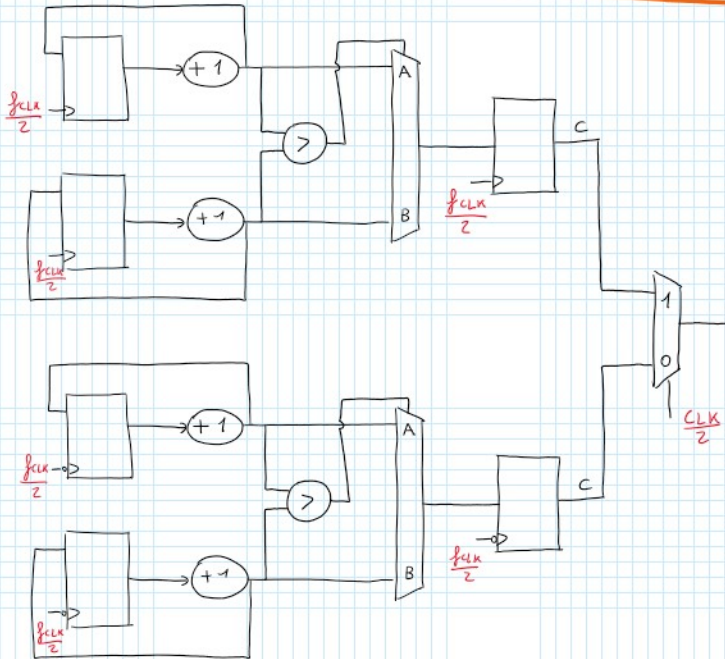ORIGINAL SOLUTION

DELAY $2 + 98 + 78 + 12 =$ 140 ns   target delay $=$ 200 ns

MAX FREQUENCY   7,14 MHz

POWER $3 \cdot 0,5 + 2 \cdot 2,35 + 2,90 + 1,72 =$ 10,32 μW ✓ @ $(N=1, \; f = 5 MHz, \; V_{DD} = 1v)$

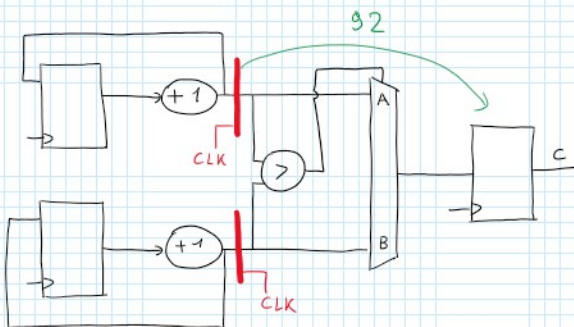AREA $3 \cdot 309 + 2 \cdot 230 + 198 + 123 =$ 1658 μm^2 ✓

PARALLELIZATION

DELAY $(2 + 98 + 78 + 12) =$ 140 ns ✓   target delay $=$ 400 ns ✓

MAX FREQUENCY   7,14 MHz

AREA $2 \cdot (3 \cdot 309 + 2 \cdot 230 + 198 + 123) + 123 =$ 3439 μm^2 ✓

$\dfrac{V_{DD}}{V_{DD \, NOM}} = u = 0,34 \Rightarrow$ $V_{DD} = 0,34 V$ ✓ $P = N \cdot f \cdot V_{DD}^2 \cdot C_L$

