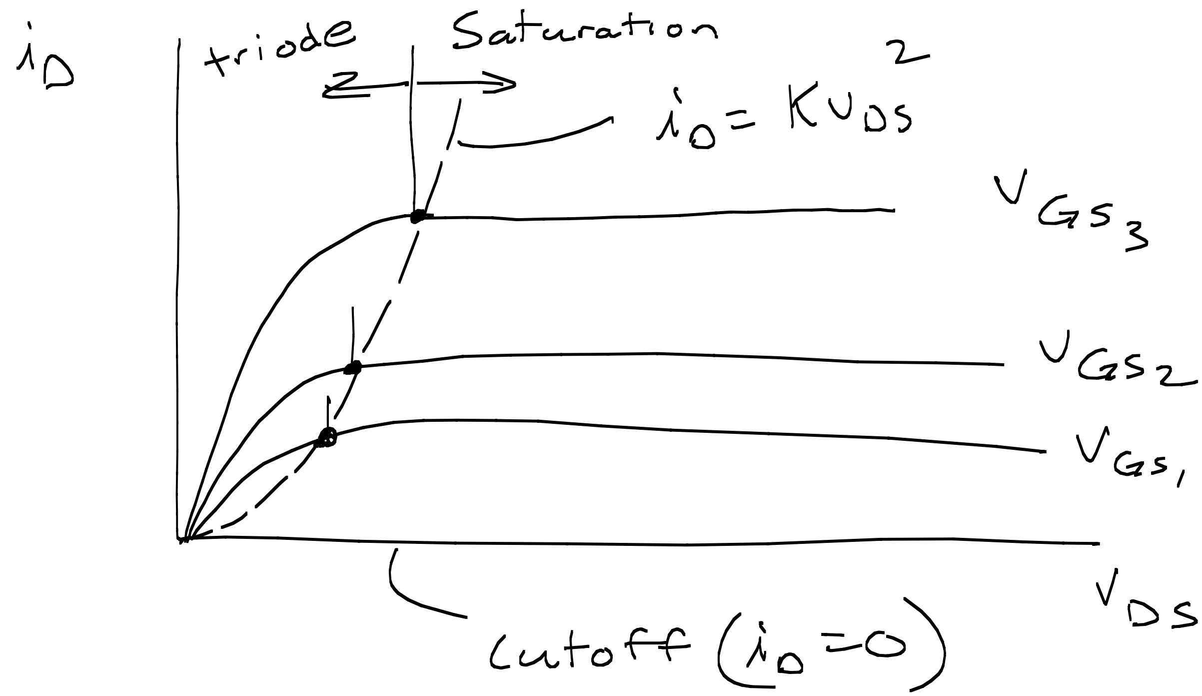
$$-v_{GS} + V_{to} + v_{DS} = 0$$

$$\boxed{v_{GS} = V_{to} + v_{DS}}$$

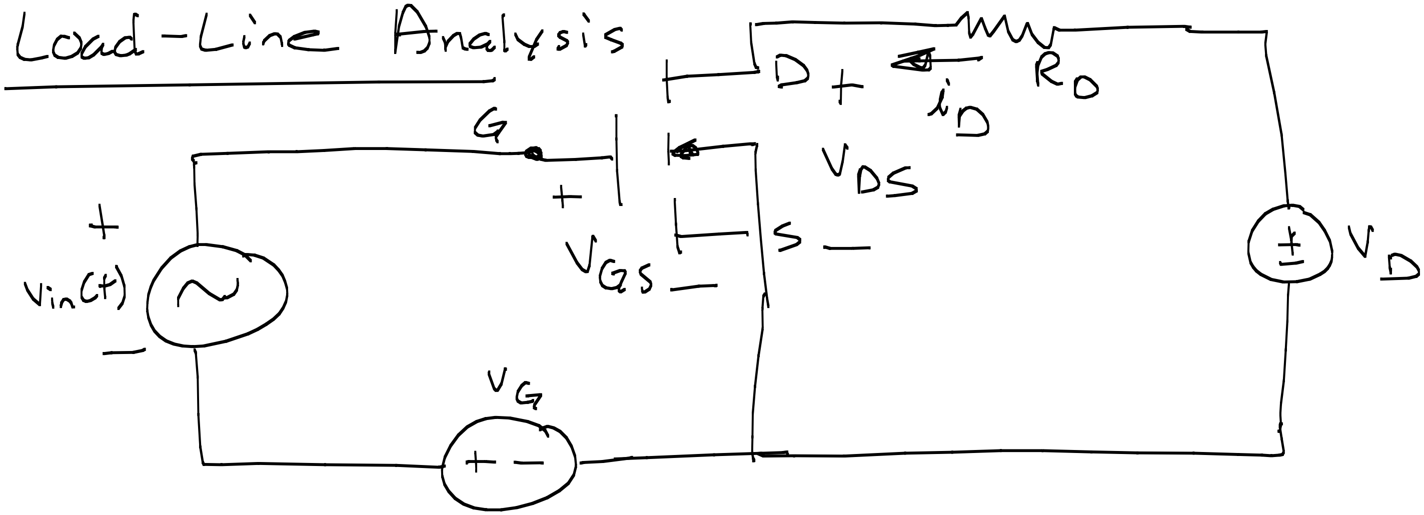
Using Saturation Region Equation

$$i_D = K\left(v_{GS} - V_{to}\right)^2 = K\left(V_{to} + v_{DS} - V_{to}\right)^2$$

