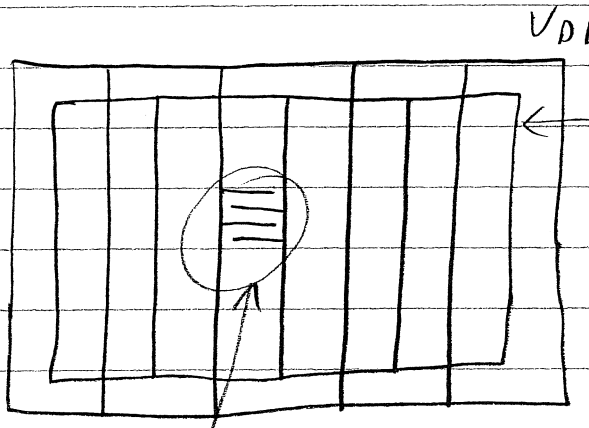
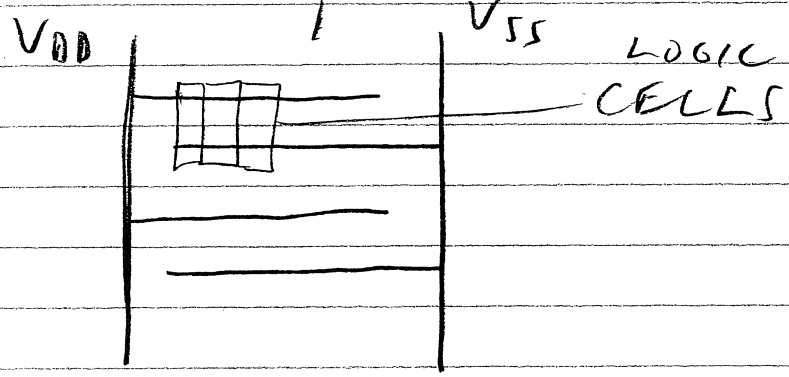
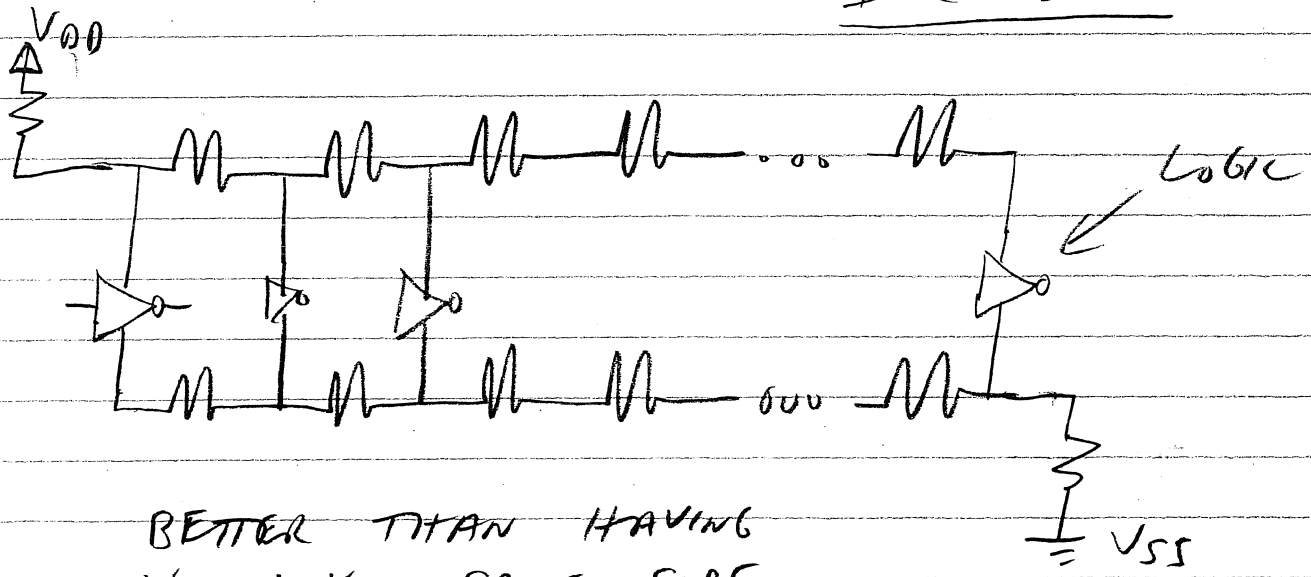
POWER DISTRIBUTION