$P_{NEW} = \left[P(1v, 5MHz) + 1,72 \right] \cdot u^2 =$ 1,39 μW ✓ @ $(N = 2, \; f = 2,5 MHz, \; V_{DD} = 0,34 v)$
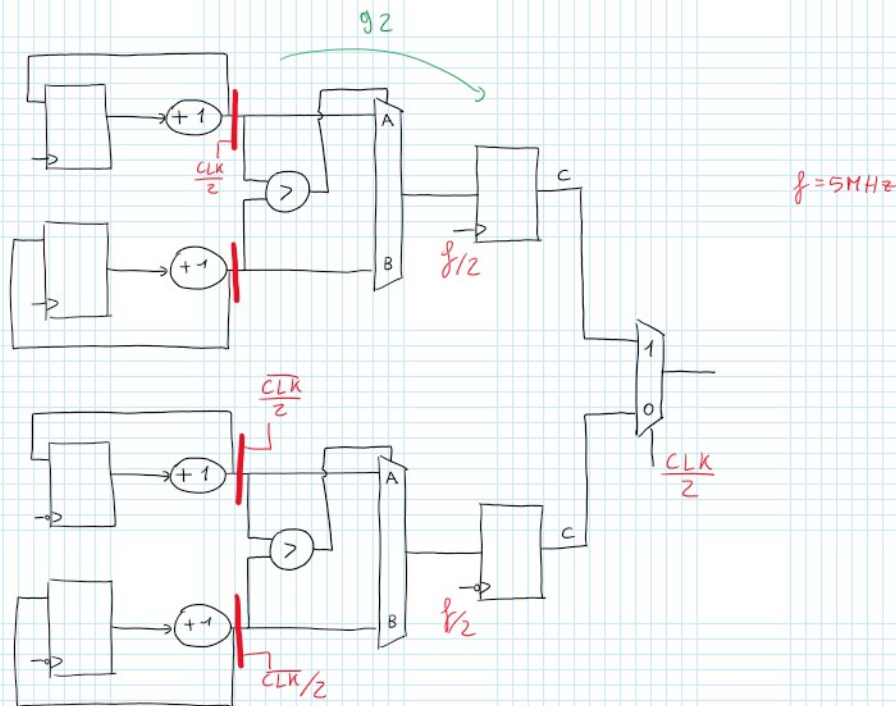

PIPELINE (1 stadio)

DELAY $(2 + 78 + 12) =$ 92 ns ✓   target Delay $=$ 200 ns ✓ (5MHz)

MAX FREQUENCY   10,2 MHz

AREA $5 \cdot 309 + 2 \cdot 230 + 198 + 123 =$ 2276 μm^2 ✓

$\dfrac{V_{DD}}{V_{DD \, NOM}} = u = 0,38 \Rightarrow V_{DD} = 0,38 V$

$$P_{NEW} = \left[P(1v, 5MHz) + (2 \cdot 0.5) \right] \cdot u^2 = 11.32 \cdot u^2 \ \mu W = \boxed{1.63 \mu W} \ \checkmark @ \ (N=1, \ f = 5MHz \quad V_{DD} = 0.38V, \quad 1 \ PIPE)$$

$f = 5MHz$

PARALLELIZZAZIONE + PIPELINE

DELAY $\quad (2 + 78 + 12) = \boxed{92 ns}$ $\checkmark$ $\quad$ target Delay $= 400 \ ns$ $\checkmark$

MAX FREQUENCY $\quad \boxed{10.2 \ MHz}$

AREA $\quad 2 \cdot (5 \cdot 309 + 2 \cdot 230 + 148 + 123) + 123 = 4675 \ \mu m^2$

$$\frac{V_{DD}}{V_{DD \ NOM}} = u = 0.3 \implies \boxed{V_{DD} = 0.3 \ V} \ \checkmark$$

