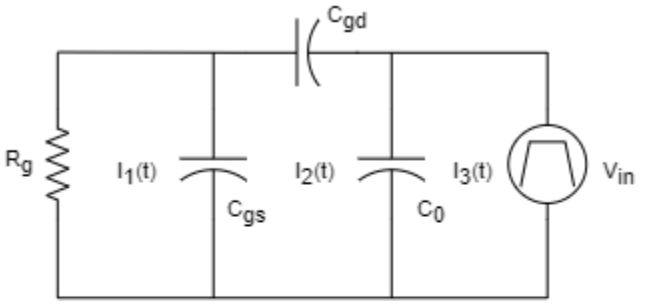
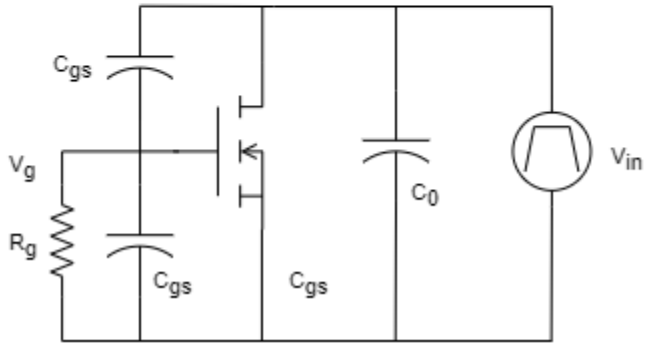
Equivalent Circuit for a MOSFET

This application derives the equations for an equivalent circuit model of a MOSFET

Simplified schematic



Equivalent circuit



$$V_{in} := a \cdot t$$

Drain voltage

$$e_1 := \frac{d}{dt}\left(V_{in} = \int \frac{I_3(t)}{C_0}\,dt - \int \frac{I_2(t)}{C_0}\,dt\right)$$

Circuit equations

$$e_1 = a = \frac{I_3(t)}{C_0} - \frac{I_2(t)}{C_0}$$

$$e_2 := I_2(t) \cdot \left(\frac{1}{C_0} + \frac{1}{C_{gd}} + \frac{1}{C_{gs}}\right) - \frac{I_3(t)}{C_0} - \frac{I_1(t)}{C_{gs}} = 0$$

$$e_2 = I_2(t) \cdot \left(\frac{1}{C_0} + \frac{1}{C_{gd}} + \frac{1}{C_{gs}}\right) - \frac{I_3(t)}{C_0} - \frac{I_1(t)}{C_{gs}} = 0$$

$$e_3 := \frac{d}{dt}\left(R_g \cdot I_1(t) + \int \frac{I_1(t)}{C_{gs}}\,dt - \int \frac{I_2(t)}{C_{gs}}\,dt = 0\right)$$

$$e_3 = R_g \cdot \left(\frac{d}{dt}\,I_1(t)\right) + \frac{I_1(t)}{C_{gs}} - \frac{I_2(t)}{C_{gs}} = 0$$

Symbolic solutions

$$sols := simplify\left(dsolve\left(\left\{e_1, e_2, e_3, I_1(0) = 0\right\}, \left\{I_1(t), I_2(t), I_3(t)\right\}\right)\right)$$

Current in the gate resistor R_g

$$I_1 := eval\left(I_1(t), sols\right) = -\left(e^{-\frac{t}{R_g \cdot \left(C_{gd} + C_{gs}\right)}} - 1\right) \cdot C_{gd} \cdot a$$

Gate voltage

$$V_g := I_1 \cdot R_g = -\left(e^{-\frac{t}{R_g \cdot \left(C_{gd} + C_{gs}\right)}} - 1\right) \cdot C_{gd} \cdot a \cdot R_g$$