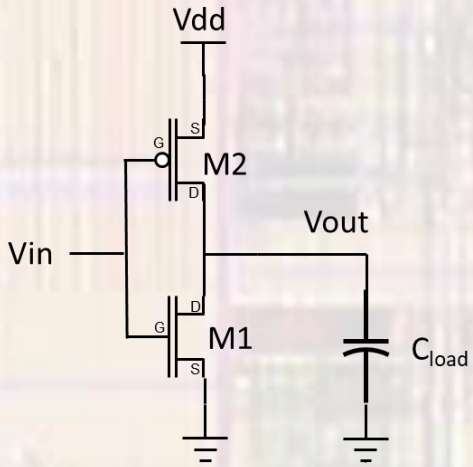
C-MOS Power

Last updated 12/23/23

C-MOS Power

- 3 Major power components
  - DC power
  - Switching Power
  - Shoot-Through

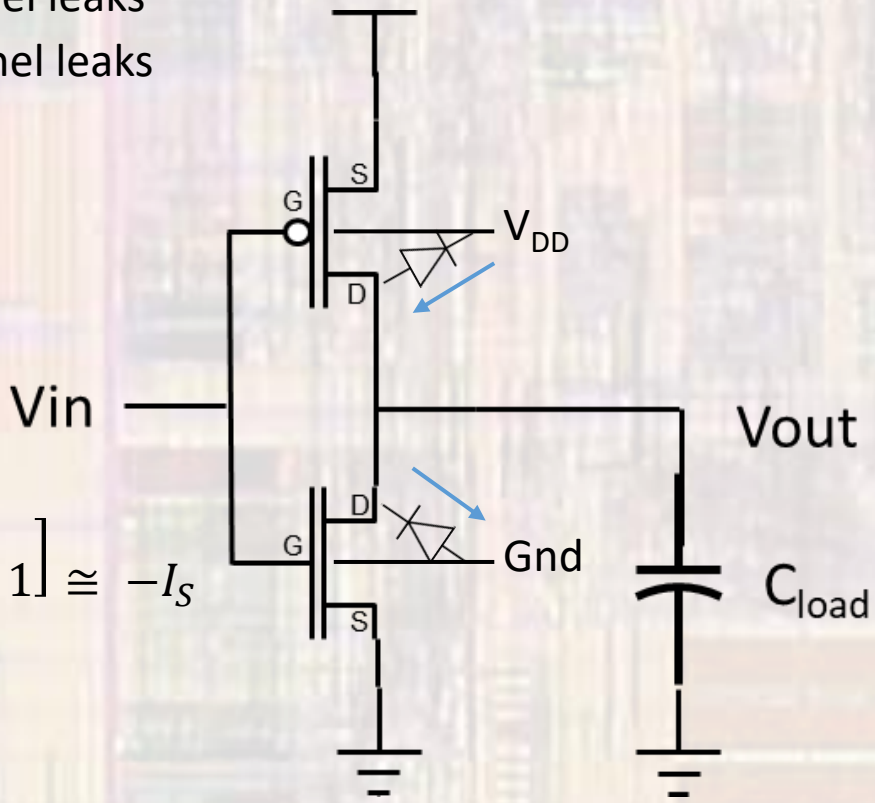


C-MOS Power

- DC power
  - Junction leakage (Drain to Body)
    - Reverse diode leakage
      - Vout = 0 P-channel leaks
      - Vout = V_{DD} N-channel leaks

Power ≅ I_S x V_{DD}

Power is proportional to V_{DD}



$$I_D = I_S\left[e^{\left(\frac{V_A}{nV_T}\right)} - 1\right] = I_S\left[e^{\left(\frac{-V_{DD}}{nV_T}\right)} - 1\right] \cong -I_S$$

$I_D \cong -I_S$ for $V_{DD} >> V_T$

C-MOS Power

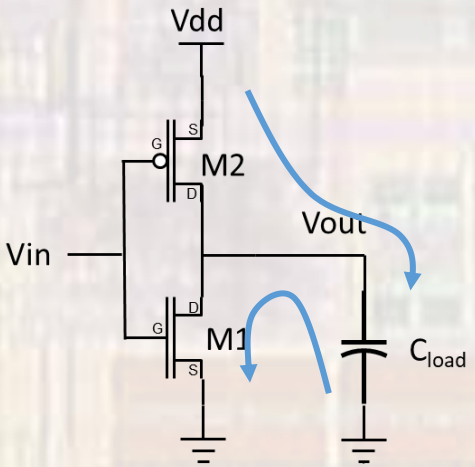
- Switching Power
  - Charging / Dis-charging the load and parasitic Cs
  - Can cause noise in V_{DD} and Gnd

$$E = \int_0^{\infty} i(t)V_{out}dt = \int_0^{\infty} C\frac{dv}{dt}V_{out}dt = \int_0^{V_{dd}} CV_{out}dv = \frac{1}{2}CV_{DD}^2$$

  - Worst case
    - Rise and fall with every clock edge
    - C_{load}^* includes parasitic capacitances

$$P = C_{load}^* V_{DD}^2 F$$

Power is proportional to V_{DD}^2

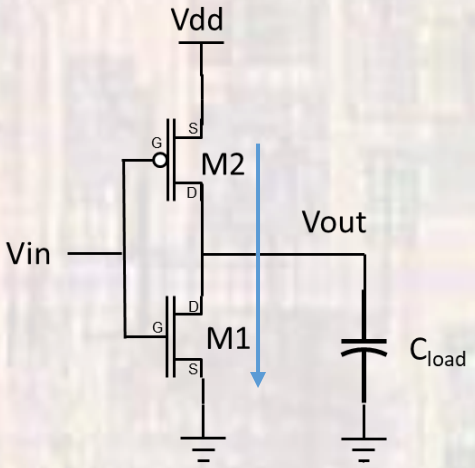


C-MOS Power

- Shoot-Through
  - Short period of time when both devices are on
  - Current from V_{DD} to Gnd
  - Can cause noise in V_{DD} and Gnd

$$P = I_{peak} V_{dd} \left(\frac{t_r + t_f}{2} \right) F$$

Power is proportional to V_{DD}

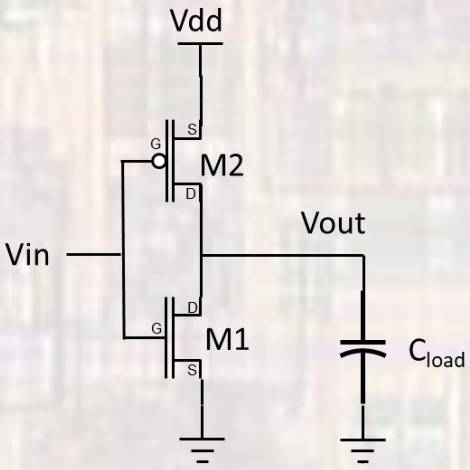


C-MOS Power

- Total power
  - α – proportion of clock intervals actually switching
  - β – leakage factor (number of gates * leakage current)

$$P = P_{DC} + P_{SW} + P_{Shoot}$$

$$P = \beta V_{DD} + \alpha C_{load} V_{DD}^2 F + \alpha I_{peak} V_{DD} \left(\frac{t_r + t_f}{2}\right) F$$



All terms a function of V_{DD}