EE434
ASIC & Digital Systems

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Lecture 9

Timing Analysis

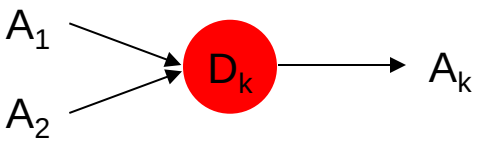
Static Timing Analysis (STA)

- Static timing analysis (STA)

- Statistical static timing analysis (SSTA)

Delay Model and Arrival Time

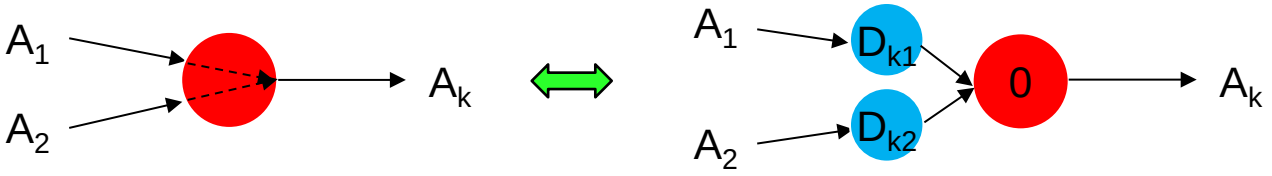
- Delay model 1



D_k: Delay at node k

A_k: Arrival time = $\max(A_1, A_2) + D_k$

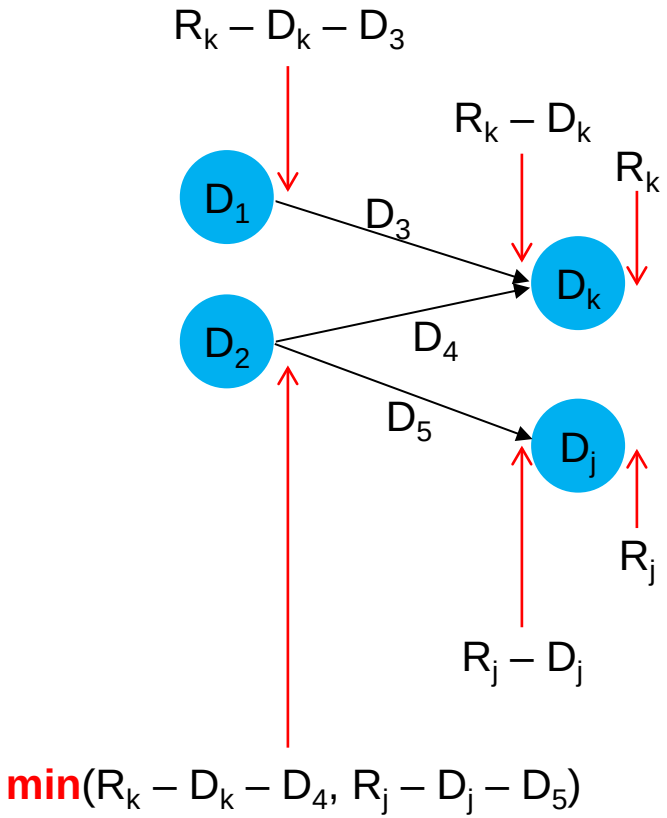
- Delay model 2



$A_k = \mathbf{max}(A_1+D_{k1}, A_2+D_{k2})$

Required Time

- Signal should arrive before the required time.

