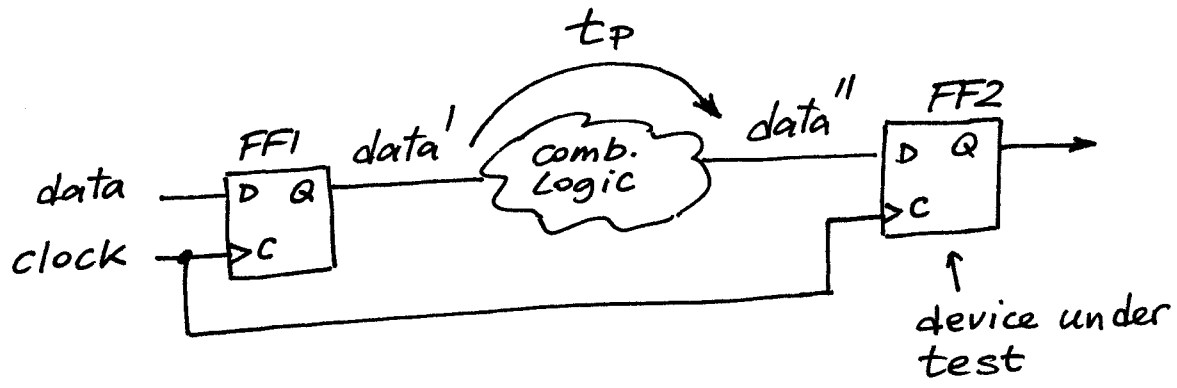


# SETUP and HOLD Time



$t_{DFF} \rightarrow$  flip-flop propagation delay (from C to Q)

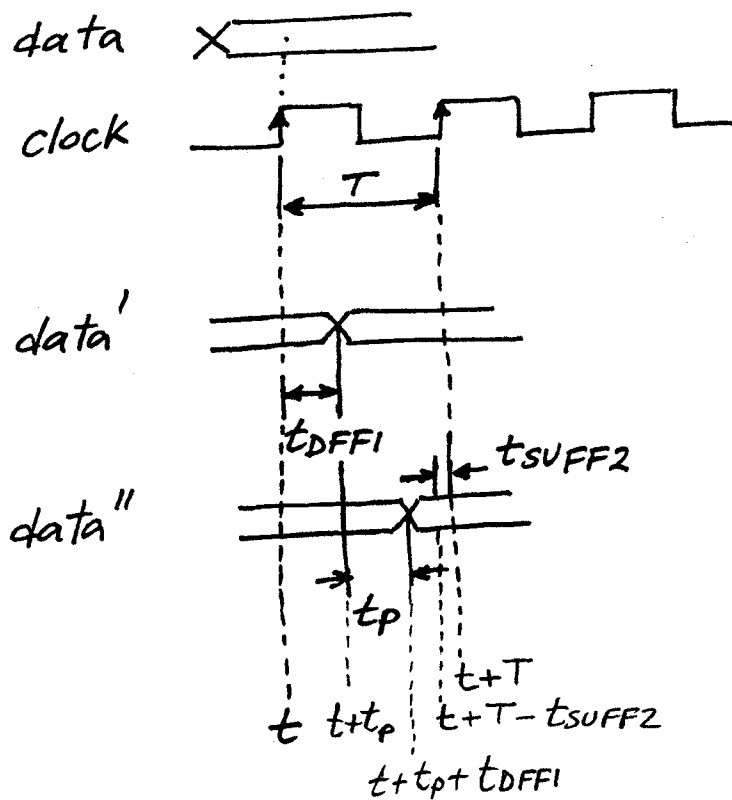
$t_{SU} \rightarrow$  flip-flop setup time

$t_{H} \rightarrow$  flip-flop hold time

$T \rightarrow$  clock period

Our goal is to build a system that will work properly.  
 In order to achieve this goal data'' must be ready at the input of FF2 a little bit before the rising edge of the clock, and must be held for a little bit after the rising edge of the clock.

