Memory elements and Flip-flops

Exercises Digital Design

Solution vs. Hints:
While not every response provided herein constitutes a comprehensive solution, some serve as helpful hints intended to guide you toward discovering the solution independently. In certain instances, only a portion of the solution is presented.

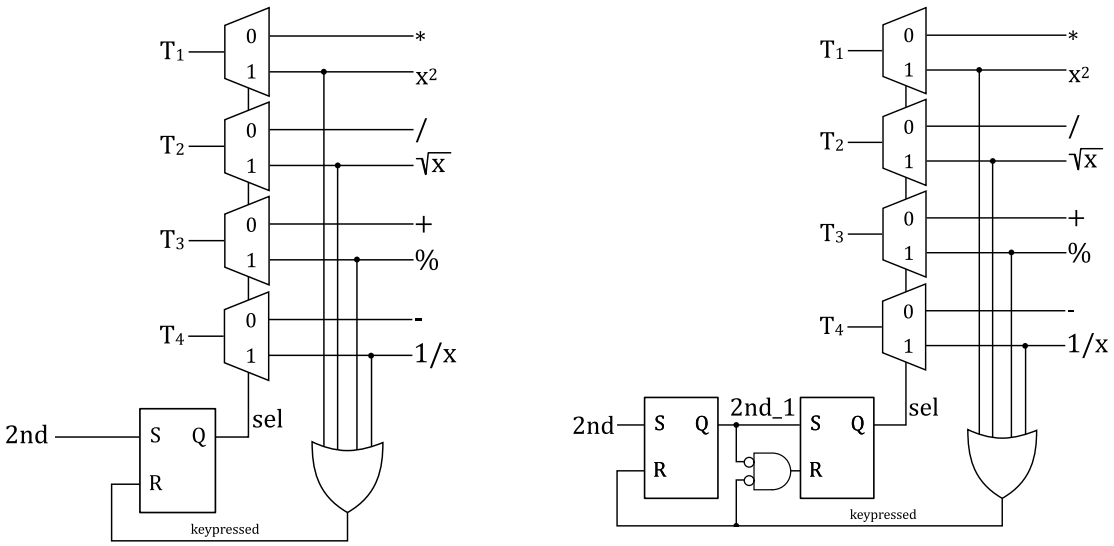
1 | LAT - Memory elements

1.1 Anti-bounce circuit

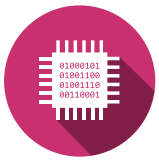
Switch on which one side is **`Reset`** and the other **`Set`**.

lat/memory-01

1.2 Key selection



lat/memory-02



1.3 Analysis of a memory element

It is a SR latch with inverted inputs

lat/memory-03

1.4 Memory Element

$$\begin{cases} g = 0 \Rightarrow s_n = 1 = r_n \Rightarrow \text{memorization} \\ g = 1 \Rightarrow \text{SR latch (set or reset)} \end{cases} \tag{1}$$

lat/memory-04

1.5 Synchronisation

Idea: Update the signal only at $\begin{cases} \text{clk=1} & \Rightarrow \text{D-Latch} \\ \text{rising\_edge} & \Rightarrow \text{D-FF} \end{cases}$

lat/memory-05

2 | LAT - Flip-flops

2.1 Detection of Transitions

Using a D-FF as delay element and compare the 2 signals together (XOR-2).

lat/flipflop-01

2.2 Shift Register

The output Y is the same as the input X with a delay of 4 clock period since there are 4 D-FF in the circuit.

lat/flipflop-02

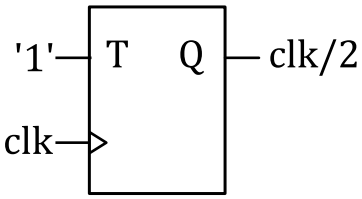
2.3 Flipflop, denoted by its characteristic equation

You need a D-FF and a multiplexer

lat/flipflop-03

2.4 Divider by 2

Only the solution for $\frac{\text{clk}}{2}$ is shown.



lat/flipflop-04

2.5 Replacement of a Flip-Flop

2.5.1.1 Equation

$$\begin{aligned} E &: Q^+ = \overline{E}Q + ED \\ T &: Q^+ = T \oplus Q \Rightarrow \overline{T}Q + T\overline{Q} \Rightarrow T\overline{Q} + \overline{T}Q \end{aligned} \tag{2}$$

2.5.1.2 Table

T	Q	Q^+	E	D
0	0	0	0	-
			1	0
0	1	1	0	-
			1	1
1	0	1	1	1
1	1	0	1	0

Two variants are possible:

$$\begin{cases} E = 1, D = T \oplus Q \\ E = T, D = \overline{Q} \end{cases} \tag{3}$$

lat/flipflop-05

2.6 Shift Register

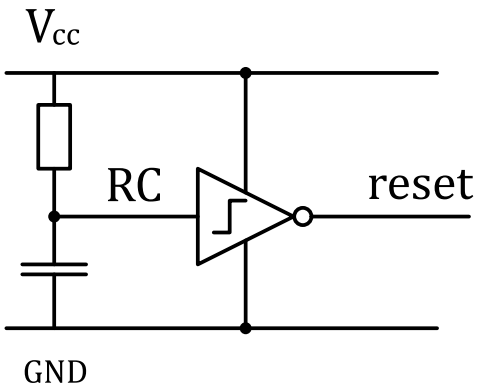
The real question is build a D-FF with a T-FF (see ex.Section 2.5 for the flipflop and ex.Section 2.2 for the shift register)

lat/flipflop-06

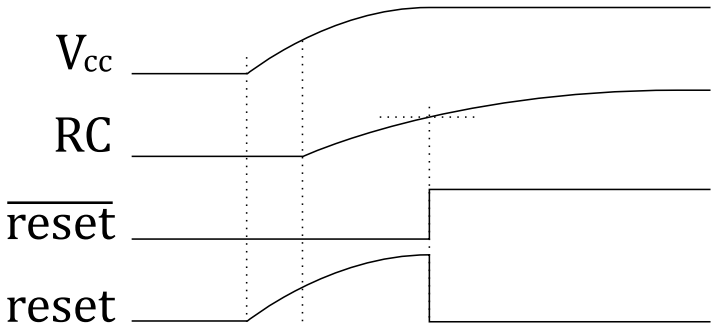
2.7 Asynchronous Zeroing

- RC-Circuit will be powere up with a delay
- Trigger converts the analog signal to a digital signal

Circuit

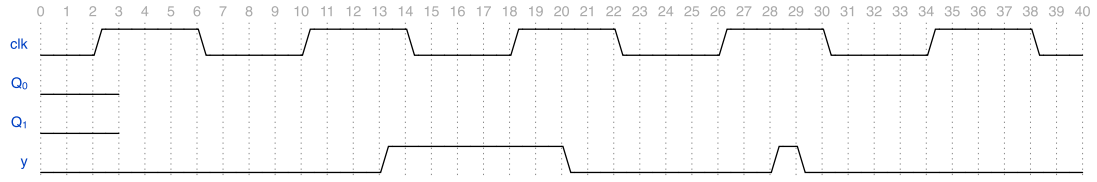


Schema



lat/flipflop-07

2.8 Asynchronous Circuit



lat/flipflop-08