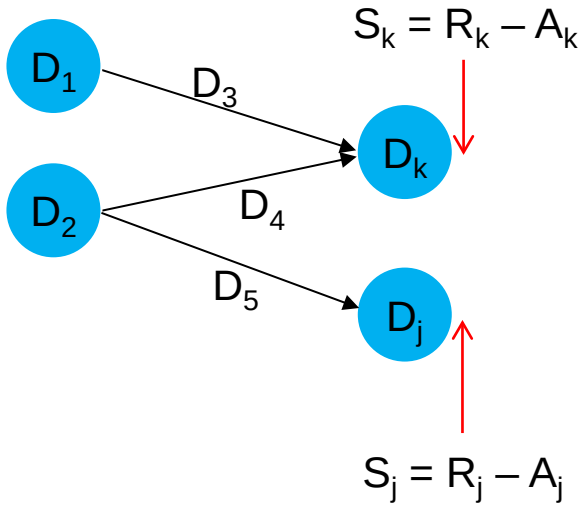


Slack

- Slack = Required Time – Arrival Time

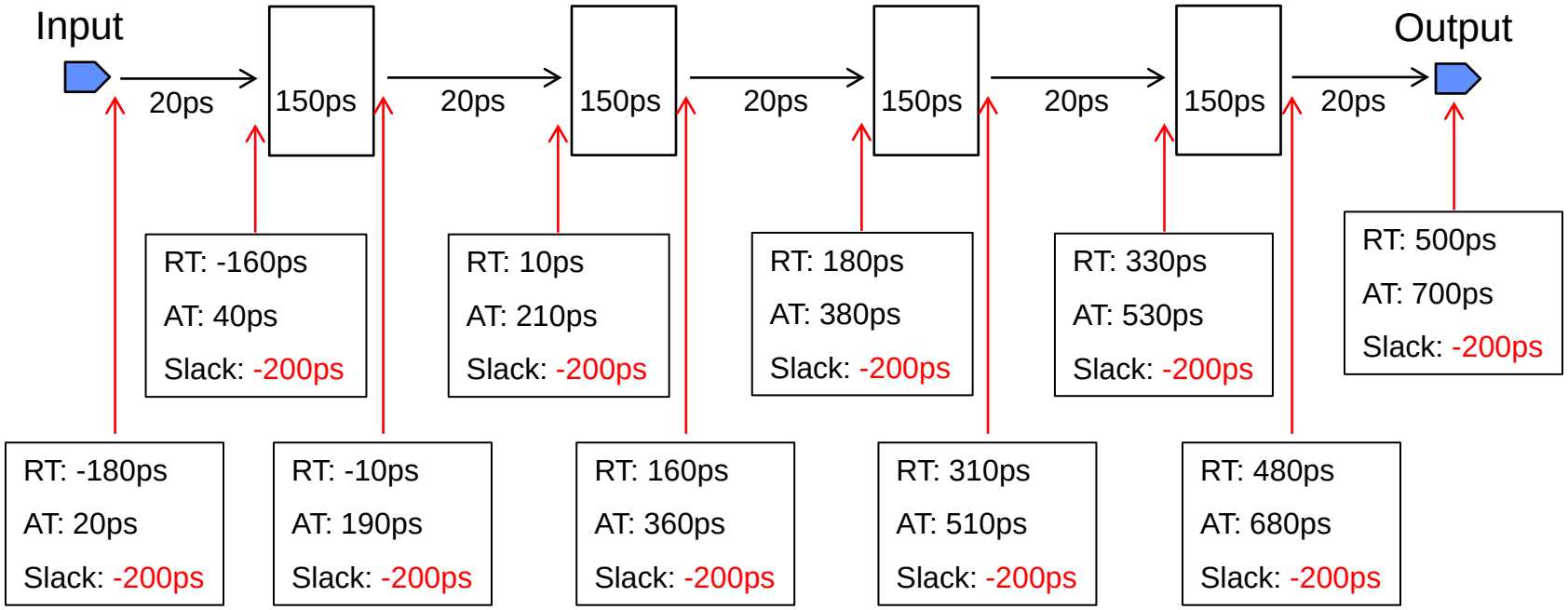
- Positive slack: good
  - Slack > 0
  - Arrival time < Required time

