Homework 11

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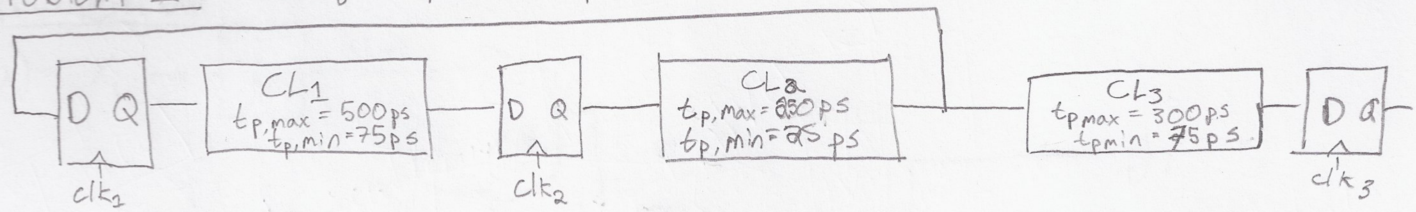
Problem 1

$t_{clk\text{-}q} = 50ps$ $\quad t_{setup} = 100ps$ $\quad t_{hold} = 100ps$



a) no clock skew

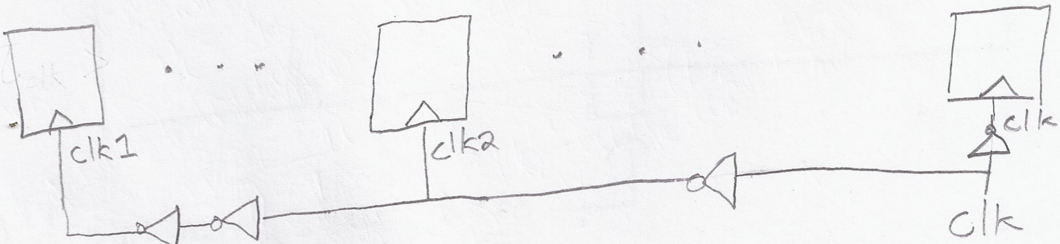
$\tau_{clock} > \tau_{clk\text{-}q} + \tau_{logic,max} + \tau_{setup} = (50ps) + (300ps) + (250ps) + (100ps) = \boxed{700ps}$

hold time: $\tau_{hold} < \tau_{clk\text{-}q,min} + \tau_{logic,min}$ ← condition for no violation

since $\tau_{clk\text{-}q,min} + \tau_{logic,min} = 50ps + 25ps = 75ps < \tau_{hold} = 100ps$

there is a hold time violation. $\quad \tau_{hold} \not< \tau_{cq} + \tau_{logic,min}$

b) $\tau_{inv} = 50ps \pm 5ps$



clk2 and clk3 are delayed by at most 55ps each.

clk1 has a maximum delay of 110ps (2 inverters)

critical path $= t_{cq} + t_{logic,max} + \tau_{setup} + \tau_{skew,max}$

$= 50ps + 500ps + 100ps + 110ps = 760ps$

$\boxed{t_{clk} > 760ps}$

c) condition: $t_{hold} + t_{skew} < t_{cq,min} + t_{logic,min}$

but $t_{hold} + t_{skew} = 100 + 110 \not< 50ps + 25$

so we must add a delay to logic block #2 in order to avoid a race. The minimum delay necessary is $210 - 50ps - 25ps = t_{hold} + t_{skew} - t_{cq} - t_{logic,min}$