IR DROP





IR DROP



BETTER THAN HAVING
V_{DD} & V_{SS} SAME SIDE

EX

64 REPEATERS $V_{DD} = 1.8V$

EACH POWER BUS IS 320 μm LONG
1 μm WIDE

RESISTANCE IS 0.05 Ω/□

REPEATERS EACH DRIVE 0.4pF + DESIRED 200 ps TRANSITION

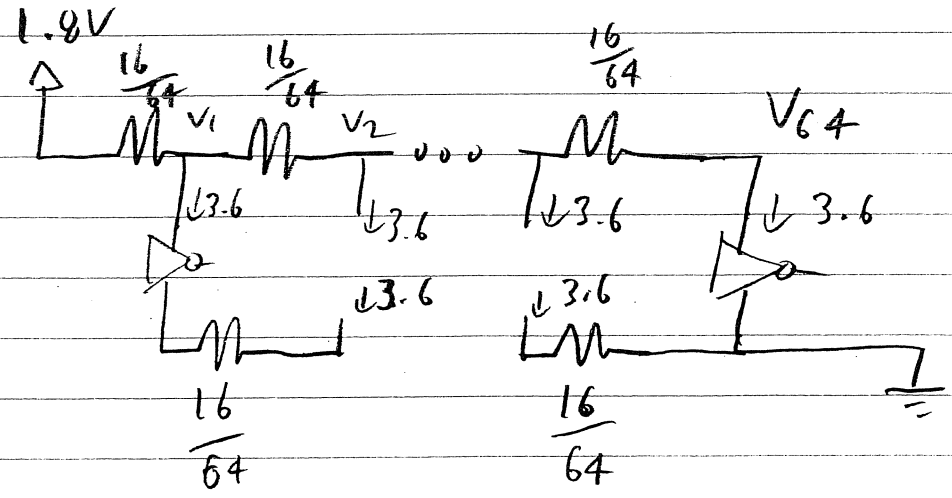
ESTIMATE POWER SUPPLY DROP.

SOLN

FOR EACH REPEATER

$$I = C\frac{\Delta V}{\Delta t} = (0.4pF)\frac{1.8V}{200ps} = 3.6mA$$

EACH POWER BUS HAS 320 □ ⇒ 16Ω R TOTAL



$$V_{64} = 1.8 - \left[\left(\frac{R_{TOTAL}}{64}\right)(64)(3.6) + \left(\frac{R_{TOTAL}}{64}\right)(63)(3.6) + \right.$$

