B2. Clock Summary

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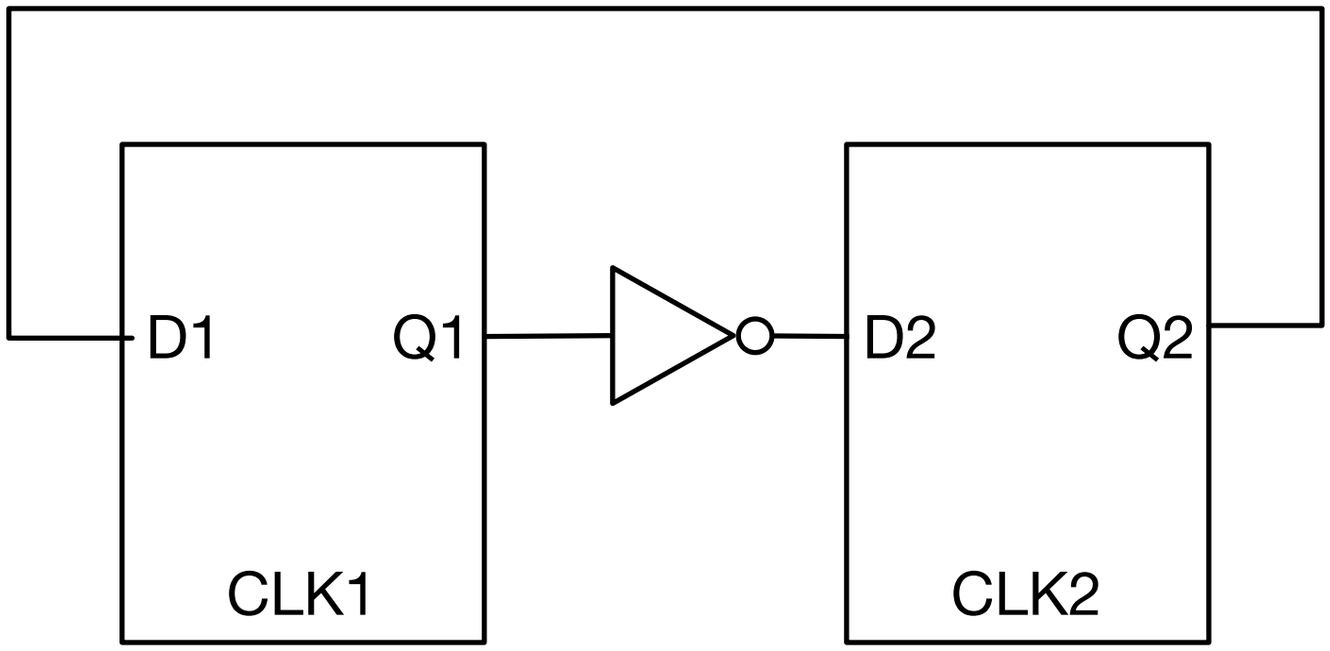
Reference:

- Chapter 11 Clock Distribution
- **High speed digital design**
- by Johnson and Graham