- Negative slack
  - Slack < 0
  - Arrival time > Required time
  - Need to fix



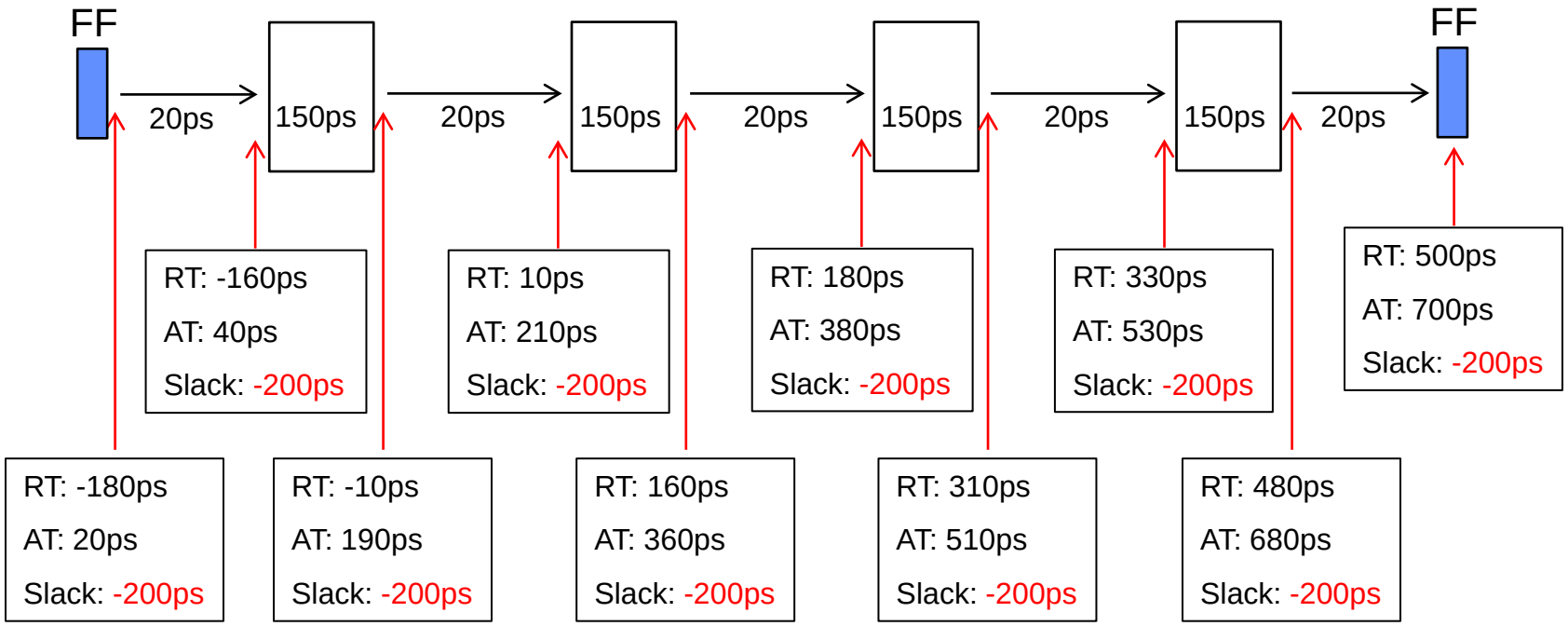
Example

- A combinational logic
- Max. delay between primary inputs and outputs: 500ps



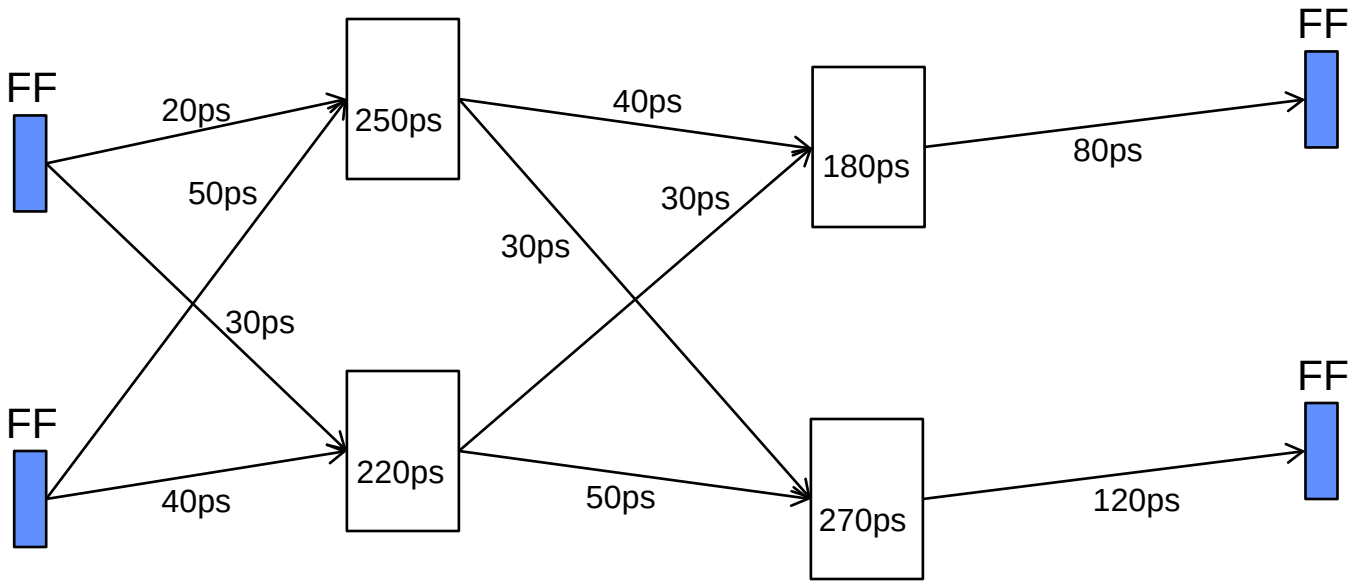
Example

- A sequential logic
- Clock period: 500ps (2GHz)