$$\left. \ldots + \left(\frac{R_{TOTAL}}{64}\right)(1)(3.6)\right]$$

$$= 1.8 - \left(\frac{R_{TOTAL}}{64}\right)(3.6) \sum_{i=1}^{64} i$$

$$= 1.8 - \frac{R_{TOTAL}}{64}(3.6)\frac{(64)(65)}{2}$$

$$= 1.8 - 64\frac{(R_{TOTAL})(I)}{2}$$

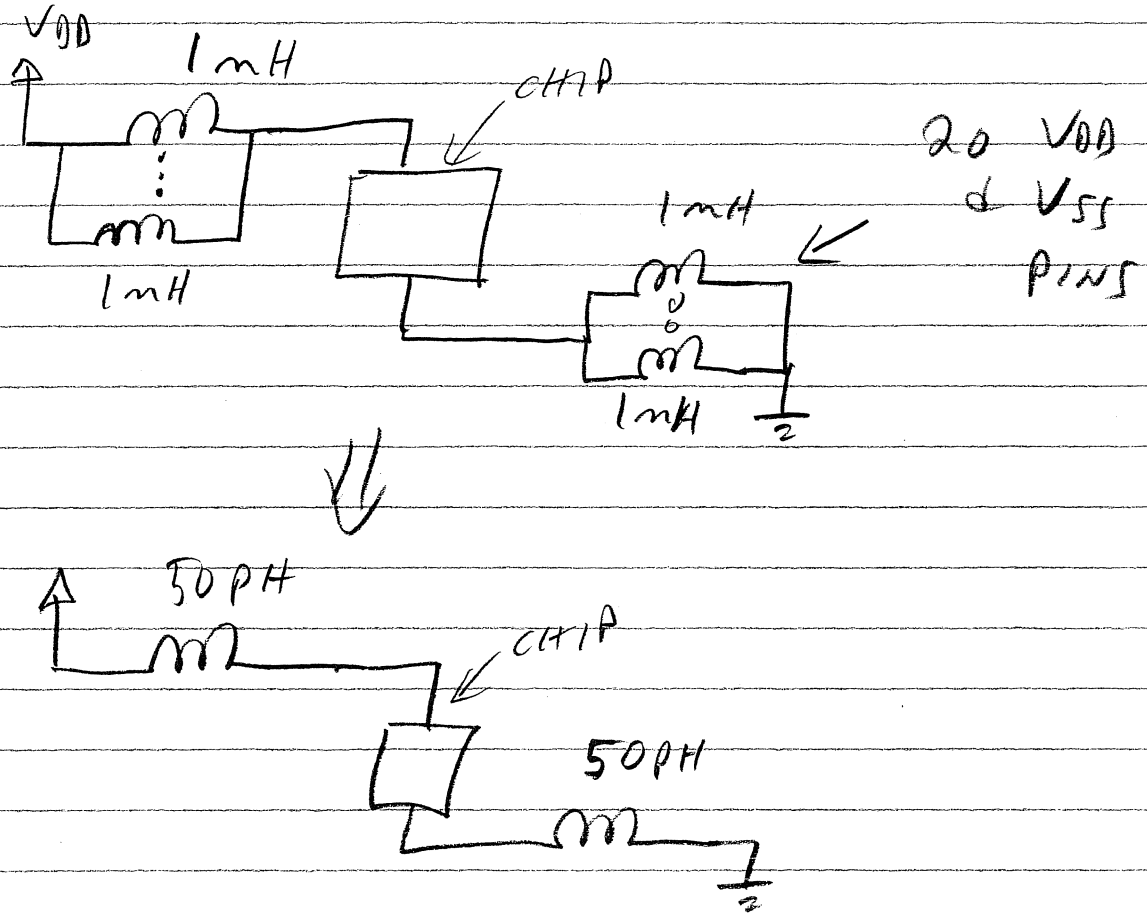
$$= 1.8 - 1.85\ V \qquad \text{LESS THAN 0!!!}$$

ACTUALLY, POWER SUPPLY WILL DROOP, SLOW DOWN GATES ⊥ "I" WILL DROP (Δt)

POWER SUPPLY MIGHT DROOP 30% & DELAY GATES & MISS TIMING!!

ALSO NEED TO BE CONSERNED WITH $L \frac{di}{dt}$ OF POWER BUS INDUCTANCE

MOSTLY DUE TO BOND WIRES



IF A 1GHz CHIP CAN TRANSITION FROM IDLE (2A) TO FULL POWER (6A) IN ONE CLOCK CYCLE

ESTIMATE POWER SUPPLY DROP.

IF NO BYPASS CAPACITANCE.

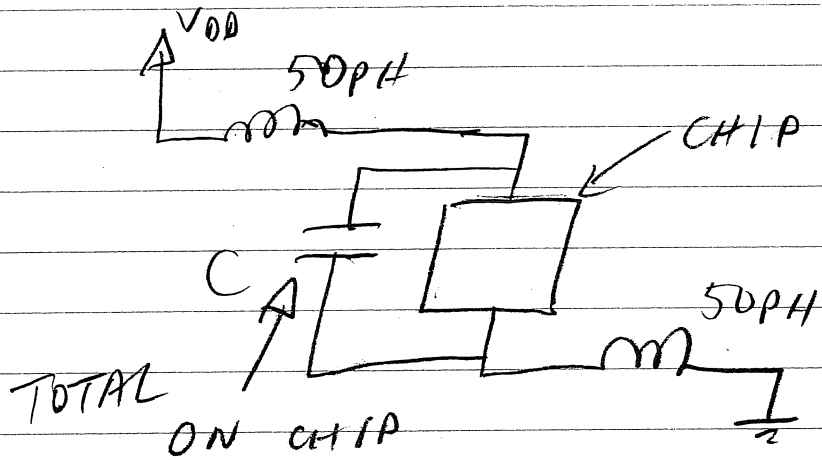
CAPACITOR $I = C \frac{dv}{dt}$

INDUCTOR $V = L \frac{di}{dt}$

$V = (100pH) \frac{(6-2)}{(1ns)} = 0.4V$ (ACROSS BOTH 50PH INDUCTORS)

SIGNIFICANT.