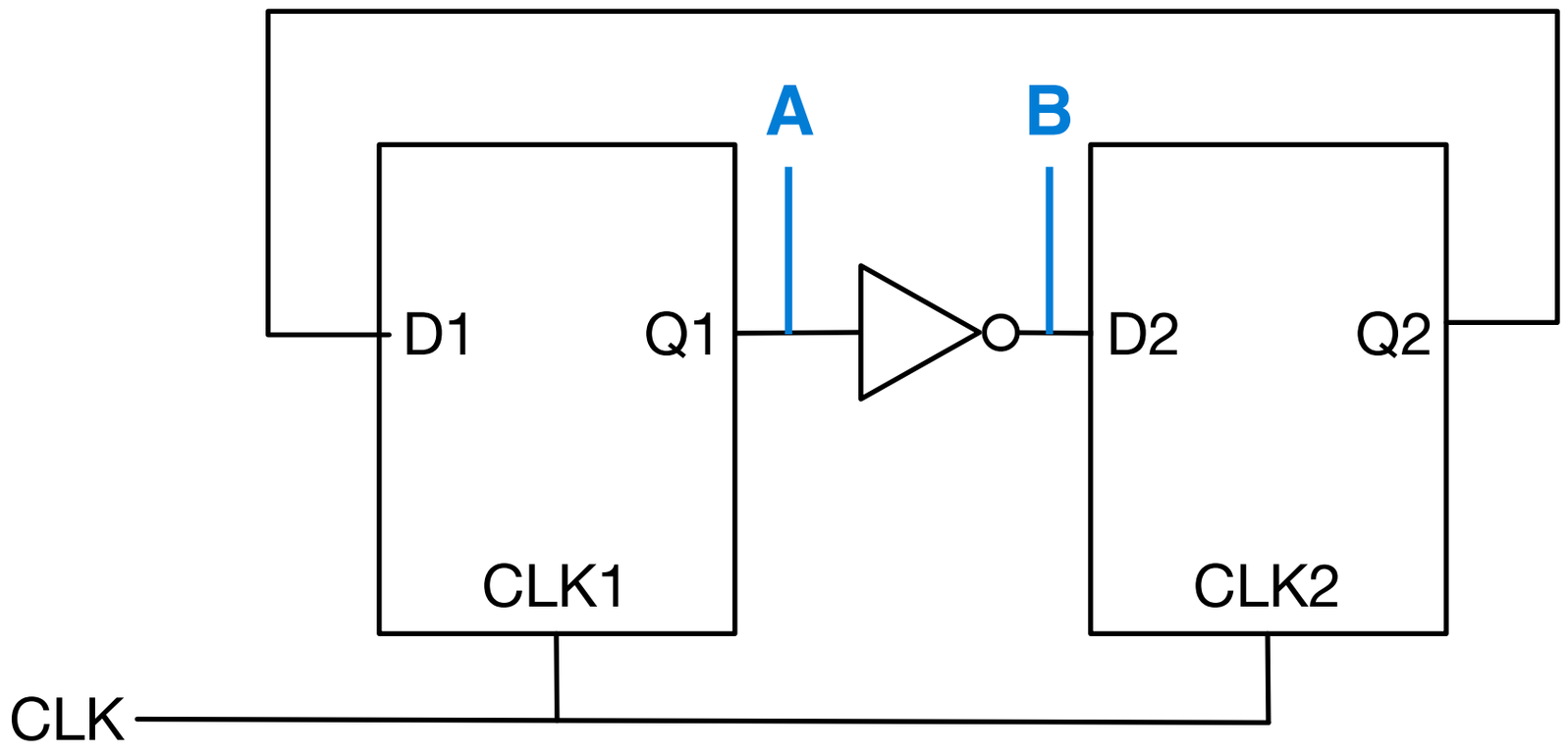
Notations in Clock Skew Calculation

- **$T_{ff,max}$**: max delay of flip-flop (FF)
- **$T_{G,max}$**: max delay of gate G, including track delay
- **T_{setup}**: worst-case setup time required by FF2, data at D2 must arrive at least T_{setup} before CLK_2
- **T_{CLK}**: clock period; interval between clocks



EX. B2-1

- CLK1 = CLK2 = 20MHz; flip flop max delay $T_{ff,max}$ = 8ns; flip-flop setup time T_{setup} = 5ns; For each gate $T_{G,max}$ = 10ns.
- **Questions**:
  - Find time margin
  - How many delay G gates can you insert between A and B without creating error?



EX. B2-1

- T_{CLK} = 1 / 20MHz = 50ns;
- A1: Time margin
  - = T_{CLK} - $T_{ff,max}$ - T_{setup} - $T_{G,max}$
  - = 50ns - 8ns - 5ns - 10ns = 27ns
- A2: since each delay is 10ns, 2 more gates can be inserted between A and B

