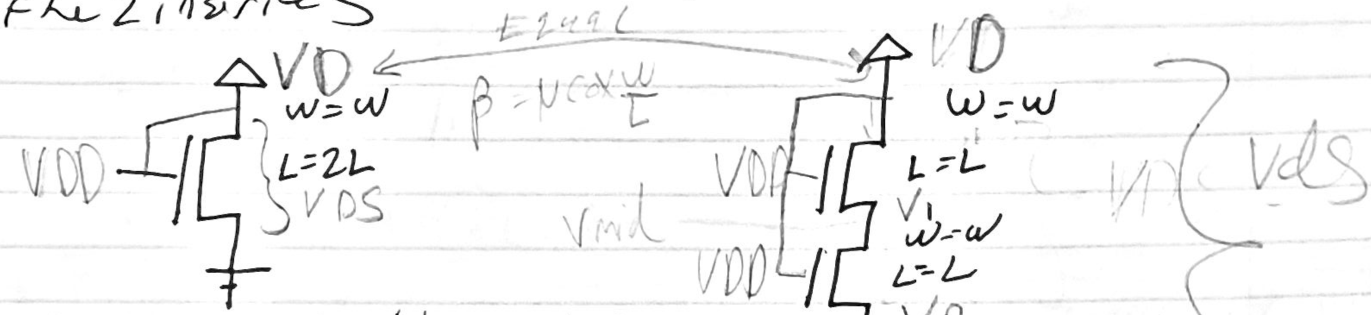
Brian Landy

Digital IC Design HW3

Lecture slides reviewed ✓

Show that current thru NMOS with L=2L is the same as 2 NMOS with length L connected in series. VDS of longer transistor is same voltage as the middle of the 2 in series



In linear regions, use linear eqns.

$I_{DS} = \beta(V_{GS} - V_t - \frac{V_{DS}}{2})V_{DS}$

$\mu C_{ox}(V_{SS} - V_t)V_{DS} - \frac{V_{DS}^2}{2}$

$\frac{W}{L}\mu C_{ox}(V_{GS} - V_t)(V_D - V_t) - \frac{(V_d - V_t)^2}{2}$

$= (V_{SS} - V_t)(V_D - V_t) - \frac{(V_d - V_t)^2}{2}$

$I_1 = (\mu C_{ox}\frac{W}{L})((V_{DD} - V_1) - V_t - \frac{(V_D - V_1)}{2})(V_D - V_1)$

$= I_2\ (\mu C_{ox}\frac{W}{L})(V_{DD} - V_t - \frac{V_1}{2})(V_1)$

$V_{DS} = V_D - 2V_t$

$V_1 = V_D - V_t$

$I_1 = I_2$

$V = V_{SS} - V_{th}$

$\frac{I_1 L}{W\mu C_{ox}} + \frac{I_2 L}{W\mu C_{ox}} = 2(V_{DD} - V_1 - V_t - V_{DS_1})(V_d - V_1) + (V_{DD} - V_t - \frac{V_1}{2})V_1$

$\frac{I_{DS} 2L}{W\mu C_{ox} 2} = \frac{I_1 L}{W\mu C_{ox} 2} + \frac{I_2 L}{W\mu C_{ox} 2}$

$2I_{DS}L = I_1 L + I_2 L$

$2I_{DS}L = I_{DS}L + I_{DS}L$

$2I_{DS}L = 2I_{DS}L$

$I_{DS} = I_{DS}$ ✓

3 L=14nm → silicon $\varepsilon_{ox}=4.5$ t_{ox} = 10 Å → 10×10^{-10}

$C_g = \varepsilon_{ox} \cdot WL / t_{ox}$

$C_g = 4.5 \cdot W \cdot 14\times10^{-9} \cdot \frac{1}{10\times10^{-10}}$

$\frac{C_g}{W} = \frac{4.5 \cdot 14\times10^{-9}}{10\times10^{-10}} = 63$

$\frac{C_g}{W} = \frac{63\ F}{M} \frac{\times10^{-6}}{\times10^{-6}} = \frac{63\times10^{-6}}{1\ \text{micron}}$

$\boxed{C_g \text{ increases by } 63\times10^{-6}\ F \text{ per micron}}$

4.) PMOS $V_t = 0.3V$. Lower V_t by magnitude of 100 mV. $V_{SS} = V_{DS} = V_{dd} = 1V$, how much will current change? (In saturation) How about power? Relation between speed + power?