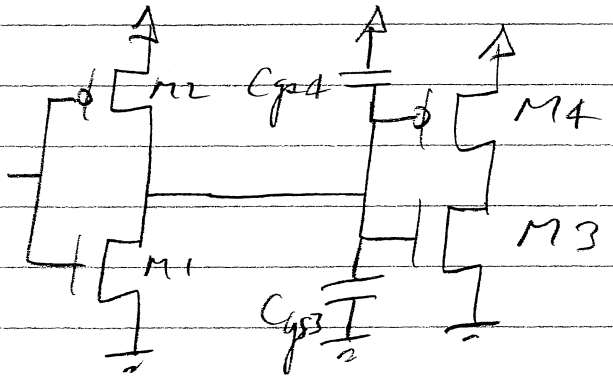
BY PASS CAPACITANCE



- SECOND ORDER SYSTEM, NEED TO ENSURE NOT TOO MUCH RINGING

REQUIRED C FOR BYPASS CAN BE QUITE LARGE. FORTUNATELY ALOT COMES FROM LOGIC GATES THEMSELVES

SYMBIOTIC BYPASS CAPACITANCE



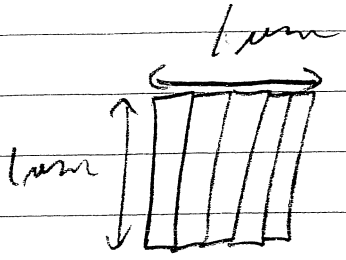
$C = C_{gs4}$ OR C_{gs3} DEPENDING WHETHER M_1 OR M_2 ON

ALSO AS C_{gs3} CHARGES UP

C_{gs4} IS DISCHARGED

$\frac{C_{gs}}{2}$ IS USED AS BYPASS CAPACITANCE

EX/ A 0.18μm HAS 2fF/μm OF GATE CAPACITANCE. IF TRANSISTOR GATES OCCUPY 9% OF CHIP AREA, CALCULATE SYMBIOTIC BYPASS CAP PER $(mm)^2$