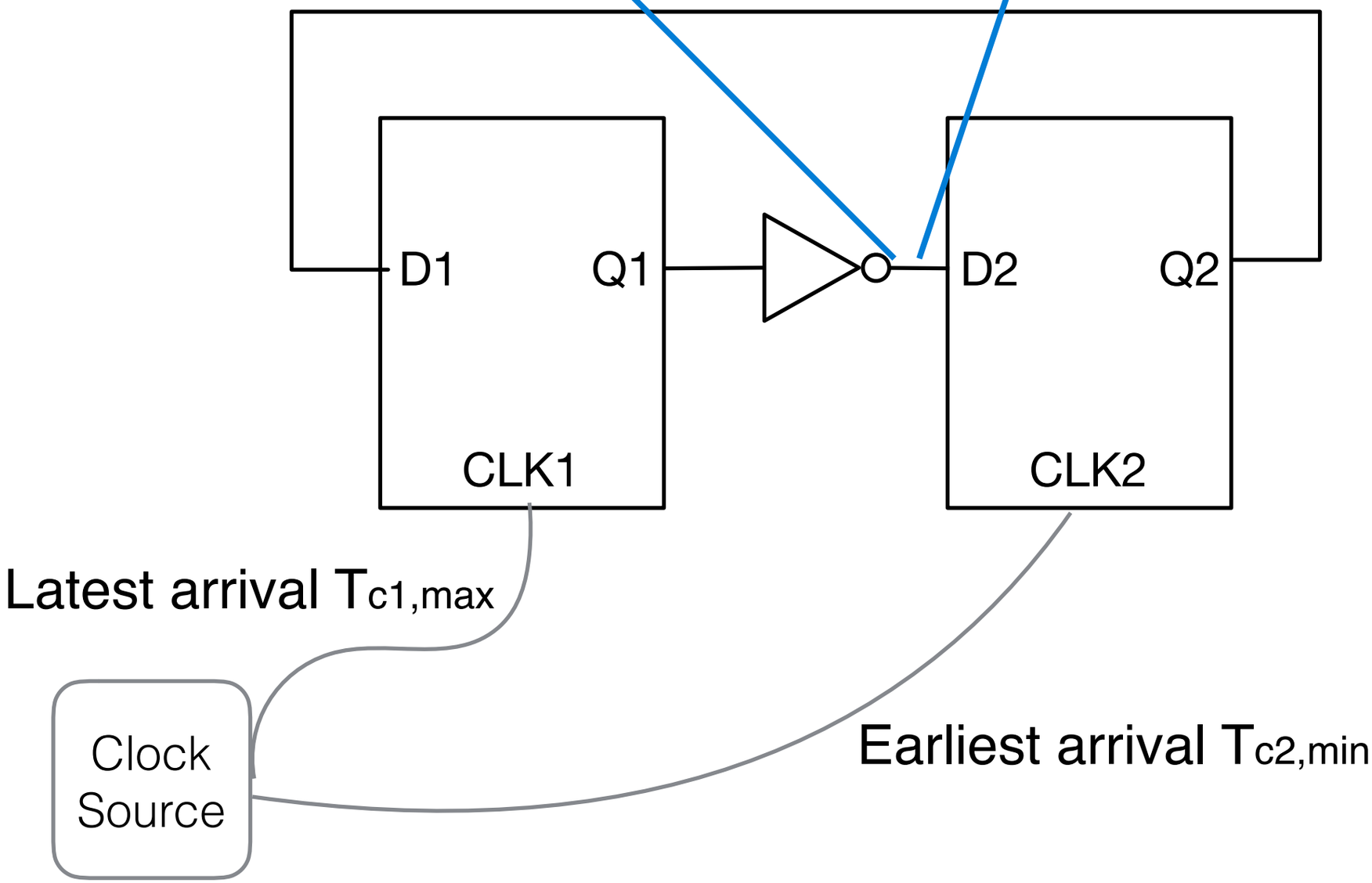
Why Care Clock Skew?

Signal arrives here no later than

$T_{c1,max} + T_{ff,max} + T_{G,max}$

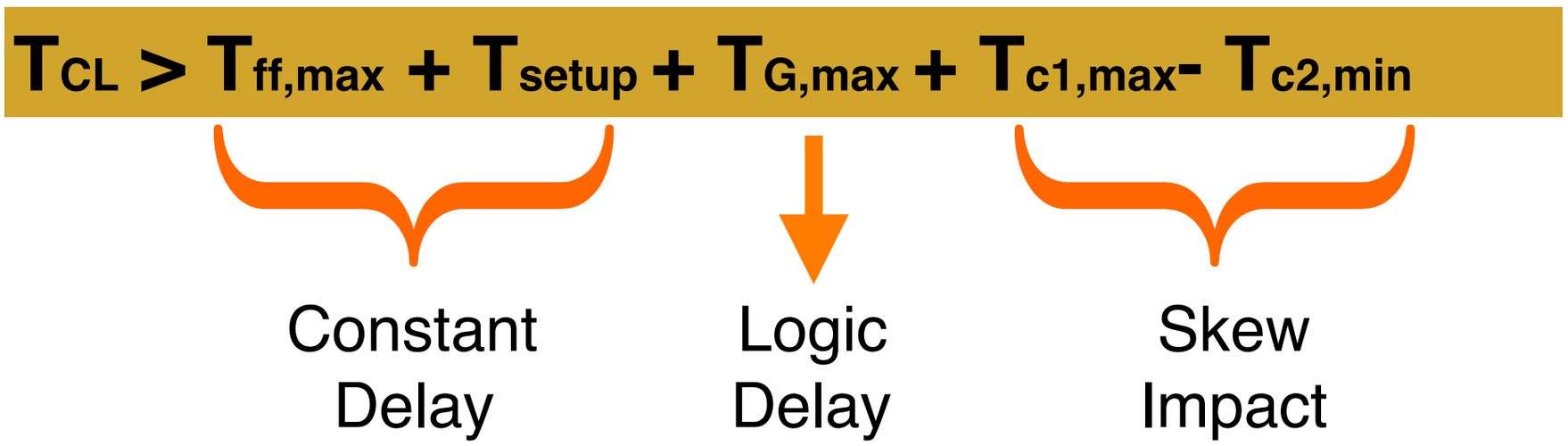
Signal arrives must be valid before next clock