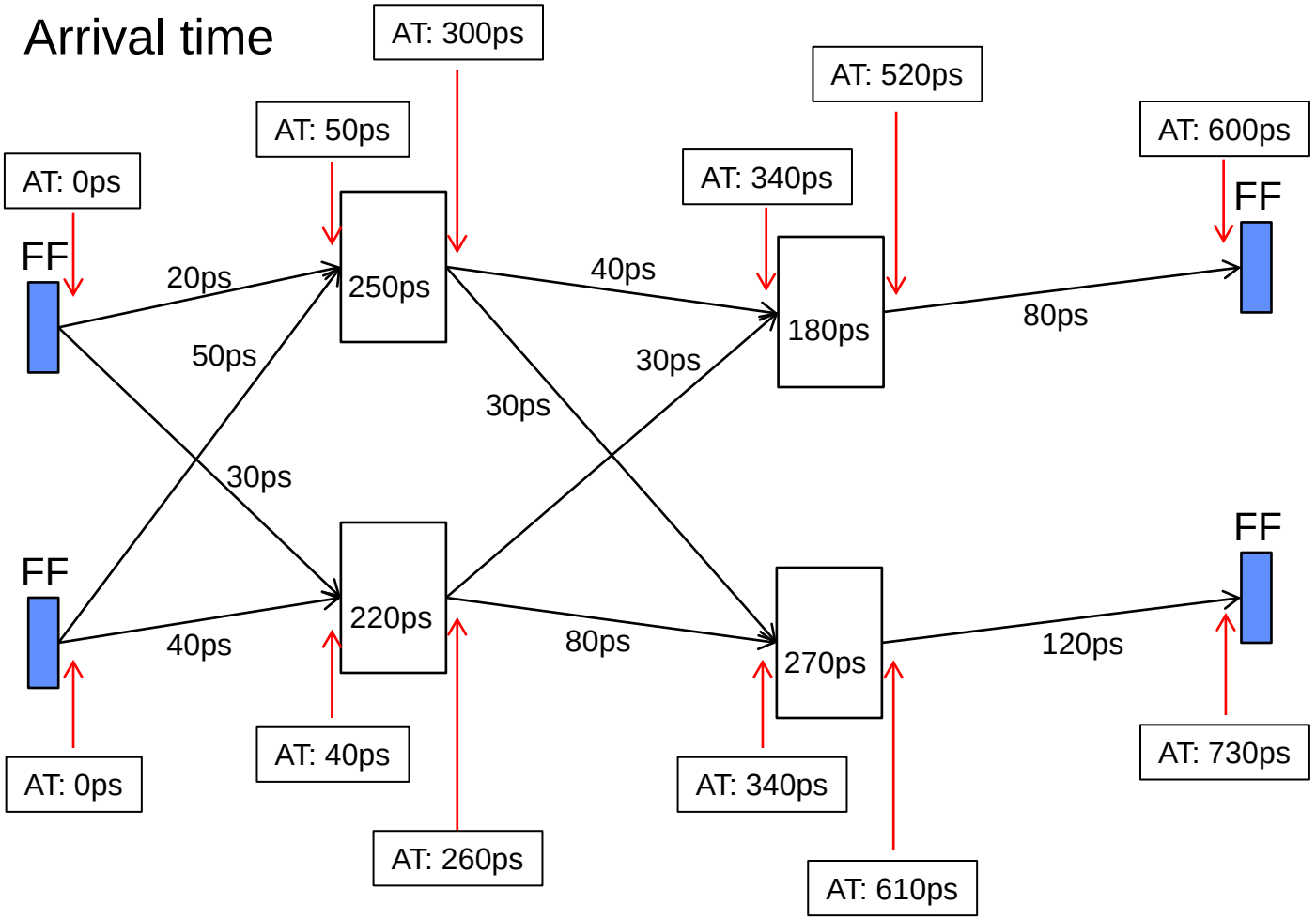
Example

- Multiple paths
  - CLK: 500ps



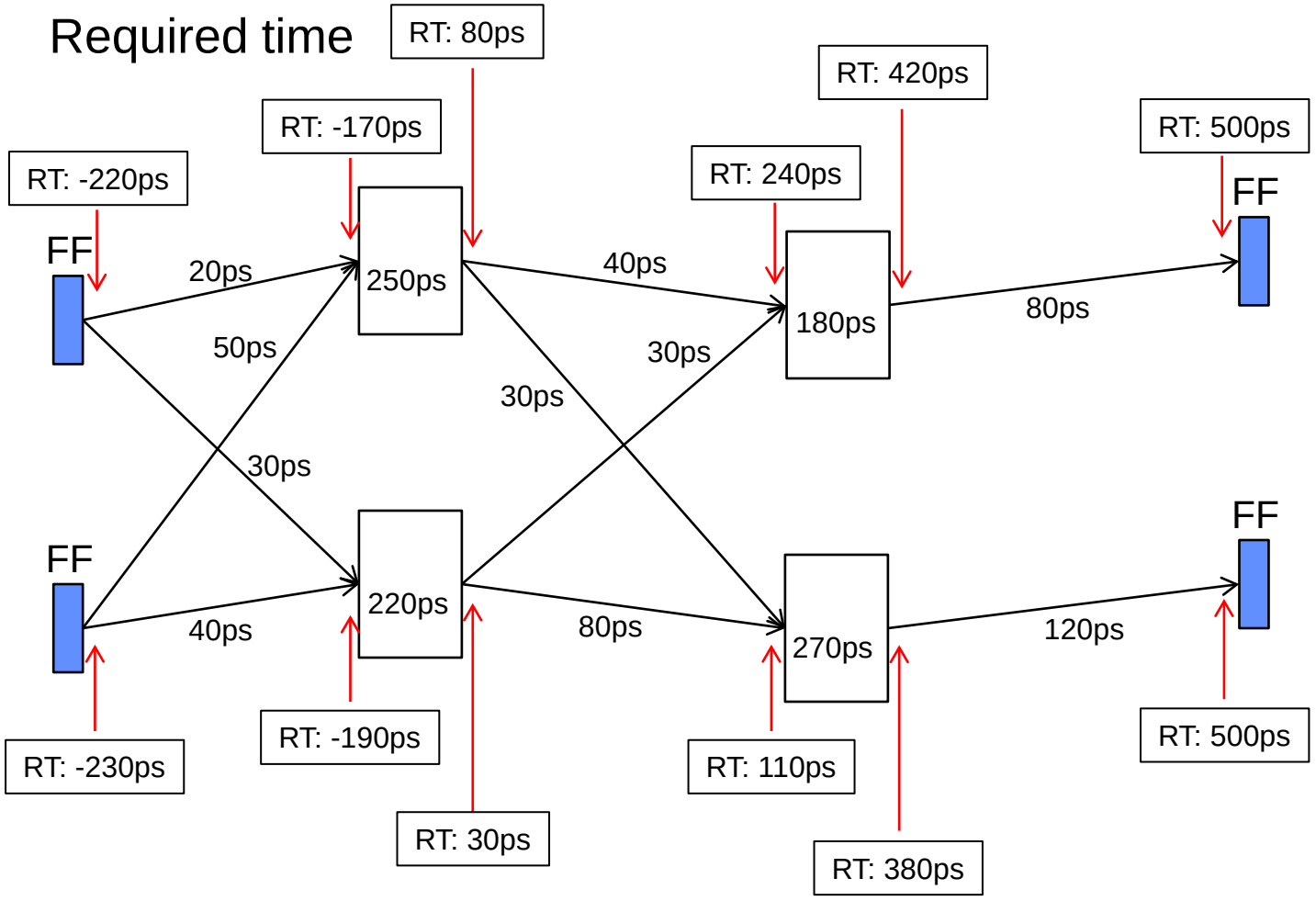
Example

- Arrival time



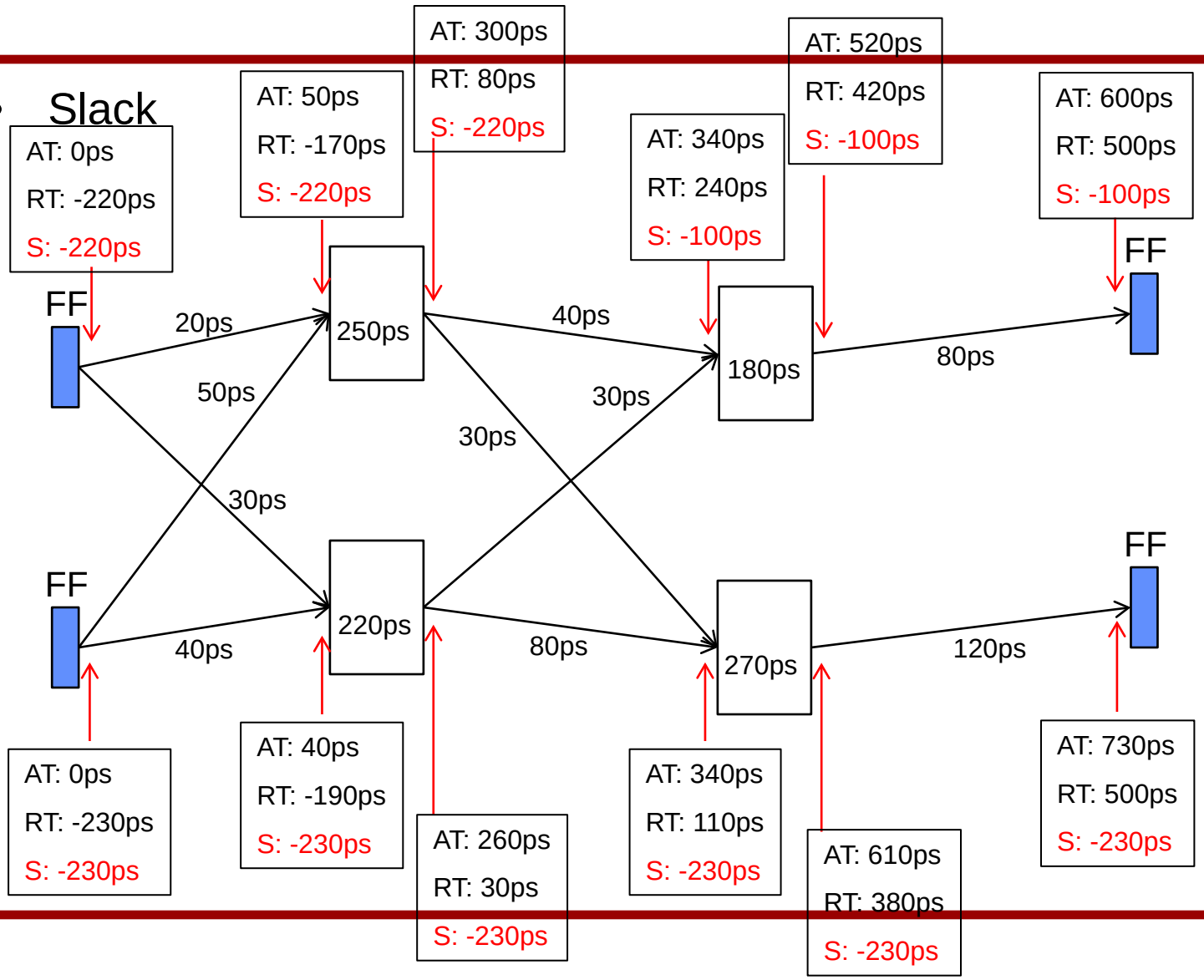
Example

- Required time