## SETUP Constraint



$$t + t_{DFF1} + t_p < t + T - t_{SUFF2}$$

$$\boxed{t_{DFF1} + t_p + t_{SUFF2} < T} \quad \leftarrow \text{Setup constraint}$$

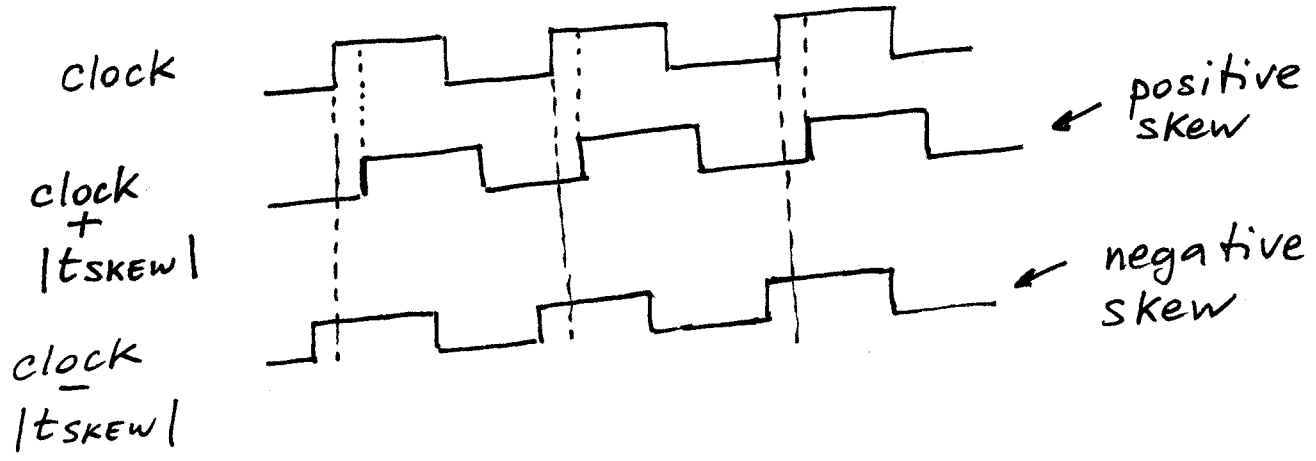
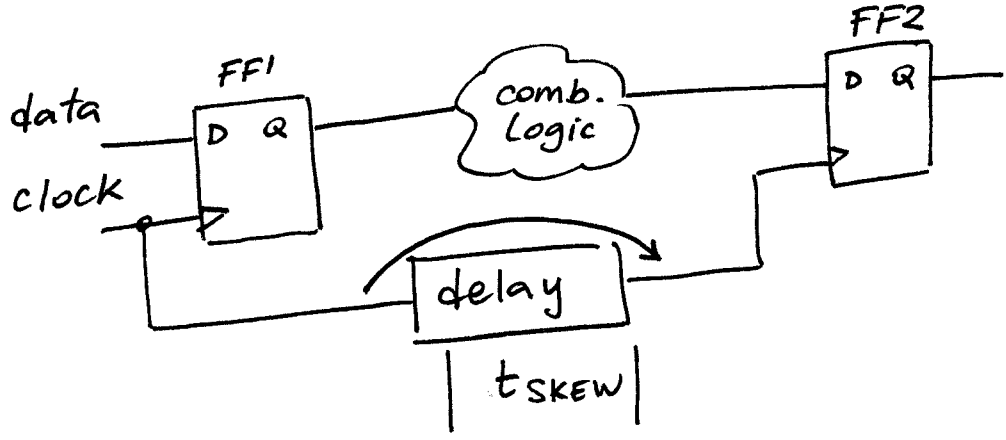
The constraint is more difficult to be satisfied when the cells have big propagation delay.

