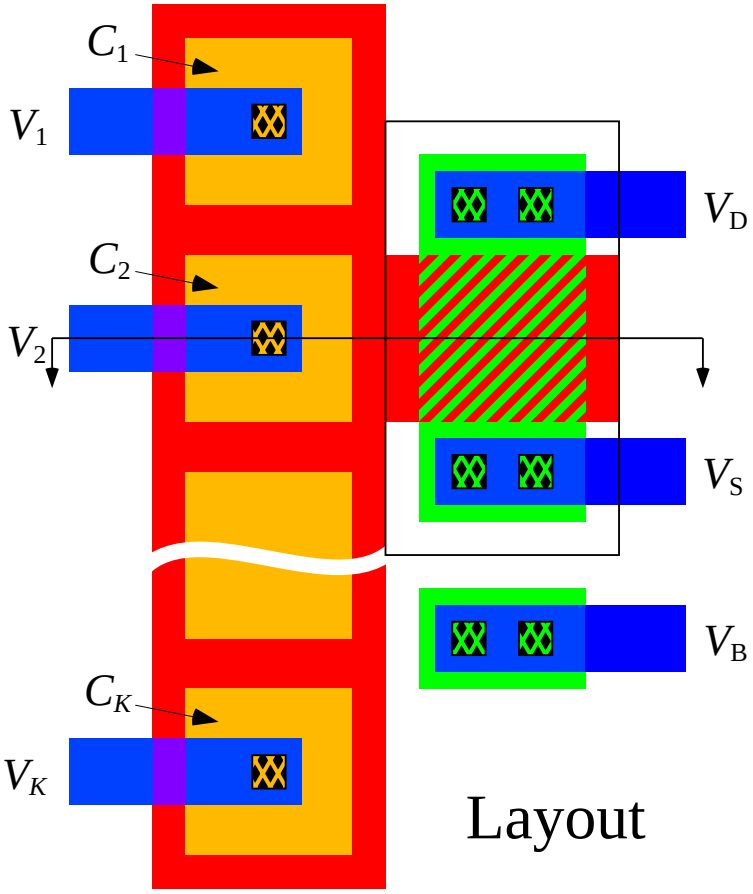
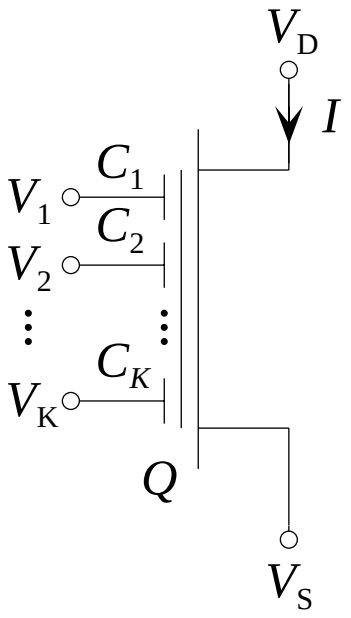
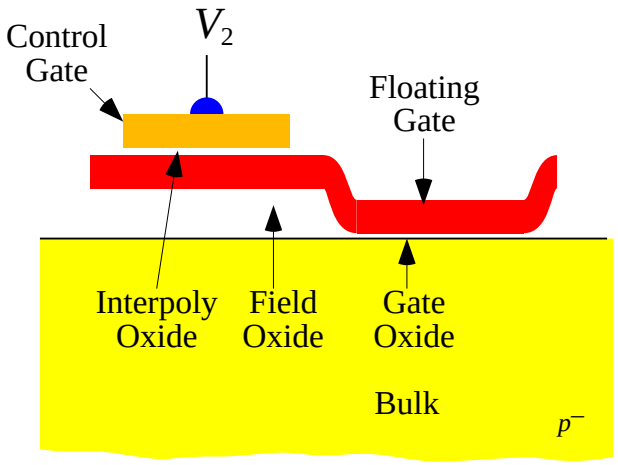
The *K*-Input Floating-Gate MOS (FGMOS) Transistor



Layout



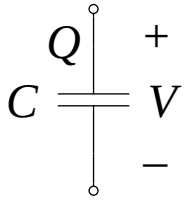
Symbol



Cross-section

Capacitive Voltage Dividers

- When trying to solve capacitor networks, think $Q = CV$ *not* $I = C\frac{dV}{dt}$!