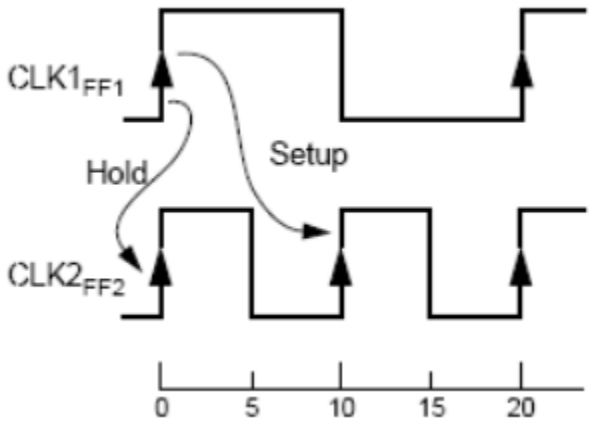


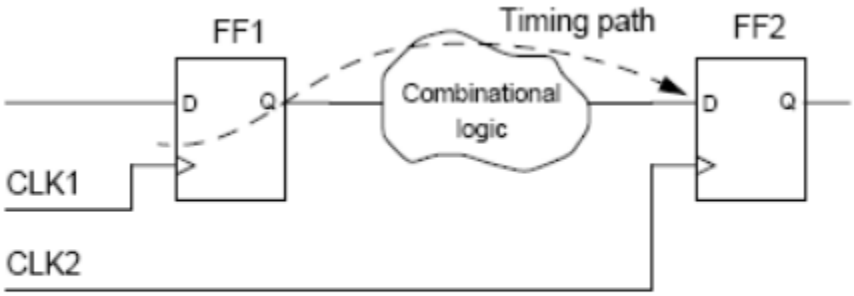
Example

- Slack



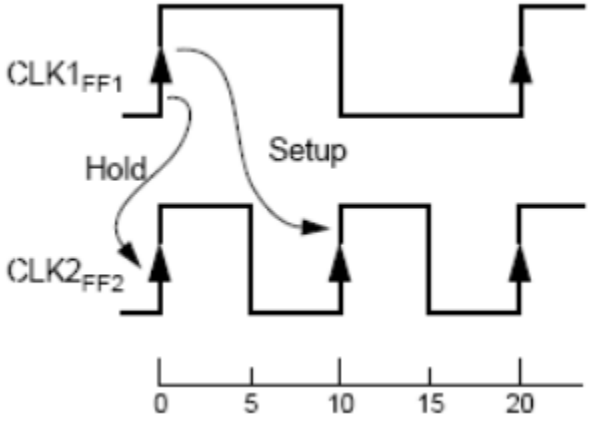
Setup Time & Hold Time

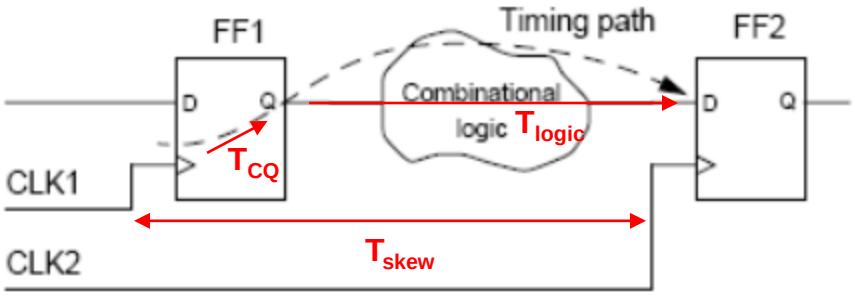