$T_{CLK} + T_{c2,min} - T_{setup}$



Why Care Clock Skew?

- $T_{slow} = T_{c1,max} + T_{ff,max} + T_{G,max}$
- $T_{required} = T_{CLK} + T_{c2,min} - T_{setup}$
- Since $T_{slow} < T_{required}$ =>



EX. B2-2

Question: Given

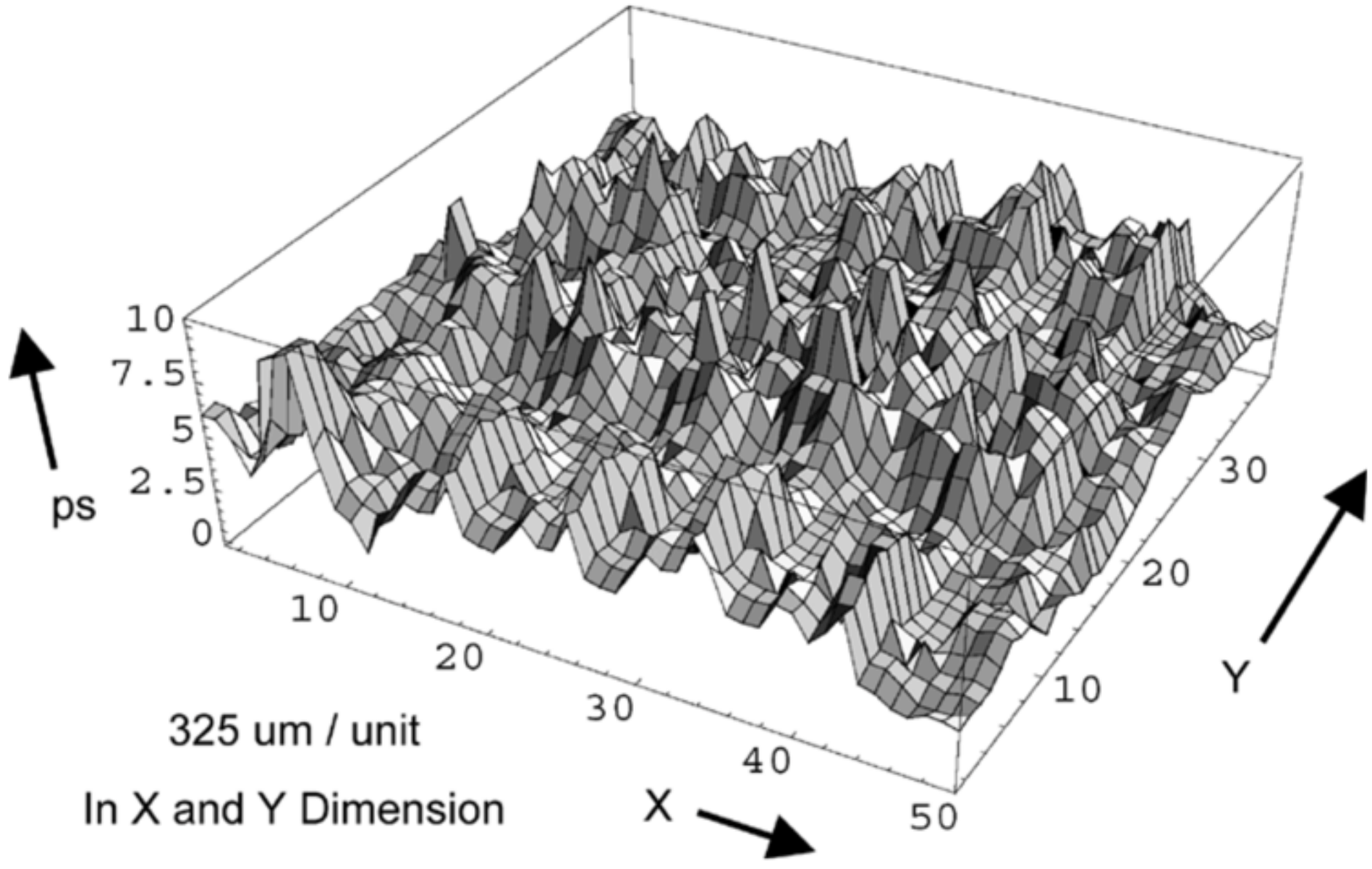
- $T_{ff,max}$ = 7ns;
- $T_{G,max}$ = 5ns;
- T_{setup} = 4ns;
- T_{CL} = 40MHZ;