$$P_{NEW} = \left[P(1v, 5MHz) + (4 \cdot 0.5) + 1.72 \right] \cdot u^2 = 14.04 \cdot u^2 = \boxed{1.26 \ \mu W} \ \checkmark @ \ (N=2, \ f = 2.5 MHz, \ V_{DD} = 0.3 \ , \quad 1 \ PIPE)$$
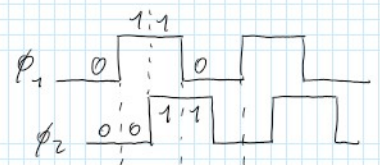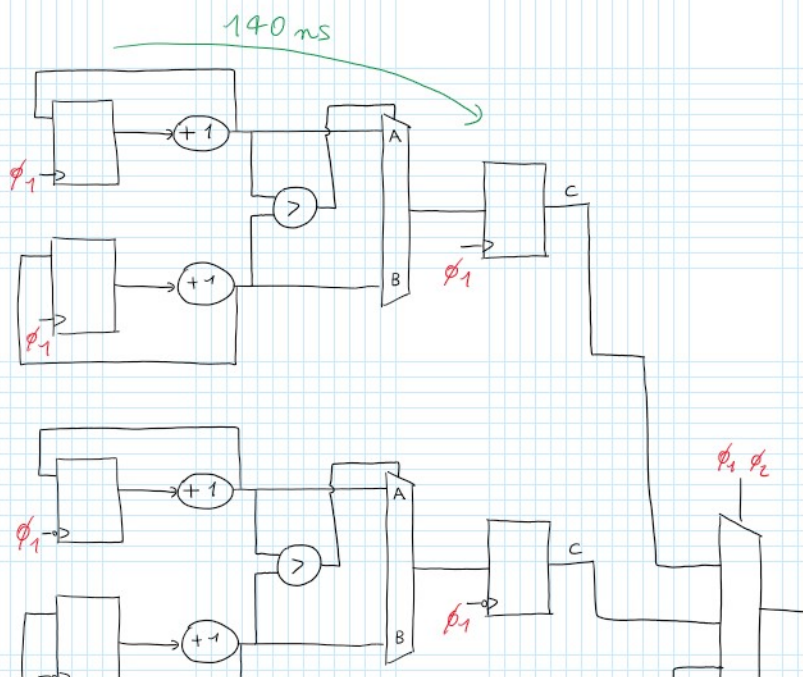
$\phi_1, \phi_2 = \dfrac{f_{CLK}}{4}$ $\qquad f_{CLK} = 5 MHz$
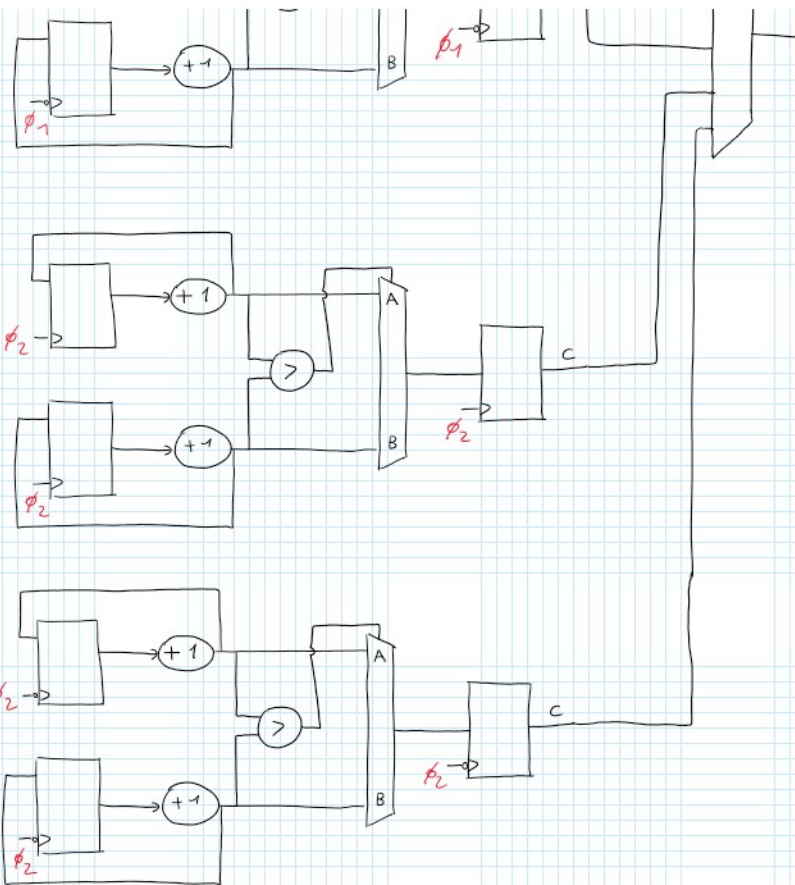
PARALLELIZZAZIONE ×4