(worst case operating condition :  
 $V \downarrow, T \uparrow, K_p \uparrow$ )



# Clock Skew

Let's make things more difficult now. In practice the clock signal is not going to arrive exactly at the same instant at the C pin of the two flip-flops. Because of the interconnect there will be a certain delay between the instants at which the two FF receive the clock signal.



$$t_{DFF1} + t_p + t_{SUFF2} < T + |t_{SKEW}|$$

↑  
setup constraint

From the hold point of view:

in order to have the system working properly

- without skew we need data" to be held  $t_{HFF2}$  seconds after  $t+T$
- with a positive skew we need data" to be held  $t_{HFF2}$  seconds after  $t+T+|t_{SKEW}|$



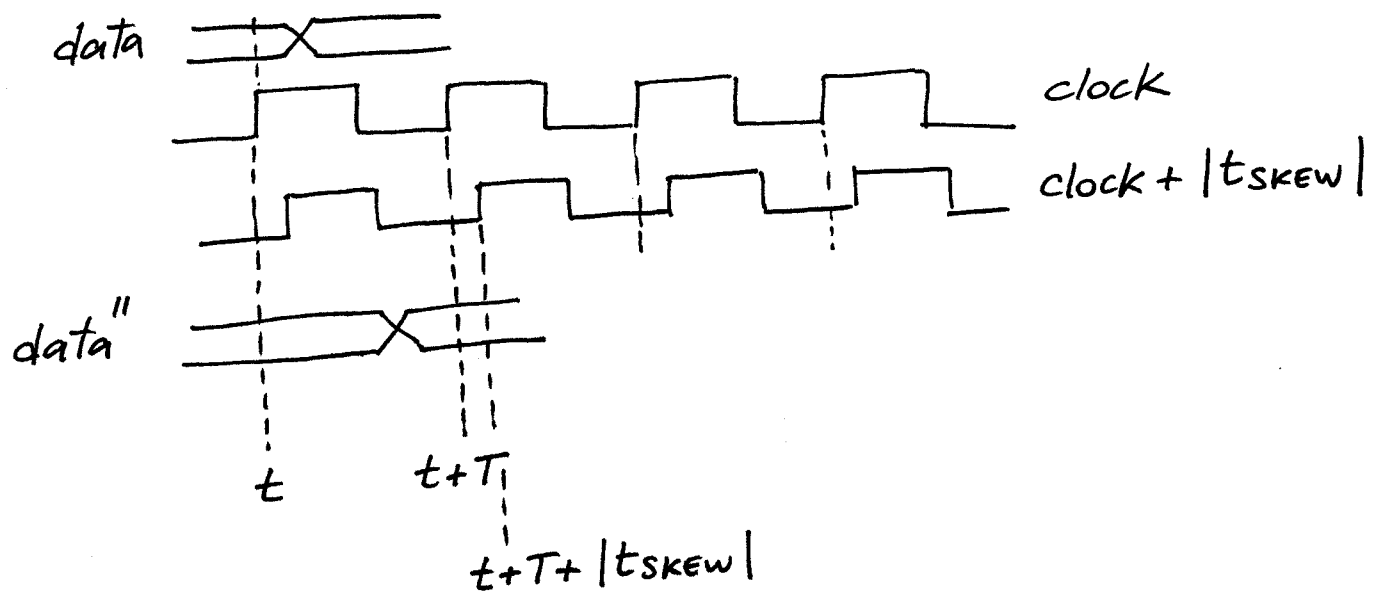
the positive skew is making more difficult to satisfy the hold constraint

$$t_{HFF2} < t_{DFF1} + t_p - |t_{SKEW}|$$

↑  
hold constraint

Let's see how the clock skew affect the setup and hold constraints.

Let's assume a positive skew.



From the setup point of view:

in order to have the system working properly

- without skew we need data'' to be ready  $t_{\text{setup}}$  seconds before  $t+T$
- with a positive skew we need data'' to be ready  $t_{\text{setup}}$  seconds before  $t+T + |t_{\text{skew}}|$



positive  
the ↓ skew is making easier to satisfy  
the setup constraint

If we consider both ~~minimum~~ positive and negative skew we will have the following constraints:

SETUP  
 $\downarrow$

$$t_{DFF1} + t_p + t_{SUFF2} < T \pm |t_{SKEW}|$$

positive skew  
 $\swarrow$   
 $\nwarrow$  negative skew

HOLD  
 $\downarrow$

$$t_{HFF2} < t_{DFF1} + t_p \mp |t_{SKEW}|$$

positive skew  
 $\swarrow$   
 $\nwarrow$  negative skew