$$\boxed{i_D = K v_{DS}^2}$$ Equation for the boundary



Load-Line Analysis



Input

KVL (Left)

$$-V_G - v_{in}(t) + V_{GS} = 0$$

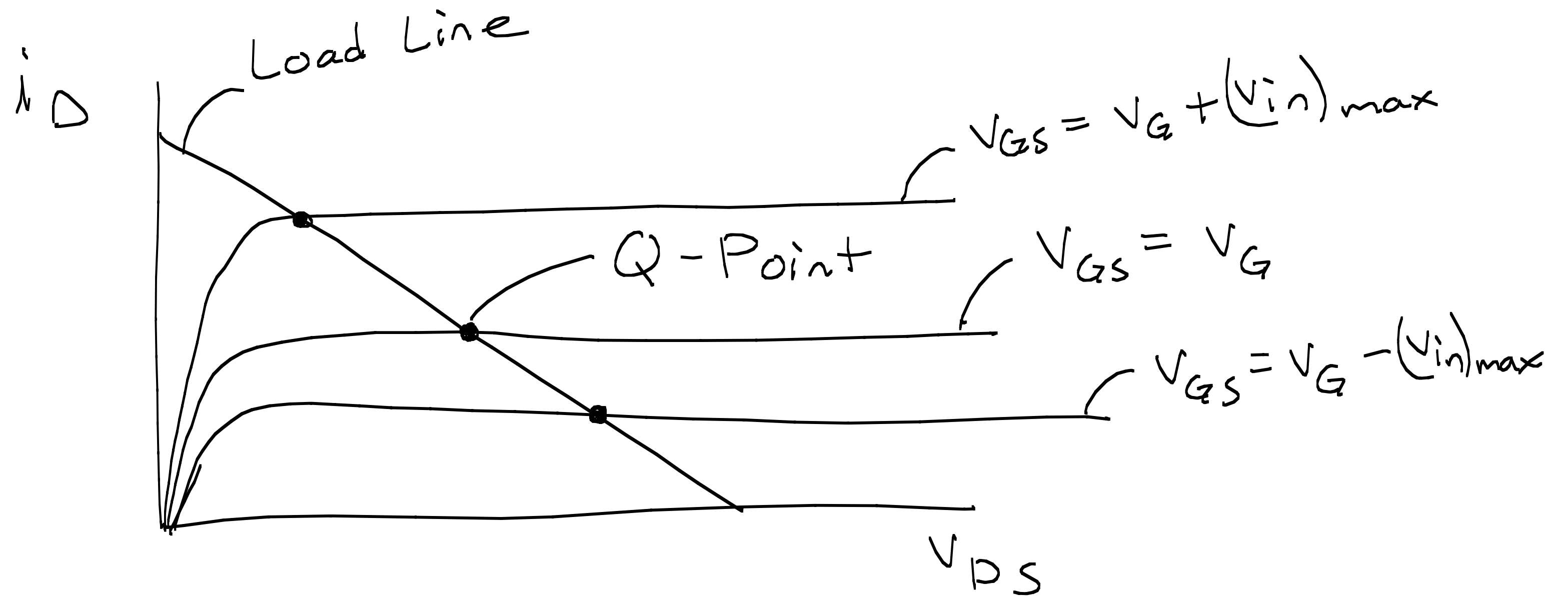
$$V_{GS} = V_G + v_{in}(t)$$

Output

KVL (Right)