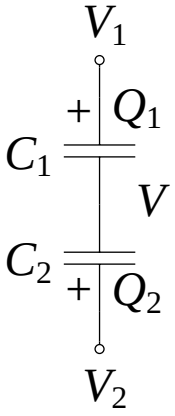


- Assume no net charge on the middle node.
- By conservation of charge,

$$-Q_1 - Q_2 = 0$$

$$\Rightarrow -C_1(V_1 - V) - C_2(V_2 - V) = 0$$

$$\Rightarrow \boxed{V = \frac{C_1}{C_1 + C_2}V_1 + \frac{C_2}{C_1 + C_2}V_2}$$



Capacitive Voltage Dividers

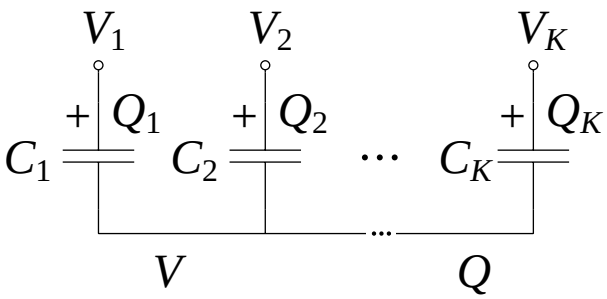
- For all k, $Q_k = C_k(V_k - V)$
- Net charge Q on the common node.
- By conservation of charge,

$$-\sum_{k=1}^{K} Q_k = Q$$

$$\Rightarrow -\sum_{k=1}^{K} C_k(V_k - V) = Q$$

$$\Rightarrow V\sum_{k=1}^{K} C_k = \sum_{k=1}^{K} C_k V_k + Q$$

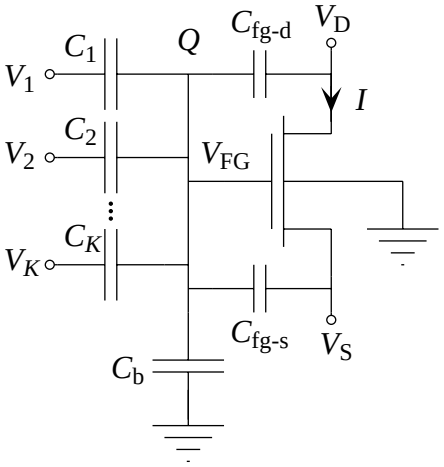
$$\Rightarrow \boxed{V = \sum_{k=1}^{K} \frac{C_k}{C_\mathrm{T}} V_k + \frac{Q}{C_\mathrm{T}}}$$

