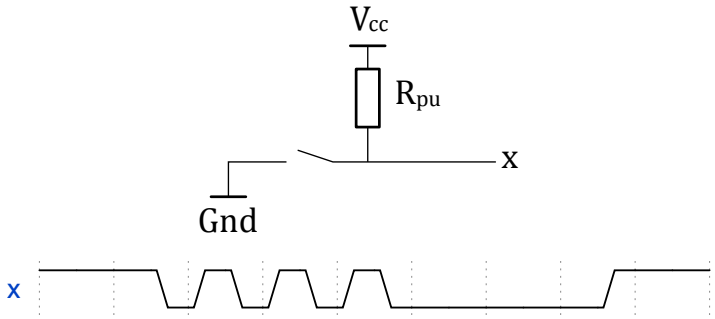
Memory elements and Flip-flops

Exercises Digital Design

1 LAT - Memory elements

1.1 Anti-bounce circuit

When a mechanical switch closes, it first bounces back several times. For example, the circuit in the following illustration creates bounces at the transition from `'1'` to `'0'`.



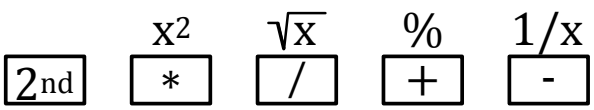
With the help of a switch and a memory element, design a circuit that provides a bounce-free signal.

lat/memory-01

1.2 Key selection

The keyboard of a calculator has 5 keys to select one of 8 operations. Multiplication is selected by pressing the corresponding key. The power of two is selected by pressing the 2^{nd} and then the multiplication key.

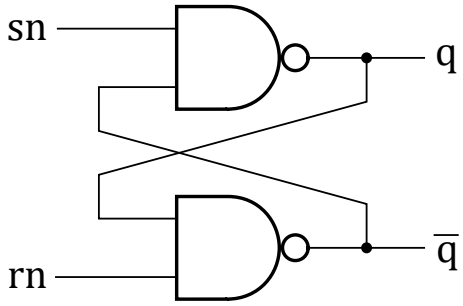
Create a circuit with 8 outputs that provides a pulse on the output corresponding to the desired function.



lat/memory-02

1.3 Analysis of a memory element

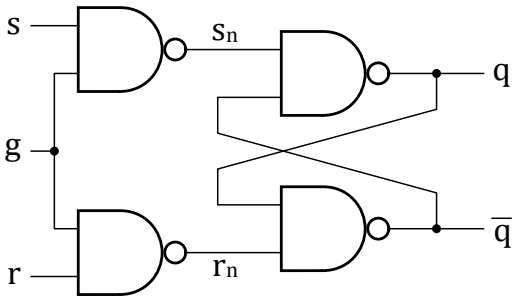
Determine how the memory element in the adjacent figure works. Perform the analyses with the combinatorial and asynchronous model.



lat/memory-03

1.4 Memory Element

Determine the function of the memory element in the adjacent figure.



lat/memory-04

1.5 Synchronisation

A clocked system provides an output signal that only varies when the clock signal is at `'0'`. Design a circuit that delays this signal until the clock signal reaches `'1'`.

lat/memory-05

2 LAT - Flip-flops

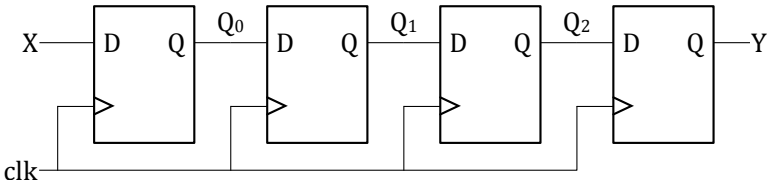
2.1 Detection of Transitions

Using a D flip-flop and logic gates, design a circuit that detects the transitions of your input signal.

lat/flipflop-01

2.2 Shift Register

The following figure shows a shift register.



lat/flipflop-02

2.3 Flipflop, denoted by its characteristic equation

A circuit to be modified contains M flip-flops, which are identified by their characteristic equation:

$$q^+ = \overline{s}a + sb \tag{1}$$

Using a D flip-flop and combinational gates, propose an equivalent circuit to the M flip-flop.

lat/flipflop-03

2.4 Divider by 2

Using a T flip-flop, create a frequency divider by 2. Using this circuit, create a divider by 4.

lat/flipflop-04

2.5 Replacement of a Flip-Flop

Using an E flip-flop and combinatorial gates, create a T flip-flop.

lat/flipflop-05

2.6 Shift Register

With the help of T flip-flops, create a 4-bit shift register.

lat/flipflop-06

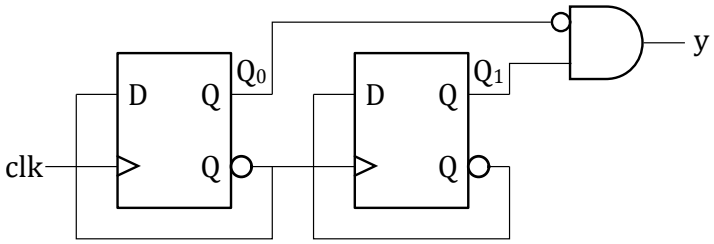
2.7 Asynchronous Zeroing

With the help of an RC element and logic gates, create a circuit to initialize the flip-flops when the electronics are switched on.

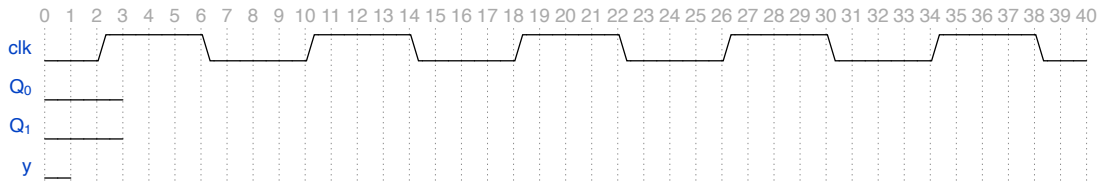
lat/flipflop-07

2.8 Asynchronous Circuit

The following figure shows an asynchronous circuit: the flip-flops have different clock signals.



Complete the following figure, which shows the timing behavior of the circuit. Assign an identical gate delay to all components of the circuit.



lat/flipflop-08