Setup Time & Hold Time

- $T_{setup} \leq T_{CLK} + T_{skew} - T_{logic} - T_{CQ}$
- $T_{hold} \leq T_{CQ} + T_{logic} - T_{skew}$

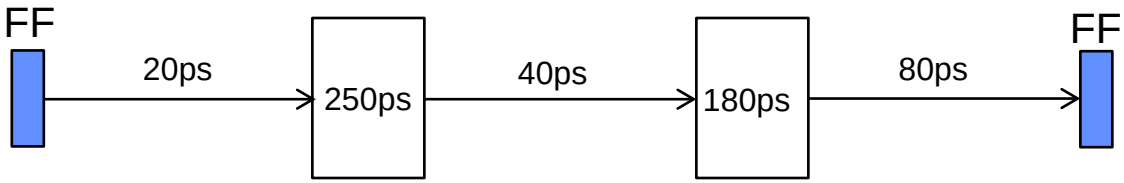




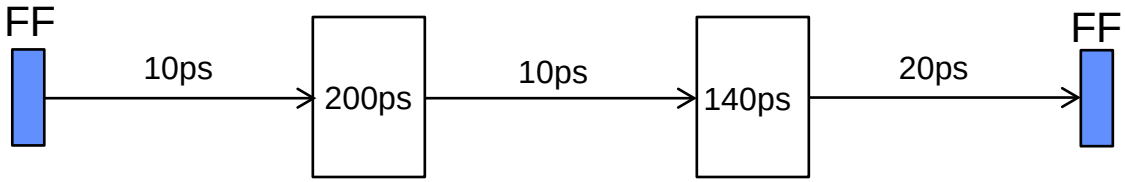
Setup Time Violation

- Spec
  - T_{CLK}: 500ps
  - T_{skew}: 0ps
  - T_{CQ}: 50ps
  - T_{setup}: 30ps

- Before optimization: $T_{CLK} + T_{skew} - T_{logic} - T_{CQ} = 500+0-570-50 = -130ps < 30ps$