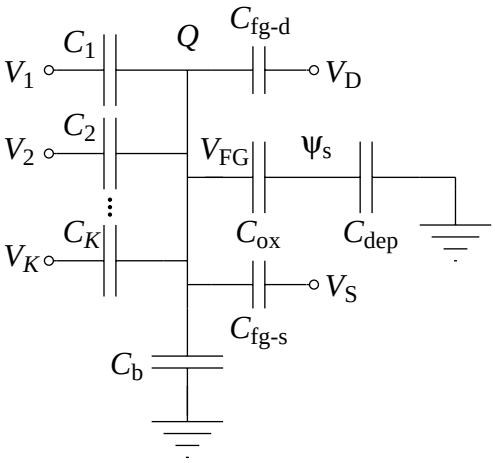


where

$$C_\mathrm{T} \equiv \sum_{k=1}^{K} C_k$$

Capacitive-Divider Model of the Subthreshold FGMOSFET



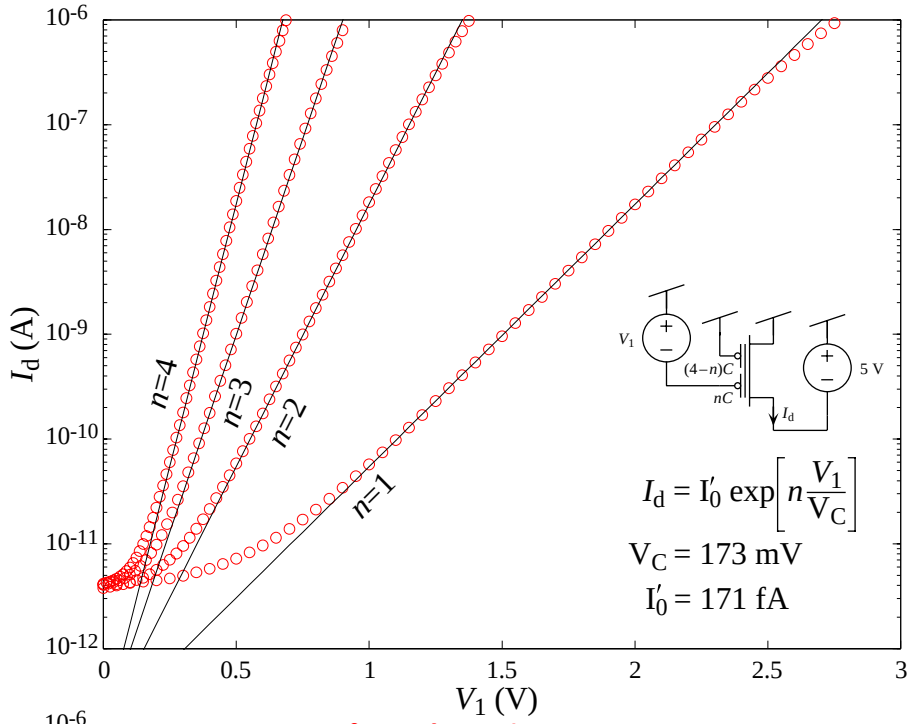


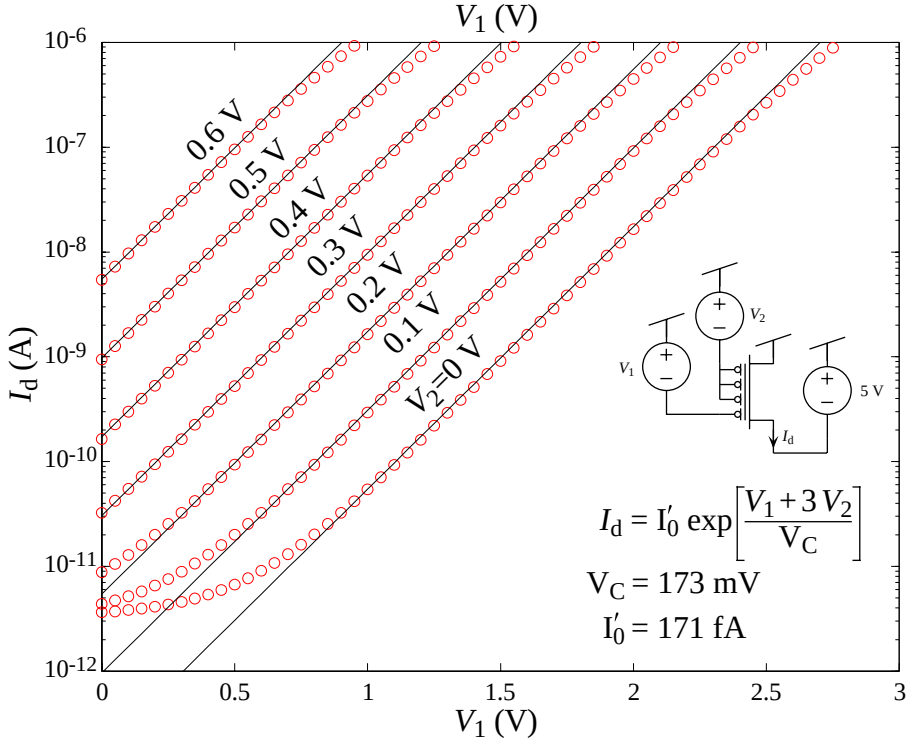
$$V_{FG} = \sum_{k=1}^{K} \frac{C_k}{C_T} V_k + \frac{C_{fg\text{-}s}}{C_T} V_S + \frac{C_{fg\text{-}d}}{C_T} V_D + \frac{Q}{C_T}$$

$$I = I_0 \, e^{\kappa \frac{V_{FG}}{U_T}} \left(e^{-\frac{V_S}{U_T}} - e^{-\frac{V_D}{U_T}} \right)$$