$V_{ds} = 1 - .3 = .7$

PMOS sat $I_{ds} = \frac{1}{2}\mu_p C_{ox}\frac{W}{L}(V_{sg} - |V_T|)^2$

I_{sd} @ $V_t = .3V$ → $= \frac{1}{2} K_p (1 - .3)^2$

$\boxed{I_{ds} = .245\, K_p\ \text{Amps}}$ power $= .7 \cdot .245 K_p = .1715\ K_p$ watts

I_{sd} @ $V_t = .2V$

$I_{ds} = \frac{1}{2} K_p (1 - .2)^2$

$\boxed{I_{ds} = .32\, K_p}$ | power $= .8 \cdot .32 K_p = .256\ K_p$ watts

For a voltage change of 100 mV, power changes by a lot more. Speeding the circuit up will require more and more power to keep increasing. It's not linear.

100 mV is at a cost of .0845 K_p watts

5 →

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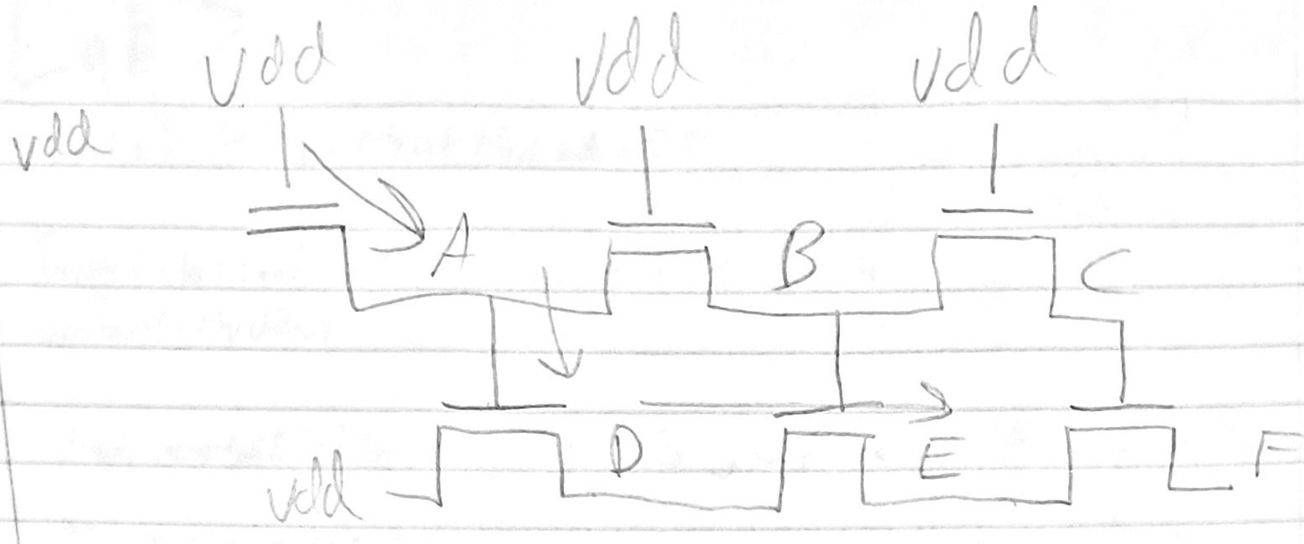

A: VDD−Vtn

B: VDD−2Vtn

C: VDD−3Vtn

D: VDD−2Vtn

E: VDD−3Vtn

F: VDD−4Vtn