$= 135ps$

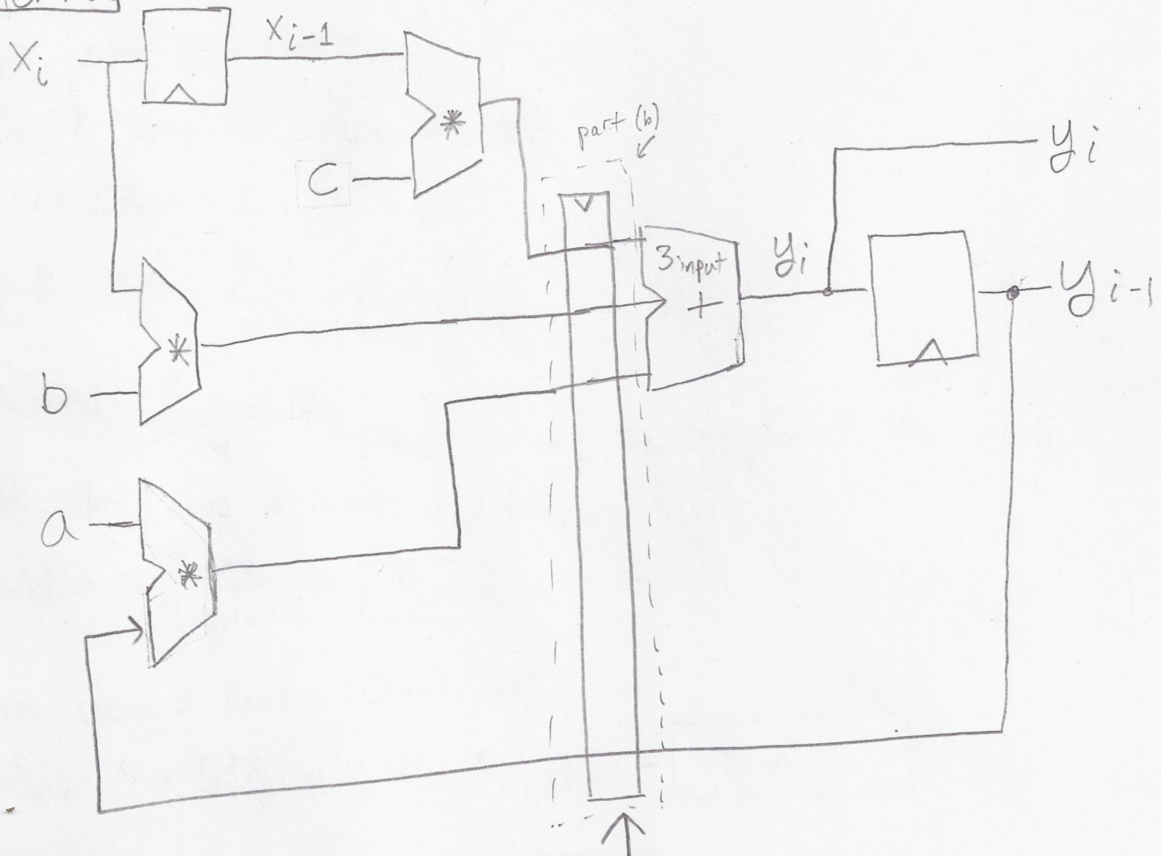
$\boxed{t_{delay} \geq 135ps}$

Add the delay between register 1 & 2

$$y_i = a * y_{i-1} + b * x_i + c * x_{i-1}$$

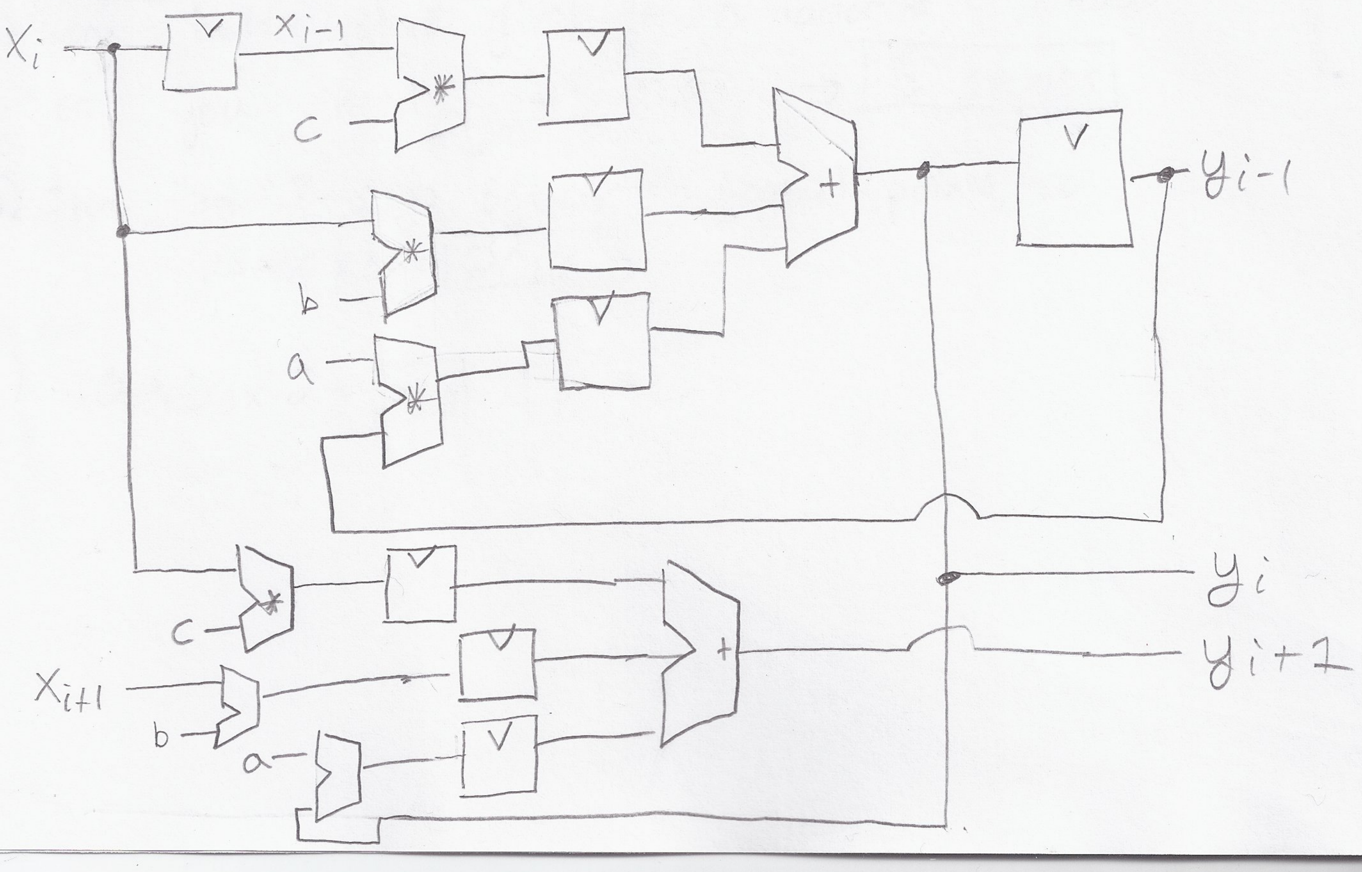
Problem 2

a)



b) Add pipeline registers here

c) $y_{i+1} = a * y_i + b * x_{i+1} + c * x_i$



Problem 3

a) 12W CPU @ $1.2V = V_{dd}$

10% IR drop $\rightarrow .1 * 1.2V = .12V$

$.12V = IR \qquad I = \frac{12W}{1.2V} = 10A$

$R = \frac{.12V}{I} = \frac{.12V}{10} = \boxed{12m\Omega}$

b) $\#\text{ squares} = \frac{R}{3m\Omega/sq} = 4$ squares along the length of the chip

since the chip is 2mm wide,

$\text{width} = \frac{2mm}{4\text{ squares}} = \boxed{.5mm}$

c) wire current limit $10mA/\mu m$

$.5mm \rightarrow 500\mu m \times 10mA/\mu m = \boxed{5A}$ max current

d) $\frac{10A}{10\frac{mA}{\mu m}} = 1000\mu m = \boxed{1mm}$

Problem 4

a) Every buffer stage gives you a factor of 4 increase so you need $4^5 = 1024 \rightarrow \boxed{5\text{ stages}}$

b) There are 8 stages between the diagonal points, so

$.05 \times 50 \times 8 = \boxed{20ps}$

c) $.05 \times 50 \times 2 = \boxed{5ps}$