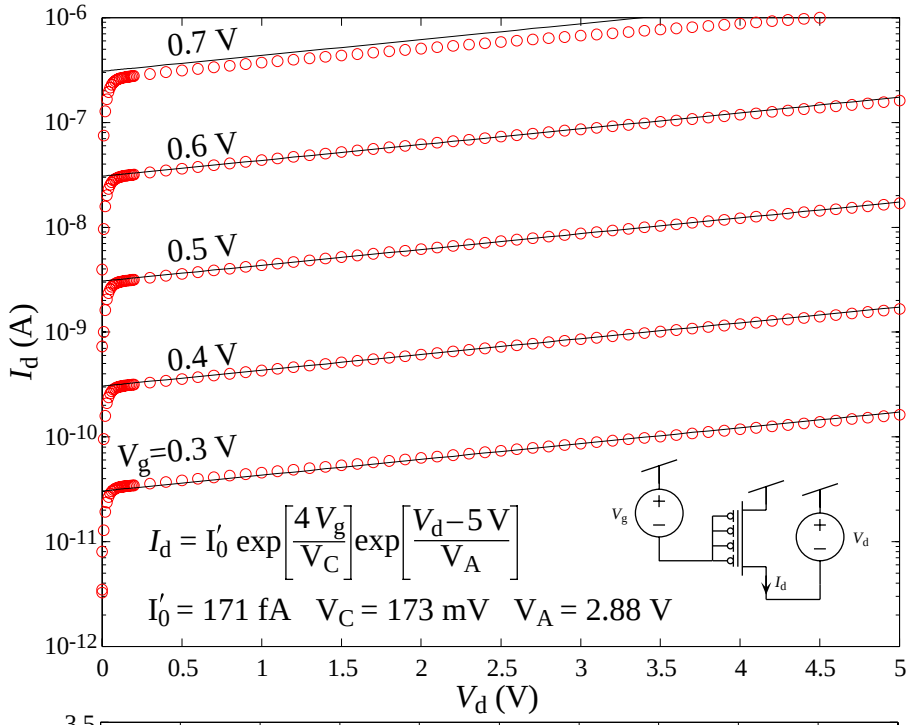
$$I = I_0 \, e^{\frac{\kappa Q}{C_T U_T}} e^{\kappa \sum_{k=1}^{K} \frac{C_k}{C_T} \frac{V_k}{U_T}} e^{\kappa \frac{C_{fg\text{-}s}}{C_T} \frac{V_S}{U_T}} e^{\kappa \frac{C_{fg\text{-}d}}{C_T} \frac{V_D}{U_T}} \left(e^{-\frac{V_S}{U_T}} - e^{-\frac{V_D}{U_T}} \right)$$