What's the biggest time skew allowed?

Answer:

$$\text{max skew} <= T_{CLK} - (T_{ff,max} + T_{G,max} + T_{setup})$$
$$= 25ns - 7ns - 5ns - 4ns = 9ns$$

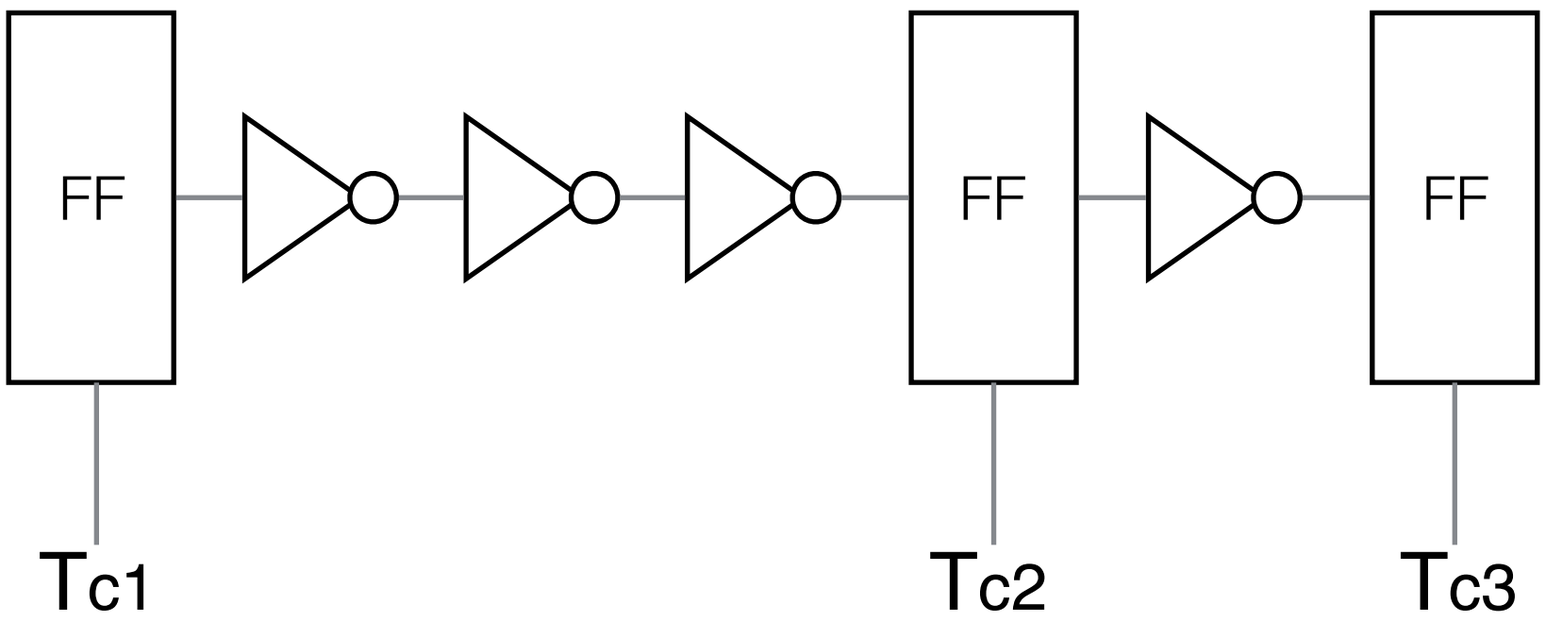
Clock Skew Distribution



[Pham et al, JSSC'2006]

EX. Skew Optimization

- Instead of Zero-Skew, take advantage of Skew.
- Question: Given $T_{G,max}$=6ns, $T_{ff,max}$=10ns, T_{setup}=2ns, what's the minimal T_{CLK}?
  - The delay from TCLK to the clock input CK1 of the flip flop (FF) is Tc1.
  - The delay from TCLK to the clock input CK2 of the flip flop (FF) is Tc2.
  - The delay from TCLK to the clock input CK3 of the flip flop (FF) is Tc3 = 0.