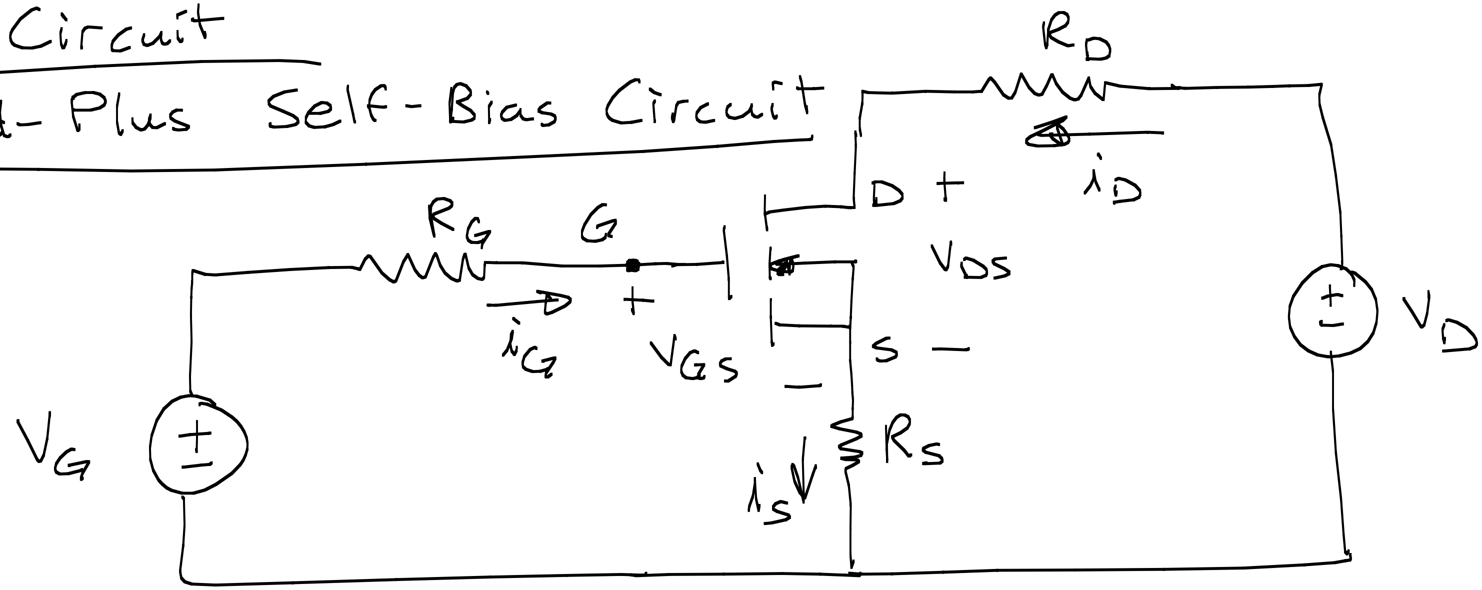
$$-V_{DS} - i_D(R_D) + V_D = 0$$

$$V_D = R_D i_D + V_{DS}$$



Bias Circuit

Fixed-Plus Self-Bias Circuit



Assume: i_G is small ≈ 0

$$i_D = i_S$$

KVL (Left)

$$-V_G + V_{GS} + i_D R_S = 0$$

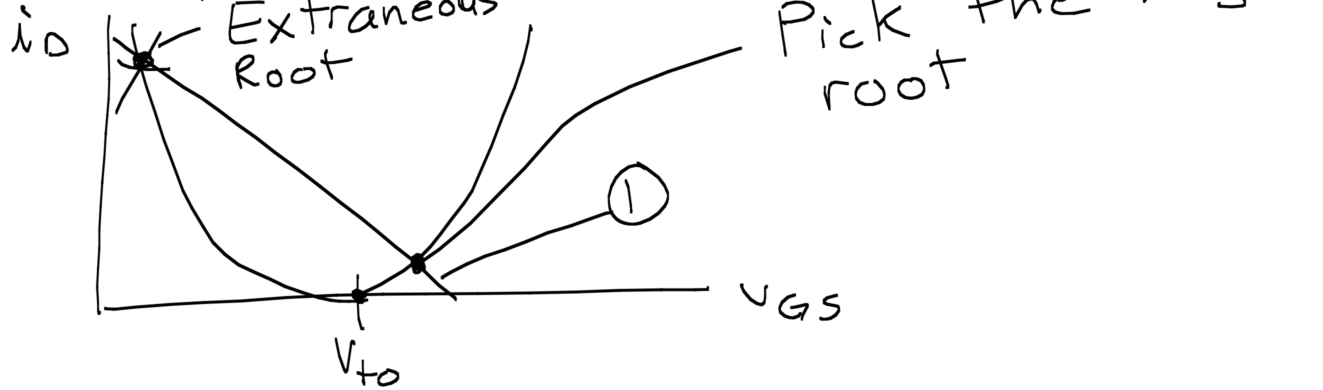
$$\boxed{V_G = V_{GS} + i_D R_S} \quad (1)$$

For this circuit, typically want the saturation region

$$i_D = K(V_{GS} - V_{to})^2 \quad (2)$$

Two Equations, Two unknowns (i_D, V_{GS})

$\Rightarrow$ Operating Point



KVL (Right)

$$-V_{DS} - i_D R_D + V_D - i_D R_S = 0$$

$$V_{DS} = V_D - i_D(R_S + R_D)$$

Verify Saturation Region

$$V_{GS} > V_{to} \qquad V_{DS} > V_{GS} - V_{to}$$

Procedure

① Convert the circuit into the standard model

② KVL (Left) assuming $i_G = 0$

③ Assume Saturation Region => $i_D = K(V_{GS} - V_{to})^2$

④ Two equations, Two Unknowns => Solve for i_D & V_{GS}

⑤ KVL Right => V_{DS}

⑥ Verify Saturation Region

$$V_{GS} > V_{to}, \quad V_{DS} > V_{GS} - V_{to}$$