DELAY $\qquad$ $2 + 98 + 78 + 12 = 140\,ns$ ✓ $\qquad$ target Delay $= 800\,ns$ $(1,25\,MHz)$ ✓

MAX FREQUENCY $\qquad$ 7,14

AREA $\qquad$ $4 \cdot (1658\,\mu m^2 \text{ (ORIGINAL)}) + 3 \cdot 123\,\mu m^2 = 7001\,\mu m^2$

$\dfrac{V_{DD}}{V_{DD\,NOM}} = u = 0,29 \implies V_{DD} = 0,29\,V$ ✓

$P_{NEW} = \left[P(1V, 5MHz) + 3 \cdot 1,72 \right] \cdot u^2 = 1,3\,\mu W$ ✓ @ $(N=4,\ f=1,25MHz,\ V_{DD} = 0,29\,V)$
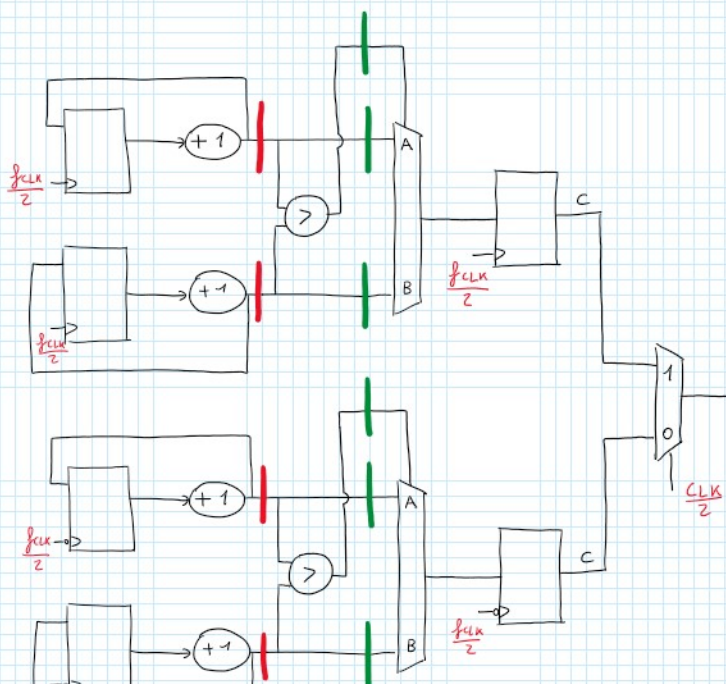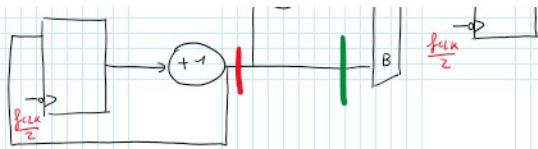
PARALLELIZZAZIONE + PIPELINE x2

DELAY $2 + 78 =$ **80 ns** ✓   target Delay = 400 ns (2,5 MHz) ✓
MAX FREQUENCY   **12,5 MHz**

AREA

$\dfrac{V_{DD}}{V_{DD\,NOM}} = u = 0,294 \Rightarrow V_{OD} =$ **0,294 V** ✓

$P_{NEW} = \left[P(1v, 5MHz) + 10 \cdot 0,5 + 1,72 \right] \cdot u^2 =$ **1,47 μW** ✓ @ $(N=2, \; f = 2,5 MHz, V_{OD} = 0,294v)$