OF TRANSISTORS $= \frac{1\,\mu m}{0.18} = 5.55$

SO IF $100^{\%}$ GATE UTILIZATION

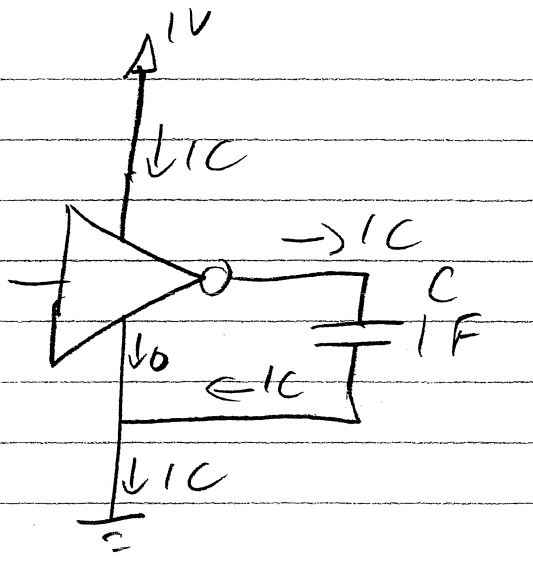
$2 \times 5.55 = 11\,fF/(\mu m)^2$

AT $9^{\%}$ GATE UTILIZATION

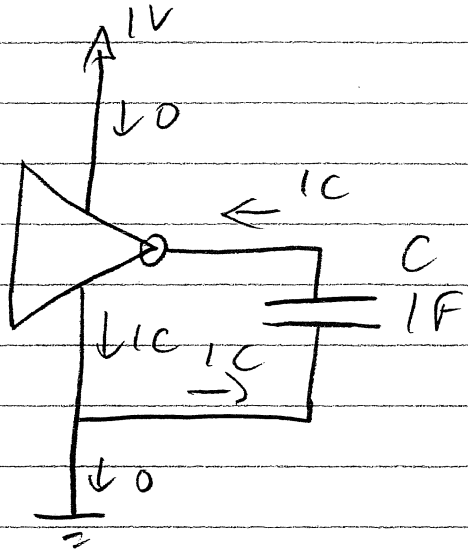
$11\,fF/(\mu m)^2 \times 9^{\%} = 1\,fF/(\mu m)^2$

$C_{SYM} = 0.5\,fF/(\mu m)^2$ ← HALF IS C_{SYM}

$= \underline{0.5\,nF/(mm)^2}$

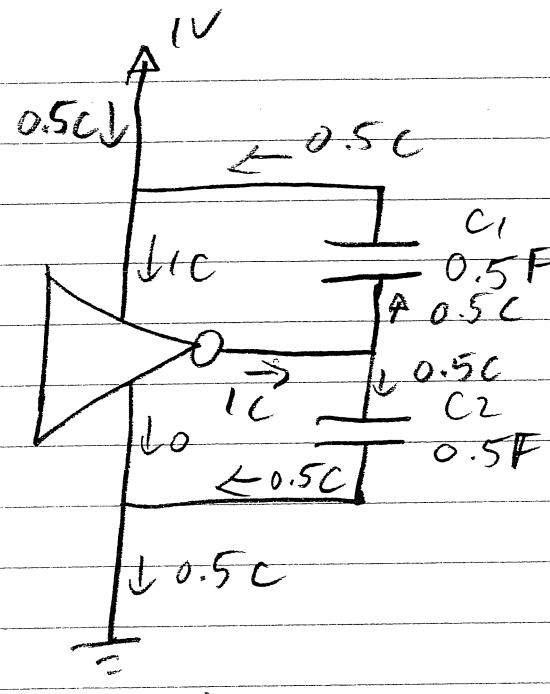


CHARGING C



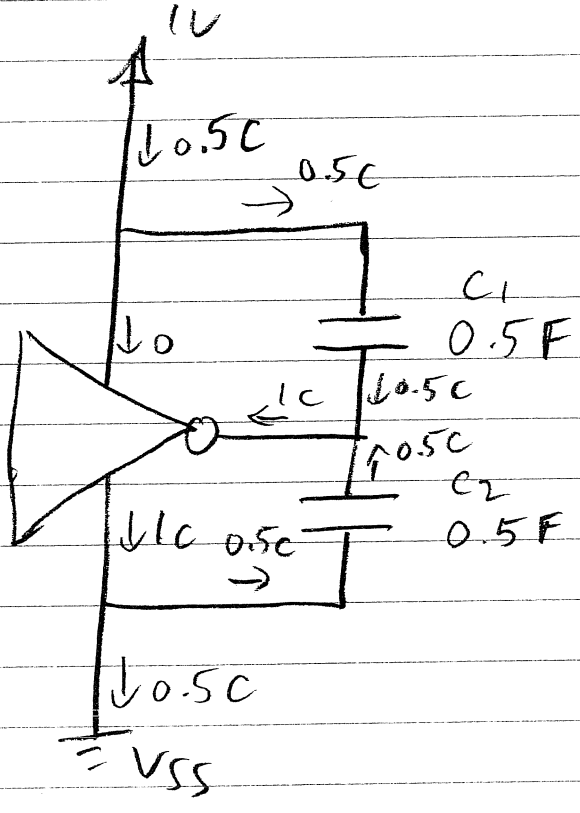
DISCHARGING C

- 1C IN BOTH V_{DD} & V_{SS} WHEN CHARGING
- 0C FOR BOTH WHEN DISCHARGING



DISCHARGE C_1

CHARGE C_2



CHARGE C_1

DISCHARGE C_2

- 0.5C IN BOTH CASES IN V_{DD} & V_{SS}