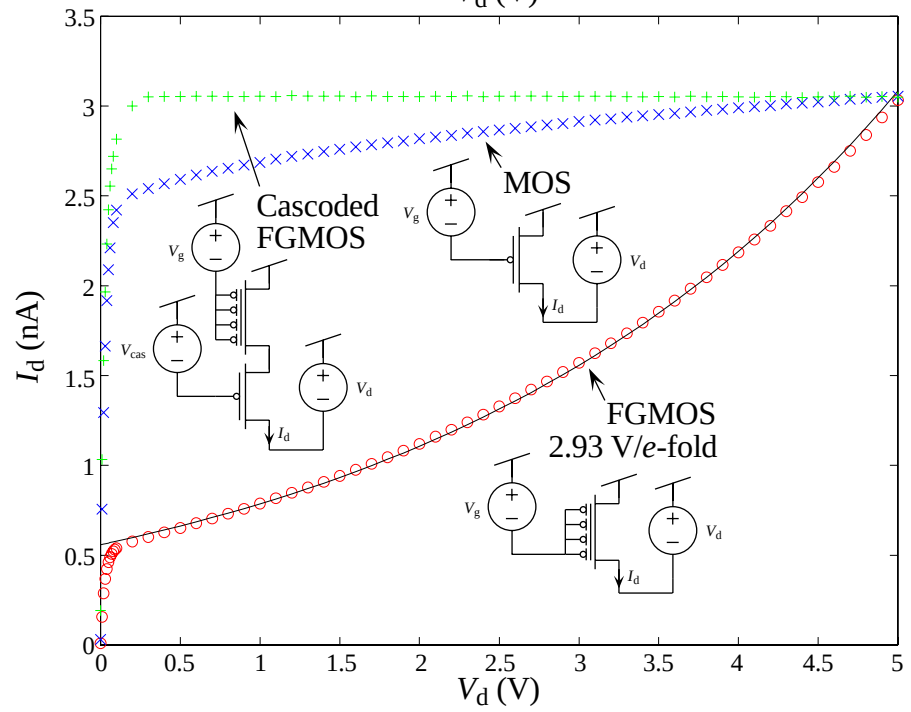
Subthreshold FGMOS Transistor: Transconductance



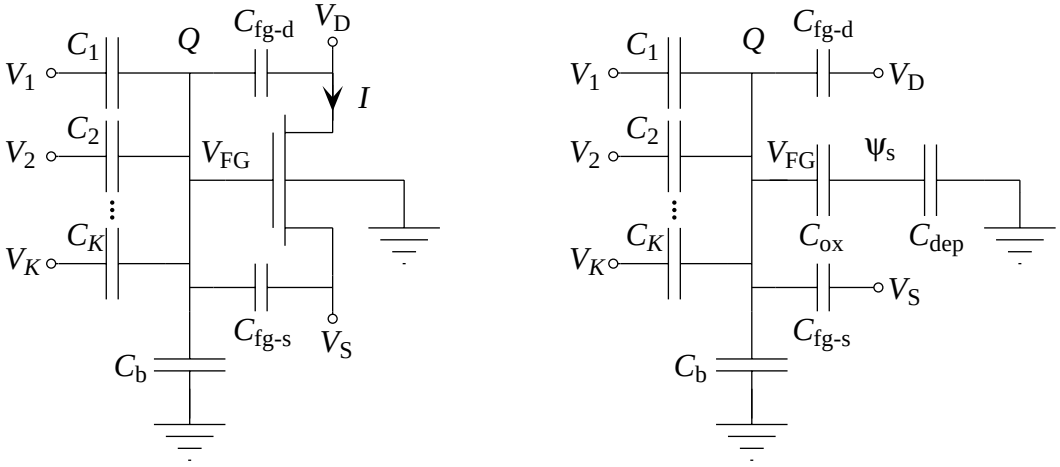


Subthreshold FGMOS Transistor: Drain Characteristics





Capacitive-Divider Model of the Above-Threshold FGMOSFET



$$V_{FG} = \sum_{k=1}^{K} \frac{C_k}{C_T} V_k + \frac{C_{fg\text{-}s}}{C_T} V_S + \frac{C_{fg\text{-}d}}{C_T} V_D + \frac{Q}{C_T}$$

$$I = \frac{W}{L} \frac{\mu C_{ox}}{2\kappa} [(\kappa(V_{FG} - V_{T0}) - V_S)^2 - (\kappa(V_{FG} - V_{T0}) - V_D)^2]$$

$$I = \frac{W}{L} \frac{\mu C_{ox}}{2\kappa} [(\kappa(\sum_{k=1}^{K} \frac{C_k}{C_T} V_k - V_{T0}^*) - V_S)^2 - (\kappa(\sum_{k=1}^{K} \frac{C_k}{C_T} V_k - V_{T0}^*) - V_D)^2]$$

$$V_{T0}^* = V_{T0} - \frac{C_{fg\text{-}s}}{C_T} V_S - \frac{C_{fg\text{-}d}}{C_T} V_D - \frac{Q}{C_T}$$

Above-Threshold FGMOSFET