EX. Skew Optimization

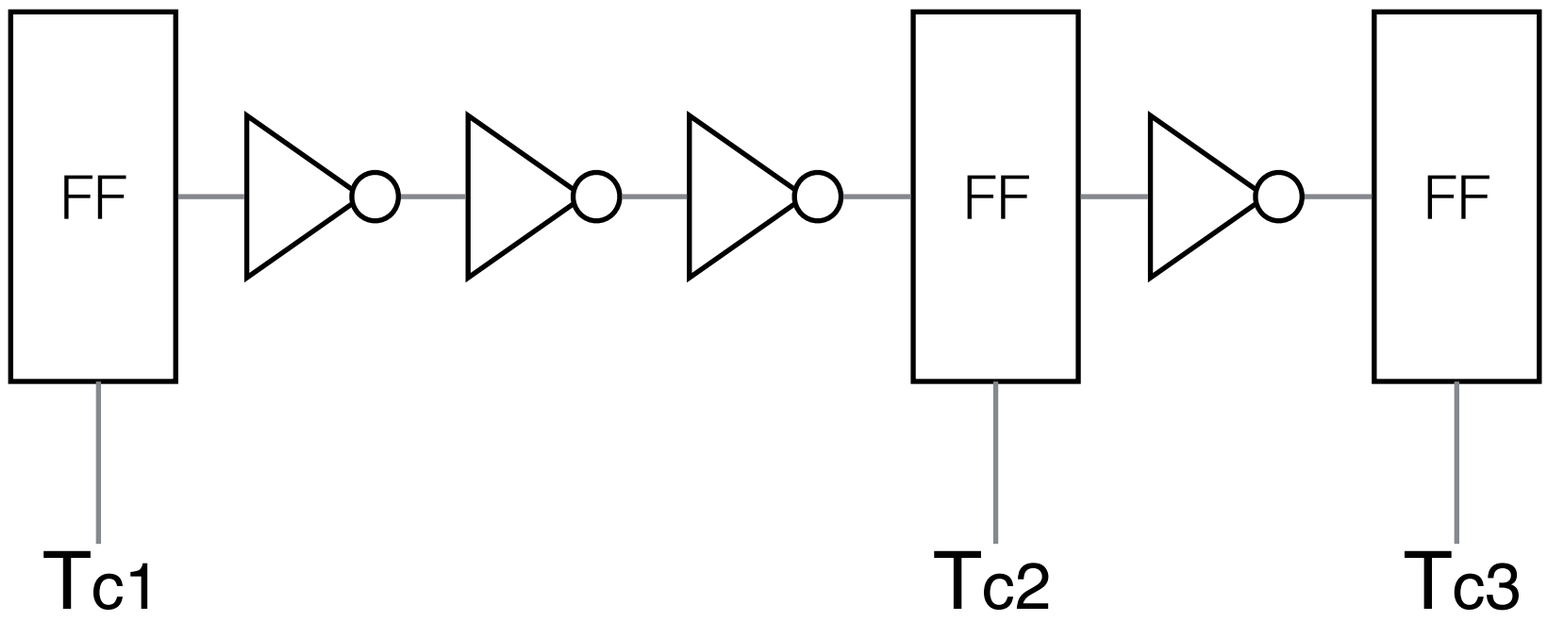
- Answer:

$$\begin{cases} T_{CLK1} >= T_{ff} + T_{setup} + 3 * T_G + (T_{C1} - T_{C2}) = 30 + (T_{C1} - T_{C2}) \\ T_{CLK2} >= T_{ff} + T_{setup} + T_G + (T_{C2} - T_{C3}) = 18 + (T_{C2} - T_{C3}) \end{cases}$$

When T_{CLK} is minimum => $T_{CLK1} = T_{CLK2}$

Since T_{C3}=0, Set $T_{C1} = 0$, $T_{C2} = 6$,

=> $T_{CLK} = 24$.



Thank You :-)