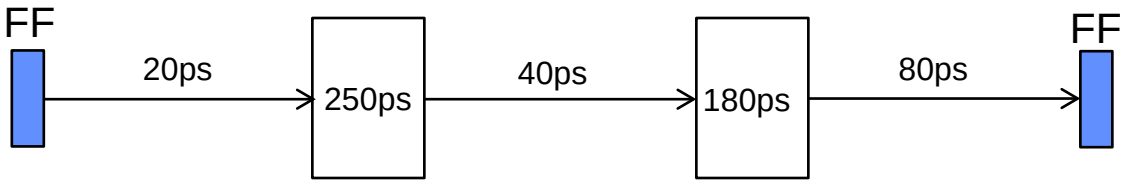
- After optimization: $T_{CLK} + T_{skew} - T_{logic} - T_{CQ} = 500+0-380-50 = 70ps > 30ps$



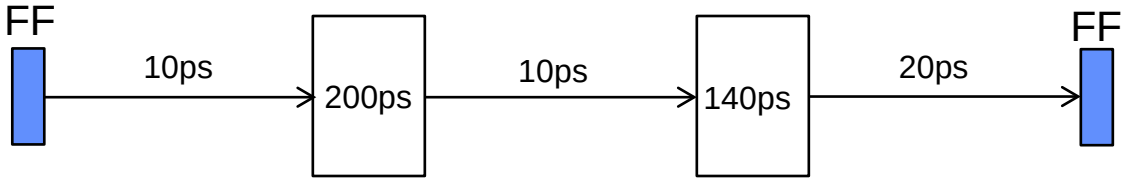
Setup Time Violation

- Spec
  - T_{CLK}: 500ps
  - T_{skew}: -50ps
  - T_{CQ}: 50ps
  - T_{setup}: 30ps

- Before optimization: $T_{CLK} + T_{skew} - T_{logic} - T_{CQ}$ = 500-50-570-50 = -180ps < 30ps

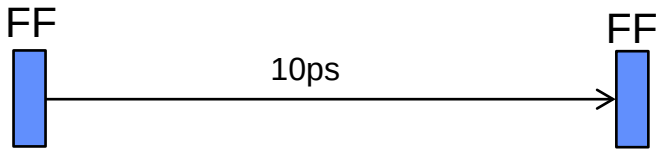


- After optimization: $T_{CLK} + T_{skew} - T_{logic} - T_{CQ}$ = 500-50-380-50 = 20ps < 30ps

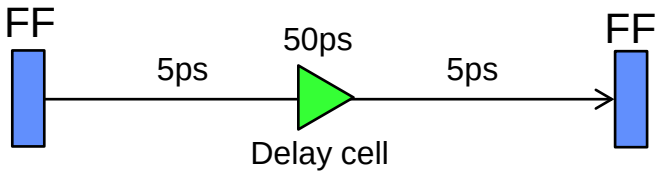


Hold Time Violation

- Spec
  - T_{CQ}: 10ps
  - T_{skew}: 0ps
  - T_{hold}: 30ps
- Before optimization: $T_{CQ} + T_{logic} – T_{skew}$ = 10+10-0 = 20ps < 30ps



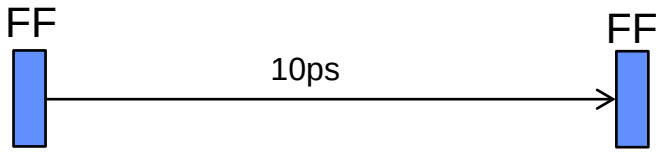
- After optimization: $T_{CQ} + T_{logic} – T_{skew}$ = 10+60-0 = 70ps > 30ps



Hold Time Violation

- Spec
  - T_{CQ}: 10ps
  - T_{skew}: 30ps
  - T_{hold}: 30ps

- Before optimization: $T_{CQ} + T_{logic} - T_{skew} = 10+10-30 = -10ps < 30ps$



- After optimization: $T_{CQ} + T_{logic} - T_{skew} = 10+60-30 = 40ps > 30ps$